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Interregional Competition in the United States Turkey Industry

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The purpose of this study is to predict the future locational changes of the turkey industry, both in the short and long run, with particular attention given to the competitive position of California.

Three spatial equilibrium models, including 60 producing and 58 consuming regions, are developed. The components of the various models include regional production and processing costs, regional demand and supply functions, and transportation costs.

The short-run ex post model suggested that, given the present location of production and consumption in the United States, the transportation of turkey follows reasonably efficient shipment patterns. The short-run ex ante model predicted prices, quantities, and shipments by region recursively for the three-year period 1962–1963–1964, based on data available in 1961. Predictions for the first year were reasonably accurate, but errors tended to accumulate beyond this. The long-run ex ante model predicted a long-run relocation of the industry, with concentrations of production in the Midwest and South, with the West (including California) dropping out of turkey production.

Various policies designed to improve California's long-run competitive position were examined, using the interregional models. Neither a uniform United States minimum wage of up to \$1.25 per hour nor a 50 per cent reduction in transportation rates on dressed turkey exports from California would prevent the state from being a net importer of turkey. Transportation rates on feed inshipments would need to be reduced nearly 40 per cent for California to remain even self-sufficient in turkey production.

The interregional models also were used to examine certain aspects of the 1962 turkey marketing order. Freezing production location by historical allotment could increase the aggregate production and processing cost of meeting long-run demand by up to 14 per cent. Adapted to the specific case, and supplemented with judgment and political considerations, the models could be useful in assessing the effects of various types and levels of production control and even in the administration of such programs.

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Interregional Competition in the United States Turkey Industry¹

INTRODUCTION

THE TURKEY industry in California and in the United States has in the last two decades experienced vast changes in production and marketing technology. These changes have had an impact upon every phase of the industry, from the turkey breeder to the processor—and ultimately to the consumer. Important technological changes in the meat production sector of the industry include improved turkey breeding stock, better disease and parasite controls, scientifically formulated rations, and improvements in equipment and facilities. Developments in other sections of the industry have included construction of highly automated processing plants, expansion and improvement of cold storage facilities and refrigerated transportation, and innovations in packaging and retailing through supermarket outlets.

The response in production to these technological changes has been striking in the postwar period. Figure 1 shows that turkey production has approximately tripled. However, the sharply increased quantities produced were moved into consumption only at markedly lower prices.² Figure 1 shows that turkey prices at the farm level have dropped to nearly one-half the level experienced immediately after World War II.

While the improved technology, increased output, and lower prices have obviously benefited consumers, the effects on growers and processors have not always been beneficial. Price uncertainty and narrowing grower profit margins have been a major concern of the turkey industry and, together with the technological changes encouraged by feed companies and processors, have led large numbers of growers to make formal contractual ties with other segments of the industry. For example, Eidman (1964)³ shows that in 1961 in California some 30 per cent of the growers marketing 40 per cent of the turkeys operated under some sort of contract. Concurrently, there has been a shift to fewer but larger flocks. Again, Eidman (1964) shows that in California between 1954 and 1961 the number of turkey growers decreased from 1,384 to 638 while the proportion of turkeys raised in flocks of more than 10,000 birds increased from 18 to 43 per cent. Similar trends in contracting and flock size have occurred in other regions of the country.

Turkeys are raised in all 50 states with the concentrations of production indicated in figure 2. Two states—California and Minnesota—together produce more than one-third of the total. The leading

¹ Submitted for publication May 28, 1965.

² A demand study by Brandow (1961) indicates that per capita turkey consumption in the postwar period would have fallen if prices and incomes had remained constant.

³ See "Literature Cited" for citations referred to in the text by author and date.

TABLE 1
PERCENTAGE OF TOTAL UNITED STATES TURKEYS RAISED,
BY REGION FOR SELECTED YEARS

Region	Pre-war			Post-war			
	1931	1936	1941	1946	1951	1956	1961
	<i>per cent</i>						
North Atlantic.....	4.2	5.5	6.3	8.7	8.7	5.9	3.3
East North Central.....	6.5	8.4	8.3	11.6	11.4	13.1	15.4
West North Central.....	24.4	30.3	34.5	29.6	24.0	28.1	36.2
South Atlantic.....	9.0	7.8	6.6	8.7	15.3	16.5	10.5
South Central.....	31.5	23.7	17.1	12.0	10.3	11.4	10.3
West.....	24.4	24.4	27.2	29.4	30.3	24.9	24.3

SOURCE: Columns 1-3: U. S. Bureau of Agricultural Economics, 1953, pp. 18-20.
Column 4: U. S. Bureau of Agricultural Economics, 1952, p. 3.
Columns 5-6: U. S. Economic Research Service, 1961a, p. 34.
Column 7: U. S. Statistical Reporting Service, 1962a, p. 6.

four states produce about one-half of the total, while the top ten states produce nearly three-fourths of the total raised in the United States. Output growth has been rapid in the four leading states as shown in figure 3. Absolute output growth has been greatest in Minnesota since 1950, with California a close second. Figure 4 shows that, from a regional standpoint, rapid output growth in the West North Central states has carried this region to the position of the major production area in the country. Growth in the West has been at a somewhat slower rate, but sufficient to make it the second greatest producing region of the country. The East North Central states have expanded more slowly, and so has the South Central region but, in the opinion of some experts, this area represents considerable potential for future expansion. The once important North and South Atlantic states have declined to relatively less importance. The distribution of turkey production in the United States and the changes over time are also demonstrated in tables 1 and 2.

This picture of the changing turkey industry raises a number of economic questions: Why does the most intensive turkey production take place in such widely scattered states as California, Minnesota, and Virginia? Why have

there been relative shifts in production from the West to the Midwest? Are these shifts expected to continue in the future? Are geographical differences affecting production costs responsible for the present location of production and shifts in production? If so, which input costs are most important in determining location?

TABLE 2
PERCENTAGE CHANGE IN TURKEYS
RAISED, BY REGION FOR
SELECTED PERIODS

Region	1946-1951	1951-1956	1956-1961
	<i>per cent</i>		
United States.....	33	44	41
North Atlantic.....	33	- 1	-21
East North Central.....	30	66	66
West North Central.....	8	69	81
South Atlantic.....	135	55	-10
South Central.....	14	60	26
West.....	37	19	37

SOURCE: Computed from sources for table 1.

Are transportation costs for feed and processed turkeys an important factor determining location? Will future production shifts be closely linked to regional population (consumption) shifts? How have producers in certain regions been able to increase production in the face of falling prices? Will this increase continue in the future?

Fig. 1. Turkey price and production in the United States, 1962-1964.

Fig. 2. Turkeys raised in the United States, 1959.

Fig. 3. Turkeys raised in major producing states, 1950-1963.

The general objective of the study is to provide answers to these questions dealing with the locational aspects of the turkey industry in the United States.

Alternative spatial equilibrium models will be developed which are appropriate to deal with the range of these questions. A final objective is to investigate briefly

Fig. 4. Turkeys raised in major producing regions, 1950–1963.

the locational aspects of the industry raised by a national marketing order such as was proposed in 1962 and subsequently defeated by an industry referendum.

The main focus of the report is on

prediction of future locational changes of the industry in the short and long run. Although the predictions developed have obvious limitations, they should be useful in suggesting to growers and processors the areas into which the concentra-

tions of production and processing might move and thus in providing guidance for long-run investment decisions by growers and processors. Also, such models

should be useful in providing administrators with means of simulating the industry response to alternative price and supply policies.

THEORETICAL FRAMEWORK

Previous Work

The emergence of the location of economic activity as a special field of inquiry can be traced to 1826, when von *Thünen (1826) wrote of the location of agricultural activities around a population center.* Except for Weber (1909) the field received relatively little attention until the 1930's, 1940's and early 1950's with the work of Hoover (1937), Lösch (1944), Bressler (1952), Mighell and Black (1951), but it was not until the 1950's that spatial economics became a major area for economic research.

Important theoretical studies were published by such writers as Koopmans (1949, pp. 136-45), Enke (1951, pp. 40-47), Samuelson (1952, pp. 283-303), Beckman (1952, pp. 643-60), Isard (1951, pp. 318-28), (1952, pp. 406-30), and Fox (1953, pp. 547-66), which provided the basis for the numerous empirical studies conducted since 1955.⁴ Because reviews of these studies and an evaluation of the present state of knowledge can be found in Lefebvre (1958), Baker (1961, pp. 231-52), Bawden (1964, pp. 1372-79a) and elsewhere, the present study emphasizes only the specific models developed for the U. S. turkey industry.

Theoretical Models for the U. S. Turkey Industry

The present study employs three different models, one of which has not been *empirically applied previously.* The three models differ principally in the assumptions made concerning producing and consuming activities and the time dimension. However, all three models assume: (1) competitive shipping activities, (2) a single product, turkey meat, (3) spatially separated markets within the United States with no foreign imports or exports, and (4) constant storage levels of frozen turkey. One point is designated in each producing and consuming area to represent all activity within each region, thus all models assume homogeneity throughout each region.

Each model will be described and evaluated theoretically according to its potential usefulness to decision makers.

Short-run Ex Post Model

Our "short-run ex post model," the simplest of spatial models, often called the "transportation model," is the model most often applied empirically.⁵ Given regional quantities produced and consumed in some time period, a shipping pattern is specified which minimizes total

⁴ Accompanying the profusion of spatial studies was the development of a special terminology. Plant location studies, analysis of interregional competition, transportation studies, and spatial equilibrium analysis are somewhat overlapping terms, each referring to special areas of inquiry within the more general field of spatial economics.

⁵ The mathematician Hitchcock (1941, pp. 224-30) was the first to formally define this model, but his interest lay in solving it rather than developing its economic implications. Nearly ten years elapsed before Koopmans independently reformulated the problem and recognized its economic significance (1949, pp. 136-45 & 1951, pp. 22-259). For examples of empirical applications see Henry and Bishop (1957) or Hertzgaard (1961). Modifications of this model have been employed in studies conducted by Fox and Taueber (1955, pp. 584-608), Judge (1956), Judge and Wallace (1959, 1960), and Seale and Allen (1959), to mention a few.

transportation costs and satisfies all regional surpluses and deficits. Given this shipping pattern, relative regional prices can then be derived assuming a perfectly competitive shipping activity. That is, the price differential between two areas engaging in trade is equal to the transfer cost between them, and is less than their common transfer cost if no trade takes place. This model will be applied to the U. S. turkey industry for the calendar year 1961.

Such a model might serve one of three different purposes:

(1) To measure the efficiency of distribution of turkey supplies from processor to consumer during a specified period.

(2) To predict, given relatively constant regional production and consumption, the direction of changes in shipping routes and traffic loads which might take place in the near future.

(3) To evaluate the effects on turkey shipments of changes in exogenous forces, such as a change in the transportation rate structure.

