The Northeast and Interregional Competition for Broilers

Hui-Yuan Chen Wu, Robert L. Jack, Dale Colyer

An interregional model which minimizes production and transportation costs for broilers was developed and tested. Ten production and 22 consumption regions were defined. The results indicate that current flow patterns are relatively efficient given the existing production capacities. As demand increases the increased production will tend to be in the Southwest (Texas) and to a lesser extent in the Southeast (North Carolina). Shadow prices indicate that in the longer run production in the Northeast will continue to decline in relative terms and perhaps in absolute terms.

Broiler production, which tends to be concentrated in relatively small geographic areas, has experienced substantial location shifts along with greatly expanded production during the last three decades. The Delmarva (Delaware, Maryland, Virginia) and other areas in the Northeast were among the early leaders but lost relative position as production expanded in the south and southwest (Via and Crothers). The Delmarva area led the nation in broiler production until 1957 when Georgia became the leading producer. In 1971 Arkansas took over as the largest broiler production state. Because of growth in the industry, however, the Northeast still produces more broilers than in the 1950's and three areas, Maine and Pennsylvania in addition to Delmarva, are among the top ten production areas.

The location of broiler production and the changes that continue to occur are important concerns for both producers and consumers. The poultry industry and many other agricultural sectors are subject to a high level of interregional competition (Reimund, Martin and Moore; Faber and Irvin; Heien). It has been suggested that decreasing relative broiler prices and increased feed and energy (transportation) costs have caused northeastern producers to be placed at an economic disadvantage (Bender; Lee and Seaver; Seaver; Spilka, Kenyon and Shabman). Lower freight rates for grain, a shifting population and less severe winters may favor the south and southwest. While previous research has helped develop a better understanding of the situation important gaps remain and there has been no fully developed interregional model for broiler production.

The authors are, respectively. Graduate Research Assistant and Professors of Agricultural Economics, West Virginia University.

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been used for several interregional agricultural applications (Bawden, Carter, and Dean; Brain and Jack; Stemberger; Brokken and Heady), but have not been fully applied to the broiler industry. Several related studies, however, have had implications for interregional analyses. The findings have been used to infer that production costs are more important than transportation costs (Seale; Lee and Seaver, 1971 and 1972; Skinner, Seaver and Lee; Benson, Bender and Lafourcade). Lee and Seaver (1972) used a simultaneous equation model and concluded that the supply of broilers does not depend on current price but that demand depends largely on current price and disposable income. This study builds on the preceding work through development of an interregional programming model of the broiler industry. Specific objectives were to accurately model the existing situation and then to use the model to analyze the impacts of variations in some of the assumptions and of projected changes in demand for 1990. The previous work described and analyzed the trends and situation and provided a data base for the broiler industry. The interregional programming model was developed by use of these analyses and the data base that had been generated .

Procedures and Data

A spatially competitive model was developed to obtain the least-cost shipping pattern for broilers in the United States. Adjusted aggregate regional consumption, truck rates between all possible combinations of production and consumption regions, quantities supplied, and production and processing plant costs were used to construct the model. This was solved by using linear programming to determine the distribution patterns that could minimize total production and transportation costs. A number of variations from the basic model were developed to examine the effects of alternative production capacities, transportation rates, production costs, and projected 1990 consumption.

Production and consumption of broilers take place throughout the country. To simplify the modeling problem, major production and consumption areas were delineated for this study. Ten production regions and 22 consumption regions were used. The twelve leading producing states which produced 87.5 percent of the nation's broilers in 1980 were divided into 10 major production regions on the basis of location, with each state as a region except that Maryland, Delaware, and Virginia were combined into one region. Broiler production in those states is concentrated in the Delmarva Peninsula which includes parts of the three states. Each production region is represented by a city located in or near the major broiler production area within the region (Table 1).

Twenty-two consumption regions encompassing the 48 contiguous states were defined for the analysis. Each consumption region also is represented by one city, chosen on the basis of population density and geographic centrality (Table 1).

