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SUMMARY AND CONCLUSIONS

This study analyzed the current and potential location of the United States broiler industry regionally so as to minimize the overall cost of feed transportation, production and processing, and distributing the finished dressed broiler to the consumer. The general distribution model formulation of the broiler industry combined elements of the standard linear programming formulation as well as the transportation model. (See Appendix A for details). This model formulation allows for a determination of the optimal share of total United States broiler production to allocate among the major producing regions for overall cost minimization.

The analysis divided the 48 contiguous states into 11 active producing regions and four potential Midwestern producing regions. In addition, the country was divided into 18 consuming regions to be supplied by the producing regions at an overall cost minimum.

The study was formulated in terms of postwar historical perspective regarding changes in the production of broilers in the United States Two major trends characterized the broiler industry in the postwar period. These were:

1. The development of a vertically integrated production system centered on the processor-distributor as the primary decision maker, with most grow out contracted to producers located within 25 miles of the processor-distributor.

2. A continued shift of production and processing to the southeastern United States starting with the Delmarva peninsula in the Northeast and extending south of the line through Arkansas and then south to the Gulf of Mexico. In 1982 approximately 88 percent of total United States broiler production was concentrated in this quadrant.

The Southeastern portion of the United States needs to import part or all of its feed input. This research asked whether a lower cost system of production and distribution would result from a partial shift of United States broiler production to the major feed producing areas of the Midwest and/or to closer proximity to major population consuming centers of the Northeast and West Coast. The basic hypothesis tested in the study was that no difference in overall cost of broiler production and distribution would result from reallocation of some or all of the current regional production of the Southeast to other potential producing regions in the Midwest and along the West Coast.

The study used the linear programming formulation with a set of parameters which described the industry in 1982. The 1982 analysis determined the correspondence of current production and distribution system to an optimal allocation based on cost minimization. This served as the comparison for how production and distribution might change under changing parameters regarding key supply and demand factors.

Changes in supply (cost factors) that were evaluated included several step level changes in feed import requirements as well as several level changes in energy input costs. Demand factor changes evaluated included regional population changes projected through the year 2000 as well as changes in per capita consumption.

The most important supply cost factor was the regional availability of feed produced within that region. It is the interaction of available local feed production for broiler production with costs of feed imports which determines the overall cost advantage or disadvantage of a particular producing-processing region. Thus, it was decided to make varying level assumptions about local feed availability for broiler production and to determine the impact on the optimal location of broiler production-processing. Forcing the feed deficit Southeast to varied levels of feed imports determined relative cost advantages as well as production-processing reallocation that would result.

Specifically, an optimal location determination was made by parameters of 100, 50, 25, and zero percent for locally produced feed available for broiler production in the southern regions. The potential Midwest producing regions were assumed to have adequate local feed for broiler production as well as enough for exporting to the feed deficit regions. Several changes were made in regional slaughter capacity and the impacts evaluated.

The model evaluated the impact on the location of production and processing that would result from doubling and tripling cost of energy inputs. Finally, the consequences of regional demand increases resulting from population growth through the year 2000 were evaluated. Both population and per capita increases in broiler consumption were evaluated under two different energy cost assumptions.

The model was also used to determine relative cost differences between regions both in terms of production and processing as well as distribution costs. Major conclusions of the analysis were:

1. The current location of broiler production appears nearly optimal in terms of minimizing overall cost of production, processing and distribution in the base analysis year of 1982.

2. The southern producing regions, particularly Georgia and Alabama, had a substantial cost advantage in broiler production-processing as well as distribution. Although the cost advantage is not large for any one particular aspect of the system, the overall cost advantage is the result of the synergistic effects of several interlocking factors. Labor cost and utilities costs were generally lower in southern producing locations. The feed deficit did not appear to be a cost problem as the South would continue to retain a large part of the total industry output even if forced to import all feed.

3. In spite of advantages of surplus feed in the Midwest, broiler production is not likely to relocate in the Midwest barring a drastic restructuring of cost relations in the South. Presently, overall Midwest production-processing costs are approximately 1.9 to 3.5 cents per pound ready-to-cook more than the lowest cost producers in the South. Distribution costs also are higher in the Midwest. Expansion in the Midwest likely will be limited to partially meeting local market needs and not for export to other regions.

4. West Coast producing regions could become major producers in the future and could supply most of the West Coast consumption centers. Several factors would cause a shift of production to those regions. Product shipping costs from southern producers and Iowa are about five cents more per pound than if the West Coast producer satisfies the local demand. The West Coast feed deficit problem may be offset by improved transportation technology lowering the transport costs of corn and soybean meal from the Midwest to West Coast broiler producers.

5. Local feed availability had the largest impact on reallocation of broiler production of any of the factors evaluated. The quantity of corn and soybean meal available for broiler production was based on an estimate of the region's total production of each product. Thus, the larger the regional production of feedstuffs, the less the change in percentage of feed assumed to be available for local production would affect the overall position of the region in producing broilers competitively. In several cases, regional output of broilers was restricted to the constraints of local feed available. As local feed supplies were depleted, further increases in total broiler production would shift to other regions.

6. Energy costs were of relatively minor importance in determining the optimal location of the broiler industry. Even tripling energy costs would result in only minor shifts of broiler production to the Midwest. Some production, however, would shift to the West Coast.

7. Major shifts of broiler output will not likely result from projected changes in regional population or per capita consumption patterns. Major shifts induced by consumption are unlikely to affect potential broiler production in the feed surplus Midwest barring unforeseen cost of production increases in the South.

INTRODUCTION

The United States broiler industry has undergone profound changes in processes of production and location of production during the last 30 years. A gradual shift from producers making their own production and marketing decisions to contract growers operating primarily under the decision authority of the processing sector of the industry has occurred during the postwar period. At the same time production has gradually shifted to the Southeast with approximately 88 percent of the United States production now concentrated in a region from the Delmarva peninsula across a southern tier of states extending through Arkansas.

The South produces insufficient carbohydrate feed to sustain the current level of broiler production. In addition, much of the South's production is located long distances from population centers and must be shipped at considerable expense to those centers. Superficially, it would appear that economies could be achieved by locating production at closer proximity to consumption centers or to feed grain production areas.

But the South has some advantages. Historically, Southern farmers have a long experience with broiler production. Slow economic development and demise of the cotton industry forced farmers, particularly in Georgia, Alabama, and Mississippi, to look for alternative agricultural pursuits. Partly because of the rate of economic development in the South, wages and construction costs have remained well below the national average.

The major focus of this research centered on two major issues. The first issue is whether the current concentration of broiler production is justified by cost considerations given the feed deficit problem and the necessity to ship the finished product relatively long distances to population-consumption centers. The second issue is the determination of the changes in regional cost of production that might provide economic incentives for a major relocation of broiler production and processing to other regions of the country.

Feed transportation cost impacts the least cost location pattern of broiler production. However, even as a deficit feedstuff area, the South currently appears to have other cost advantages that allow for rail shipment of grain into those areas and still remain more than competitive with other potential regional areas of expansion including the Midwest.

Specific objectives of the study were to determine from a linear programming formulation:

1. how closely the present location of broiler production corresponds to an optimal location given current overall transportation, production and processing costs.

2. how major changes in consumption, production, and transportation costs might bring about an optimal reallocation of broiler production among assumed producing regions.

3. cost differences among the production and consumption regions.

Procedure

To evaluate the location of the broiler industry in terms of the objectives outlined above and evaluate the potential for relocation among producing regions, a linear programming formulation was developed. This formulation was similar to, but not the same as, that developed by Schrader and King in their analysis of the location of the beef cattle feeding industry (see Appendix A page 53 for mathematical formulation).

GENERAL OVERVIEW OF THE U.S. BROILER INDUSTRY AND FRAMEWORK FOR THIS STUDY

The broiler industry was divided into the following four sectors for purposes of this study. These were:

1. Distribution sector - The United States was divided into 18 consumption regions with respective distribution centers (see Figure 1),

2. Production sector - The United States was divided into 11 producing and 4 potential producing regions (see Figures 2 and 3),

3. Processing sector - The United States was divided in the same way as production because of the vertical integration of the broiler industry. Production and processing are generally within 25 miles of each other (see Figure 2), and

4. Feed sector - The sector consisted of a corn and soybean meal category (see Figure 3). Broiler feed rations were assumed to be 70 percent corn and 30 percent soybean meal. Production regions were the primary users of locally produced corn and soybean meal. Under the initial assumption, 25 percent of the corn and 50 percent of the soybean meal produced in each broiler producing region were assumed to be available for broiler production.

The overall assumptions were that:

1. Technology was equivalent in each production region.

2. Regional production constraints were based on each region's processing capacity determined by the number and size of processing plants. These capacity constraints were relaxed in varying

Figure 1

Population Regions and Their Respective Distribution Centers

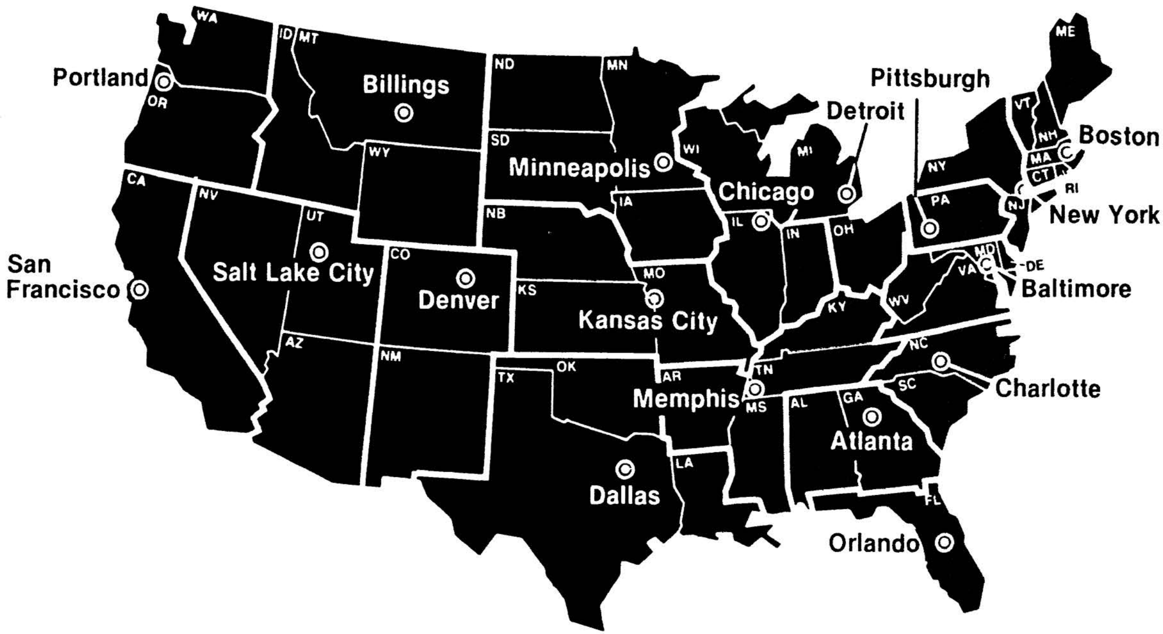


Figure 2

Potential Broiler Production Centers

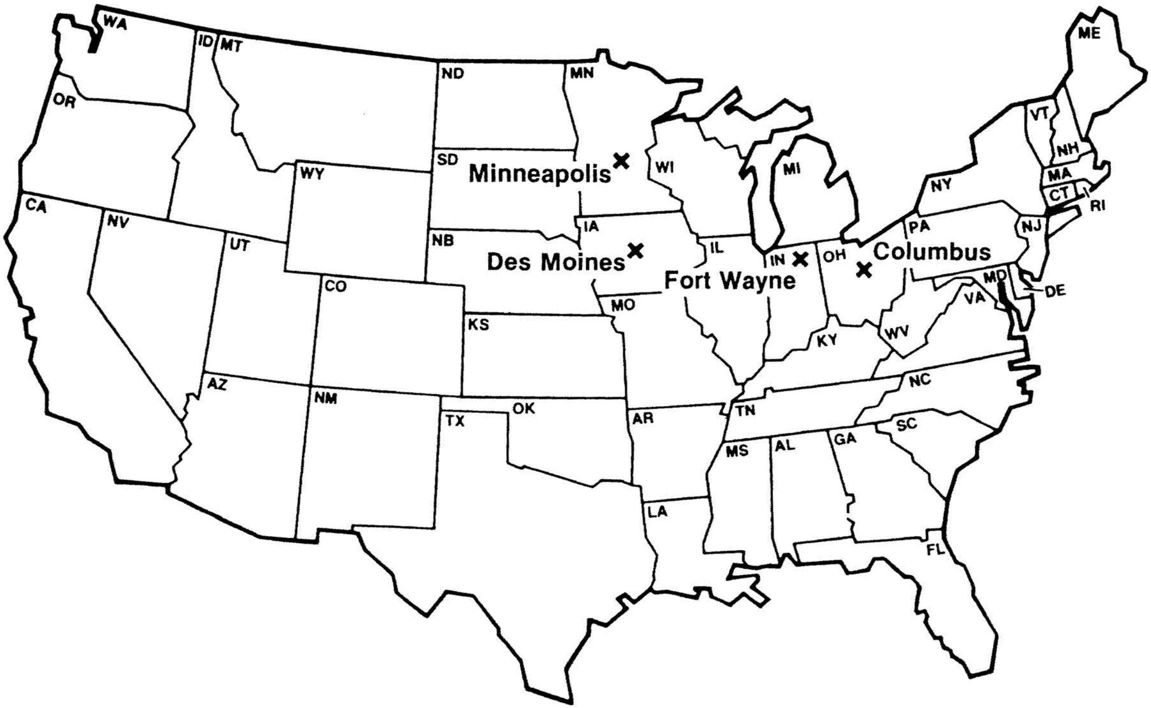
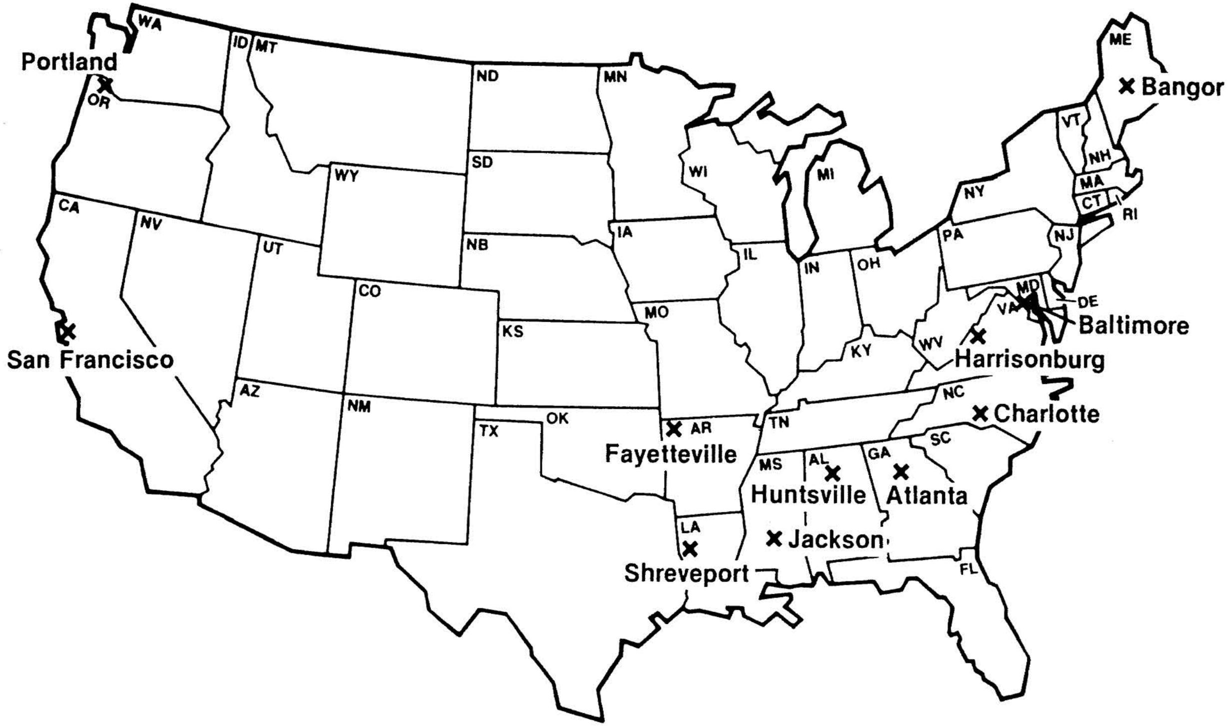


