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OPTIMAL LOCATION OF THE U.S. BROILER INDUSTRY

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INTRODUCTION

The U.S. broiler industry has undergone profound changes in processes of production and location of production between 1955 and 1985. 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 occurred during this period. At the same time production has gradually shifted to the Southeast with approximately 88% of the U.S. production now concentrated in a region from the Delmarva Peninsula across a Southern tier of states extending through Arkansas.

Insufficient carbohydrate feed is produced in the South to sustain the current level of broiler production. Moreover, much of the 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 seek alternative agricultural pursuits. Partly because of the rate of economic development in the South, wages and construction costs have remained 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 areas of expansion including the North Central States.

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 potentially alternate producing regions.

3) cost differences among the production and consumption regions.

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 (1) in their analysis of the location of beef cattle feeding industry.

OVERVIEW OF THE U.S. BROILER

Industry and Study Framework

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

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

2. Production sector - The United States was divided into 11 producing and 4 potential producing regions (table 1),

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 a radius of 25 miles (table 1), and

4. Distribution sector - The United States was divided into 18 consumption regions with respective distribution centers (table 2).

The overall assumptions were:

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 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 North Central Region where little or no activity is now occurring. Central points in the North Central Region 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% of a region's corn and 50% of its production of soybean meal were utilized for boiler 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% 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 8 population regions (table 2). 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.

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 Briemyer definition of vertical integration as "the exercise by a single firm of control over a product at two or more contiguous stages in marketing" (2).

The development of confinement production technology with accompanying economies of size gradually evolved the current coordinated system which in turn induced very strong centralization. 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 North Central Regions, 4 centers were arbitrarily chosen to represent production points. 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%. 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 (3).

3. Regional production estimates for soybean meal and corn for 1982 were obtained from the Bureau of Census and Agricultural Statistics, respectively. Regional surplus and deficit estimates were calculated for the 1980s location pattern.

4. Because of competing uses, each of the current 11 major production-processing regions could differ in the availability of locally produced corn and soybean meal for broiler production. Availability percentages were varied by increments from 100 to 50 to 25 to 0% 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 North Central 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 into grain surplus areas.

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 U.S. Department of Transportation (4).

7. Rail rates for each area were based on an average of shipments from the Corn Belt 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 (5).

Specific parmaters of 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 cost per mile for a 35,000 pound truck load.

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 (6). 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 the consuming regions so as to 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 in this section.

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

the model are highly 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 North Central Region. 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 10% 1982 increased 20%, 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% of corn and 50% of soybean available, 100% of both feeds, 50% local feedstuffs, 25% of local feedstuffs and 0% 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 analysis of the supply and demand parameters. 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 fully depreciated 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. Unconstrained slaughter capacity in each region was used in scenarios 21 through 35 which involved time condition variables on demand parameters. 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.

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 utility 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 North Central Region, broiler production is not likely to relocate barring a drastic restructuring of cost relations in the South. Presently, total production-processing costs in the North Central Region 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 North Central Region. Expansion in the North Central Region 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 grain surplus regions to West Cost broiler producers.

5. Local feed availability had the largest impact on reallocation of broiler production from the Southeast to the North Central and West producing regions 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 North Central Region. 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 areas barring unforeseen cost of production increases in the South.

Edward H. Easterling, Curtis H. Braschler and John A. Kuehn were Research Assistant, Professor of Agricultural Economics, Economist, USDA-ERS and Associate Professor of Agricultural Economics, respectively, University of Missouri-Columbia at the time of this study.

NOTES AND REFERENCES

(1) Schrader, Lee, F. Gordon, A. King. "Regional Location of Beef Cattle Feeding, "Journal of Farm Economics 44 (1962), :64-81.

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(3) Bureau of Labor Statistics. "LABSTAT Series Report for Food and Kindred Products Processing (SIC-20)." Unpublished computer run. March 1984.

(4) U.S. Department of Transportation, "Rail Waybill Sample." Unpublished computer run. March 1984.

(5) Bureau of Census. "1980 Census of Population, Vol 1, Characteristics of the Population." PC 80-1-A1, April 1983. Table 8.

(6) King, Richard A. Interregional Competition Research Methods. Agricultural Policy Institute Series 10, North Carolina State University. Raleigh, N.C. 1963.

Table 1. Broiler production regions and centers, 1982.

Region	Center	Production[a]	
		1,000 lbs	- % -
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 Arkasnas	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

a. Ready-to-cook basis.

Table 2. States, consumption centers, and percentage of United States' population, 1980, 1990 and 2000.

State	Consumption center	Population 1980	1990	2000
		%		
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	Pittsburgh	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
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

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