Data from U.S. Government and State Experiment Station studies were obtained from publications and included information from 1934 to 1980. The latter date is used for the interregional analysis. Population information was obtained from U.S. Bureau of the Census (1979, 1981) while information on broiler production and consumption was from USDA statistical publications (1981a, 1981b, I981c, and 1981d). Transportation costs were based on updated data from **Boles** with mileages from the Rand McNally Atlas. Production and plant processing costs were from a joint USDA-Experiment Station study reported by Henson (Table 2).[1] Production costs were adjusted to a 1980 basis using appropriate indices. All data were converted to a ready to cook (RTC) basis. Regional consumption estimates were derived by multiplying the 1980

Table 1. Broiler Production and Consumption Regions Used for the Interregional Analysis, 1980

Production Regions and Centers	Regional Production	Regional Share
	(Million Pounds)	(Percentage)
Arkansas (Little Rock)	1,761.8	15.1
Georgia (Atlanta)	1,635.6	14.0
Alabama (Birmingham)	1,409.9	12.1
North Carolina (Raleigh)	1,198.8	10.3
Mississippi (Jackson)	786.5	6.7
Delmarva (Salisbury, MD)	1,669.5	14.3
Texas (Dallas)	646.7	5.5
California (Fresno)	525.8	4.5
Pennsylvania (Harrisburg)	334.7	2.9
Maine (Waterville)	231.2	2.0
10 Region Total	10,200.5	87.5
U.S. Total	11,655.8	100.0
Consumption Regions and Centers	**Population**	**Estimated Consumption[a]**
	(thousands)	(million pounds)
New England (Boston)	12,348.5	579.1
NY (New York)	17,557.3	823.4
PA-NJ (Philadelphia)	19,230.9	901.9
MD-DE-DC (Baltimore)	5,449.3	255.6
VA-WV (Richmond)	7,295.9	342.2
NC-SC (Charlotte)	8,993.6	421.8
GA-AL (Atlanta)	9,354.3	438.7
FL (Tampa)	9,740.0	456.8
MI (Detroit)	9,258.3	434.2
OH-IN (Columbus)	16,287.6	763.9
IN-KY (Nashville)	8,252.2	387.0
IL-WI (Chicago)	16,123.8	756.2
MS-LA-AR (Jackson)	9,010.1	422.6
MN-SD-ND (Minneapolis)	5,420.0	254.2
MO-IA (Springfield)	7,830.8	367.3
KS-NE (Topeka)	3,933.2	184.5
TX-OK (Dallas)	17,253.6	809.2
MT-ID-WY (Billings)	2,201.4	103.2
CO-MN (Denver)	4,188.8	196.5
AZ-UT-NV (Phoenix)	4,978.1	233.5
OR-WA (Portland)	6,762.8	317.2
CA (Los Angeles)	23,668.6	1,110.1
TOTALS	225,139.1	10,559.1

[a] Regional consumption was estimated by multiplying natural per capita consumption by regional population.

[1] Costs of production vary greatly not only between regions but between firms within a region. The data reported by Hanson were used because they were the results of a large effort to synthesize the myriad of individual studies. The reader is referred to that report for more detail since space limitations do not permit an adequate explanation here.

Table 2. Estimated Broiler Production and Processing Costs

Item	North Atlantic	South	West	Delmarva
Production Costs (1974-76)		(Cents per pound, RTC Basis)		
Feed	21.68	21.15	24.51	a.
Chicks	3.72	3.46	5.49	
Grower Payment	5.59	3.19	2.86	
Other	*1.33*	*1.20*	*1.18*	
Total	32.32	29.00	34.04	
Total 1980 Basis	46.42	41.65	49.53	
Processing Costs (1973-75)				
Total Variable Costs	6.98	6.67	6.52	6.67
Total Fixed Costs	0.70	0.84	1.55	1.84
Assembly Costs	*0.65*	*1.08*	*1.00*	*1.08*
Total	8.33	7.48	9.07	8.59
Total, 1980 Basis	13.01	13.05	15.08	14.24