Figure 3

Present Broiler Production Centers



increments for a normative determination of an optimal location pattern.

3. Regional slaughter increases were contingent on supplying broilers at minimum production, processing and distribution costs.

4. The four potential producing regions were chosen to allow production and processing in the Midwest where little or no activity is now occurring. Central points in the Midwest were also chosen as assembly points for the purpose of estimating feed shipment costs. This delineation was to determine if economies could be achieved by locating broiler production and processing in close proximity to surplus feed producing regions (Table 1).

5. The model allowed feed to be shipped between surplus and deficit regions at fixed transport costs. Since it was assumed that a maximum of 25 percent of a region's corn and 50 percent of its production of soybean meal were utilized for broiler production before the exports or imports of the two feed ingredients occurred, the level of broiler production interacted with the local feed supply in initial determination of feed deficit or surplus production-processing regions. This simply says that an overall optimal solution of the model was required under a given set of assumptions before the feed surplus-deficit position of each region was determinable. Extremes under conditions at the time of this study were Maine with no internal feed supply and Alabama and Arkansas with a total soybean crushing capacity 70 percent in excess of that needed for their current broiler production.

6. Transport distribution costs for processed broilers were determined for the wholesale level, and distribution centers were chosen for the 18 population regions (Table 2 and Figure 1). The chosen distribution centers were as close to the geographic center of the consumption regions as possible and represented a major metropolitan center in each of the consumption regions.

7. Demand was assumed constant in all consumption regions with equivalent per capita consumption. Equivalent homogenous product was assumed for all production-processing regions.

8. International exports and imports of broilers were ignored and all output was consumed domestically.

9. Costs of hatching and breeder flock costs were the same in all production-processing regions.

10. Potential broiler producers were available in all processing regions. Activity in a particular region depended upon the broiler processors' location as the vertical integrator. Contract payments to growers were based on the average received in each production region.

Table 1. Broiler Production Regions and Centers 1982

Region		Center	Production	
			Pounds 1/	Percentage
1.	Maine	Bangor, Me.	74,361	.6
2.	Delaware, Pennsylvania, Maryland	Baltimore, Md.	1,385,080	11.8
3.	Virginia, West Virginia - Shenandoah Valley	Harrisonburg, Va.	717,123	6.0
4.	North Carolina	Charlotte, N.C.	1,297,590	10.8
5.	Georgia, South Carolina, Florida, Southeast Tennessee	Atlanta, Ga.	2,378,487	19.9
6.	Alabama	Huntsville, Ala.	1,404,883	11.7
7.	Mississippi	Jackson, Miss.	872,029	7.3
8.	Northwest Arkansas, Southwest Missouri	Fayetteville, Ark.	2,020,894	16.9
9.	Louisiana, Texas, Southern Arkansas	Shreveport, La.	986,525	8.2
10.	California	San Francisco, Calif.	565,027	4.7
11.	Washington, Oregon	Portland, Oreg.	107,823	.9
	Potential Production Regions			
12.	Wisconsin, Minnesota	St. Paul, Minn.	104,518	.9
13.	Illinois, Iowa, Missouri	Des Moines, Iowa	2,690	.0
14.	Indiana, Ohio, Michigan	Fort Wayne, Ind.	48,112	.4
15.	Ohio	Columbus, Ohio	2,054	.0
	Total		11,967,196	100.0

1/ Ready-to-cook basis.

Table 2. States, Consumption Centers, and Percentage of United States' Population, 1980, 1990 and 2000

States	Consumption Center	Population 1980	Population 1990	Population 2000
			Percentage	
Maine New Hampshire Vermont Massachusetts Connecticut Rhode Island	Boston	5.5	5.2	4.9
Delaware Maryland Virginia West Virginia Washington, D.C.	Baltimore	5.7	5.5	5.3
New York New Jersey	New York	11.1	9.7	8.5
North Carolina South Carolina	Charlotte	4.0	4.0	3.8
Georgia Alabama	Atlanta	4.2	4.2	4.2
Pennsylvania	Pittsburg	5.3	4.7	4.2
Florida	Orlando	4.3	5.4	6.6
Michigan Ohio	Detroit	8.9	8.2	7.4
Wisconsin Illinois Indiana	Chicago	9.6	9.0	8.3
Kentucky Tennessee Arkansas Mississippi	Memphis	5.8	5.7	5.9
Missouri Nebraska Kansas	Kansas City	3.9	3.7	3.5

Table 2. States, Consumption Centers, and Percentage of United States' Population, 1980, 1990 and 2000

States	Consumption Center	Population 1980	1990	2000
			Percentage	
Minnesota Iowa North Dakota South Dakota	Minneapolis	3.7	3.5	3.3
Oklahoma Texas Louisiana	Dallas	9.5	10.4	11.3
Montana Idaho Wyoming	Billings	1.0	1.3	1.3
Colorado New Mexico	Denver	1.9	2.1	2.4
Utah Nevada Arizona	Salt Lake City	2.2	3.0	3.9
California	San Francisco	10.5	11.1	11.6
Washington Oregon	Portland	3.0	3.4	3.7
Total		100.0	100.0	100.0
Number of population		225,107,308	247,342,800	264,956,800

Source: Bureau of Census, PC-1-A1, April 1983.

Broiler Production-Processing and Feed Utilization Framework

The broiler industry is vertically integrated. The structure of this industry is such that the processor is the primary decision maker determining the location of the individual production-processing complex. This is consistent with the Breimyer definition of vertical integration as "the exercise by a single firm of control over a product at two or more contiguous stages in marketing" (Breimyer, page 202).

The development of confinement production technology with accompanying economies of size gradually evolved the current coordinated system which in turn induced very strong centralization tendencies. For instance, an integrator's production facilities (owned or contracted) were generally no more than 25 miles from the processing plant. Therefore, this centralization allowed designation of specific points throughout the United States where production and processing costs may differ. These production and processing locations are referred to as broiler production centers.

The United States was divided into 11 production centers and 4 potential centers. In order to analyze the potential for locating production in the Midwest, 4 centers were arbitrarily chosen to represent production points scattered throughout the Midwest. It was assumed that these points were adequately distributed to represent potential production areas that broiler integrators would consider because of proximity to feed grains and to the population centers.

Specific production-processing cost and feed utilization parameters included the following:

1. All costs associated with production and processing were determined on the basis of 1,000 broilers. Four pound live weight broilers were used and broiler dressing percentage was specified 75 percent. Thus, 1,000 broilers would produce 3,000 pounds of dressed broilers for distribution to consumption.

2. Production costs include a payment to growers and costs for gas (or oil), and electricity. Processing costs include the average hourly wage and utilities. These costs are shown for the production-processing regions in Appendix B, Table 1 and 2.

3. Regional production estimates for soybean meal and corn for 1982 were obtained from the Bureau of Census and Agricultural Statistics, respectively (Appendix B, Table 3). Regional surplus and deficit figures were calculated for the present location pattern. These values are shown in Appendix B, Table 3.

4. Because of competing uses, each of the current 11 major production-processing regions could have differences in the availability of locally produced corn and soybean meal for broiler production. Availability percentages were varied by increments from 100, 50, 25 and zero percent of local production of these feedstuffs available for regional broiler production.

5. Locally produced feed was priced uniformly across regions and charged a transport cost of $2.00 per ton for internal regional feed usage. The 11 major production-processing regions imported necessary feed requirements from any of the four Midwest potential broiler producing centers at fixed rate transport charges. This configuration of regional feed production and utilization for broiler production was designed for evaluation of the economic conditions needed to provide economic incentive for relocation of broiler production in the Midwest.

6. Rail rates for soybean meal and corn transport between feed surplus and deficit regions were obtained from the 1982 Waybill. These statistics were furnished by the United States Department of Transportation. These rates are shown in Appendix B, Table 4.

7. Rail rates for each area were based on an average of shipments from the Midwest to 11 broiler production centers.

8. If Waybill statistics were not available because of little movement between areas, estimated rail rates were provided by USDA-Agricultural Stabilization and Conservation Service.

Broiler Distribution to Wholesale

The distribution of broilers was evaluated on the basis of costs of shipment to wholesale markets. As indicated earlier, 18 consumption regions were delineated with a specific city as the distribution center for a respective region (Table 2). Allowances were made for unequal spatial distribution of population in the selection of regional centers. Population estimates were obtained from the Bureau of Census.

Specific parameters of the distribution component of the model were:

1. Per capita consumption was the same in all regions so that total regional demand was determined by multiplying per capita consumption estimates by the regional population.

2. Distances from consumption and production centers were determined from a Rand McNally Atlas.

3. Shipment costs between production and consumption regions were determined per 1,000 pounds ready-to-cook broilers by using a $1.1602 constant cost per mile for a 35,000 pound truck load. Inter-regional cost of transport between production and consumption centers per 1,000 pounds of ready-to-cook product is shown in Appendix B, Table 5.

Overview of the Model

The mathematical model chosen for this analysis can best be described as a generalized distribution model along the lines discussed by Rohdy (see King, pp. 79-112). This model is an extension of the transportation model and the standard linear programming formulation and determines simultaneously the optimal (cost minimum) source of raw materials (feed products of corn and soybean meal), production and processing location of intermediate product, and distribution of the product to consuming regions.

In this analysis regional consumer demand is assumed to be the overall exogenous variable. Processing regions supply to consuming regions and production-processing locations minimize overall total costs of the following:

1. transportation of the ready-to-cook broiler from processing regions to consuming regions;

2. processing;

3. production;

4. transportation of corn and soybean meal from feed surplus to feed deficit regions.

The relative importance of location to various cost and performance factors are listed in Table 3.

There are four interrelated parts of the model. The broiler production and processing sections are structured to satisfy the consumer demand constraints and are a standard linear programming formulation. The two transportation sections were formulated to supply consuming regions with finished products and to supply producing regions with sufficient feed to produce the finished product.

ANALYSIS AND RESULTS

The programming formulation of the broiler production, processing and distribution system compares 1982 conformity of the existing industry to an optimal production and processing allocation of regional industry output. This is subsequently referred to as the control solution. Thus, the present situation was compared with the normative or control solution in terms of changes in aggregate production percentages. Several scenarios were evaluated in which individual variables were changed and the model solved for an optimal cost solution. These results are discussed subsequently in this section.

In evaluating the results of this analysis and their implications, it should be kept in mind that many factors affect the location and structure of the broiler industry. Results of the model are highly

Table 3.--Relative Importance of Location in Cost Competitiveness

Cost and performance factors	Overall importance	Principle influence: locational (L) vs. non-locational (N)
<u>Cost factors</u>		
Chick cost	moderate	N
Grow-out cost:		
Feed	very high	L, N*
Fuel	moderate	1/ L, N*
Grower payment	low	N*
Live haul	low	N
Processing costs:		
Labor	high	L, N*
Packaging	low	N
Utilities	low	L, N*
Depreciation, rent	very low	N
Repairs, maintenance	very low	N
Taxes, insurance	very low	N
Inspection	very low	N
Freight out	moderate	L*
General, administrative	moderate	N
<u>Performance factors</u>		
Sales price	very high	L, N
Feed conversion 2/	moderate-high	L, N*
Yield	high	N
Hatchability	moderate	N
Liveability	low-moderate	N

1/ All starred factors are specifically addressed in the broiler model.
2/ Feed conversion performance factor is included in model but held constant for all production regions.