The first purpose of the model—as an indicator of distributional efficiency—raises certain questions. A comparison of quantity shipped or number of shipments over similar routes, or of area prices, can be misleading. Perhaps the best measure of distributional efficiency in the sense of transfer cost minimization is a comparison of the total transfer cost incurred by actual shipments with the total shipping cost of the optimum solution. Industry or government policy makers might use the potential savings from an improved shipment pattern to determine the advisability of improved market information or of new shipping regulations. A more extreme use might be in assessing the value of a centralized control mechanism for use in wartime or under other arrangements where the in-

dustry would be closely regulated. Of course, these uses assume that complete data on actual shipments are available as a basis for comparison with the optimum pattern. As will be seen later, such data are not available for the turkey industry.

The second purpose of the model assumes that there is a strong tendency in the short run for a shift from the actual toward the optimum shipping pattern. That is, shippers attempting to maximize profits would tend to revise their shipments toward the optimum pattern as dictated by relative area prices and transfer costs.

The third purpose of the model could be achieved effectively only if the actual shipping pattern closely approximated the optimum pattern. Then, the measurement of changes in the shipping pattern in response to induced stimuli such as changes in transportation costs should be a fairly accurate description of reality.

Short-Run Ex Ante Model

The “short-run ex ante model” is designed to predict short-run market behavior in the U. S. turkey industry for 1962, 1963, and 1964, based on data available through 1961. The model is descriptive (behavioral) in nature with emphasis on production adjustment—in both quantity and location—through time. Although such a model was suggested by Fox in 1953 (pp. 547–66), it has neither been developed nor empirically tested.

This model has three essential components—a transfer cost matrix, a lagged supply function for each producing area, and a demand function for each consuming area. Area supply predictions for the initial period may be based on any information known at the end of the previous period. Thereafter, the forecast must rely on price in the previous period, as

predicted by the model, and on the projected values of selected exogenous variables. In practice, the exogenous forces are often represented simply by a time trend. Area production costs are not introduced explicitly for they are reflected in the supply equations. Area consumption, prices, and shipments are simultaneously determined for each period; thus, the determinants of area consumption predictions are limited to the level of area prices during the current period and to any exogenous forces that lend themselves to projection or representation by a time variable.

Equilibrium area production, consumption, relative and absolute prices, and shipments are determined by minimizing transfer costs. Prices between any two areas cannot differ by more than the transport cost between them. Forecasts of relevant variables are made sequentially by the model for each of several successive time periods ($t + 1$ through $t + n$), based only on information known at the beginning of the initial period $t + 1$. Thus, the model is recursive—the data necessary for the solution in any period are generated by the solution of the previous time period. While solutions can be found for any number of consecutive time periods, accuracy may decrease very rapidly as errors become compounded through successive iterations. The number of time periods for which useful solutions can be generated depends on the accuracy of the equations, the stability of the industry, and the purpose of the analysis.

The model is dynamic, but not in the classical sense in which a determination of the stability or equilibrium conditions over time is critical; such an equilibrium is neither sought nor assured. Rather, the model is said to be dynamic because it determines a series of interdependent solutions through time. Following the

terminology of Baumol (1959), the model employs the "equilibrium method" of "period analysis"—supply in any one time period is dependent on the previous period (period analysis) and price during the present period is determined by the reaction of demand to this fixed supply (equilibrium method, analogous to the "temporary equilibrium" of Hicks, 1946). A cobweb situation is represented, but it is a moving cobweb because of the existence of time shifts in the demand and supply equations.

Because this model has not been developed fully elsewhere, it will be described in more detail than the previous model:

Let: subscript i indicate the producing area ($i = 1 \cdots n$)

subscript j indicate the consuming area ($j = 1 \cdots m$)

subscript t indicate time in years

Q_i^s = quantity produced in area i

Q_j^c = quantity consumed in area j

X_{ij} = quantity shipped from area i to area j

TC_{ij} = transfer cost from area i to area j

P_i = price at the producer level in area i

R_j = price to the wholesaler in area j .

Given: $Q_{(t+1)i}^s = f(P_{(t)i} / \cdots)$

$Q_{(t+1)j}^c = (R_{(t+1)j} / \cdots)$

$P_{(t)i}$

TC_{ij} .

Find for $t = 1 \cdots h$:

$Q_{(t)i}^s$ for all i (area production)

$Q_{(t)j}^c$ for all j (area consumption)

$X_{(t)ij}$ for all i and j (shipping pattern).

Which minimizes:

$$\sum_{i=1}^n \sum_{j=1}^m X_{(t)ij} TC_{ij} .$$

Subject to:

$$X_{(t)ij} \geq 0$$

$$Q^s_{(t)i} = \sum_{j=1}^m X_{(t)ij} \qquad Q^c_{(t)j} = \sum_{i=1}^n X_{(t)ij}$$

$$\sum_{i=1}^n Q^s_{(t)i} = \sum_{j=1}^m Q^c_{(t)j} .$$

To better understand the sequential solution procedure, the steps are outlined below. A simple numerical example involving three regions, each producing and consuming turkey, illustrates the procedure. Assume demand and supply functions for each region as follows:

Region 1: $Q^c_{(t+1)1} = 300,000R_{(t+1)1}^{-0.9}(1.02)^t$

$$Q^s_{(t+1)1} = 10P_{(t)1}^{0.5}t^{0.3}$$

Region 2: $Q^c_{(t+1)2} = 120,000R_{(t+1)2}^{-0.9}(1.02)^t$

$$Q^s_{(t+1)2} = 60P_{(t)2}^{0.5}t^{0.3}$$

Region 3: $Q^c_{(t+1)3} = 30,000R_{(t+1)3}^{-0.9}(1.02)^t$

$$Q^s_{(t+1)3} = 100P_{(t)3}^{0.5}t^{0.3} .$$

The transportation cost matrix TC_{ij} is as follows:

		Consuming region		
		1	2	3
Producing region	1	6	30	16
	2	30	5	22
	3	16	22	4

For simplicity, assume that in each region producer prices equal wholesale prices ($P_i = R_i, i = j$) and that the prices in period $t = 0$ are:

$$P_{(0)1} = 380$$

$$P_{(0)2} = 260$$

$$P_{(0)3} = 265.$$

The solution procedure is as follows:

1. Time period $t + 1$

A. Stage 1: Insert in each regional supply function the area price in time period t and the appropriate value for the trend term; solve each equation for predicted area production in time period $t + 1$.

$$Q_{11}^s = 10(380)^{0.5}(1)^{0.3} = 194.9$$

$$Q_{12}^s = 60(260)^{0.5}(1)^{0.3} = 967.5$$

$$Q_{13}^s = 100(265)^{0.5}(1)^{0.3} = 1,627.9$$

$$\sum_{i=1}^3 Q_{1i}^s = 2,790.3$$

B. Stage 2:⁶

(1) Trial 1:

- (a) Arbitrarily choose regional consumption figures so that they sum to the total production obtained in Stage 1. Thus, select $Q_{11}^c = 1,690.3$, $Q_{12}^c = 900$, and $Q_{13}^c = 200$ such that $\sum_{j=1}^3 Q_{1j}^c = 2,790.3$.
- (b) Given these area production and consumption estimates, solve a transportation model for the minimum-cost shipping pattern and the corresponding relative area prices.

		Consuming region ⁷						Q_{1i}^s
		1		2		3		
Producing region	1	194.9	6	0	30	0	16	194.9
	2	67.5	30	900	5	0	22	967.5
	3	1,427.9	16	0	22	200	4	1,627.9
Q_{1j}^c		1,690.3		900		200		$2,790.3 = \sum_{i=1}^3 Q_{1i}^s = \sum_{j=1}^3 Q_{1j}^c$
Relative prices		0		-25		-12		

- (c) Using these relative prices, solve for absolute destination prices by finding that price level which, when added to the area price differentials and inserted in the area demand equations, yields quantities consumed which sum to the total U. S. production predicted in Stage 1. That is, find absolute regional price levels which maintain the area differential and which satisfy the condition $\sum_{i=1}^3 Q_{1i}^s = \sum_{j=1}^3 Q_{1j}^c$. By successive approximation the prices which satisfy these conditions are determined to be $P_{11} = 297.8$, $P_{12} = 272.8$, and $P_{13} = 285.8$, as shown below:

⁶ The procedure in Stage 2 was first developed by Judge (1956). A similar procedure called reactive programming has since been devised by Tramel and Seale (1959, pp. 1012-1022).

⁷ Figures in center of each box indicate amount shipped from producing region listed on left to consuming region listed on top. Similarly, figures in upper right corner of each box show per-unit transportation costs.

$$Q_{11}^c = 250,000 (297.8)^{-0.9} (1.02)^1 = 1,815.9$$

$$Q_{12}^c = 100,000 (272.8)^{-0.9} (1.02)^1 = 786.1$$

$$Q_{13}^c = 25,000 (285.8)^{-0.9} (1.02)^1 = 188.3$$

$$\sum_{j=1}^3 Q_{1j}^c = 2,790.3$$

(2) Trial 2:

- (a) Given the predicted area production in Stage 1 and the revised area consumption figures in (c) of Stage 2 above, re-solve the transportation model for the minimum-cost shipping pattern and the corresponding relative area prices.

		Consuming region						Q_{1i}^*
		1		2		3		
Producing region	1	194.9	6	0	30	0	16	194.9
	2	181.4	30	786.1	5	0	22	967.5
	3	1,439.6	16	0	22	188.3	4	1,627.9
Q_{1j}^c		1,815.9		786.1		188.3		$2,790.3 = \sum_{i=1}^3 Q_{1i}^* = \sum_{j=1}^3 Q_{1j}^c$
Relative prices		0		-25		-12		
Absolute prices		297.8		272.8		285.8		

- (b) Compare these regional price differentials with those found in the previous iteration. If they are identical, a unique equilibrium solution has been found for period $t + 1 = 1$ and we proceed to the analysis for time period $t + 2 = 2$. In the numerical example, this is the case. However, if the regional price differentials differ from those in the previous iteration, we proceed to step (c).

- (c) Using these new relative area prices, solve for absolute destination prices by finding that price level which, when added to the area price differentials and inserted in the area demand equations, yields quantities consumed which sum to the total United States production predicted in Stage 1.

- (3) Trial 3: Proceed as in Trial 2, and continue until an equilibrium solution has been reached.

2. Time period $t + 2 = 2$

- A. Stage 1: Insert in each regional supply function the equilibrium absolute origin price in period $t + 1 = 1$ for that region derived in the previous

solution (Step (b) or (c) of the last trial) and a new value for the trend term, then solve each equation for predicted area production in time period $t + 2 = 2$.

$$Q_{21}^* = 10(297.8)^{0.5} (2)^{0.3} = 212.4$$

$$Q_{22}^* = 60(272.8)^{0.5} (2)^{0.3} = 1,219.9$$

$$Q_{23}^* = 100(285.8)^{0.5} (2)^{0.3} = 2,081.0$$

$$\sum_{i=1}^3 Q_{2i}^* = 3,513.3$$

B. Stage 2: Proceed for $t + 2 = 2$ as outlined for time period $t + 1 = 1$ above.

This procedure may be repeated until forecasts for the desired number of time periods are obtained. Table 3 summarizes the results of the numerical model when solved sequentially for five periods. In this particular example, the optimum transportation routes do not change over the five-year period, although the quantities shipped obviously change. Also, the particular demand and supply equations selected generate a series of increasing quantities demanded and supplied and decreasing prices in all regions. The particular time configuration of quantities demanded and supplied depends on the relative price elasticities of demand and supply and the rate at which these functions shift over time in response to exogenous variables. In the empirical results shown later, much more complex adjustments take place from year to year.