Sources: Henson; Benson and Witzig
[a] The Delmarva region was not separated from the North Atlantic states in the production cost studies.

regional populations by the average U.S. per capita consumption of broilers (46.9 pounds).[2] Production capacities were assumed to be the 1980 regional production levels. The solution to the basic model should closely approximate the situation existing in 1980, which can help validate the model. Modification can then be made to the basic model to analyze such impact changes in assumption or projected changes in demand, cost, or other parameters. Several variations from the basic model are used for this analysis. In the basic model production was limited to the existing 1980 capacity while production and processing were allowed to increase in the model variations. With a least cost model these capacities would be increased in such a way that the combination of production, processing, and transportation costs would be minimized.

An important model variation is the projection of consumers demand to 1990. With increases and a redistribution in population and an expected continued growth in the demand for broilers, future changes in the location of production will depend on how the increased demand is met. An LP model assumes that it will be used by the region with lower costs. The 1990 population levels were based on U.S. Bureau of the Census projections. Consumption of broilers was projected to be 58.6 pounds per capita.[3]

Other model variation included one where feed costs were increased and another where transportation costs were increased. For the feed cost model feed costs were increased by 10 percent for all areas except the South under the assumption that the South will continue to gain relative to other regions due to lower barge rates. In the transportation cost model, all transportation costs were increased by 10 percent to test for the impacts of a change in transportation relative to other costs. The changes from the basic model in production and flow patterns and their associated shadow prices can assist in helping analyze expected development in the broiler industry.

Results

The basic model was solved to determine the interregional movements which would minimize the combined production, processing and transportation costs to satisfy the estimated 1980 regional consumption with the assumed 1980 regional production capacities. This model was not totally inclusive since it omitted 12.5 percent of the production outside the 10 designated regions and hence was not able to satisfy total demand. The results, however, were fairly close to flow patterns which actually existed in 1975. Thus, the estimates of the production, processing, and transportation costs appear realistic.

[2] Per capita consumption data on a regional or state basis are not available. While data from studies of specific places indicate that per capita consumption may vary, the specific data needed to derive reliable estimates of regional or state consumption was not available.

[3] Per Capita Consumption was established by use of a log trend function based on 1934-1980 data (log Y = -.771977 + 1.44632 log X, R" = .958). Several other methods of predicting per capita consumption were tested and the interregional model was run with the revised estimates. While the actual numbers in the solutions differed the interregional flow patterns were similar and the shadow prices were identical to those of the projections reported here.

The interregional consumption and flow patterns for the basic model and for the projected 1990 demand model are shown in Figure 1. In the alternative models the production capacities were allowed to increase to take care of unsatisfied or projected increases in states demand. However, the production capacities were not allowed to decrease and had to be used at least at the 1980 capacities. Actual production levels have not declined through time in any of the major areas, although the proportion of total output has changed as the broiler industry has grown. Thus, it seems realistic to assume that in the near future current levels of production can be expected to be maintained in most regions, especially if total demand and production continue to expand.

Model Variations

An interregional model can be modified in many ways to test for the effects of alternative costs or production and consumption levels. In one model variation production capacities for all of the regions could have increased, if profitable, to satisfy the previously unsatisfied demand on the West Coast. The results indicated that this demand would be met by an increase in capacity and production in Texas. In the model variation where there was expanded demand for 1990, the increases would all be met by expanded capacities and outputs in Texas and North Carolina. Texas would be converted from a deficit to a surplus production area with its surplus being shipped west to meet unfilled and expanded needs in California and other western states. North Carolina would expand to meet increased needs of the eastern population centers. Those two states are nearer to the primary deficit areas than any of the other southern states. It was assumed that all southern states could produce broilers at the same production and processing costs.[4] However, transportation costs are dependent on distance and in a cost minimization model the production regions closer to deficit consumption areas can satisfy the demand more cheaply.