Source: David Shaw Associates. "An Analysis of the Economic Viability of the Maine Broiler Industry". May 1981.

dependent upon validity of specification, data, and the specific assumptions that were made and discussed in an earlier section. Any change will significantly affect the results of the analysis.

Several values of specific variables were changed and the model solved for an optimal solution. Probably the most critical variable for broiler production in the South is the need to import corn and soybean meal in addition to that produced locally. In order to evaluate the purported advantage of the South in producing broilers, several different scenarios were evaluated based on different assumptions about the amount of locally produced feed inputs that would be available to local broiler producers.

The different local utilization percentages were evaluated to specifically determine the cost and production effects of forcing huge imports of corn and soybean meal from surplus producing regions in the Midwest.

Several different analyses were made with the model based on different assumptions about varying supply and demand factors. Each analysis is based on different levels in which one or more parameters are changed. These analyses were attempts to project potential shifts in broiler production to minimum cost areas.

The supply parameters used in the model were slaughter capacity by region, regional feed availability and energy costs. Five levels of slaughter capacity were used in analysis of different model scenarios. These were fixed (1982 capacity), 1982 increased ten percent, 1982 increased 20 percent, each regional capacity constrained at three billion pounds RTC broilers, and finally unconstrained regional slaughter capacity. Five levels of regional feed availability were also evaluated in different model scenarios. These were the control level with 25 percent of corn and 50 percent of soybean available, 100 percent of both feeds, 50 percent local feedstuffs, 25 percent of local feedstuffs and zero percent of local feedstuffs. Finally, three levels of energy costs were evaluated in various scenarios. These were the 1982 level (control), double the 1982 level and triple the 1982 level.

Demand parameters evaluated in the study were regional population and per capita consumption. Three population levels were evaluated in various scenarios and these were control (1982), 1990 projections and 2000 projections. Per capita consumption condition levels evaluated were control (1982), 1990 55 pounds per capita and 2000 58 pounds per capita.

Thirty-five different scenarios were analyzed using the model with different condition levels of the supply and demand parameters. The supply and demand parameters, condition levels of the thirty-five scenarios evaluated, and table number of analysis results are summarized in matrix format in Figure 4. The reader may wish to refer to Figure 4 for the condition levels of the supply and demand

FIGURE 4: Supply and Demand Parameters, Variable Condition and Scenarios Analyzed

Variable Condition/ Scenario	SC_1	SC_2	SC_3	SC_4	SC_5	SC_6	SC_7	SC_8	SC_9	SC_{10}	SC_{11}	SC_{12}	SC_{13}	SC_{14}	SC_{15}	SC_{16}	SC_{17}	SC_{18}	SC_{19}	SC_{20}	SC_{21}	SC_{22}	SC_{23}	SC_{24}	SC_{25}	SC_{26}	SC_{27}	SC_{28}	SC_{29}	SC_{30}	SC_{31}	SC_{32}	SC_{33}	SC_{34}	SC_{35}
	T_4	T_4	T_4	T_4	T_5	T_5	T_5	T_5	T_6	T_6	T_6	T_6	T_7	T_7	T_7	T_7	T_8	T_8	T_8	T_8	T_9	T_9	T_9	T_{10}	T_{10}	T_{10}	T_{11}	T_{11}	T_{11}	T_{12}	T_{12}	T_{12}	T_{13}	T_{13}	T_{13}
Demand Parameters:																																			
1. Population Condition Levels:																																			
P_1. Control (1982)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X								
P_2. 1990																									X			X		X	X	X			
P_3. 2000																										X			X				X	X	X
2. Per Capita Consumption Condition Levels:																																			
C_1. Control (1982)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								
C_2. 1990 - 55 P.P.C.																												X		X	X	X			
C_3. 2000 - 58 P.P.C.																													X				X	X	X
Supply Parameters:																																			
1. Slaughter Capacity Condition Levels:																																			
S_1. Fixed Control (1982)	X				X				X				X				X																		
S_2. Increase 10%		X				X				X				X				X																	
S_3. Increase 20%			X				X				X				X				X																
S_4. 3 Billion Lbs. in Each Region				X				X				X				X				X															
S_5. Uncon- strained																					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
2. Regional Feed Availability Condition Levels:																																			
F_1. Control 25% Corn 50% Soybean	X	X	X	X																	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
F_2. 100%					X	X	X	X																											
F_3. 50%									X	X	X	X																							
F_4. 25%													X	X	X	X																			
F_5. 0%																	X	X	X	X															
3. Energy Cost Condition Levels:																																			
E_1. Control (1982)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X			X	X	X	X	X	X	X			X		
E_2. Double																						X									X			X	
E_3. Triple																							X									X			X

X = Variable Condition Under Scenario

SC_x = Scenario 1 to 35

T_x = Results of Scenario Reported in Table 4 through 13 parameters in evaluating the results of the scenarios analysis reported in Tables 4 through 13.

The analysis of the supply and demand parameters and condition levels of the 35 different scenarios represented the investigators' best judgment of the most important parameters in determining the optimal location of the broiler producing-processing system. Regional slaughter capacity probably places the longest lasting constraints upon regional output expansion or contraction. New capital facilities take substantial time to plan and build and old capacity will likely be depreciated out before regional output is reduced. Thus, an analysis of several different regional slaughter capacity condition levels was deemed to be a critical part of the analysis. Four constrained slaughter capacity levels were evaluated in the first twenty scenarios for each of the various regional feed availability constraints evaluated (Figure 4). Unconstrained slaughter capacity in each region was used in scenarios 21 through 35 which involved time condition variables on demand parameters (Figure 4). Given the time frame for the demand expansion, regional slaughter capacity could be increased in response to change in demand as well as in response to increases in energy costs evaluated in scenarios 21 through 35.

Minimum Cost Allocations Based on Expanded Slaughter Capacity

The first analysis determined an optimum solution based on changing regional slaughter capacity. Slaughter capacity of each region was expanded in three increments: 10 percent; 20 percent; and set at three billion pounds (ready-to-cook) and an optimal solution determined for each level. It was assumed that a specific percentage of local feed production, 25 percent for corn and 50 percent for soybean meal, in a region was available for broiler production in that region. Results and optimal allocation of production and processing are shown in Table 4.

A ten percent increase represents a small adjustment in production, and indicates which regions may have a locational advantage (Table 4). Six production centers would reduce their slaughter as a consequence by expansion of other regions (Table 4). Maine and Indiana would cease production with a general ten percent regional increase in slaughter capacity. This suggests that these regions were at a locational disadvantage relative to other producing regions.

With an additional 20 percent overall increase in slaughter capacity, only Arkansas would reduce production from its previously established level. Increased production in the West Coast and Minnesota production regions would replace this Arkansas output.

Table 4. Percentage of United States' Broiler Production at Varying Assumptions of Slaughter Capacity, 1982

Broiler production center	Present situation	Increase slaughter capacity 10%	Increase slaughter capacity 20%	Set slaughter capacity 1/	Present situation	Increase slaughter capacity 10%	Increase slaughter capacity 20%	Set slaughter capacity 1/
	1,000 lbs. ready-to-cook				Percentage of aggregate production			
P-1 Bangor, Me.	74,361	0	0	0	0.6	0.0	0.0	0.0
P-2 Baltimore, Md.	1,385,080	2/*1,523,588	1,614,630	1,614,630	11.6	12.7	13.5	13.5
P-3 Harrisonburg, Va.	717,123	520,313	520,313	520,313	6.0	4.3	4.3	4.3
P-4 Charlotte, N.C.	1,297,590	1,234,725	1,234,725	1,234,725	10.8	10.3	10.3	10.3
P-5 Atlanta, Ga.	2,378,487	*2,616,336	2,849,875	1,526,964	19.9	21.9	23.8	12.8
P-6 Huntsville, Ala.	1,404,883	*1,545,371	*1,685,860	2,222,750	11.7	12.9	14.1	18.6
P-7 Jackson, Miss.	872,029	571,375	571,375	571,375	7.3	4.8	4.8	4.8
P-8 Fayetteville, Ark.	2,020,894	2,174,015	1,630,733	1,555,050	16.9	18.2	13.6	13.0
P-9 Shreveport, La.	986,525	921,150	921,150	921,150	8.2	7.7	7.7	7.7
P-10 San Francisco, Calif.	565,027	*621,530	*678,032	1,258,271	4.7	5.2	5.7	10.5
P-11 Portland, Oreg.	107,823	*118,605	*129,388	242,325	.9	1.0	1.1	2.0
P-12 St. Paul, Minn.	104,518	*114,970	*125,422	182,610	.9	1.0	1.0	1.5
P-13 Des Moines, Iowa	2,690	*2,959	*3,228	0	.0	.0	.0	.0
P-14 Fort Wayne, Ind.	48,112	0	0	0	.4	.0	.0	.0
P-15 Columbus, Ohio	2,054	*2,259	*2,465	117,033	.0	.0	.0	1.0
Total	11,967,196	11,967,196	11,967,196	11,967,196	100.0	100.0	100.0	100.0

1/ Slaughter capacity set at three billion pounds (ready-to-cook) in each region. 2/ Starred quantities represent an increase to the upper limit of a broiler production center's assumed capacity.

Slaughter capacity would not be an effective constraint when all regions were assumed to have a slaughter capacity of three billion pounds (Table 4). A large portion of aggregate production would shift to the West. The two western consumption centers would be totally supplied by West Coast production (Table 4). This shift would greatly reduce Arkansas' competitive position. Delmarva would increase production to supply the Northeast. Some shifts would occur in production among states in the South; however, while the total aggregate percentage of production would remain approximately the same.

CHANGES IN SLAUGHTER CAPACITY AND ASSUMED FEED INGREDIENT UTILIZATION

The amount of local corn and soybean meal available for broilers in each region is an important factor in determining optimal location of production and processing. However, even a high percentage of utilization of local feed production does not mean the region is self sufficient in feed output needs. Local production of the feedstuff may be relatively low compared to broiler production in a specific region and thus create a deficit feedstuff area even when this analysis assumed a high proportion of local feed output available for broiler production.

Local Feed Ingredient Availability of 100 Percent

The next analysis assumed four percentage levels of local feed output available for broiler production in each region except Midwest centers. An analysis of the optimal solution was determined for local feed availability of 100, 50, 25, and zero percent. The Midwest centers were assumed to have 100 percent of their corn and soybean meal production available for local production and for exports to other production centers.

An optimal solution of the model was determined with slaughter capacity varying by ten percent, 20 percent, and set at three billion pounds assuming 100 percent of local feed production available for broiler production and the results are shown in Table 5. This assumption of 100 percent availability understates costs in production areas more distant from the Midwest, giving those areas a greater competitive advantage.

A ten percent increase in regional slaughter capacity would result in an expansion in some areas at the expense of the higher cost regions. Maine, Iowa and Indiana would go out of production in the optimal solution with these parameters. Virginia and Mississippi would decrease their proportion of aggregate production by more than three percentage points. All other regions would expand their output to the full ten percent capacity to supply broilers no longer produced in those higher cost regions.

Table 5. Percentage of United States' Broiler Production Assuming 100 Percent of Local Feed Ingredient Utilization and Varying Slaughter Capacity 1982

Broiler production center	Present situation	Increase slaughter capacity 10%	Increase slaughter capacity 20%	Set slaughter capacity[1]	Present situation	Increase slaughter capacity 10%	Increase slaughter capacity 20%	Set slaughter capacity[1]
	1,000 lbs. ready-to-cook				Percentage of aggregate production			
P-1 Bangor, Me.	74,361	0	0	0	0.6	0.0	0.0	0.0
P-2 Baltimore, Md.	1,385,080	2/*1,523,588	1,426,204	0	11.6	12.7	11.9	.0
P-3 Harrisonburg, Va.	717,123	184,665	0	0	6.0	1.5	.0	.0
P-4 Charlotte, N.C.	1,297,590	*1,427,349	*1,557,108	*3,000,000	10.8	11.9	13.0	25.1
P-5 Atlanta, Ga.	2,378,487	*2,616,336	*2,854,184	*3,000,000	19.9	21.9	23.9	25.1
P-6 Huntsville, Ala.	1,404,883	*1,545,371	*1,685,860	1,181,997	11.7	12.9	14.1	9.9
P-7 Jackson, Miss.	872,029	504,361	167,400	167,400	7.3	4.2	1.4	1.4
P-8 Fayetteville, Ark.	2,020,894	*2,222,983	*2,425,073	*3,000,000	16.9	18.6	20.3	25.1
P-9 Shreveport, La.	986,525	*1,085,178	1,043,946	0	8.2	9.1	8.7	.0
P-10 San Francisco, Ca.	565,027	*621,530	*678,032	1,258,271	4.7	5.2	5.7	10.5
P-11 Portland, Oreg.	107,823	*118,605	*129,388	359,527	.9	1.0	1.1	3.0
P-12 St. Paul, Minn.	104,518	*114,970	0	0	.9	1.0	.0	.0
P-13 Des Moines, Iowa	2,690	0	0	0	.0	.0	.0	.0
P-14 Fort Wayne, Ind.	48,112	0	0	0	.4	.0	.0	.0
P-15 Columbus, Ohio	2,054	*2,259	0	0	.0	.0	.0	.0
Total	11,967,196	11,967,196	11,967,196	11,967,196	100.0	100.0	100.0	100.0

1/ Slaughter capacity set at three billion pounds (ready-to-cook) in each region. 2/ Starred quantities represent an increase to the upper limit of all broiler production center's assumed capacity.

An assumed expansion of 20 percent in regional slaughter capacity would result in further concentration of aggregate production in the southeastern production quadrant. Six production areas would expand the full 20 percent. The southern regions comprising North Carolina, Georgia, and Alabama combined would account for over 50 percent of aggregate production in an optimal allocation based on these assumptions. California, Oregon, and Arkansas would also expand to their limit. Maryland and Louisiana would remain in the optimal solution at levels slightly higher than the base production.

With the three billion pound capacity and 100 percent local feed utilization assumed in all regions, the lowest cost of production, processing, and distribution would be in the producing regions of North Carolina, Georgia, and Arkansas. These three states would expand to produce over 75 percent of aggregate output. California and Oregon would expand to supply the western region's needs. No Midwest production would result.