Successful application of this model will depend to a considerable extent on the accuracy of area production forecasts, for they have an indirect but profound influence on the relative prices, shipping patterns, and quantities consumed. In most previous regional models, the supply aspects have been treated in a rather cursory fashion. This model

requires a more explicit treatment of supply which is discussed in detail in a separate section later in the report.

This model should prove useful in making short- and intermediate-range forecasts of prices and quantities and, therefore, be a source of improved information for all segments of the industry. As discussed later, such a model could also prove useful to industry groups and government policy makers in the formulation and execution of industry programs.

Long-Run Ex Ante Model

This model is intended to predict absolute production advantages among areas under "long-run" conditions. Given regional population and per capita demand estimates for 1976,⁸ the geographic distribution of turkey production will be derived assuming all costs are variable and area factor supplies are perfectly elastic. Thus, the positively sloping turkey supply function for each region specified in the previous model is replaced by a perfectly elastic supply function at the level of the estimated long-run production costs in that region. Thus, the long-run model represents a natural extension on the supply side of

⁸ The year 1976 was selected as representing the long run because it was a 15-year projection from the published data available through 1961 at the time the major portion of the analysis was done in 1962-63.

the assumptions in the previous models. In the short-run ex post model, factors and supplies by region were fixed, i.e., supply perfectly inelastic. In the short-run ex ante model the supply function was positively sloped, representing the fact that some factors are fixed and others variable. In the long-run model all factors are variable and the supply function is assumed to be perfectly elastic at the level of production costs.

The long-run ex ante model is thus similar to the short-run ex post model except that: (1) unit production costs in each area are given, (2) regional supply is assumed to be perfectly elastic, with the amount of production endogenous to the model, (3) the demand function in each region is negatively sloped rather than perfectly inelastic at a fixed amount, and (4) both production and transportation costs are minimized by the solution. As in the first model, relative area prices are specified by the dual solution, but in this case area price differentials are less than or equal to the sum of area differences in production costs and the transfer cost between them.⁹

Unlike the short-run ex post model which is principally concerned with shipping patterns and the short-run ex ante model which is concerned with short-run forecasts of prices and quantities, this model focuses on locational production shifts in the long run. Its purpose is to indicate the direction and the ultimate magnitude of production shifts in the future based on the assumption that producers will move in the direction of increased efficiency. Neither the path of

this shift nor the speed with which it will occur is specified.

This model can prove useful to policy makers in evaluating the effects over time of specific programs (e.g., assessing the effect on long-run equilibrium of non-transferable producer allotments). It might also provide information upon which an industry group could base decisions on whether to advocate local or national policy to improve or protect its present (geographic) economic position. It should also be useful to individual firms in accelerating their adjustments toward more efficient resource utilization, for it provides a guide for long-term investment decisions (e.g., which enterprises to expand and contract or where to build a processing plant).

The long-run ex ante model includes several assumptions worth noting. Inter-area transfer charges and regional production costs are assumed to remain relatively constant through time, implying stable factor prices and no change or a neutral change in technology. External economies of scale and alternative production opportunities, although of considerable importance, are difficult to accurately measure and are omitted from this model. The production industry is assumed to be flexible as to location in the long run. Given the previous simplifying assumptions, this implies profit maximizing behavior of producers. Factor industries are assumed to be as flexible in location and production capacity as is the turkey meat producing industry. This appears to be a realistic assumption. Feed, land, labor, and capital requirements are each so

⁹ This model is the most common version of a group of formulations known as activity analysis models (see Bechmann and Marschak, 1955, pp. 331-79, for a generalized description). Although various assumptions may be made with respect to fixed and variable costs and the number of production processes to include, the common property of all models in this group is that they explicitly include physical production relationships (as opposed to supply functions). Studies by Snodgrass and French (1958), Dennis and Sammet (1961, pp. 499-604), Heady and Egbert (1959, pp. 718-33), and King and Schrader (1963, pp. 331-416) are examples of empirical applications of this class of models.

TABLE 3
SOLUTION FOR FIVE PERIODS OF HYPOTHETICAL THREE-REGION
"SHORT-RUN EX ANTE MODEL"

Time period t	Producing region i	Quantities shipped from region i to region $j = X_{ij}$			Regional equilibrium values		
		Consuming region			Price $P_{ti} = R_{ti}$	Quantity supplied Q^s_{ti}	Quantity consumed Q^c_{ti}
		1	2	3			
0	1	.....	.....	.....	380	.....	.....
	2	.....	.....	.....	260	.....	.....
	3	.....	.....	.....	265	.....	.....
1	1	194.9	0	0	297.8	194.9	1,815.9
	2	181.4	786.1	0	272.8	967.5	786.1
	3	1,439.6	0	188.3	285.8	1,627.9	188.3
2	1	212.4	0	0	237.5	212.4	2,271.2
	2	215.7	1,004.2	0	212.5	1,219.9	1,004.2
	3	1,843.1	0	237.9	225.5	2,081.0	237.9
3	1	214.2	0	0	242.2	214.2	2,275.1
	2	211.7	1,004.0	0	217.2	1,215.7	1,004.0
	3	1,849.2	0	238.2	230.2	2,087.4	238.2
4	1	235.9	0	0	223.0	235.9	2,500.3
	2	227.2	1,113.3	0	198.0	1,340.5	1,113.3
	3	2,037.2	0	262.9	211.0	2,300.1	262.9
5	1	242.1	0	0	222.3	242.1	2,557.5
	2	229.5	1,139.1	0	197.3	1,368.6	1,139.1
	3	2,085.9	0	268.8	210.3	2,354.7	268.8

small in relation to the total available in any one area that their supplies, for practical purposes, can be considered perfectly elastic. Poult and egg production need not be (and are not) regionally tied to turkey production, and their production can be varied considerably.¹⁰ Processing facilities are also assumed to be as flexible in location and capacity as are the turkey producing facilities. While processing costs are considered a part of

total production costs in the model, they probably have less influence on producers' decisions than do factor costs; nevertheless, they could conceivably be a limitational factor in production adjustment.¹¹ Processing facilities are not assumed to be restrictive in this study. To treat processing facilities otherwise would require specification of the limitation in a precise form requiring a separate study.

¹⁰ A prominent foundation breeder estimated that a 10 to 15 per cent variation in poult and egg production after January 1 could easily be achieved, and a seasonal increase of 50 per cent could occur with a planned effort.

¹¹ An analysis of turkey processing plants in the North Central states (Mortenson, 1960) indicates that existing plants could increase their hourly output by 13.7 per cent with only minor changes to remove bottlenecks (the most common being freezing capacity) and 12.6 per cent by expanding operations to the 150-day level. However, the main concern in the study was capacity only during the peak months.

DERIVATION OF BASIC COMPONENTS OF MODELS

This section is concerned with the derivation and specification of the components necessary to implement empirically the three spatial equilibrium models discussed. Specifically, the models require: (1) delineation of geographic areas of turkey meat production and consumption within the United States, (2) supply functions by areas for turkey meat, (3) demand function by areas for turkey meat, (4) the transportation cost matrix, and (5) production and processing costs for turkeys by areas.

SPATIAL DIVISIONS

The level of aggregation is, within limits, an arbitrary choice. Computer capacity and available data may limit the degree of disaggregation; otherwise, it is a choice between descriptive accuracy and computational complexity. Time and costs required for data preparation and computation of solutions increase rapidly as areas are added.

Primarily because most annual turkey statistics are published on a state basis, the *general* criterion for delineating areas in this study is to let each state be a separate producing and a consuming region. This general objective is modified as follows:

1. Producing areas—if any of the surplus-producing states have two or more geographically separated production concentrations, the state is divided into two or more producing areas. Eight of the top ten producing states are so divided, making a total of 60 separate producing areas.

2. Consuming areas—if two (or more) large population concentrations (say in excess of 500,000 people) existing in a single state are spatially separated so that one point cannot accurately repre-

sent both (e.g., Los Angeles and San Francisco), or if a large population concentration appears to be the metropolitan focal point for more than one state (e.g., New York City or Kansas City), then states are divided and sometimes regrouped to define more homogenous consuming areas. Nineteen states are divided into two or more consuming areas and regrouped according to this criterion, making 58 consuming regions in all.

The 60 producing and 58 consuming areas are defined in table 4 and figures 5 and 6. One city, appropriately located geographically, is selected to represent the production or consumption point for each area in the model. Rather than choosing the largest city to represent this point (in the case of consuming areas) or the city nearest the heaviest concentration of turkeys (in the case of producing areas), both population density and distance are considered. For a consuming area, the chosen point represents the weighted (by distance) population center of the area. For example, Boston is not chosen to represent the consuming area of Massachusetts because it lies on the eastern edge of the state. Instead, the city of Wellesley located slightly west of Boston is chosen because it best represents the weighted (by distance) population center of Massachusetts. Likewise, the location chosen to represent each production region is chosen as the weighted (by distance) center of turkey production concentrations in that region.