Although transportation costs would be substantially less for broilers produced and consumed in California (or produced in California and consumed in other western states), the production costs are enough higher to rule out expanded output on the West Coast. From Fresno, the California production center, to Portland, Oregon it costs 1.9 cents per pound (RTC) to ship broilers while from Dallas, Texas it costs 4.52 cents or 2.62 more cents per pound. However, production costs were estimated to be nearly 8 cents per pound higher in California than in the south. The major contributers to the higher production costs in California are feed and chick costs. Most grain must be shipped to California from the midwest making the costs substantially higher than in the south where barge transportation can be used or in the East which grows more grain and also is closer to major grain producing states.

The interregional model also was varied by increasing feed costs in all regions except the south under the assumption that grain could be transported in barges to the South at lower rates than by train or truck to the other regions. However, the resulting interregional flow patterns were similar to those of the other models where production capacities were allowed to expand. Since the South already had lower production costs this variation did not have much impact on the locations for producing the broilers required to meet the demand. Similar results also were obtained when all transportation costs were increased by 10 percent. Thus, while transportation costs appear to favor Texas due to the relative close location of that state to the major deficit areas, production and/or processing costs appear to be more a factor in the location between regions.

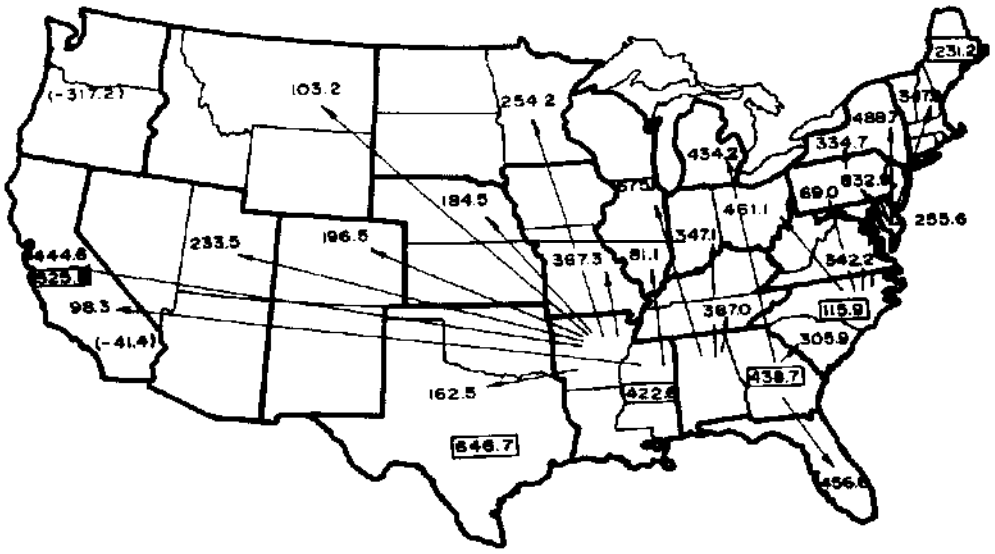
Shadow Prices

Shadow Prices in the interregional models are similar to those of other cost minimization transportation types of linear programming. The constraints in the broiler model consist of greater than or equal to the production capacity and 'equal to' the demand levels. The shadow prices for the former type of constraints represent the amounts by which costs would be increased from forcing that source to supply one additional unit of output (or savings from reducing the amounts supplied by one unit). The shadow prices for the demand constraints are the costs of increasing the de-