Local Feed Ingredient Availability of 50 Percent

Results of the optimal solution using 50 percent feed ingredient availability parameters are shown in Table 6. The analysis was again made with the different increases in slaughter capacity previously allowed. A 10 percent increase in slaughter capacity would result in expansion of output in all regions except Maine, North Carolina, and Mississippi. Maine would not produce broilers under these assumptions. North Carolina and Mississippi would reduce their share of aggregate production by five and two and one half percent, respectively.

An expansion of 20 percent in regional slaughter capacity would result in Maryland, Virginia, Alabama, Arkansas, Louisiana, and Oregon expanding to full slaughter capacity. Although not expanding to full slaughter capacity, Georgia and California still would increase output over the present situation. An optimal allocation of regional output under these assumptions would result in no output in Maine or any of the Midwest regions.

Only Arkansas would expand production to the three billion pound limit. Maryland, Louisiana, Alabama and West Coast production centers would expand production relative to the present situation. Virginia, North Carolina, and Mississippi would decrease production relative to the present situation.

Local Feed Ingredient Availability of 25 Percent

Probably the most competitively realistic assumption constrains current producing regions to only 25 percent of locally produced feed available for broiler production. Optimal solutions were again determined with the ten and 20 percent increases in regional slaughter capacity and finally a three billion pound increase. The results are shown in Table 7. Production expansion of ten percent

Table 6. Percentage of United States' Broiler Production Assuming 50 Percent of Local Feed Ingredient Utilization, 1982

Broiler production center	Present situation	Increase slaughter capacity 10%	Increase slaughter capacity 20%	Set slaughter capacity[1]	Present situation	Increase slaughter capacity 10%	Increase slaughter capacity 20%	Set slaughter capacity[1]
	1,000 lbs. ready-to-cook				Percentage of aggregate production			
P-1 Bangor, Me.	74,361	0	0	0	0.6	0.0	0.0	0.0
P-2 Baltimore, Md.	1,385,080	2/*1,523,588	*1,662,096	1,981,351	11.6	12.7	13.9	16.6
P-3 Harrisonburg, Va.	717,123	*788,835	*860,548	329,991	6.0	6.6	7.2	2.8
P-4 Charlotte, N.C.	1,297,590	700,283	246,945	246,945	10.8	5.9	2.1	2.1
P-5 Atlanta, Ga.	2,378,487	*2,616,336	2,558,580	1,725,975	19.9	21.9	21.4	14.4
P-6 Huntsville, Ala.	1,404,883	*1,545,371	*1,685,860	2,033,018	11.7	12.9	14.1	17.0
P-7 Jackson, Miss.	872,029	571,375	571,375	83,700	7.3	4.8	4.8	.7
P-8 Fayetteville, Ark.	2,020,894	*2,222,983	*2,425,073	*3,000,000	16.9	18.6	20.3	25.1
P-9 Shreveport, La.	986,525	*1,085,178	*1,183,830	1,563,187	8.2	9.1	9.9	13.1
P-10 San Francisco, Ca.	565,027	*621,530	643,500	643,500	4.7	5.2	5.4	5.4
P-11 Portland, Oreg.	107,823	*118,605	*129,388	359,527	.9	1.0	1.1	3.0
P-12 St. Paul, Minn.	104,518	*114,970	0	0	.9	1.0	.0	.0
P-13 Des Moines, Iowa	2,690	*2,959	0	0	.0	.0	.0	.0
P-14 Fort Wayne, Ind.	48,112	*52,923	0	0	.4	.4	.0	.0
P-15 Columbus, Ohio	2,054	*2,259	0	0	.0	.0	.0	.0
Total	11,967,196	11,967,196	11,967,196	11,967,196	100.0	100.0	100.0	100.0

1/ Slaughter capacity set at three billion pounds (ready-to-cook) in each region. 2/ Starred quantities represent an increase to the upper limit of all broiler production center's assumed capacity.

Table 7. Percentage of United States' Broiler Production Assuming 25 Percent of Local Feed Utilization, 1982

Broiler production center	Present situation	Increase slaughter capacity 10%	Increase slaughter capacity 20%	Set slaughter capacity[1]	Present situation	Increase slaughter capacity 10%	Increase slaughter capacity 20%	Set slaughter capacity[1]
	1,000 lbs. ready-to-cook				Percentage of aggregate production			
P-1 Bangor, Me.	74,361	0	0	0	0.6	0.0	0.0	0.0
P-2 Baltimore, Md.	1,385,080	2/*1,523,588	*1,662,096	1,614,630	11.6	12.7	13.9	13.5
P-3 Harrisonburg, Va.	717,123	690,359	520,312	520,312	6.0	5.8	4.3	4.3
P-4 Charlotte, N.C.	1,297,590	1,234,725	1,234,725	1,234,725	10.8	10.3	10.3	10.3
P-5 Atlanta, Ga.	2,378,487	*2,616,336	2,337,160	1,424,938	19.9	21.9	19.5	11.9
P-6 Huntsville, Ala.	1,404,883	*1,545,371	*1,685,860	2,350,052	11.7	12.9	14.1	19.6
P-7 Jackson, Miss.	872,029	*959,232	*1,046,435	285,688	7.3	8.0	8.7	2.4
P-8 Fayetteville, Ark.	2,020,894	1,563,187	1,563,187	1,555,050	16.9	13.1	13.1	13.0
P-9 Shreveport, La.	986,525	921,150	921,150	921,150	8.2	7.7	7.7	7.7
P-10 San Francisco, Ca.	565,027	*621,530	*678,032	1,258,271	4.7	5.2	5.7	10.5
P-11 Portland, Oreg.	107,823	*118,605	*129,388	242,325	.9	1.0	1.1	2.0
P-12 St. Paul, Minn.	104,518	*114,970	*125,422	443,022	.9	1.0	1.0	3.7
P-13 Des Moines, Iowa	2,690	*2,959	*3,228	0	.0	.0	.0	.0
P-14 Fort Wayne, Ind.	48,112	*52,923	*57,734	0	.4	.4	.5	.0
P-15 Columbus, Ohio	2,054	*2,259	*2,465	117,033	.0	.0	.0	1.0
Total	11,967,196	11,967,196	11,967,196	11,967,196	100.0	100.0	100.0	100.0

1/ Slaughter capacity set at three billion pounds (ready-to-cook) in each region. 2/ Starred quantities represent an increase to the upper limit of all broiler production center's assumed capacity.

would occur in ten of the regions. An optimal solution would result in the full ten percent increase in output in ten of the producing regions. Aggregate production percentage would drop slightly in Virginia, North Carolina, Arkansas, and Louisiana. Maine would not be in the optimal solution.

In general, the same relationship held assuming the 20 percent increase in slaughter capacity. All of the previous regions would expand with the exception of Georgia, which would have a slight decrease in its aggregate production percentage.

Assuming an increase in production capacity to three billion pounds produced some interesting results. Alabama and Georgia would reverse their aggregate production percentages from that of the current (1982) situation. California and Oregon expand to meet the West Coast's needs. The four Midwestern centers would produce a total of less than five percent of aggregate production.

Local Feed Ingredient Availability of Zero Percent

Finally, present broiler producing regions were competitively handicapped by being forced to import all feed for their broiler production. All 11 production centers outside the Midwest were assumed to import all feed ingredients. The optimal regional production of broilers, shown in Table 8, was determined under the three slaughter capacity assumptions.

A ten percent increase in slaughter capacity would result in an expansion of production in all regions except Maine, Oregon, and North Carolina. Both Maine and Oregon would go out of production completely. North Carolina would decrease its share of aggregate production by over seven percentage points.

When constrained to import all feed and slaughter capacity increased 20 percent for all regions, North Carolina would produce no broilers. All other areas currently producing, except Mississippi, would produce a higher proportion of aggregate production than at present.

With the assumption of three billion pounds increase in regional slaughter capacity, substantial production would finally move to the Midwest. However, even then less than 30 percent of the aggregate production would locate in the four Midwest centers. Over 55 percent of the aggregate production would locate in Alabama, Louisiana, and Maryland. Only Alabama would expand to the full amount of capacity.

Table 8. Percentage of United States' Broiler Production Assuming No Local Feed Ingredient Utilization, 1982

Broiler production center	Present situation	Increase slaughter capacity		Set slaughter capacity[1]	Present situation	Increase slaughter capacity		Set slaughter capacity[1]
		10%	20%			10%	20%	
		1,000 lbs. ready-to-cook			% of aggregate production			
P-1 Bangor, Me.	74,361	0	0	0	0.6	0.0	0.0	0.0
P-2 Baltimore, Md.	1,385,080	2/*1,523,588	*1,662,096	2,658,916	11.6	12.7	13.9	22.2
P-3 Harrisonburg, Va.	717,123	*788,835	860,548	0	6.0	6.6	7.2	.0
P-4 Charlotte, N.C.	1,297,590	431,031	0	0	10.8	3.6	.0	.0
P-5 Atlanta, Ga.	2,378,487	*2,616,336	2,730,308	476,686	19.9	21.9	22.8	4.0
P-6 Huntsville, Ala.	1,404,883	*1,545,371	*1,685,860	*3,000,000	11.7	12.9	14.1	25.1
P-7 Jackson, Miss.	872,029	*959,232	713,608	0	7.3	8.0	6.0	.0
P-8 Fayetteville, Ark.	2,020,894	*2,222,982	2,264,064	0	16.9	18.6	18.9	.0
P-9 Shreveport, La.	986,525	*1,085,178	*1,183,830	1,140,734	8.2	9.1	9.9	9.5
P-10 San Francisco, Ca.	565,027	*621,530	*678,032	1,258,271	4.7	5.2	5.7	10.5
P-11 Portland, Oreg.	107,823	0	0	0	.9	.0	.0	.0
P-12 St. Paul, Minn.	104,518	*114,970	*125,422	919,582	.9	1.0	1.0	7.7
P-13 Des Moines, Iowa	2,690	*2,959	*3,228	1,860,358	.0	.0	.0	15.5
P-14 Fort Wayne, Ind.	48,112	*52,923	*57,734	317,750	.4	.4	.5	2.7
P-15 Columbus, Ohio	2,054	*2,259	*2,465	334,898	.0	.0	.0	2.8
Total	11,967,196	11,967,196	11,967,196	11,967,196	100.0	100.0	100.0	100.0

1/ Slaughter capacity set at three billion pounds (ready-to-cook) in each region. 2/ Starred quantities represent an increase to the upper limit of all broiler production center's assumed capacity.

IMPACT OF ENERGY COST CHANGES ON OPTIMAL BROILER INDUSTRY LOCATION

Although the cost of feed is the major factor in the cost of producing broilers, energy is also an important element of the total cost structure (see Appendix B, Table 1). Thus, the impact on the optimal location of the broiler industry with major changes in the price of energy was determined.

The analysis assumes a doubling and tripling of energy costs with no regional constraints on slaughter capacity. The initial solution's local feed utilization rate of 25 percent for corn and 50 percent for soybean meal was assumed.

Energy costs are implicit in every cost in the production, processing, and distribution chain. This analysis examined only specific, directly defined costs. The energy costs were as follows:

1. fuel component in truck transportation costs,

2. utilities used in processing,

3. fuel and electricity used in production,

4. fuel component in rail transportation costs.

It was assumed that fuel accounts for 25 percent of truck transportation costs and ten percent of a rail rate. The differential in these two transportation costs was due to the high overhead charge associated with rail transportation. The utilities for processing, along with fuel and electricity for production, were directly doubled and tripled.

Results of Energy Cost Changes on Optimal Location

Table 9 shows the changes in optimal location of the broiler industry under 1982 conditions resulting from the assumed doubling and tripling of energy costs. Overall, energy costs would have very little effect on the optimal location in terms of the percentage allocation of aggregate production located in the various regions. When compared with the optimal solution under present costs, there are only four states with changes in their aggregate production percentages. These states include Georgia, Minnesota, California, and Mississippi.

The assumed increases in energy costs would cause Georgia to decrease its shipments of broilers to the Midwest. Minnesota would increase production to fulfill the contraction of output in Georgia.

Doubling energy costs expands California production under optimal regional allocations. But a tripling of energy costs would reduce California production percentages to about the current level. The

Table 9. Percentage of United States' Broiler Production When Double and Triple All Energy Costs, 1982

Broiler production center	Present situation	Unconstrained slaughter capacity			Present situation	Unconstrained slaughter capacity		
		present costs	double energy	Triple energy cost		Present costs	Double energy costs	Triple energy costs
		1,000 lbs. ready-to-cook			Percentage of aggregate production			
P-1 Bangor, Me.	74,361	0	0	0	0.6	0.0	0.0	0.0
P-2 Baltimore, Md.	1,385,080	1,614,630	1,614,630	1,614,630	11.6	13.5	13.5	13.5
P-3 Harrisonburg, Va.	717,123	520,313	520,313	520,313	6.0	4.3	4.3	4.3
P-4 Charlotte, N.C.	1,297,590	1,234,725	1,234,725	1,234,725	10.8	10.3	10.3	10.3
P-5 Atlanta, Ga.	2,378,487	1,526,963	1,411,890	1,411,890	19.9	12.8	11.8	11.8
P-6 Huntsville, Ala.	1,404,883	2,222,750	2,222,750	2,222,750	11.7	18.6	18.6	18.6
P-7 Jackson, Miss.	872,029	571,375	308,834	426,036	7.3	4.8	2.6	3.6
P-8 Fayetteville, Ark.	2,020,894	1,555,050	1,555,050	1,555,050	16.9	13.0	13.0	13.0
P-9 Shreveport, La.	986,525	921,150	921,150	921,150	8.2	7.7	7.7	7.7
P-10 San Francisco, Ca.	565,027	1,258,271	1,375,473	1,258,271	4.7	10.5	11.5	10.5
P-11 Portland, Oreg.	107,823	242,325	242,325	242,325	.9	2.0	2.0	2.0
P-12 St. Paul, Minn.	104,518	182,610	443,022	433,022	.9	1.5	3.7	3.7
P-13 Des Moines, Iowa	2,690	0	0	0	.0	.0	.0	.0
P-14 Fort Wayne, Ind.	48,112	0	0	0	.4	.0	.0	.0
P-15 Columbus, Ohio	2,054	117,033	117,033	117,033	.0	1.0	1.0	1.0
Total	11,967,196	11,967,196	11,967,196	11,967,196	100.0	100.0	100.0	100.0

doubling of energy costs would cause California to expand and supply all of California's demand and to meet a portion of the other West Coast's consumption needs. But tripling energy costs reduces California production to the initial level with Mississippi expanding to fill the demand.