SUPPLY FUNCTION FOR TURKEY MEAT

Area supply functions were derived indirectly from an estimated U. S. turkey supply function. An alternative

TABLE 4
TURKEY PRODUCING AND CONSUMING AREAS AND
THEIR REPRESENTATIVE POINTS

Production			Consumption		
No.	Area	Representative point	No.	Area	Representative point
1.	Maine.....	Augusta	1.	Maine.....	Augusta
2.	New Hampshire.....	Manchester	2.	New Hampshire.....	Concord
3.	Vermont.....	St. Albans	3.	Vermont.....	Montpelier
4.	Massachusetts.....	Framingham	4.	Massachusetts.....	Wellesley
5.	Rhode Island.....	Cranston	5.	Rhode Island.....	Providence
6.	Connecticut.....	Hartford	6.	N.E. Connecticut.....	Hartford
7.	New York.....	Syracuse	7.	S. New York-S.W. Connecticut-N. New Jersey.....	New York City
8.	New Jersey.....	New Brunswick	8.	N. New York.....	Syracuse
9.	Pennsylvania.....	Reading	9.	S. New Jersey-N. Delaware-E. Pennsylvania.....	Philadelphia
10.	Delaware.....	Milford	10.	S. Delaware-Maryland-Washington, D.C.....	Baltimore
11.	Maryland.....	Baltimore	11.	W. Pennsylvania.....	Pittsburgh
12.	E. Ohio.....	Coshocton	12.	N. Ohio.....	Cleveland
13.	W. Ohio.....	Lima	13.	S. Ohio.....	Springfield
14.	N. Indiana.....	Warsaw	14.	S. E. Michigan.....	Detroit
15.	S. Indiana.....	Washington	15.	S.W. Michigan.....	Lansing
16.	Illinois.....	Peoria	16.	S. Indiana.....	Indianapolis
17.	Michigan.....	Grand Rapids	17.	N.W. Indiana-N.E. Illinois.....	Chicago
18.	N. Wisconsin.....	Eau Claire	18.	Central Illinois.....	Peoria
19.	S. Wisconsin.....	Madison	19.	S. Illinois-E. Missouri.....	St. Louis
20.	N. Minnesota.....	Thief River Falls	20.	W. Missouri-E. Kansas.....	Kansas City
21.	N.C. Minnesota.....	Brainerd	21.	W. Kansas.....	Salina
22.	S.C. Minnesota.....	Willmar	22.	N. Minnesota-N. Wisconsin-N. Michigan.....	Duluth
23.	S. Minnesota.....	Owatonna	23.	S. Minnesota-W. Wisconsin.....	Minneapolis
24.	N.W. Iowa.....	Webster City	24.	S.E. Wisconsin.....	Madison
25.	S.E. Iowa.....	Washington	25.	E. Iowa.....	Cedar Rapids
26.	N. Missouri.....	Trenton	26.	W. Iowa-E. Nebraska.....	Omaha
27.	S. Missouri.....	Springfield	27.	E. South Dakota.....	Huron
28.	North Dakota.....	Devils Lake	28.	North Dakota.....	Bismarck
29.	South Dakota.....	Watertown	29.	Virginia.....	Richmond
30.	Nebraska.....	Grand Island	30.	West Virginia.....	Charleston
31.	Kansas.....	McPherson	31.	North Carolina.....	Greensboro
32.	Virginia.....	Harrisonburg	32.	South Carolina.....	Columbia
33.	W. Virginia.....	Petersburg	33.	Georgia.....	Atlanta
34.	North Carolina.....	Fayetteville	34.	N. Florida.....	Gainesville
35.	South Carolina.....	Camden	35.	S. Florida.....	Ft. Lauderdale
36.	Georgia.....	Covington	36.	Kentucky.....	Lexington
37.	Florida.....	Ocala	37.	Tennessee.....	Nashville
38.	Kentucky.....	Winchester	38.	Alabama.....	Birmingham
39.	Tennessee.....	Athens	39.	Mississippi.....	Jackson
40.	Alabama.....	Gadsden	40.	Arkansas.....	Little Rock
41.	Mississippi.....	Tupelo	41.	Louisiana.....	Alexandria
42.	Arkansas.....	Fayetteville	42.	Oklahoma.....	Oklahoma City
43.	Louisiana.....	Alexandria	43.	N.E. Texas.....	Dallas
44.	Oklahoma.....	Oklahoma City	44.	S.E. Texas.....	Houston
45.	N.E. Texas.....	Hillsboro	45.	S. Texas.....	San Antonio
46.	S.E. Texas.....	San Marcos	46.	W. Texas.....	Lubbock
47.	W. Texas.....	Lubbock	47.	Montana.....	Helena
48.	Montana.....	Billings	48.	Idaho.....	Boise
49.	Idaho.....	Caldwell	49.	Wyoming-W. South Dakota-W. Nebraska.....	Casper
50.	Wyoming.....	Casper	50.	Colorado.....	Denver
51.	Colorado.....	Colorado Springs	51.	New Mexico.....	Albuquerque
52.	New Mexico.....	Las Cruces	52.	Arizona.....	Phoenix
53.	Arizona.....	Phoenix	53.	Utah.....	Salt Lake City
54.	Utah.....	Provo	54.	Nevada.....	Tonopah
55.	Nevada.....	Austin	55.	Washington.....	Seattle
56.	Washington.....	Yakima	56.	Oregon.....	Salem
57.	Oregon.....	Salem	57.	N. California.....	Oakland
58.	N. California.....	Yuba City	58.	S. California.....	Los Angeles
59.	C. California.....	Fresno			
60.	S. California.....	Los Angeles

Fig. 5. Turkey producing areas and their representative points.

approach considered, and having greater appeal from a theoretical standpoint, was to estimate directly each area function using area time series data. Data requirements for the later approach proved insurmountable, however. A discussion of the supply structure of the turkey industry is presented first to provide a basis for the formulation of the United States and area turkey supply equations.

Supply Structure for the Turkey Industry

Factors hypothesized to influence the total quantity of turkey supplied in any one year are illustrated in figure 7. Expected profit in year (t) is likely to have the strongest influence on how many poult are purchased by producers. Because profit expectations do not lend themselves to measurement (except, perhaps, by individual survey), a model to determine expected profit is specified, based on variables that can be observed. Of these, profit in the previous year is hypothesized to be the most important. Other facts known on January 1 of year (t) and thought to be important determinants of expected profits in year (t) are present feed prices, poult prices, and cold storage holdings.¹²

Expected profit is a relative figure; it must be weighed against profit expectations in other investments. Because roughly 90 per cent of the value of all inputs used in turkey production are variable on an annual basis (perhaps 95 per cent if labor is considered variable—see later section on production costs),

alternative investments are essentially unlimited. The inclusion of some index of these alternative investments as a variable in the equation would be desirable if available. The closest single alternative investment for a turkey producer is broiler production since buildings and equipment requirements are similar. However, both turkeys and broilers ordinarily could not be raised in the same location because of disease problems.

Intangible factors hypothesized to influence producers in their decisions on the number of poult to buy are prestige, security, uncertainty, and irrationality. These, coupled with profit expectations and alternative investment opportunities, form the decision model for purchasing poult as depicted in figure 7.

Forces determining the total turkey supplied from the poult purchased are also diagrammed in figure 7. Death loss is an important factor which varies greatly on a micro level, but in the aggregate is quite stable and can be predicted quite accurately by a time trend. Average weight per bird sold also is relatively stable in aggregate. Production economic theory would suggest that marketing weight depends directly on the feed-turkey price ratio existing near the end of the feeding period, but this actually has a very small effect. Apparently, the type of bird, established customer demand for certain sizes of birds, and producer habits far outweigh economic criteria in deciding when to market the birds.

The amount of turkey produced on

¹² In practice, most decisions involving production in the last six months of year (t) are made between October, year ($t - 1$), and June, year (t). For our analysis, all decisions are assumed to be made on January 1, year (t). Little accuracy should be lost by this simplification. With the exception of poult prices, the producer has nearly as much knowledge about decision factors at his disposal on January 1 as he has on June 30. The two major factors influencing profit—the price of feed and the price of turkey—fall in this category. Price of feed during year (t) is usually well established after the harvesting season in year ($t - 1$); price of turkey is not established until after June 30, year (t), so nearly as much is known about its expected value on January 1, year (t), as on June 30, year (t).

Fig. 6. Turkey consuming areas and their representative points.

Fig. 7 Supply structure of the turkey industry.

farms approximately equals the amount sold off farms since the inventory of turkeys on farms changes little from year to year. In fact, farm inventory changes affect the total quantity of turkey sold annually by less than 1 per cent. Farm inventory changes occur through changes in the number of turkeys that

are kept for breeding, not because of producer speculation on the meat market. Processed turkey is stored in frozen form by processors and may enter the total later in the marketing process. This will be considered in the discussion of demand.

Turkey produced in any one year,

then, is hypothesized to be essentially predetermined by factors observable at the beginning of the year. Because of the seasonality of and lag in the production process, the decision of how many poult to buy is made long before the product can be sold. Pounds of turkey produced from these poult are a function of exogenous forces, and pounds sold by producers are essentially equal to those produced.

These supply determinants have been proposed with independent turkey producers in mind but, as pointed out earlier, the turkey industry is now highly integrated, primarily with feed companies or cooperatives. In an integrated arrangement it is often the feed dealer or the cooperative manager, rather than the farmer, who decides how many poult to buy. While their decision process is undoubtedly somewhat different, these agents probably are influenced by the same factors as the farmer. It can be hypothesized that the response function of a feed dealer is more elastic than that of an individual farmer because more of his inputs are variable; or that integrated production will be greater than independent production for any given profit level because the feed dealer will accept a lower profit on the turkey operation in return for an outlet for his feed; or that the feed dealer's response to January 1 feed prices will be greater because he will try to compensate for lower feed prices

by larger feed sales through expansion of grower contracts. None of these arguments alters the hypotheses about which factors influence turkey production. However, the degree of response could be different and, therefore, the supply function as estimated by regression analysis of time series data may be affected.

Empirical Estimate of the U. S. Turkey Supply Function

Within the general framework of the hypothesized decision structure of the turkey industry, 25 alternative supply equations embodying different expectation models, equation forms, combinations of variables, and data series were estimated by regression analysis of time series data.¹³ The estimated parameters for these 25 equations and their corresponding significance levels are presented in appendix table A-1, grouped according to equation form. Also, elasticities derived for selected variables (using the mean of the observations when necessary) are presented in appendix table A-2.

The functional supply relation that appeared most appropriate from the combined standpoint of statistical significance, signs of important variables, rationality and suitability for integration into the transportation model is presented in equation (1).

$$(1) \quad Q_T^*(t) = 45.501 \pi_{(t-1)}^{0.539} P_{FG(t-1)}^{-0.239} P_{B(t-1)}^{-0.475} t^{0.273} \\ (1.92) \quad (1.72) \quad (2.09) \quad (2.63)$$

$$R^2 = 0.97$$

¹³ Because most inputs for turkey production are variable, a preliminary investigation was conducted to test the hypothesis that supply adjustment in the industry is fairly rapid. Two distributed lag equations were fitted to time series data for the 15-year period 1946-1960. The coefficient of the lagged production variable was .044 in one case and .066 in the other, indicating that 94 to 95 per cent of the total adjustment made by the industry was accomplished within one year. As the hypothesis and findings were compatible, distributed lags were not introduced in any of the 25 equations.

where

t = time in years (1947–1961)

Q_T^* = turkey supplied (1,000 ready-to-cook (RTC) pounds)

π° = profit index (price per RTC pound $\div$ cost per RTC pound, P_T/C_T) with feed costs based on USDA feed conversion ratio (FCR) data. (See Appendix A for additional detail.)

${}^\circ P_{FG}$ = weighted average feed grain price (cents per pound) received by farmers during October–December deflated by index of prices paid by farmers for all commodities. Weighted average computed on the basis of one-half corn, one-sixth oats, one-sixth barley, and one-sixth milo by weight.

${}^\circ P_B$ = price of broilers (cents per liveweight pound) received by farmers, deflated by the index of prices paid by farmers for all commodities.

t - values are given in parentheses under the variables.