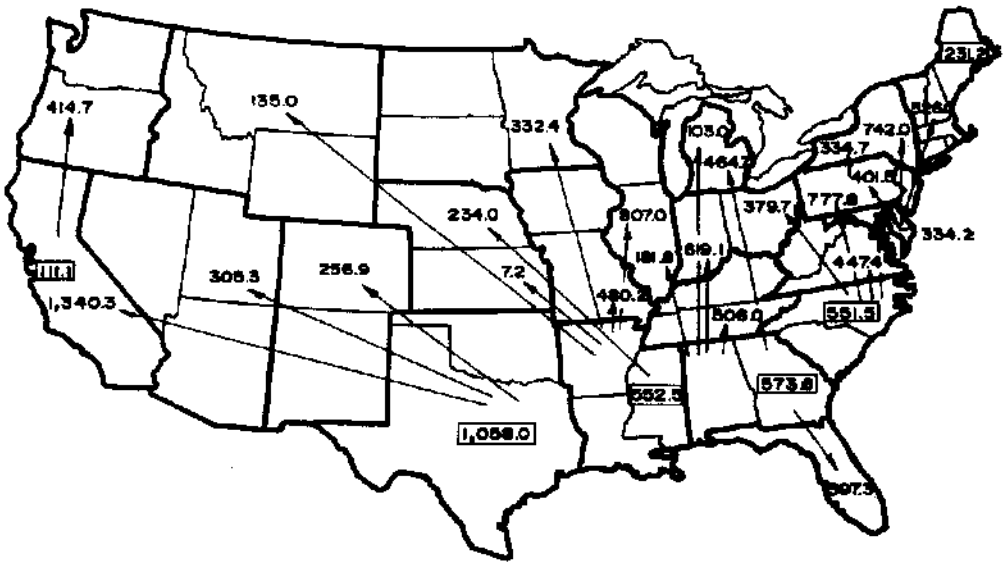
[4] As indicated in footnote one actual costs do vary considerably but the available data do not justify using different costs within the major regions. Individual producers who can frequently, for unique reasons, produce with less cost, may have a competitive advantage although the existence of an adequate infrastructure and processing industry will affect survival or wells.

Figure I. Interregional Flows of Broilers

A. Basic Model



B. Increased Demand Model



→ Denotes flows of broilers in millions of **pounds.**

I I Denotes production **consumed** within the **production region**

( ) Denotes deficit supply for Basic Model.

mand by one unit in a particular region or the savings that could be obtained by reducing demand by one unit.

Shadow prices for the alternative models are shown in Table 3. Those from the basic model are not reported since their values were distorted as the result of not satisfying the demand in two regions. The shadow prices for the production regions from the other models, however, are indicators of the relative efficiency between regions. In all models, the shadow prices were considerably higher in California, Pennsylvania and Maine than in the other regions. They also were higher for Delmarva, but, except for the model with higher feed costs, they were only slightly higher than for the southern states. Because feed costs were raised for all non-southern regions the shadow prices were substantially higher for the northeastern and western producing areas in the feed cost model. However, for Delmarva the shadow price was only about one half the values in the other nonsouthern areas. It also should be noted that the shadow prices in the projected demand model were lower than in the other models. The advantage of Texas, in this model, appears considerably less than in the other models.[5]

The values of the shadow prices indicate that California, Pennsylvania and Maine have very substantial costs relative to the South and the Delmarva region. While the Delmarva Peninsula also is at a competitive disadvantage, the extent is not so noticeable. Differences nearly as large exist between some of the southern states due to transportation differences.

[5] These smaller differences indicate that the expansion in production due to increased demand will not all occur in Texas. Firms in the other southern states will be able to expand due to advantages of research of scale on agglomeration or due to their existing base, the sunk costs which may have been recovered and hence given them an advantage in relation to firm which must control entirely new facilities, although the latter may be more efficient.

Table 3. Shadow Prices From the Interregional Models

Region	Transportation Cost Model	Feed Cost Model	Projected Demand Model
Production Regions			
Arkansas	7.20	6.50	1.80
Georgia	8.30	7.40	1.30
Alabama	8.30	7.50	1.80
N. Carolina	6.40	5.70	0.00
Mississippi	10.20	9.20	3.50
Delmarva	12.50	54.10	6.70
Texas	0.00	0.00	0.00
California	73.50	125.20	75.10
Pennsylvania	54.60	101.00	48.90
Maine	52.40	99.10	47.00
Consumption Region			
New England	558.00	557.00	562.70
NY	555.60	554.90	560.60
PA-NJ	553.30	552.80	558.50
MD-DE-DC	551.20	550.90	556.60
VA-WV	547.90	547.90	553.60
NC-SC	548.20	548.20	553.90
GA-AL	538.70	539.60	545.70
FL	553.00	552.60	558.70
MI	559.10	558.10	564.20
OH-IN	555.60	554.90	560.60
TN-KY	547.00	547.00	552.70
IL-WI	557.40	556.50	562.20
MS-LA-AR	536.80	537.80	543.50
MN-SD-ND	562.20	560.90	565.50
MO-IA	548.70	548.30	553.30
KS-NE	554.50	552.90	558.60
TX-OK	547.00	547.00	547.00
MT-ID-WY	575.70	573.10	577.80
CO-NM	564.80	563.20	566.60
AZ-UT-NV	573.50	571.10	571.10
OR-WA	592.70	588.60	590.00
CA	581.50	578.40	579.00