This analysis suggests that energy costs are of relatively minor importance in determining the optimal location of the broiler industry. Although Minnesota would increase production, only one of the other three Midwestern production centers would come into the optimal solution. And the Minnesota and Ohio production centers would still amount to less than five percent of aggregate production in either doubling or tripling energy costs.

OPTIMAL BROILER INDUSTRY LOCATION FOR PROJECTED POPULATION TRENDS AND INCREASED PER CAPITA CONSUMPTION

In addition to an analysis of changes in the cost factors affecting the optimal location of the broiler industry, this study also attempted to analyze changes in the optimal location of the industry resulting from changes in certain demand factors affecting optimal location. This is a normative projection of future shifts due to interaction of projected supply and demand changes. The study, in order to reduce the complexity, made rather restrictive demand change assumptions. Per capita demand was assumed to be the same across regions and product prices and consumer income equivalent between regions. Only regional population and per capita consumption changed through time.

Population and per capita consumption affect the broiler industry. An analysis was made with two different population trends. The regional population levels were first projected for the years 1990 and 2000 based on the Bureau of Census projected population levels for consumption centers with per capita consumption fixed at 1982 levels. The second analysis assumed the same population projections but per capita consumption was increased to 55 pounds and 58 pounds ready-to-cook for 1990 and 2000, respectively. Results of the optimal model solutions are shown in Tables 10 and 11 for the two population and per capita consumption cases, respectively. In both cases, slaughter capacity for each production region is unconstrained. Both analyses assumed 1982 conditions other than for the two demand variables. Fifty percent of regional soybean meal and 25 percent of regional corn were again locally available for broiler production.

With projected population increases and constant per capita consumption in 1990, both Alabama and California would increase their share of total broiler output by over five percentage points. The Midwest regions of Minnesota and Ohio would combine to produce slightly under five percent of total broiler production. There would be some shifts among the southern producing regions with the total output from these regions ten percentage points less than in 1982.

Table 10. Percentage of United States' Broiler Production for Projected Population Levels, 1990 and 2000 1/

Broiler production center	1982	1990	2000	1982	1990	2000
		1,000 lbs. ready-to-cook		Percentage of aggregate production		
P-1 Bangor, Me.	74,361	0	0	0.6	0.0	0.0
P-2 Baltimore, Md.	1,385,08	1,586,216	1,550,391	11.6	12.1	11.0
P-3 Harrisonburg, Va.	717,123	520,313	520,313	6.0	4.0	3.7
P-4 Charlotte, N.C.	1,297,590	1,234,725	1,234,725	10.8	9.4	8.8
P-5 Atlanta, Ga.	2,378,487	2,219,330	2,849,876	19.9	16.9	20.2
P-6 Huntsville, Ala.	1,404,883	2,222,750	2,222,750	11.7	16.9	15.8
P-7 Jackson, Miss.	872,029	571,375	571,375	7.3	4.3	4.1
P-8 Fayetteville, Ark.	2,020,894	1,555,050	1,555,050	16.9	11.8	11.0
P-9 Shreveport, La.	986,525	921,150	921,150	8.2	7.0	6.5
P-10 San Francisco, Ca.	565,027	1,463,261	1,627,392	4.7	11.1	11.6
P-11 Portland, Oreg.	107,823	242,325	242,325	.9	1.8	1.7
P-12 St. Paul, Minn.	104,518	463,215	604,890	.9	3.5	4.3
P-13 Des Moines, Iowa	2,690	0	0	.0	.0	.0
P-14 Fort Wayne, Ind.	48,112	0	0	.4	.0	.0
P-15 Columbus, Ohio	2,054	149,034	184,859	.0	1.1	1.3
Total	11,967,196	13,148,743	14,085,096	100.0	100.0	100.0

1/ Assuming per capita broiler consumption is held constant at 1982 levels; unconstrained slaughter capacity.

Table 11. Percentage of United States' Broiler Production Assuming Increasing Levels of Per Capita Consumption, 1990 and 2000 1/

Broiler production center	1982	1990	2000	1982	1990	2000
	1,000 lbs. ready-to-cook			Percentage of aggregate production		
P-1 Bangor, Me.	74,361	0	0	0.6	0.0	0.0
P-2 Baltimore, Md.	1,385,080	1,581,057	1,614,630	11.6	11.6	10.5
P-3 Harrisonburg, Va.	717,123	520,313	520,313	6.0	3.8	3.4
P-4 Charlotte, N.C.	1,297,590	1,234,725	1,234,725	10.8	9.1	8.0
P-5 Atlanta, Ga.	2,378,487	2,607,764	2,849,876	19.9	19.2	18.5
P-6 Huntsville, Ala.	1,404,883	2,222,750	2,853,676	11.7	16.3	18.6
P-7 Jackson, Miss.	872,029	571,375	756,871	7.3	4.2	4.9
P-8 Fayetteville, Ark.	2,020,894	1,555,050	1,555,050	16.9	11.4	10.1
P-9 Shreveport, La.	986,525	921,150	921,150	8.2	6.8	6.0
P-10 San Francisco, Ca.	565,027	1,513,908	1,775,560	4.7	11.1	11.6
P-11 Portland, Oreg.	107,823	242,325	242,325	.9	1.8	1.6
P-12 St. Paul, Minn.	104,518	479,248	841,631	.9	3.5	5.5
P-13 Des Moines, Iowa	2,690	0	0	.0	.0	.0
P-14 Fort Wayne, Ind.	48,112	0	0	.4	.0	.0
P-15 Columbus, Ohio	2,054	154,193	201,689	.0	1.1	1.3
Total	11,967,196	13,603,857	13,367,496	100.0	100.0	100.0

1/ 1990-55 pounds per capita consumption; 200-58 pounds per capita consumption; unconstrained slaughter capacity.

The first analysis with population projection to 2000 would result in two locations in the South, Midwest, and West expanding their percentage of total output. The Southern states of Alabama and Georgia, the Midwestern states of Minnesota and Ohio, and the Western region of California and Oregon would account for 36, 13.3, and 5.6 percent of total output, respectively. Arkansas and Mississippi would be reduced by three percentage points relative to total output from 1982 levels.

In the second demand analysis, consumption was assumed to increase to 55 and 58 pounds per capita in 1990 and 2000, respectively. Results of this analysis are shown in Table 11. Production would increase in seven broiler centers in the 1990 projection. These centers include Maryland, Georgia, Alabama, California, Oregon, Minnesota, and Ohio. Although production would increase in these six centers, their share of aggregate production would fluctuate. Alabama is the only Southern production center that would increase its share of aggregate production.

Alabama and Mississippi would increase their share of aggregate production in the year 2000 over 1990 levels to meet the growth in the Sunbelt demand. Minnesota would increase its share of total output to over five percent.

Results From Changing Both Consumption and Energy Costs

Finally, an analysis was made to determine how the increase in energy cost combined with the previous demand projections would impact the location of broiler production in the years 1990 and 2000.

The energy cost increases would have little apparent effect on optimal location in the 1990 situation (Table 12). Georgia and California would adjust their aggregate production percentages among themselves in the different cases of doubling and tripling energy costs.

Although optimal location would change only slightly in these different cost situations, the optimal flow of product to the consumption centers would change considerably. This result implies that as energy costs escalate, integrators constantly need to reassess the markets they are serving. There may be cost advantages in shifting to new areas, while dropping less profitable centers.

The model for the year 2000, with energy costs increases, shows some growth in production for the Midwestern production centers, (Table 13). The total aggregate production percentages of the four Midwestern centers would increase to over 12 percent in the three-fold increase in energy costs scenario. However, the Midwest production centers only supplied nearby markets. It is still optimal, in a least cost sense, for the South to supply itself and other regional deficit areas.

Table 12. Percentage of United States' Broiler Production When All Energy Costs Double and Triple, 1990

Broiler production center	Present situation	Unconstrained slaughter capacity			Present situation	Unconstrained slaughter capacity		
		Present costs	Double energy costs	Triple Energy costs		Present costs	Double energy costs	Triple energy costs
	1,000 lbs. ready-to-cook				Percentage of aggregate production			
P-1 Bangor, Me.	74,361	0	0	0	0.6	0.0	0.0	0.0
P-2 Baltimore, Md.	1,385,080	1,581,057	1,581,057	1,581,057	11.6	11.6	11.6	11.6
P-3 Harrisonburg, Va.	717,123	520,313	520,313	520,313	6.0	3.8	3.8	3.8
P-4 Charlotte, N.C.	1,297,590	1,234,725	1,234,725	1,234,725	10.8	9.1	9.1	9.1
P-5 Atlanta, Ga.	2,378,487	2,607,764	2,391,916	2,607.763	19.9	19.2	17.6	19.2
P-6 Huntsville, Ala.	1,404,883	2,222,750	2,222,750	2,222,750	11.7	16.3	16.3	16.3
P-7 Jackson, Miss.	872,029	571,375	571,375	571,375	7.3	4.2	4.2	4.2
P-8 Fayetteville, Ark.	2,020,894	1,555,050	1,555,050	1,555,050	16.9	11.4	11.4	11.4
P-9 Shreveport, La.	986,525	921,150	921,150	921,150	8.2	6.8	6.8	6.8
P-10 San Francisco, Ca.	565,027	1,513,908	1,729,755	1,513,908	4.7	11.1	12.7	11.1
P-11 Portland, Oreg.	107,823	242,325	242,325	242,325	.9	1.8	1.8	1.8
P-12 St. Paul, Minn.	104,518	479,248	479,248	479,248	.9	3.5	3.5	3.5
P-13 Des Moines, Iowa	2,690	0	0	0	.0	.0	.0	.0
P-14 Fort Wayne, Ind.	48,112	0	0	0	.4	.0	.0	.0
P-15 Columbus, Ohio	2,054	154,193	154,193	154,193	.0	1.1	1.1	1.1
Total	11,967,196	13,603,857	13,603,857	13,603,857	100.0	100.0	100.0	100.0

Table 13. Percentage of United States' Broiler Production When All Energy Costs Double and Triple, 2000

Broiler production center	Present situation	Unconstrained slaughter capacity			Present situation	Unconstrained slaughter capacity		
		Present costs	Double energy costs	Triple Energy costs		Present costs	Double energy costs	Triple energy costs
		1,000 lbs. ready-to-cook			Percentage of aggregate production			
P-1 Bangor, Me.	74,361	0	0	0	0.6	0.0	0.0	0.0
P-2 Baltimore, Md.	1,385,080	1,614,630	1,614,630	1,533,561	11.6	10.5	10.5	10.0
P-3 Harrisonburg, Va.	717,123	520,313	520,313	520,313	6.0	3.4	3.4	3.4
P-4 Charlotte, N.C.	1,297,590	1,234,725	1,234,725	1,234,725	10.8	8.0	8.0	8.0
P-5 Atlanta, Ga.	2,378,487	2,849,875	2,849,875	2,849,875	19.9	18.5	18.5	18.5
P-6 Huntsville, Ala.	1,404,883	2,853,676	2,222,750	2,222,750	11.7	18.6	14.5	14.5
P-7 Jackson, Miss.	872,029	756,871	756,871	571,375	7.3	4.9	4.9	3.7
P-8 Fayetteville, Ark.	2,020,894	1,555,050	1,555,050	1,555,050	16.9	10.1	10.1	10.1
P-9 Shreveport, La.	986,525	921,150	921,150	921,150	8.2	6.0	6.0	6.0
P-10 San Francisco, Ca.	565,027	1,775,560	2,104,987	1,775,560	4.7	11.6	13.7	11.6
P-11 Portland, Oreg.	107,823	242,325	242,325	242,325	.9	1.6	1.6	1.6
P-12 St. Paul, Minn.	104,518	841,631	512,204	512,204	.9	5.5	3.3	3.3
P-13 Des Moines, Iowa	2,690	0	0	514,923	.0	.0	.0	3.4
P-14 Fort Wayne, Ind.	48,112	0	630,926	711,996	.4	.0	4.1	4.6
P-15 Columbus, Ohio	2,054	201,689	201,689	201,689	.0	1.3	1.3	1.3
Total	11,967,196	15,367,496	15,367,496	15,367,496	100.0	100.0	100.0	100.0

Production, Processing and Distribution Cost Differences Among Producing Regions of the Broiler Industry

A further comparison of the relative cost advantages of the various production-processing regions was developed. Cost differences among regions was determined using the control solution and its feed availability assumptions. The control solution was the model's estimation of the present cost situation. This analysis was performed to determine the magnitude of the production, processing and distribution costs differences among the potential producing regions. No slaughter constraints were used in this analysis.

Cost Analysis of Regions with Control Solution Under Assumptions of this Study

A control solution allowed a determination of the relative cost differences among the various producing-processing and potential producing regions in the Midwest. Cost differences between producing and processing regions that vary with regional output arise from differences in feed import cost, production costs, processing cost, and differences between shipment costs of broiler output to the different consumption regions.

Cost comparisons among regions for both producing and distribution were made by arraying the regions sequentially from low cost to high cost regions for each one of the local feed availability scenarios described in the earlier section. A production and distribution cost difference was determined between each successive region from lowest to highest cost producer. In addition, a cumulative cost difference was also determined for the array from low to high cost regions. This analysis was determined for the local feed availability parameters of 100, 50, 25, and zero percent for the producing and distribution cost for each region. Assumptions were that all corn and soybean production in the four potential Midwest producing regions were again available for all local broiler production and for shipment to the feed deficit broiler production processing regions for the southeastern U.S.