The null hypothesis of autocorrelation in the disturbances term was tested using the Durbin-Watson statistic (1950, pp. 409–428 and 1951, pp. 159–178). The test statistic for equation (1) is 2.10. For $N = 15$ and $K = 4$, the tabled values of the upper and lower bounds are 1.84 and 0.59, respectively. In checking for positive correlation, $2.10 > 1.84$; for the negative correlation check, $4 - 2.10 = 1.90 > 1.84$. Hence, the hypothesis that the disturbances are not random is rejected.

Theoretical limitations of the estimated supply function.—On the basis of the previous discussion on the supply structure, it should be noted that neither current poult prices nor cold storage holdings are included in equation (1). A variable for cold storage holdings was inserted in 14 of the 25 equations, but its coefficient was never significant (the highest t -ratio was 1.07; most were considerably less than one), and it was of incorrect sign in 8 of the 14 cases.

Current poult prices were excluded because of lack of data. December prices are not available for 1946–1949, and January prices are unavailable for 1946–1951. A possibility, not attempted, would have been to include February or

March prices of year t and assume that they are representative of January prices. The only alternative investment considered is broilers.

The nebulous forces of prestige, security, uncertainty, and irrationality are not an explicit part of equation (1). It might be argued that these are accounted for by the disturbance term—containing plus and minus components which tend to cancel out—but this argument is not entirely convincing. It is easier to visualize some forces (e.g., irrationality) canceling between individuals than it is others (e.g., uncertainty). Uncertainty can be caused by an exogenous force so powerful (say, a radical policy change under consideration by Congress) that it tends to move all individuals in one direction in any one year. On the other hand, uncertainty is more likely to cancel between years than is some factor like ignorance, which tends to move in a steady trend.

After the poults are purchased, the equation implicitly assumes that turkey production in the aggregate is highly predictable and related principally to slow-moving, exogenous trends highly correlated with time. These are probably satisfactorily represented by the time variable in the equation.

The equation takes no account of the possibility that elasticities may differ depending on whether the change called for is an increase or decrease in supply. While not as important as on an individual level, the effects of capital restrictions and asset inflexibilities do depend on the direction of change (Halvorson, 1955, pp. 1186-97).

Statistical problems in estimating the supply function.—One basic statistical consideration is the specification of equation form. It is hypothesized that turkey production increases at an increasing rate with respect to rising profits and decreases at an increasing rate with respect to increasing feed and broiler prices. Thus, a quadratic or some higher level polynomial would be preferred to the logarithmic specification of equation (1). However, insufficient observations limit the degrees of freedom and virtually exclude their use. Perhaps within the relevant range the equation form is not overly important. However, care must be exercised in drawing conclusions from extrapolations.

Another statistical problem encountered is the aggregation problem. With the increase in integration since 1946, the type of people making the production decisions has been under constant change. If different types of decision makers respond differently to economic forces, as hypothesized previously, the estimated coefficients will be biased.

The omission of variables known to be important, such as management, is likely to bias the estimated parameters—which way and how much is uncertain. And even though many factors were lumped together into one profit variable, multicollinearity remains a problem. For example, the simple correlation between time and broiler price is -0.95 ; between time and price of feed grains, -0.85 ; between broiler and grain prices, 0.84 .

High intercorrelations among the independent variables will tend to make the variance of the estimates very large, resulting in unstable coefficients.

The effect of intercorrelation on certain estimates of the supply equation may be relatively small. An argument having considerable intuitive appeal but little statistical basis can be advanced to support this. In estimating several equations with different variable combinations, the coefficient of feed grain price remained fairly stable regardless of whether time or broiler price or both were included. This seems to indicate that their high correlation with feed grain price had little effect on the estimated coefficient. On the other hand, the coefficient of broiler price seemed to be highly sensitive to the inclusion of time, and vice versa.

Derivation of Area Supply Functions

As mentioned at the outset of the discussion on supply, the ultimate aim is to develop supply functions for each of the 60 producing regions. Individually estimated supply functions for each area, or at least supply functions for each major region of the United States such as the West and North Central region, would be preferred. However, time and data limitations forced the use of an alternate procedure whereby area supply functions were derived from the United States supply equation (1). This was done by fixing the dependent variable (Q_T^*) and all of the independent variables $\pi_{t-1}^* = P_{T(t-1)}/C_{T(t-1)}$, $^{\circ}P_{FG(t-1)}$, $^{\circ}P_{B(t-1)}$, and t at their area values for 1961 and solving for an equation constant K_i . Then all independent variables except t and $P_{T(t-1)}$ were held at their fixed level and combined with the equation constant, forming the new constant

A_i for each of the 60 areas.¹⁴ Area supply functions are then of the form:

$$(2) \quad Q_{T(t)i}^s = A_i P_{T(t-1)}^{0.539} i^{0.273}$$

where i represents the area. Because the equation is in logarithmic form, the elasticity of P_T is equivalent to the elasticity for π_T° since π_T° is a profit index (P_T/C_T) where C_T represents the cost of producing a unit of turkey meat. However, A_i can be estimated more directly by fixing Q_T , P_T and t for each area and solving for A_i . This is the method used. Area prices for 1960 and area production for 1961 are substituted in equation (2) and, letting $t = 15$, the A_i values are determined. Data relevant to the derivation and the resulting constants are presented in Appendix Table A-3.

Certain limitations inherent in the above derivation procedure can be seen more readily when the assumptions are stated explicitly. These are:

1. Aggregate reactions by producers in different areas are motivated by the same forces (same independent variables in each equation).
2. Aggregate producer reactions to these forces are the same in all areas (identical elasticities for all areas).
3. Every area produces the same product (Q_T is homogeneous between areas).

With respect to the first assumption, producers are likely to be motivated by the same general forces, but these are not homogeneous among areas. For example, consider the price of feed grains. All producers are influenced by feed grain prices, but not by the price of the same feed grains. The United States equation uses a composite of one-half corn and

one-sixth each of barley, oats, and milo. The West may be concerned only with barley and milo, the Midwest with corn and oats, and the South with corn and milo. This is an imperfect aggregation, resulting in biased estimates of the United States equation and some misrepresentation of the area estimates.

The second assumption—equal elasticities in all areas—is also a simplification. There will be some differences among areas in how producers react, but there seems little justification for stating *a priori* the magnitude of this difference.

The third assumption is also somewhat of a simplification. Both light and heavy birds are raised, and their proportions are not the same throughout the country—the East raises a higher proportion of light birds than does the West. Despite the difference in product, the consideration of turkey on a pound basis rather than by number of birds probably avoids serious misrepresentation by this assumption.

DEMAND FUNCTIONS FOR TURKEY MEAT

Area demand functions were derived using an approach similar to that developed previously in deriving area supply functions.¹⁵ However, a recent demand analysis for turkeys published by Brandow (1961) provided the basic United States demand equations in lieu of making a separate demand estimate as part of this study. Brandow's procedure is described and evaluated below since area demand functions are then derived from the Brandow United States demand equation and form an integral part of the short-run ex ante model.

¹⁴ Note that $P_{T(t-1)}$ does not appear directly in the U. S. function, but is a component of π_{t-1}° (i.e., $\pi_{t-1}^\circ = P_{T(t-1)}/C_{T(t-1)}$). Thus, all components of π° other than P_T were held fixed in the procedure.

¹⁵ As on the supply side, attempts were made to estimate area demand functions directly from area time series and/or cross-section data. However, consumption statistics of the nature required were unavailable or nonexistent.

Brandow's Turkey Meat Demand Equation

Brandow estimates the demands for 24 farm products, showing the direct price elasticities and the cross-price elasticities between each commodity and the other 23. His final estimates are synthesized and pertain to the three-year period 1955–1957. The synthesis is based on independent regression analysis (of 1948–1957 data in the case of turkeys), internal consistency (by applying the homogeneity condition, the symmetry relation, and others), and results of previous studies (Brandow, 1961, pp. 13–16, 30). Both retail and farm-level price elasticities are estimated by Brandow. As his retail demand for turkey was derived from the farm-level demand (because of the absence of retail turkey prices), the latter will be used in this study. Brandow's farm-level turkey consumption function is:

$$(3) \quad Q_T^* = BP_T^{-0.9240} P_B^{0.0662} P_{CA}^{0.0182} \\ P_P^{0.0388} P_S^{0.0135} P_C^{0.3170} Y^{0.3900} \\ Z(-1.007)^t \dots$$

where

Q_T^* = total quantity of liveweight turkey slaughtered under federal inspection.

B = a constant.

P = farm price (dollars per live-weight pound); subscript T = turkey, B = beef, CA = calves, P = pork, S = sheep and lambs, and C = chicken.

Y = real per capita disposable personal income.

Z = population.

t = time in years.

... indicates that cross elasticities are also listed for the 18 other products in the model.

The last three terms (Y, Z, t) are derived from Brandow's table 3 (1961, p. 25). The final term is a trend term which, assuming population and income constant, indicates a 0.7 per cent per year decrease in turkey consumption.¹⁶

Evaluation of Brandow's demand equation.—In the Brandow turkey demand equation, storage is apparently ignored—quantity consumed is assumed equal to quantity slaughtered under federal inspection. The result is not a consumption demand, but a consumption-plus-storage demand. That is, Brandow's equation is actually $Q^{*}_{T(t)} = Q^{c}_{T(t)} + \Delta S_{T(t)} = f(P_{T(t)} \dots)$, where $Q^{*}_{T(t)}$ = quantity slaughtered, $Q^{c}_{T(t)}$ = quantity consumed, and $\Delta S_{T(t)}$ = change in cold storage inventory. Thus, quantity consumed will exactly equal quantity slaughtered only if cold storage inventory levels remain constant from year to year. While this theoretical condition obviously will not hold precisely, the relevant empirical question is how seriously it is violated in practice. The lowest storage figure in a particular year can be considered the carryover from one production period to the next. While the lowest inventory has been in different months during different years (the trend has been for this low point to come earlier in the year), it has generally occurred during or near the end of July. Column 3 of table 5 shows that July 31 storage as a percentage of turkey produced in the previous year has ranged from 11.07 to 4.20 per cent, with an average inventory of 6.87 per cent.

¹⁶ A negative trend may seem inconsistent with the rapidly rising per capita consumption of turkey experienced since 1946, but Brandow's equation attributes the latter to the rapidly falling turkey prices and rising per capita incomes.