The shadow prices associated with the consuming regions varied closely with the transportation costs from the supply area. Washington and Oregon have the highest values because they are further from the supply areas. California followed by the other western states, has the next to highest shadow price. The areas with their supplies located entirely within the region have the lower shadow prices due, largely, to lower transportation costs. There are transportation costs within a region or state since the consumption centers for the model generally are not the same as the production centers which were used to calculate the transportation distances.

Conclusions

The analysis of the least cost models of interregional competition for broilers indicate that the industry is fairly efficient with respect to interregional movements given current production capacities. The southern states have cost of production advantages over regions in the Northeast and West which more than offset the costs of transporting the processed broilers. However, to the extent that production costs are similar the transportation costs became the more important determinant of potential shifts in the location of production.

Three areas in the Northeast remain among the top ten production regions. Two of these, Pennsylvania and Maine, appear to have costs that cause them to be at a severe disadvantage relative to many other areas.[6] The Delmarva Peninsula, however, appears to be much less disadvantaged although production costs are higher than in the South. Production in Maine has increased only slightly since the early 1970s while substantial increases have occurred in Pennsylvania and in the three states in the Delmarva area. Production increases have occurred much more rapidly in the south from which most of the increased demand for broilers has been met. Between 1955 and 1980 broiler production increased by 364 percent in the U.S., by 156 percent in Maine, 346 percent in Pennsylvania, and 292 percent in the Delmarva area.

The results of applying the interregional competition model developed in this study indicated that the trends of recent years should continue. Production has moved from the east toward the south and southwest, from the Delmarva region to Georgia, and then to Arkansas as the leaders in production. The model indicates that production should continue in the same direction with Texas gaining relative to other states. The shadow prices in the model can be used to infer that Maine and Pennsylvania should not continue to be very competitive. Production in Pennsylvania, however, has increased nearly as rapidly as for the nation, 346 percent from 1955 to 1980 compared to 364 percent for the Nation.

The Northeast as an area, however, has lost production relative to the Nation. It appears that the trend will continue although broiler production should remain an important enterprise in areas where grain may be relatively low priced, for producers who can hold costs down, and where the costs of established facilities do not enter into short run production decisions. However, population also is shifting toward the South and West which should mean larger relative and total shares for these production areas.

The least cost model provides valuable information for analyzing the broiler industry, but is only one possible approach. Noneconomic factors and marketing strategies as well as alternative assumption about costs on other parameters can affect the development of the industry. Rogers, for example, expects the cost advantage of the south and especially of Texas to decline as growth increases the demand for labor. In addition the development of brand names may affect future growth patterns. The shadow prices from the interregional models indicate that the Southern states should continue to have a substantial advantage, although it sppears unrealistic that most of the growth will occur in Texas. To the extent that the cost advantage of the South is reduced, the Northeast may benefit, due, at least in part, to the relative economic decline in the area, which can result in relatively lower labor costs than in the past. A lack of economically viable alternatives also could contribute to the retention or continued expansion of broiler production in the Northeast while economic growth in the South will provide broiler producers with attractive alternatives.

[6] This appears unrealistic, especially for Pennsylvania where production has continued to increase. This may be due to available cost data which are averages for the regions. The situation of the Delmarva region may be more relevant for eastern Pennsylvania where most of the increase has occurred.

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