Georgia, presently the largest aggregate producer, would be the lowest cost producing region under the control solution (Table 14). Three other Southern centers (Alabama, Mississippi, and North Carolina) would have less than a one cent difference in production and processing cost. Although the Midwest centers would have no interregional feed transport costs, three of four prospective centers (Iowa, Minnesota, Ohio) would be the highest cost of any center east of the Rocky Mountains. Higher labor, energy and distribution costs all appear to contribute to the higher costs of Midwest locations. The two West Coast production centers would have a difference of over seven cents per pound production and processing costs when compared with Georgia. Arkansas enjoys over six cents per pound advantage in production cost over West Coast production centers.

A control solution analysis of cost differences in production, processing, and distribution under the basic model assumptions was

Table 14. The Control Solution Marginal and Cumulative Cost Differences Among Production Centers, 1982[1]

Production Center	Aggregate Production	Marginal Cost Difference[2]	Cumulative Cost Difference
	Percent	Cents per pound, ready-to-cook	
P-5 Atlanta, Ga.	19.9		
P-6 Huntsville, Ala.	11.7	0.17	0.17
P-7 Jackson, Miss.	7.3	0.14	0.31
P-4 Charlotte, N.C.	10.8	0.32	0.62
P-9 Shreveport, La.	8.2	0.42	1.04
P-8 Fayetteville, Ark.	16.9	0.10	1.15
P-3 Harrisonburg, Va.	6.0	0.39	1.54
P-14 Fort Wayne, Ind.	0.4	0.35	1.89
P-2 Baltimore, Md.	11.8	0.12	2.01
P-1 Bangor, Me.	0.6	0.51	2.52
P-13 Des Moines, Iowa	0.0	0.07	2.59
P-12 St. Paul, Minn.	0.9	0.65	3.23
P-15 Columbus, Ohio	0.0	0.24	3.47
P-10 San Francisco, Ca.	4.7	3.80	7.27
P-11 Portland, Oreg.	0.9	0.70	7.97
Total	100.0	NA	NA

[1]The production centers are ranked beginning with the lowest cost center and ending with the highest cost center.

[2]Cost differences between the previously lowest cost center.

made for each of the 18 distribution centers. In a long-run competition, this difference should approximate the difference in wholesale broiler prices among the distribution centers. The results of this analysis are shown in Table 15. Cost relationship between each ranked region are shown in the same manner as the production cost analysis.

The lowest cost distribution centers were in the South (Table 15). Less than a one cent difference would exist between Atlanta, Georgia, Charlotte, North Carolina, and Memphis, Tennessee. Georgia would enjoy over 2.5 cents per pound delivered cost advantage over the New York center.

Cost Analysis with 100 Percent Local Feed Availability Parameter

The 100 percent local feed utilization parameter would result in over 30 percent of aggregate production in Arkansas (Table 16). Just under 30 percent of aggregate production would go to Georgia. The cost difference between Georgia and Arkansas would be less than .4 cent per pound.

No Midwest production center would compete even though they would not be the most expensive production areas. As with other production, this would result because the model minimizes overall production and distribution costs and higher distribution costs in the Midwest would still preclude production. The West Coast production centers would produce for West Coast distribution only.

Atlanta, Georgia would be the lowest cost distribution center using 100 percent feed utilization parameter (Table 17). The three most centrally geographically located United States distribution centers were the next lowest cost distribution centers. The largest market of New York would have delivered costs of about 2.7 cents per pound more than the Georgia distribution center with the 100 percent local feed availability parameters.

Cost Analysis with 50 Percent Local Feed Availability Parameter

Assuming 50 percent of local feed available, Louisiana would become the lowest cost production-processing area and would account for over 13 percent of aggregate production (Table 18). Although Arkansas would be slightly higher in costs (.13 cents per pound) it still would account for the largest aggregate production, 26 percent. Arkansas would supply part of the distribution centers: Chicago, Kansas City, Minneapolis-St. Paul, Billings, Montana, Denver, Salt Lake, and San Francisco.

Under the 50 per cent feed available parameter, Dallas, Texas would be the lowest cost distribution center (Table 19). The largest breaks in costs would be between New York and Boston with a difference of over .75 cent per pound and between the Mountain centers to the West Coast with approximately one cent per pound difference.

Table 15. The Control Solution Marginal and Cumulative Cost Differences Among Distribution Centers, 1982[1]

Distribution Center	Aggregate Consumption	Marginal Cost Difference[2]	Cumulative Cost Difference
	Percent	Cents per pound, ready-to-cook	
D-5 Atlanta, Ga.	4.2		
D-4 Charlotte, N.C.	4.0	0.62	0.62
D-10 Memphis, Tenn.	5.8	0.23	0.85
D-7 Orlando, Fla.	4.3	0.40	1.25
D-13 Dallas, Tex.	9.5	0.24	1.49
D-11 Kansas City, Mo.	3.9	0.27	1.76
D-2 Baltimore, Md.	5.7	0.03	1.79
D-6 Pittsburg, Pa.	5.3	0.31	2.10
D-9 Chicago, Ill.	9.6	0.08	2.18
D-8 Detroit, Mich.	8.9	0.08	2.26
D-3 New York, N.Y.	11.1	0.25	2.51
D-12 Minneapolis, Minn.	3.7	0.73	3.23
D-1 Boston, Mass.	5.5	0.03	3.26
D-15 Denver, Colo.	1.9	0.51	3.77
D-14 Billings, Mont.	1.0	1.44	5.21

Table 15. The Control Solution Marginal and Cumulative Cost Differences Among Distribution Centers, 1982[1]

Distribution Center	Aggregate Consumption	Marginal Cost Difference[2]	Cumulative Cost Difference
	Percent	Cents per pound, ready-to-cook	
D-16 Salt Lake City, UT	2.2	0.21	5.43
D-17 San Francisco, CA	10.4	1.85	7.27
D-18 Portland, OR	3.0	0.70	7.97

[1]The distribution centers are ranked beginning with the lowest cost center and ending with the highest cost center.

[2]Cost differences between the previously lowest cost center.

Table 16. Marginal and Cumulative Cost Differences Among production Centers Assuming 100 percent Local Feed Utilization, 1982[1]

Production Center	Aggregate Production	Marginal Cost Difference[2]	Cumulative Cost Difference
	Percent	Cents per pound, ready-to-cook	
P-8 Fayetteville, Ark.	31.8		
P-6 Huntsville, Ala.	7.4	0.25	0.25
P-5 Atlanta, Ga.	28.8	0.08	0.33
P-9 Shreveport, La.	0.0	0.05	0.38
P-7 Jackson, Miss.	1.4	0.01	0.39
P-4 Charlotte, N.C.	17.0	0.72	1.11
P-13 Des Moines, Iowa	0.0	0.33	1.44
P-12 St. Paul, Minn.	0.0	0.65	2.09
P-14 Fort Wayne, Ind.	0.0	0.13	2.22
P-15 Columbus, Ohio	0.0	0.11	2.33
P-2 Baltimore, Md.	0.0	0.18	2.51
P-3 Harrisonburg, Va.	0.0	0.40	2.91
P-1 Bangor, ME	0.0	0.11	3.01
P-10 San Francisco, CA	10.5	2.39	5.40
P-11 Portland, OR	3.0	0.47	5.87
Total	100.0	NA	NA

[1]The production centers are ranked beginning with the lowest cost center and ending with the highest cost center.

[2]Cost differences between the previously lowest cost center.

Table 17. Marginal and Cumulative Cost Differences Among Distribution Centers Assuming 100 Percent Local Feed Utilization, 1982[1]

Distribution Center	Aggregate Consumption	Marginal Cost Difference[2]	Cumulative Cost Difference
	Percent	Cents per pound, ready-to-cook	
D-5 Atlanta, Ga.	4.2		
D-11 Kansas City, Mo.	3.9	0.29	0.29
D-13 Dallas, Tex.	9.5	0.21	0.50
D-10 Memphis, Tenn.	5.8	0.10	0.60
D-4 Charlotte, N.C.	4.0	0.03	0.63
D-7 Orlando, Fla.	4.3	0.62	1.25
D-9 Chicago, Ill	9.6	0.16	1.41
D-12 Minneapolis, Minn.	3.7	0.35	1.76
D-2 Baltimore, Md.	5.7	0.24	2.00
D-6 Pittsburg, Pa.	5.3	0.10	2.10
D-8 Detroit, Mich.	8.9	0.16	2.26
D-15 Denver, Colo.	1.9	0.04	2.30
D-3 New York, N.Y.	11.1	0.37	2.67
D-1 Boston, Mass.	5.5	0.76	3.43
D-14 Billings, Mont.	1.0	0.31	3.74
D-16 Salt Lake City, Utah	2.2	0.21	3.95
D-17 San Francisco, Calif.	10.4	1.12	5.08
D-18 Portland, Oreg.	3.0	0.47	5.54

[1]The distribution centers are ranked beginningwith the lowest cost center and ending with the highest cost center.

[2]Cost differences between the previously lowest cost center.

Table 18. Marginal and Cumulative Cost Differences Among Production Centers Assuming 50 Percent Local Feed Utilization, 1982[1]

Production Center	Aggregate Production	Marginal Cost Difference cents/lb. RTC[2]	Cumulative Cost Difference cents/lb. RTC
	Percent	Cents per pound, ready-to-cook	
P-9 Shreveport, La.	13.1		
P-8 Fayetteville, Ark.	26.0	0.13	0.13
P-6 Huntsville, Ala.	16.1	0.18	0.30
P-7 Jackson, Miss.	0.7	0.14	0.44
P-5 Atlanta, Ga.	14.4	0.21	0.65
P-4 Charlotte, N.C.	2.1	0.78	1.43
P-13 Des Moines, Iowa	0.0	0.13	1.57
P-12 St. Paul, Minn.	0.0	0.65	2.21
P-14 Fort Wayne, Ind.	0.0	0.06	2.28
P-3 Harrisonburg, Va.	2.8	0.12	2.40
P-15 Columbus, Ohio	0.0	0.05	2.46
P-2 Baltimore, Md.	16.6	0.32	2.78
P-1 Bangor, Me.	0.0	0.51	3.29
P-11 Portland, Oreg.	3.0	2.08	5.37
P-10 San Francisco, Ca.	5.4	0.89	6.26

[1]The production centers are ranked beginning with the lowest cost center and ending with the highest cost center.

[2]Cost differences between the previously lowest cost center.

Table 19. Marginal and Cumulative Cost Differences Among Distribution Centers Assuming 50 Percent Local Feed Utilization, 1982[1]

Distribution Center	Aggregate Consumption	Marginal Cost Difference[2]	Cumulative Cost Difference
	Percent	Cents per pound, ready-to-cook	
D-13 Dallas, Tex.	9.5		
D-5 Atlanta, Ga.	4.2	0.19	0.19
D-11 Kansas City, Mo.	3.9	0.11	0.30
D-10 Memphis, Tenn.	5.8	0.24	0.54
D-4 Charlotte, N.C.	4.0	0.30	0.83
D-9 Chicago, Ill.	9.6	0.58	1.42
D-7 Orlando, Fla.	4.3	0.04	1.45
D-12 Minneapolis, Minn.	3.7	0.32	1.77
D-8 Detroit, Mich.	8.9	0.43	2.20
D-2 Baltimore, Md.	5.7	0.01	2.21
D-6 Pittsburg, Pa.	5.3	0.09	2.30
D-15 Denver, Colo.	1.9	.01	2.31
D-3 New York, N.Y.	11.1	0.52	2.83
D-1 Boston, Mass.	5.5	0.75	3.58
D-14 Billings, Mont.	1.0	0.16	3.75
D-16 Salt Lake City, Utah	2.2	0.21	3.96
D-17 San Francisco, Calif.	10.4	0.96	4.92
D-18 Portland, Oreg.	3.0	0.89	5.81
Total	100.0	NA	NA

[1]The distribution centers are ranked beginning with the lowest cost center and ending with the highest cost center.

[2]Cost differences between the previously lowest cost center.

Cumulative cost difference from lowest to highest cost would be more than five cents per pound.

Cost Analysis with 25 Percent Local Feed Availability Parameter

With 25 percent local feed utilization, Alabama would be both the lowest cost production center and the largest producer in terms of its share of aggregate production with slightly less than 20 percent of the total (Table 20). This restriction on local feed use would result in some Midwest production. Both St. Paul, Minnesota and Columbus, Ohio would produce at 3.7 and one percent, respectively, of total output at a cost approximately 2-1/4 cents greater than Alabama. The West Coast would produce all of its broilers needed for consumption.

With 25 percent local feed use, there would be over seven cents difference in cost per pound between the lowest (Atlanta, Georgia) and the highest cost (Portland, Oregon) distribution center (Table 21). The range of difference would be 2-1/2 cents among distribution centers east of the Mississippi River.

Cost Analysis with No Local Feed Availability Paramater

With the South forced to import all of its feed for broilers, it would still enjoy substantial cost advantages in production and some distribution cost advantage over most other distribution centers. Alabama would be the lowest cost production center and would account for over 40 percent of total United States production (Table 22). Baltimore would supply 16.6 percent of total output which would partially serve the Northeast markets.

Midwestern locations of Iowa and Minnesota would account for 15.5 and 7.7 percent of total output respectively. Their production and processing cost would be approximately one cent per pound more than Alabama.

Atlanta, Georgia would be the lowest cost distribution center (Table 23). The restrictive feed utilization analysis would reduce Minnesota's cost disadvantage from 3.23 cents per pound under the base analysis to .77 cents per pound over the lowest cost distribution center (Table 15 and Table 23).