TABLE 5
COLD STORAGE, PRODUCTION, AND FARM PRICE OF TURKEY
IN THE UNITED STATES, 1946-1961

Year	Turkey production in year (<i>t</i>)	Turkey storage July 31 year (<i>t</i> + 1)	Storage in (<i>t</i> + 1) as percent of production in (<i>t</i>)	Change in July 31 storage (<i>t</i> + 1) minus (<i>t</i>)	Change in storage (<i>t</i> + 1) minus (<i>t</i>) as percentage of production in (<i>t</i>)	Farm turkey price per thousand pounds liveweight
	1,000 RTC pounds		per cent	1,000 RTC pounds	per cent	dollars
1946.....	535,838	59,319	11.07	- 4,088	- .76	363
1947.....	458,053	19,219	4.20	-40,100	-8.75	365
1948.....	430,439	21,302	4.95	2,083	.48	468
1949.....	577,013	46,979	8.14	25,677	4.45	352
1950.....	613,112	29,812	4.86	-17,167	-2.80	329
1951.....	712,399	46,460	6.52	16,648	2.34	375
1952.....	786,914	43,709	5.55	- 2,691	- .34	336
1953.....	755,996	47,961	6.34	4,252	.56	337
1954.....	870,408	44,954	5.16	- 3,007	- .35	288
1955.....	818,051	36,097	4.41	- 8,857	-1.08	302
1956.....	968,466	90,011	9.29	53,914	5.57	272
1957.....	1,030,593	79,192	7.68	-10,819	-1.05	234
1958.....	1,044,289	66,885	6.40	-12,307	-1.18	239
1959.....	1,117,783	70,891	6.34	4,006	.36	239
1960.....	1,178,193	128,257	10.89	57,366	4.87	254
1961.....	1,502,705	123,007	8.19	- 5,250	- .35	189

SOURCES:

Column 1: Computed by dividing liveweight turkey produced (U. S. Statistical Reporting Service, 1962d, p. 95. U. S. Statistical Reporting Service, 1962a, pp. 5 and 7) by the yield or dressing percentage (U. S. Statistical Reporting Service, 1962d, p. 166; U. S. Economic Research Service, 1962a, p. 37).

Column 2: U. S. Statistical Reporting Service, 1962d, p. 155. U. S. Statistical Reporting Service, 1962e, p. 6. U. S. Statistical Reporting Service, 1962f, p. 6.

Column 3: Column 1 ÷ column 2.

Column 4: Computed from column 2.

Column 5: Column 1 ÷ column 4.

Column 6: Same sources as shown for column 1.

Change in storage from year (*t*) to (*t* + 1) as a percentage of production in year (*t*) has ranged from -8.75 to +5.57 per cent (column 5). While this represents a considerable annual change, the change has been < 3 per cent in 12 of the 16 years, < 2 per cent in 10 of 16 years, and < 1 per cent in 7 of 16 years.

The year-to-year inventory changes are seen to be substantial in a few years. Are these changes random, determined by exogenous variables not included in Brandow's demand equation, or determined by some of the same variables as in Brandow's demand equation? In the latter case, Brandow's equation would give biased estimates of the variable $Q_{T(t)}^c$ desired. This possibility was examined by determining statistically whether storage demand was determined

to some extent by turkey prices and time—two variables in Brandow's demand equation. Retail turkey price statistics are not published for the United States. While they are available for ten selected cities (beginning in 1956 for five of them and in 1958 for the remainder), it would be misleading to use any average of these as a representative United States figure. In measuring the responsiveness of inventories to price, then, prices at the farm rather than at the retail level must be used. Thus, the relationship was estimated by regressing July 31 cold storage (*S*) in year (*t* + 1) against farm price of turkeys (P_T) in year (*t*) and time. Storage in (*t* + 1) is used because this relates to production in (*t*). The price variable should logically represent farm prices from August in

year (t) through July in year ($t + 1$), but weighted averages are published only on a calendar-year basis. Thus, price in year (t) is used to approximate the August (t) to July ($t + 1$) price, as most of the turkey is consumed during the first five months (August–December) of this period. Results of the regression are:

$$(4) \quad S_{T(t+1)} = 2,173,913,043 P_T^{-1.868} t^{0.012} \quad R^2 = 0.638. \\ (2.96) (0.06)$$

A fairly strong relationship between inventories and farm price is shown, the price elasticity of storage demand being -1.868 . This means that $Q^*_{T(t)}$ is not an unbiased estimate of $Q^c_{T(t)}$ as Brandow's equation implies. That is, under Brandow's assumption, elasticity estimates will be biased unless storage remains a constant percentage of production. However, there appears to be little basis for measuring the extent of the bias. Assuming price elasticity of storage is approximately -1.9 , based on equation (4), Brandow's consumption-plus-storage price elasticity of -0.9 is likely to overestimate the true consumption price elasticity. Unfortunately, neither the size of the bias nor its effect on other parameters is known. Hence, Brandow's Q^*_T is assumed to be equivalent to Q^c_T in the formulations to follow.

Another consideration in using Brandow's equation is that Brandow used farm prices whereas consumers react to retail prices. Consequently, any conclusions about how consumers respond to retail turkey prices imply some assumption about the marketing margin. In a logarithmic demand function such as Brandow employed, the farm price elasticity (E_{P_f}) and retail price elasticity (E_{P_r}) are equal only if the marketing margin (M) is a constant percentage of

farm price. If the margin (M) is a constant (C) plus a constant percentage (D) of farm price (P_f), then $M = C + DP_f$ and $E_{P_r} = [P_r/(P_r - C)]E_{P_f}$. Consequently, $E_{P_r} > E_{P_f}$ if $C > 0$, as is the usual case. If the margin is fixed regardless of price ($M = K$), then $E_{P_r} = [P_r/(P_r - K)]E_{P_f}$. Again $E_{P_r} > E_{P_f}$, but

the difference is greater than in the previous situation because K would exceed C (except in the unlikely case in which $D < 0$).

An attempt was made to estimate the relationship between marketing margins and farm price in the turkey industry. Selected margins from ten cities were plotted against farm price, but no meaningful relationship could be distinguished.¹⁷ An alternative attempt was made using these margins but assuming that the farm price near each city was the same as the average statewide farm price. Here a statistical relationship of the form $M = C + DP_f$ did emerge, but with a negative coefficient for D of about 0.8 . Since this did not correspond with *a priori* reasoning, it too was rejected. It was concluded that either the data were not representative, or that omitted variables significantly affected the margins.

Without knowing the actual relationship between margins and farm price in the turkey industry, Brandow's farm price elasticity cannot be adjusted to represent retail price. One would expect the relationship to be $M = C + DP_f$ where $C, D, > 0$. If this is so, Brandow's farm price elasticity underestimates the retail price elasticity.

Modification of the Brandow equation.—Demand equation (3) omits the

¹⁷ Marketing margin data are published periodically by the U. S. Economic Research Service. Summary statistics for turkeys are found in U. S. Economic Research Service (1961b, pp. 37–42, and 1962c, pp. 12–15).

price variable for 18 of the 23 other farm products considered by Brandow. These were excluded because the cross-price elasticities of each of these with turkey was less than 0.0026. Similarly, the magnitudes of the coefficients for veal (calves) and mutton (sheep and lambs) are relatively small, suggesting that neither are close substitutes for turkey and also can be excluded to simplify the formulation with negligible loss in precision.

For further simplification, the last three terms of equation (3) can be combined in one composite trend term. Real per capita income has risen at the average rate of about 1.8 per cent per year (Brandow, 1961, p. 24). With a coefficient of 0.390, this increases turkey consumption by 0.7 per cent per year, exactly offsetting the "taste" trend. Population is expected to rise about 1.7 per cent per year through 1965 (Brandow, 1961). The composite trend, then, is 1.7 per cent per year.

One further modification is required to make the Brandow equation consistent with the formulation of the inter-regional models. The turkey price elasticity in equation (3) is based on farm price. Consumption in the interregional models is related to a "quasi-retail" price (P_{ri}) whose relation to farm price

(P_{fi}) is simply $(P_{ri} - P_{fi}) \leq T_{ij}$ where T_{ij} is the transfer cost between the producing and consuming point. (If the same point represents both the producing and consuming area, there is still a minimum fixed transfer cost assumed in the model; thus, T_{ij} is never zero.) Because of the inequality in this equation P_{ri} may equal P_{fi} , but the usual case is where $P_{ri} > P_{fi}$. In such cases Brandow's farm price elasticity should be adjusted to reflect the retail price. If the prices differ by T_{ij} , the maximum bias occurs. Assuming $E_{pfi} = \alpha$, then $E_{pri} = \alpha [P_{ri} / (P_{ri} - T_{ij})]$ where T_{ij} is the transportation cost between the consuming center and its *closest* (not necessarily its own) producing center.¹⁸ Whether $P_{ri} - P_{fi}$ does actually equal T_{ij} will not be known until the equilibrium solution is reached; nor will E_{pri} , needed for correcting the elasticity, be known until the final solution. Perhaps an iterative solution could be designed which would take this into account, but for our purpose a less precise method is used. P_{ri} and P_{fi} are assumed to differ by T_{ij} in all cases, and P_{ri} is fixed at \$250 per 1,000 RTC pounds of turkey (a figure which approximates the average 1961-1962 farm price plus ten per cent). Each area price elasticity is then adjusted accordingly (the revised values are shown in column 5, table 6)

¹⁸ This is demonstrated as follows:

Given Brandow's demand $Q = AP_{fi}^\alpha$

and the identity $P_{ri} - P_{fi} = T_{ij}$

solve for P_{fi} in the latter $P_{fi} = P_{ri} - T_{ij}$

and substitute for P_{fi} in Brandow's demand $Q = A(P_{ri} - T_{ij})^\alpha$.

Take the partial derivative with respect to P_{ri}

$$\frac{\partial Q}{\partial P_{ri}} = \alpha A \frac{(P_{ri} - T_{ij})^{\alpha-1}}{P_{ri} - T_{ij}} = \alpha \frac{Q}{P_{ri} - T_{ij}}$$