Table 20. Marginal and Cumulative Cost Difference Among Production Centers Assuming 25 Percent Local Feed Utilization, 1982[1]

Production Center	Aggregate Consumption	Marginal Cost Difference[2]	Cumulative Cost Difference
	Percent	Cents per pound, ready-to-cook	
P-6 Huntsville, Ala.	19.6		
P-5 Atlanta, Ga.	11.9	0.08	0.08
P-7 Jackson, Miss.	2.4	0.06	0.14
P-8 Fayetteville, Ark.	13.0	0.14	0.28
P-9 Shreveport, La.	7.7	0.38	0.66
P-4 Charlotte, N.C.	10.3	0.05	0.70
P-13 Des Moines, Iowa	0.0	0.88	1.59
P-3 Harrisonburg, Va.	4.3	0.08	1.67
P-14 Fort Wayne, Ind.	0.0	0.30	1.97
P-2 Baltimore, Md.	13.5	0.12	2.09
P-12 St. Paul, Minn.	3.7	0.14	2.23
P-15 Columbus, Ohio	1.0	0.09	2.32
P-1 Bangor, Me.	0.0	0.28	2.60
P-10 San Francisco, Ca.	10.5	3.54	6.14
P-11 Portland, Oreg.	2.0	0.96	7.10
Total	100.0	NA	NA

[1]The production centers are ranked beginning with the lowest cost center and ending with the highest cost center.

[2]Cost differences between the previously lowest cost center.

Table 21. Marginal and Cumulative Cost Differences Among Distribution Centers Assuming 25 Percent Local Feed Utilization, 1982[1]

Distribution Center	Aggregate Consumption	Marginal Cost Difference[2]	Cumulative Cost Difference
	Percent	Cents per pound, ready-to-cook	
D-5 Atlanta, Ga.	4.2		
D-10 Memphis, Tenn.	5.8	0.60	0.60
D-4 Charlotte, N.C.	4.0	0.02	0.62
D-11 KansaS City, Mo.	3.9	0.19	0.82
D-13 Dallas, Tex.	9.5	0.21	1.02
D-7 Orlando, Fla.	4.3	0.22	1.25
D-2 Baltimore, Md.	5.7	0.60	1.84
D-9 Chicago, Ill.	9.6	0.09	1.93
D-6 Pittsburg, Pa.	5.3	0.17	2.10
D-12 Minneapolis, Minn.	3.7	0.06	2.15
D-8 Detroit, Mich.	8.9	0.11	2.26
D-3 New York, N.Y.	11.1	0.25	2.51
D-15 Denver, Colo.	1.9	0.32	2.82
D-1 Boston, Mass.	5.5	0.44	3.26
D-14 Billings, Mont.	1.0	0.72	3.98
D-16 Salt Lake City, Utah	2.2	0.50	4.48
D-17 San Francisco, Calif.	10.4	1.58	6.06
D-18 Portland, Oreg.	3.0	0.96	7.02
Total	100.0	NA	NA

[1]The distribution centers are ranked beginning with the lowest cost center and ending with the highest cost center.

[2]Cost differences between the previously lowest cost center.

Table 22. Marginal and Cumulative Cost Difference Among Production Centers Assuming Zero Percent Local Feed Utilization, 1982[1]

Production Center	Aggregate Production	Marginal Cost Difference[2]	Cumulative Cost Difference
	Percent	Cents per pound, ready-to-cook	
P-6 Huntsville, Ala.	40.2		
P-7 Jackson, Miss.	0.0	0.39	0.39
P-5 Atlanta, Ga.	0.0	0.11	0.50
P-8 Fayetteville, Ark.	0.0	0.41	0.91
P-13 Des Moines, Iowa	15.5	0.13	1.04
P-12 St. Paul, Minn.	7.7	0.06	1.10
P-9 Shreveport, La.	9.5	0.02	1.12
P-4 Charlotte, N.C.	0.0	0.05	1.17
P-14 Fort Wayne, Ind.	0.0	0.80	1.97
P-15 Columbus, Ohio	0.0	0.02	1.99
P-3 Harrisonburg, Va.	0.0	0.14	2.14
P-2 Baltimore, Md.	16.6	0.30	2.44
P-1 Bangor, Me.	0.0	0.51	2.95
P-10 San Francisco, Calif.	10.5	2.06	5.01
P-11 Portland, Oreg.	0.0	1.64	6.65
Total	100.0	NA	NA

[1]The production centers are ranked beginning with the lowest cost center and ending with the highest cost center.

[2]Cost differences between the previously lowest cost center.

Table 23. Marginal and Cumulative Cost Difference Among Distribution Centers Assuming Zero Percent Local Feed Utilization, 1982[1]

Distribution Center	Aggregate Consumption	Marginal Cost Difference[2]	Cumulative Cost Difference
	Percent	Cents per pound, ready-to-cook	
D-5 Atlanta, Ga.	4.2		
D-10 Memphis, Tenn.	5.8	0.35	0.35
D-12 Minneapolis, Minn.	3.7	0.42	0.77
D-4 Charlotte, N.C.	4.0	0.03	0.80
D-11 Kansas City, Mo.	3.9	0.39	1.19
D-13 Dallas, Tex.	9.5	0.05	1.24
D-7 Orlando, Fla.	4.3	0.07	1.31
D-9 Chicago, Ill.	9.6	0.37	1.68
D-8 Detroit, Mich.	8.9	0.33	2.01
D-2 Baltimore, Md.	5.7	0.05	2.06
D-6 Pittsburg, Pa.	5.3	0.06	2.12
D-3 New York, N.Y.	11.1	0.49	2.60
D-15 Denver, Colo.	1.9	0.16	2.76
D-14 Billings, Mont.	1.0	0.58	3.34
D-1 Boston, Mass.	5.5	0.01	3.36
D-16 Salt Lake City, Utah	2.2	0.73	4.09
D-17 San Francisco, Calif.	10.4	0.59	4.68
D-18 Portland, Oreg.	3.0	1.64	6.32

[1]The distribution centers are ranked beginning with the lowest cost center and ending with the highest cost center.

[2]Cost differences between the previously lowest cost center.

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APPENDIX A
THE BROILER MODEL DEVELOPMENT AND FORMULATION

The analytical tool used for study can be described as a constructed model based on the general distribution problem discussed by Rohdy (King). The general distribution problem is similar to the transportation problem but also combines elements of the general linear programming formulation discussed below. This system allows for handling distribution problems with intermediate processes between the origins and destinations. In terms of the broiler industry, the origins of concern were corn and soybean availability by regions, with the production-processing as the intermediate processes and finally the 18 consumption regions as the ultimate destinations. In the broiler model formulation, regional broiler consumption is the demand oriented element of the analysis and the primary constraint to be supplied at an overall minimum cost of delivery associated with feed transport, production, processing and distribution.

Level of output in each processing region depends upon the following:

1. Minimum cost to transport the ready-to-cook broilers from processing.
2. Least cost processing.
3. Least cost production.
4. Minimum costs associated with supplying feed ingredients to production areas.

The model contains four interrelated but distinct matrices which function to determine the level of production and processing as well as regional distribution to consumption. Production and processing parts of the model components correspond to the standard linear programming formulation. Two component matrices correspond to the transportation model which is a special case of the standard linear programming model. The following describes the mathematical formulation and construction of the simplex tableau.

The standard linear programming model contains an objective function to be minimized or maximized and that is dependent upon the level output of the various production activities and the limited or restricted resources available for the production activities (Agrawal and Heady, p. 30; also see Chaing, p. 636).

The standard linear programing model in equation form is as follows:

$$\text{Min } Z = C_1X_1 + C_2X_2 + \ldots + C_nX_n \quad \text{(objective function)}$$

Subject to:

$A_{11}X_1 + A_{12}X_2 + \ldots + A_{1n}X_n \leqq b_1$ (inequality constraints)

$A_{21}X_1 + A_{22}X_2 + \ldots + A_{2n}X_n \leqq b_2$

$A_{m1}X_1 + A_{m2}X_2 + \ldots + A_{mn}X_n \leqq b_n$

Where:

(1) $X_1, X_2 \ldots X_n \geqq 0$ (non-negativity restrictions)
(2) X_j = level of output of the $_j$th production activity

(3) A_{ij} = amount of the $_i$th resource used in production of one unit of output of the $_j$th production activity

(4) C_j = cost of one unit of the $_j$th production activity

(5) b_j = the amount of the b_j resource available for production.

Specifically, the production and processing activities for the 15 regions were as follows:

Processing:

(6) X_j = broilers processed in the $_j$th processing region

(7) L_j = labor use in the $_j$th processing region

(8) U_j = Utility use in the $_j$th processing region

(9) R_j = broiler produced in the $_i$th production region (must equal X_j in equilibrium)

(10) H_j = total broiler housing used in the production of broilers in the $_j$th production region

(11) W_j = total production labor used in the $_j$th production region

(12) G_j = total gas used in the $_j$th production region

(13) O_j = total oil used in the $_j$th production region

(14) E_j = total electricity used in the $_j$th production region

(15) F_j = total feed required in the $_j$th production region

Input Coefficients:

(16) A_{ij} = the amount of $_i$th resource used in the production or processing of 1,000 head of live broilers.

Resource Constraints:

(17) b_j = slaughter capacity in the $_j$th processing region (it was assumed that housing and other activities would become available in response to increases in regional slaughter capacity and would not constrain regional output capabilities).

The regional feed import component and the distribution component of the broiler industry were constructed in the model formulation as a reflection of the transportation model. The formulation of the transportation matrices requires that the product be available in known quantities at each of m production points. These quantities are then shipped to n consumption points given their demand. Cost of shipping is assumed to be known and constant. Therefore, the objective is to find the routes which minimize the shipping costs.

Mathematical formulation of the transportation model is:

$$\text{Min } Z = \sum_{i}^{m} \sum_{j}^{n} C_{ij} X_{ij}$$

Subject to:

$$
\begin{array}{llllllllllll}
X_{11} + X_{12} + X_{1n} & & & & & & & & & \geq a_1 \\
& & & X_{21} + X_{22} + X_{2n} & & & & & & \geq a_2 \\
& & & & & & X_{m1} + X_{m2} + X_{mn} & & & \geq a_n \\
X_{11} & & & X_{21} & & & X_{m1} & & & \leq b_1 \\
& X_{12} & & & X_{22} & & & X_{m2} & & \leq b_2 \\
& & X_{1n} & & & X_{2n} & & & X_{mn} & \leq b_n
\end{array}
$$

$$X_{ij} \geq 0$$

Where:

(18) C_{ij} = cost of transporting one unit of broilers (1,000 pounds of ready-to-cook broilers) from processing region $_i$ to consumption region $_j$

(19) X_{ij} = number of broiler units transported from processing region $_i$ to consuming region $_j$

(20) a_i = quantity of product available in the $_i$th region

(21) b_j = quantity of product demanded in $_j$th region

Specifically, the broiler model formulation required the following values for the feed import and broiler distribution components of the model.

Costs:

(22) B_{ij} = cost of shipping one unit of broilers from production region $_i$ to consuming region $_j$

(23) C_{ij} = cost of shipping one unit of corn from region $_i$ to region $_j$

(24) M_{ij} = cost of shipping one unit of soybean meal from region $_i$ to region $_j$

(25) X_{ij} = quantity of broilers in production units transported from production region $_i$ to consuming region $_j$

(26) CF_{ij} = quantity of corn shipped from region $_i$ to region $_j$

(27) SF_{ij} = quantity of soybean meal shipped from region $_i$ to region $_j$

Constraints were:

(28) a_i = quantity of broiler units available in region $_i$

(29) b_j = quantity of broiler units consumed in region $_j$

(30) CF_j = corn available in region $_j$

(31) SF_j = soybean meal available in region $_j$

The four components of the model consisting of production, processing, distribution and feed input transportation were merged into a simplex tableau for computational purpose. The construction of the tableau for a two production-processing region is shown in Appendix Table 1. The objective function is listed directly under each activity and indicates the cost associated with total activity. Resources are listed on the left side of the tableau, constraints are on the right side. The transfer rows were constructed in accordance with the methods discussed in Beneke. These transfer rows are necessary to allow for the transfer of the activity between the four different components of the tableau (Beneke, page 38). All coefficients associated with the transfer row are either - 1 or + 1 (Appendix Table 1).

Appendix A

Appendix Table 1. Simplex tableau of two production-processing and two region consumption model

		Broiler transport				Processing						Production									right hand sides
Item		X11	X12	X21	X22	X1	X2	L1	L2	U1	U2	R1	R2	H1	H2	W1	W2	G1	02		
Objective																					N
Restriction:	Region																				
Demand	1	1	1																	≥	a1
Demand	2			1	1															≥	a2
Transfer	1	1		1		-1														≤	0
Transfer	2		1		1		-1													≤	0
Slaughter	1					1														≤	h1
Slaughter	2						1													≤	h2
Labor	1					1		-1												≤	0
Labor	2						12		-1											≤	0
Utilities	1					u1				-1										≤	0
Utilities	2						u2				-1									≤	0
Transfer	1					1						-1								≤	0
Transfer	2						1						-1							≤	0
Housing	1											h1		-1						≤	0
Housing	2												h2		-1					≤	0
Labor	1											w1				-1				≤	0
Labor	2												w2							≤	0
Gas	1											g1					-1			≤	0
Oil	2												o2					-1		≤	0
Electricity	1											e1							-1	≤	0
Electricity	2												e2							≤	0
Feed	1											f1								≤	0
Feed	2												f2							≤	0
Corn	1																			≤	hc11
Corn	2																			≤	hc22
Corn	3																			≤	hc33
Meal	1																			≤	hm11
Meal	2																			≤	hm22
Meal	3																			≤	hm33
Transfer	1																			≤	0
Transfer	2																			≤	0
Transfer	1																			≤	0
Transfer	2																			≤	0

Appendix Table. Simplex tableau of two production-processing and two region consumption model

Item	Region	Production E1	Production E2	Feed Ingredient transport F1	F2	C11	C13	C22	C23	M11	M13	M22	M23		right hand sides
Objective															N
Restriction:	Region														
Demand	1													≥	a1
Demand	2													≥	a2
Transfer	1													≤	0
Transfer	2													≤	0
Slaughter	1													≤	h1
Slaughter	2													≤	h2
Labor	1													≤	0
Labor	2													≤	0
Utilities	1													≤	0
Utilities	2													≤	0
Transfer	1													≤	0
Transfer	2													≤	0
Housing	1													≤	0
Housing	2													≤	0
Labor	1													≤	0
Labor	2													≤	0
Gas	1													≤	0
Oil	2													≤	0
Electricity	1	-1												≤	0
Electricity	2		-1											≤	0
Feed	1			-1										≤	0
Feed	2				-1									≤	0
Corn	1					1	-1							≤	hc11
Corn	2							1	-1					≤	hc22
Corn	3						1		1					≤	hc33
Meal	1									1	-1			≤	bm11
Meal	2											1	-1	≤	bm22
Meal	3										1		1	≤	bm33
Transfer	1			c1		-1								≤	0
Transfer	2				c2			-1						≤	0
Transfer	1			m1						-1				≤	0
Transfer	2				m2							-1		≤	0

Appendix B

Appendix Table 1. Factors and costs used in broiler production, 1982

Production Center	Factor & usage per 1000 birds Electricity kWh	LP Gas gal	Price Electricity $/kWh	LP Gas $/gal	Grower Payment $/lb. lv.wt.
P-1 Bangor, Me.	250	30[1]	0.068	1.150	0.0321
P-2 Baltimore, Md.	117	42	0.069	0.823	0.0320
P-3 Harrisonburg, Va.	140	38	0.061	0.787	0.0315
P-4 Charlotte, N.C.	75	32	0.064	0.758	0.0288
P-5 Atlanta, Ga.	75	32	0.060	0.748	0.0293
P-6 Huntsville, Ala.	75	32	0.067	0.678	0.0278
P-7 Jackson, Miss.	75	32	0.060	0.760	0.0299
P-8 Fayetteville, Ark.	75	32	0.067	0.733	0.0288
P-9 Shreveport, La.	75	32	0.068	0.797	0.0312
P-10 San Francisco, Calif.	75	32	0.072	0.818	0.0351
P-11 Portland, Oreg.	220	44	0.030	0.900	0.0351
P-12 St. Paul, Minn.	220	44	0.065	0.690	0.0351
P-13 Des Moines, Iowa	220	44	0.066	0.642	0.0351
P -14 Fort Wayne, Ind.	220	44	0.057	0.713	0.0351
P-15 Columbus, Ohio	220	44	0.058	0.720	0.0351

[1]Fuel oil was substituted for LP gas in factor usage and cost columns for Maine.

Sources: Crews; Halbrook; Henson; Jones; Lance; Rahn; Shaw; Via; Wildey; Agricultural Prices.

Appendix Table 2. Labor and utility costs used in broiler processing, 1982

Production Center	Average Hourly Wage $/hr	Utilities $/lb. ready-to-cook
P-1 Bangor, Me.	5.84	0.0100
P-2 Baltimore, Md.	7.14	0.0100
P-3 Harrisonburg, Mo.	6.70	0.0100
P-4 Charlotte, N.C.	5.91	0.0061
P-5 Atlanta, Ga.	6.24	0.0061
P-6 Huntsville, Ala.	5.52	0.0061
P-7 Jackson, Miss.	5.17	0.0061
P-8 Fayetteville, Ark.	5.35	0.0061
P-9 Shreveport, La.	6.29	0.0061
P-10 San Francisco, Calif.	9.35	0.0100
P-11 Portland, Oreg.	8.14	0.0100
P-12 St. Paul, Minn.	8.35	0.0100
P-13 Des Moines, Iowa	10.35	0.0100
P-14 Fort Wayne, Ind.	8.81	0.0100
P-15 Columbus, Ohio	9.37	0.0100

Sources: Bureau of Labor Statistics; Henson; Jones; Rahn; Via.

Appendix Table 3. Present situation of feedstuff surplus or deficit, 1982

Broiler Production Center	States	Broiler Production 1000 head	Aggregate Percentage %	Feed Required[1] 1000 lbs.	Soybean Meal Production[2] 1000 lbs.	Corn Production[3] 1000 lbs.	Soybean Meal 50% Utilization	Corn 25% Utilization	Soybean Meal + or -[4] 1000 lbs	Corn + or -[4] 1000 lbs
P-1 Bangor, Me.	Maine	24,787	0.6	198,296	0	0	0	0	-59,489	-138,807
P-2 Baltimore, Md.	Pennsylvania Delaware Maryland	461,693	11.6	3,693,544	0	12,055,904	0	3,013,976	-1,108,063	428,495
P-3 Harrisonburg, Va.	Virginia W. Virginia	239,041	6.0	1,912,328	0	3,885,000	0	971,250	-573698	-367,380
P-4 Charlotte, N.C.	North Carolina	432,530	10.8	3,460,240	2,474,000	9,219,280	1,237,000	2,304,820	198,928	-117,348
P-5 Atlanta, Ga.	South Carolina Florida Georgia	792,829	19.9	6,342,632	4,559,800	6,443,640	2,279,900	1,610,910	377,110	-2,828,932
P-6 Huntsville, Ala.	Alabama	468,294	11.7	3,746,352	3,556,400	1,663,200	1,778,200	415,800	654,294	-2,206,646
P-7 Jackson, Miss.	Mississippi	290,676	7.3	2,325,408	914,200	312,380	457,100	78,120	240,522	-1,549,666
P-8 Fayetteville, Ark.	N.W. Arkansas S.W. Missouri	673,631	16.9	5,389,048	5,002,200	11,611,040	2,501,100	2,902,760	884,386	-869,574
P-9 Shreveport, La.	Texas Louisiana S.E. Arkansas	328,842	8.2	2,630,736	0	6,877,920	0	1,719,480	-789,221	-122,035

[1]Assume 2 lbs. of feed per lb. of gain; Broiler ration of 70 percent corn and 30 percent meal.
[2]Bureau of Census. "Fats and Oils - Oilseed Crushings."
[3]Agricultural Statistics, 1983.
[4]Surplus or Deficit = (amount of feedstuff production * local utilization rate)
- (feed required * feedstuff percentage requirement)

Appendix Table 3. Present situation of feedstuff surplus or deficit, 1982 (continued)

Broiler Production Center	States	Broiler Production 1000 head	Aggregate Percentage %	Feed Required[1] 1000 lbs.	Soybean Meal Production[2] 1000 lbs.	Corn Production[3] 1000 lbs.	Soybean Meal 50% Utilization	Corn 25% Utilization	Soybean Meal + or -[4] 1000 lbs	Corn + or -[4] 1000 lbs
P-10 San Francisco, Ca.	California	188342	4.7	1,506,737	0	2,402,400	0	600,600	-452,021	-454,115
P-11 Portland, Or	Washington Oregon	35,941	0.9	287,528	0	1,809,360	0	452,340	-86,258	251,070
P-12 St. Paul, Minn.	Wisconsin Minnesota	34,839	0.9	278,712	3,455,200	6,1392,800			3,371,586	61,197,702
P-13 Des Moines, Iowa	Illinois Iowa	897	.0	7,176	19,148,400	17,449,920			19,146,247	174,494,897
P-14 Fort Wayne, Ind.	Michigan Indiana	16,037	0.4	128,296	2,654,200	62,868,960			2,615,711	62,779,153
P-15 Columbus, Ohio	Ohio	685	.0	0	2,776,400	26,601,120			2,776,400	26,601,120
Total		3,989,064	100	31,907,032	44,540,800	381,643,024	8,253,300	14,070,056	26,715,390	317,097,934

[1]Assume 2 lbs. of feed per lb. of gain; Broiler ration of 70 percent corn and 30 percent meal.
[2]Bureau of Census. "Fats and Oils - Oilseed Crushings."
[3]Agricultural Statistics, 1983.
[4]Surplus or Deficit = (amount of feedstuff production * local utilization rate)
- (feed required * feedstuff percentage requirement)

Appendix Table 4. Representative rail rates for corn and soybean meal, 1982

Destination Production Center	P-12 Minn.	Origin Grain Assembly Point P-13 Iowa	P-14 Ind.	P-15 Ohio	P-16 NE
	--------------dollars per 1000 pounds---------------				
P-1	42.00	40.70	29.70	23.30	43.10
Me.	42.00	40.70	21.71	16.70	43.10
P-2	39.90	38.70	5.36*	4.78*	41.50
Md.	39.90	38.70	15.34	11.30	41.50
P-3	39.90	38.70	7.36	6.80	41.50
Va.	39.90	38.70	9.50	24.20	41.50
P-4	37.70	34.10	9.05	8.24	36.10
N.C.	37.70	34.10	14.80	12.40	36.10
P-5	34.40	30.80	7.18	7.10	32.80
Ga.	34.40	30.80	17.64	12.80	32.80
P-6	30.30	26.70	5.36	8.02	28.70
Ala.	30.30	26.70	10.21	11.60	28.70
P-7	32.00	28.40	6.48	20.10	30.40
Miss.	32.00	28.40	11.54	20.10	30.40
P-8	23.20	16.90	26.60	27.40	16.30
Ark.	23.20	16.90	26.60	27.40	16.30
P-9	11.50*	13.90	10.60	38.20	38.20
La.	42.30	18.92	37.40	38.20	34.80
P-10	14.60*	12.90*	85.40	93.70	12.66*
Calif.	24.98	24.75	85.40	93.70	62.60
P-11	62.60	70.60	85.40	93.70	62.60
Oreg.	24.56	24.20	85.40	93.70	22.40

Top listed rate is for corn shipped in 3-car units. Starred rates are for corn shipped in unit trains of 60 or more cars. Bottom listed rates are for soybean meal shipped in a single car.

Sources: Department of Transportation. 1982 Waybill Statistics.
Department of Agriculture. Agricultural Stabilization and Conservation Service.

Appendix Table 5. Assumed truck distribution cost from production to distribution centers, 1982

Distribution Center	P-1 Me.	P-2 Md.	P-3 Va.	P-4 N.C.	P-5 Ga.	P-6 Ala.	P-7 Miss.	P-8 Ark.	P-9 La.	P-10 Calif.	P-11 Oreg.	P-12 Minn.	P-13 Iowa	P-14 Ind.	P-15 Ohio
	Origin Production Centers														
	Cost per 1000 pounds, ready-to-cook														
D-1 Boston, Mass.	9.08	14.15	19.03	28.11	36.73	40.64	48.23	50.98	54.36	103.69	104.22	46.08	44.32	29.14	26.55
D-2 Baltimore, Md.	22.08	1.66	4.18	13.86	21.68	25.56	33.55	41.63	41.70	82.31	92.72	36.89	34.44	14.82	14.09
D-3 New York, N.Y.	16.97	6.60	12.13	20.49	28.31	32.42	40.57	43.33	47.47	97.13	96.59	40.34	37.06	23.37	18.43
D-4 Charlotte, N.C.	36.93	13.86	9.94	1.66	7.96	12.96	20.95	35.20	28.94	90.20	92.12	38.15	35.17	19.46	14.42
D-5 Atlanta, Ga.	44.09	21.68	17.60	7.96	1.66	4.97	13.23	24.10	20.98	82.31	88.31	40.47	31.66	23.67	19.39
D-6 Pittsburg, Pa.	28.34	8.12	7.26	16.41	22.64	26.12	31.26	30.96	38.92	86.48	84.50	29.40	25.72	10.01	6.17
D-7 Orlando, Fla.	53.63	29.57	27.65	17.70	14.12	18.10	23.20	44.22	30.63	95.17	101.60	51.91	45.21	36.86	31.82
D-8 Detroit, Mich.	35.27	17.04	19.66	20.88	24.26	25.06	31.72	30.13	34.97	79.52	79.03	22.71	19.46	5.34	6.40
D-9 Chicago, Ill.	41.47	23.77	23.54	24.36	23.47	21.78	24.70	18.99	28.31	72.03	70.18	13.59	11.40	5.30	11.87
D-10 Memphis, Tenn.	53.93	30.20	25.03	20.88	12.66	8.45	7.06	11.44	11.50	70.14	76.51	30.30	20.65	19.72	19.62
D-11 Kansas City, Mo.	57.08	35.47	30.53	32.29	27.25	24.03	22.74	7.82	19.09	61.69	60.33	14.68	6.53	20.52	22.54
D-12 Minneapolis, Minn.	54.30	36.89	37.39	38.15	37.16	35.40	34.97	22.51	33.75	65.60	57.15	1.66	8.12	19.16	25.79
D-13 Dallas, Tex.	66.93	44.98	40.14	35.07	27.25	21.05	13.49	9.91	6.13	58.08	67.72	31.46	23.30	33.58	34.77

cost = mileage * (1.1602/35)

Sources: Rand McNally Road Atlas, 1980
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Appendix Table 5. Assumed truck distribution cost from production to distribution centers, 1982 (continued)

Distribution Center	P-1 Me.	P-2 Md.	P-3 Va.	P-4 N.C.	P-5 Ga.	P-6 Ala.	P-7 Miss.	P-8 Ark.	P-9 La.	P-10 Calif.	P-11 Oreg.	P-12 Minn.	P-13 Iowa	P-14 Ind.	P-15 Ohio
	Origin Production Centers														
	Cost per 1000 pounds, ready-to-cook														
D-14 Billings, Mont.	81.81	63.51	64.71	66.16	59.63	58.18	57.08	42.30	53.67	78.40	29.87	27.38	32.45	47.27	19.03
D-15 Denver, Co	74.15	54.46	53.07	52.37	47.40	43.92	39.71	27.91	33.02	41.60	41.80	30.40	22.24	39.25	41.14
D-16 Salt Lake City Ut	87.58	68.52	68.68	69.05	64.11	59.37	54.89	44.45	49.72	24.93	25.29	39.31	35.47	55.95	55.76
D-17 San Francisco Ca.	112.11	93.58	93.74	90.20	82.31	78.40	71.30	62.92	64.21	1.66	21.12	58.97	60.50	79.89	80.42
D-18 Portland, Oreg.	112.08	92.72	92.19	92.12	88.31	85.72	81.08	69.88	73.86	21.12	1.66	57.15	60.20	64.08	80.92

cost = mileage * (1.1602/35)
Sources: Rand McNally Road Atlas, 1980
Fruit and Vegetable Truck Report