and solve for the retail price elasticity

$$E_{pri} = \alpha \frac{Q}{P_{ri} - T_{ij}} \cdot \frac{P_{ri}}{Q}$$

$$E_{pri} = \alpha \frac{P_{ri}}{P_{ri} - T_{ij}}.$$

TABLE 6
COEFFICIENTS FOR TURKEY DEMAND FUNCTIONS BY AREAS

Consuming areas	Total area turkey consumed in 1961	1961 farm price of turkey per thousand RTC pounds	Distance to nearest producing point	Transfer cost per thousand RTC pounds to nearest producing point	E_{pr} Price elasticity of demand	(A) Demand function constant
	<i>thousand RTC pounds</i>	<i>dollars</i>	<i>miles</i>	<i>dollars</i>		
United States total*	1,399,674.733	236.25				
<i>Northeast</i>						
Maine.....	8,884.544	335.00	0	2.97	-0.9351	2,006,705.2
New Hampshire.....	5,731.427	316.25	18	3.22	-0.9361	1,233,730.7
Vermont.....	3,419.807	335.00	66	3.88	-0.9386	788,293.0
Massachusetts.....	52,447.192	358.75	7	3.07	-0.9355	12,659,282.0
Rhode Island.....	8,682.151	368.75	5	3.04	-0.9354	2,148,955.9
N.E. Connecticut.....	18,967.733	376.25	0	2.97	-0.9351	4,775,540.7
S. New York-S.W. Con- necticut-N. New Jersey	165,546.983	358.75	44	3.58	-0.9374	40,407,522.0
N. New York.....	56,722.424	351.25	0	2.97	-0.9351	13,391,820.0
S. New Jersey-N. Dela- ware-E. Pennsylvania	88,610.419	315.41	55	3.73	-0.9380	19,235,742.0
S. Delaware-Maryland- Washington, D.C.....	40,076.557	251.25	0	2.97	-0.9351	6,916,853.5
W. Pennsylvania.....	43,729.393	336.25	119	4.60	-0.9413	10,275,422.0
<i>North Central</i>						
N. Ohio.....	38,037.359	237.50	99	4.33	-0.9403	6,408,049.3
S. Ohio.....	34,374.250	237.50	66	3.88	-0.9386	5,737,334.0
S.E. Michigan.....	33,427.501	235.00	138	4.86	-0.9423	5,636,898.2
S.W. Michigan.....	22,727.798	235.00	62	3.82	-0.9383	3,749,810.7
S. Indiana.....	30,906.781	228.75	110	4.48	-0.9409	5,042,613.1
N.W. Indiana-N.E. Illi- nois.....	50,456.628	233.75	114	4.54	-0.9411	8,410,646.4
C. Illinois.....	19,564.651	238.75	0	2.97	-0.9351	3,219,333.4
S. Illinois-E. Missouri...	26,057.350	218.12	170	5.28	-0.9439	4,131,463.5
W. Missouri-E. Kansas...	19,901.468	208.12	102	4.37	-0.9404	2,962,828.0
W. Kansas.....	11,305.322	218.75	37	3.48	-0.9370	1,731,782.3
N. Minnesota-N. Wiscon- sin-N. Michigan.....	8,867.260	229.16	115	4.57	-0.9412	1,451,546.9
S. Minnesota-W. Wiscon- sin.....	22,532.770	226.25	67	3.90	-0.9386	3,593,440.2
S.E. Wisconsin.....	25,824.226	232.50	0	2.97	-0.9351	4,145,228.3
E. Iowa.....	15,220.801	210.00	60	3.80	-0.9383	2,259,721.3
W. Iowa-E. Nebraska...	14,790.642	210.00	136	4.83	-0.9422	2,242,131.3
E. South Dakota.....	4,107.807	226.25	90	4.21	-0.9398	659,373.3
North Dakota.....	4,718.892	222.50	180	5.42	-0.9445	764,842.9
<i>South</i>						
Virginia.....	24,828.138	233.75	114	4.54	-0.9411	4,138,617.6
West Virginia.....	11,169.089	243.75	171	5.30	-0.9440	1,967,761.6
North Carolina.....	28,334.872	283.75	97	4.30	-0.9402	5,639,629.5
South Carolina.....	14,768.136	270.00	32	3.41	-0.9368	2,752,366.5
Georgia.....	24,711.290	287.50	34	3.44	-0.9369	4,887,336.3
Northern Florida.....	13,130.205	321.25	37	3.48	-0.9370	2,883,118.8
Southern Florida.....	20,126.218	321.25	293	6.88	-0.9501	4,766,426.0
Kentucky.....	18,872.823	233.75	18	3.22	-0.9361	3,061,288.4
Tennessee.....	22,298.664	265.00	170	5.28	-0.9439	4,248,734.9
Alabama.....	20,278.966	273.75	61	3.81	-0.9383	3,860,950.1
Mississippi.....	13,420.176	261.25	190	5.55	-0.9450	2,538,373.0
Arkansas.....	10,925.086	235.00	188	5.52	-0.9449	1,868,641.2
Louisiana.....	20,742.556	300.00	0	2.97	-0.9351	4,225,687.4
Oklahoma.....	14,650.377	226.25	0	2.97	-0.9351	2,292,469.6
N.E. Texas.....	20,551.246	245.00	62	3.83	-0.9383	3,525,913.9
S.E. Texas.....	15,458.714	245.00	162	5.18	-0.9436	2,730,671.8
S. Texas.....	14,476.453	245.00	48	3.63	-0.9376	2,474,134.4
W. Texas.....	11,068.645	245.00	0	2.97	-0.9351	1,865,875.6

TABLE 6—Continued

Consuming areas	Total area turkey consumed in 1961	1961 farm price of turkey per thousand RTC pounds	Distance to nearest producing point	Transfer cost per thousand RTC pounds to nearest producing point	E_{Pr_i} Price elasticity of demand	(A_i) Demand function constant
	thousand RTC pounds	dollars	miles	dollars		
<i>West</i>						
Montana.....	5,304.566	275.00	227	6.03	-0.9468	1,063,871.1
Idaho.....	5,262.517	260.00	25	3.32	-0.9364	944,612.2
Wyoming-W. South						
Dakota-W. Nebraska..	4,361.354	236.25	0	2.97	-0.9351	710,624.8
Colorado.....	13,067.744	283.75	67	3.90	-0.9386	2,577,538.8
New Mexico.....	7,300.331	242.50	221	5.95	-0.9465	1,297,631.1
Arizona.....	10,060.500	277.50	0	2.97	-0.9351	1,905,433.5
Utah.....	6,619.125	227.50	44	3.58	-0.9374	1,054,177.9
Nevada.....	2,204.296	225.00	126	4.70	-0.9417	355,630.7
Washington.....	21,389.310	230.00	143	4.92	-0.9425	3,538,378.5
Oregon.....	13,403.221	240.00	0	2.97	-0.9351	2,216,275.4
N. California.....	50,399.849	242.50	112	4.51	-0.9410	8,692,045.5
S. California.....	64,871.450	242.50	0	2.97	-0.9351	10,831,199.0

* Excluding Alaska and Hawaii.

SOURCES:

Column 1: See D. Lee Bawden, Ph.D. Thesis (1964b).

Column 2: U. S. Statistical Reporting Service, 1962b, p. 47. Areas consisting of a part of one state are assigned the statewide price; areas consisting of parts of more than one state are assigned the simple average of the prices of the involved states. A dressing yield of 0.80 is assumed since 0.80 is the average 1961 dressing yield as shown in U. S. Economic Research Service, 1962b, p. 37.

Column 3: From Table 7, the mileage matrix.

Column 4: Computed by substituting the values in column 15 for D in the transportation cost function, $TC = 2.9676 + .014D - .0000021912D^2$.

- .924 (250)

Column 5: Computed by solving $\frac{-924}{250 - T_{ij}}$ where T_{ij} 's are the entries in column 4.Column 6: Computed by machine, solving for A_i in the equation $Q_T^c = A_i Pr^B 1.017^t$ where Q_T^c = entries in column 1, Pr = entries in column 2, B = entries in column 5, and $t = 1$.

but it is noted that the magnitude of the adjustment is minor.

In summary, Brandow's modified

United States turkey demand equation, which is used below in deriving area demand equations, is:

$$(5) \quad Q_{T(t)}^c = BP_{T(t)}^{-0.924} \frac{P_{r_i}}{P_{r_i} - T_{ij}} P_{B(t)}^{0.066} P_{P(t)}^{0.039} P_{C(t)}^{0.317} (1.017)^t.$$

Derivation of area demand functions.

—The dependent variable, all independent variables, and the turkey price elasticity in equation (5) are fixed at their area values in order to derive a

demand constant (A_i) for each area; but as with the supply derivation, a shorter method exists. As the final form of the area demands in the interregional model will be

$$(6) \quad Q_{T(t)i}^c = A_i P_{T(t)i}^{-0.924} \frac{P_{r_i}}{P_{r_i} - T_{ij}} (1.017)^t.$$

A_i is estimated by fixing only Q_T^c , P_T and the elasticity at their area values and setting $t = 1$. The area constants are shown in column 6, table 6.

Since turkey consumption data by

areas are not available in any form, the specification of Q_T^c for each area involves reconstructing and bringing together diverse consumption statistics. In brief, the allocation of 1961 turkey consump-

tion among areas involved three steps:¹⁹ (1) estimating area per capita holiday turkey consumption, (2) estimating area per capita nonholiday turkey consumption, and (3) adding the two and multiplying by area population to get total area turkey consumed. The most crucial assumptions in this procedure include: (1) demand elasticities are the same for all areas and are identical to Brandow's United States elasticities, (2) per capita holiday turkey consumption is the same in every area, (3) nonholiday consumption differs according to values of the variables in equation (5) above, (4) taste differs only among the four major regions defined by the U.S. Department of Agriculture (1956a, 1956b, 1956c, 1956d, 1956e) while areas within each region are assumed homogeneous with respect to taste, (5) area differences in restaurant turkey consumption are proportional to area differences in home consumption, and (6) restaurant consumption is distributed evenly throughout the year.

TRANSPORTATION COST MATRIX

Estimates of charges to the shippers for transporting turkey from each of the 60 producing areas to each of the 58 consuming areas (3,460 possible shipping combinations) are obtained from transfer cost functions estimated from sample shipment data. Two types of functions are fitted—truck and rail. A combination of the two functions provides the basis for computing the final transportation cost matrix.

Truck Transfer Functions

In 1953, dressed poultry was declared an exempt commodity under the Motor Carrier Act of 1935. Its rates and routes have not been regulated by the Inter-

state Commerce Commission since about 1955 (the time lag being due to court appeals). Under uncontrolled conditions, primary determinants of rates are hypothesized to be carrier costs, competition, and availability of backhauls. Perhaps the last two could be quantified in some manner, but information on their degree of existence is unavailable. Carrier costs data also were inaccessible. Information is published, however, showing average rates—cents per 100 pounds—for fresh and frozen poultry shipped to 12 selected cities by state of origin (U. S. Agricultural Marketing Service 1958). From these data, based upon a nationwide survey of 144 poultry processors and 67 motor carriers in 1957, observations were selected showing shipments originating only from surplus turkey producing states. Truck transfer cost equations were then fitted to these selected observations.

Little information exists on the equation form for such functions. Under the assumption that truck rates approximate some constant percentage of costs incurred by carriers for individual shipments, determinants of these costs were considered. Total truck carrier costs (costs incurred by the carrier in making a shipment) are the sum of loading cost and shipping cost. Carrier loading cost per truck ($TCLC/T$) is hypothesized to be a linear function of weight (W):

$$(7) \quad TCLC/T = a_1 + a_2W$$

Carrier shipping cost per truck ($FCSC/T$) is hypothesized to be a function of weight (W), distance (D), speed, terrain, wage rates, etc. Speed, terrain, and other cost factors are assumed constant throughout all ranges of W and D , hence

$$(8) \quad TCSC/T = f(W, D) .$$

Looking at distance first, $TCSC/T$ is

¹⁹ For the detailed procedures in making the consumption allocation see: Bawden, D. Lee (1964b).

believed to be an increasing function of D because of food, lodging, and overtime of the driver(s):

$$(9) \quad {}^dTCSC/T = a_3 + a_4D + a_5D^2.$$

With respect to weight, ${}^wTCSC/T = 0$ when $D = 0$. As weight influences only the rate per mile, it alters a_4 above, but not a_5 because extra driver expense is unrelated to weight. The relationship

between a_4 and W is complex. Friction and force are linear functions of weight, but the relationship between force (horsepower) and gas, oil, and repairs is difficult to postulate. Perhaps a_4 is either a linear or increasing function of weight. As the quadratic is more general, it is used:

$$(10) \quad a_4 = a_6 + a_7W + a_8W^2.$$

Substituting equation (10) into (9) yields a relationship for total carrier shipping cost per truck:

$$(11) \quad TCSC/T = a_3 + (a_6 + a_7W + a_8W^2)D + a_5D^2 \\ = a_3 + a_6D + a_7WD + a_8W^2D + a_5D^2;$$

Equation (11) plus loading cost [equation (7)] yields total carrier cost per truck:

$$(12) \quad TTCC/T = TCLC/T + TCSC/T = a_9 + a_2W + a_6D + a_7WD \\ + a_8W^2D + a_5D^2,$$

where $a_9 = a_1 + a_3$. Assuming full truck loads, total truck carrier cost for a specified shipment would be $TTCC/T$ times the number of trucks required:

$$(13) \quad TTCC = (TTCC/T) (T) \\ = a_9T + a_2WT + a_6DT + a_7WDT + a_8W^2DT + a_5D^2T.$$

As previously stated, rates are hypothesized to differ from this total (long run) carrier cost function by a constant per cent representing profit to the carrier. So the total truck transfer cost ($TTTC$), which is the rate charged or cost to the producer (shipper), can be expressed as a constant per cent (K) of $TTCC$:

$$(14) \quad TTTC = (TTCC) (K) \\ = a_9^*T + a_2^*WT + a_6^*DT + a_7^*WDT + a_8^*W^2DT + a_5^*D^2T,$$

where $a_i^* = K(a_i)$.

Because the data available only relate truck rates to distance, weight per truck is assumed constant for all shipments (perhaps not an unrealistic assumption for interstate shipments). Equation (14) becomes

$$(15) \quad TTTC/W = a_9^*\frac{T}{W} + a_2^*T + a_6^*\frac{DT}{W} + a_7^*DT + a_8^*WDT + a_5^*\frac{D^2T}{W}.$$

Holding W and T constant at W' and T' results in

$$(16) \quad TTTC/W = a_9^*\frac{T'}{W'} + a_2^*T' + a_6^*\frac{DT'}{W'} + a_7^*DT' + a_8^*W'DT' + a_5^*\frac{D'^2T'}{W'} \\ = a_9^{**} + a_2^{**} + a_6^{**}D + a_7^{**}D + a_8^{**}D + a_5^{**}D^2 \\ = (a_9^{**} + a_2^{**}) + (a_6^{**} + a_7^{**} + a_8^{**})D + a_5^{**}D^2 \\ = a_{10} + a_{11}D + a_{12}D^2.$$

Linear, logarithmic, and cubic functions were estimated for comparative purposes. None, including the quadratic, seemed to represent the full range of data well; data on rates of all long-distance shipments appeared disproportionately high. Upon investigation, these were found to be shipments across the Rocky Mountains from west to east. Data were then stratified into three groups by distance: 0–1,450 miles, 1,451–2,100 miles, and more than 2,100 miles. Separate equations were estimated for each group. Those chosen as the most representative are presented below:

0–1,450 miles

$$(17) \quad {}^1TTC/W = 2.9676 + 0.0140D - 0.0000021912D^2 \quad R^2 = 0.84$$

(7.58) (2.40)

1,451–2,100 miles

$$(18) \quad {}^2TTC/W = 4.594 + 0.0097D \quad R^2 = 0.83$$

(20.45)

more than 2,100 miles

$$(19) \quad {}^3TTC/W = 15.6867 + 0.0069D \quad R^2 = 0.70$$

(4.03)

where TTC/W = total transfer cost in dollars per 1,000 pounds of RTC turkey shipped and D = distance in highway miles. All D coefficients are significant at the 1 per cent level. The D^2 coefficient is significant at the 2 per cent level using a two-tail test. The equations are shown in graphic form in figure 8.

In evaluating these equations, the most serious limitation appears to be using only one independent variable—distance—to explain carrier cost per unit of weight. Other factors are known to influence rates, but appropriate data could not be found to represent them in the regression analyses.

Throughout the analysis, goodness of fit exerted considerable influence on the selection of a function because of limited confidence in the hypothesized relationships. This emphasis on statistical fit has resulted in a discontinuous transfer function. The lower rates for distance under 2,100 miles are on shipments from south to north and midwest to east; the higher rates are on west to east shipments across the Rocky Mountains. Some excluded factors, such as higher truck operating costs, scarcity of backhauls, or lack of competition, would probably explain this difference. Therefore, caution

should be exercised in interpreting east to west shipments in the interregional models, because the factors that are raising west to east rates may not affect rates on reverse hauls.

Rail Transfer Functions

Rail rates for dressed poultry are regulated by the Interstate Commerce Commission. Many factors help determine the rail rate structure, the two most important being carrier costs and competition. Availability of data limits this investigation to carrier costs and their determinants.

Total rail carrier costs ($TRCC$) are the sum of carrier loading costs ($RCLC$), shipping costs ($RCSC$), and refrigeration costs ($RCRC$). As refrigeration rates are published independently of other shipping rates, two separate functions are estimated: one to represent refrigeration rates, the other to represent load-

Fig. 8. Estimated cost functions for shipping frozen turkey.

ing and shipping rates. After estimation, they are combined to form one rail transfer function.

Nonrefrigeration costs equations.—

Loading cost per car ($RCLC/N$) is hypothesized to be a linear function of weight (W):

$$(20) \quad RCLC/N = b_1 + b_2W.$$

Carrier shipping cost per car is presumed to be a function of distance (D), weight (W), speed, terrain, and other factors. Speed, terrain, and the other factors are assumed constant throughout all ranges of D and W , so

$$(21) \quad RCSC/N = f(D, W).$$

Shipping cost is believed to be a linear function of distance:

$$(22) \quad {}^dRCSC/N = b_3 + b_4D.$$

The weight effect influences cost per mile (affects b_4 above). The exact relationship between weight and cost is uncertain, however, because the association between horsepower and fuel is not known. If overloading occurs, cost will be an increasing function of weight; but in the relevant range it could conceivably be either increasing or decreasing. To allow for this uncertainty, both a linear and quadratic form are tested:

$$(23) \quad b_4 = b_5 + b_6W$$

$$(24) \quad b_4 = b_7 + b_8W + b_9W^2.$$

Depending on which of these two forms is combined with equation (22), we get

$$(25) \quad \begin{aligned} RCSC/N &= b_3 + (b_5 + b_6W)D \\ &= b_3 + b_5D + b_6WD \end{aligned}$$

or

$$(26) \quad \begin{aligned} RCSC/N &= b_3 + (b_7 + b_8W + b_9W^2)D \\ &= b_3 + b_7D + b_8WD + b_9W^2D. \end{aligned}$$

Rail carrier loading and shipping costs will be called nonrefrigeration costs (*RCNRC*). Combining equation (20) with (25) and (26) yields

$$(27) \quad \begin{aligned} RCNRC/N &= b_1 + b_2W + b_3 + b_5D + b_6WD \\ &= b_{15} + b_2W + b_5D + b_6WD \end{aligned}$$

and

$$(28) \quad \begin{aligned} RCNRC/N &= b_1 + b_2W + b_3 + b_7D + b_8WD + b_9W^2D \\ &= b_{16} + b_2W + b_7D + b_8WD + b_9W^2D . \end{aligned}$$

Charges to the shipper are assumed to be a constant percent (K) of carrier cost, hence, the rail transfer nonrefrigeration cost (*RTNRC*) is

$$(29) \quad RTNRC/N = (RCNRC/N)K .$$

Depending on whether equation (27) or (28) is used, we get

$$(30) \quad RTNRC/N = b_{15}^* + b_2^*W + b_5^*D + b_6^*WD ,$$

or

$$(31) \quad RTNRC/N = b_{16}^* + b_2^*W + b_7^*D + b_8^*WD + b_9^*W^2D ,$$

where $b_i^* = K(b_i)$.

A 1 per cent sample of rail transfer charges exclusive of refrigeration rates is available in the annual series on Carload Waybill Statistics published by the U. S. Interstate Commerce Commission (1960a, pp. 17–18, 1961b, pp. 16–17, 1960a, pp. 31–32, 1961b, p. 27). The years 1959 and 1960 provided the data for the regression analysis below. Rates are quoted as revenue per car related to weight per car and short-line distance traveled for dressed poultry shipments in carload lots. All poultry, whether fresh or frozen, travels under the same rate, making the data representative of frozen turkey shipments.

Estimated equations corresponding to (30) and (31) are given below:

$$(32) \quad \begin{aligned} RTNRC/N &= 36.41700 + 5.10253W + 0.24572D \\ &\quad (1.76) \quad (3.80) \\ &\quad + 0.00511WD . \quad R^2 = 0.933 \\ &\quad (2.28) \end{aligned}$$

$$(33) \quad \begin{aligned} RTNRC/N &= 56.37304 + 4.56939W - 0.19512D \\ &\quad (1.61) \quad (0.95) \\ &\quad + 0.03964WD - 0.00066W^2D . \quad R^2 = 0.937 \\ &\quad (2.57) \quad (2.26) \end{aligned}$$

where $RTNRC/N$ = rail transfer nonrefrigeration costs in dollars per car, W = weight in tons, and D = distance in short-line rail miles (the shortest route over which carload traffic can be moved without transfer of loading). The only difference in form between equations (32) and (33) is the W^2D term in equation (33). As the coefficient for this term is significant at the 2 per cent level, equation (33) is chosen.

Refrigeration cost equations.—Refrigeration rates are hypothesized to be a function of both distance and weight. With respect to distance:

$$(34) \quad {}^dRCRC/N = b_{10} + b_{11}D.$$

The weight-cost relationship is different here than in shipping cost; ${}^wRCRC/N > 0$ when $D = 0$ because the car and contents must be refrigerated before the trip begins. The hypothesized relationship is linear:

$$(35) \quad {}^wRCRC/N = b_{12} + b_{13}W.$$

Combining the two equations (34) and (35) yields a total refrigeration cost function of the form:

$$(36) \quad RCRC/N = b_{14} + b_{11}D + b_{13}W,$$

where $b_{14} = b_{10} + b_{12}$.

Rates for all types of rail refrigeration are quoted in National Perishable Freight Committee (1960). Charges for mechanical refrigeration service, i.e., the manner in which frozen turkeys are protected, are listed from area to area in dollars *per car*. Since rates do not vary by the weight

of shipment as was previously hypothesized, (36), a new equation must be specified. The relationship between refrigeration cost and distance was presumed linear, so the rate with respect to distance will also be assumed linear:

$$(37) \quad RTRC/N = b_{17} + b_{18}D$$

Because Tariff 18 lists rates from area to area, a sample of rates and corresponding distances could not be taken directly. An alternative procedure was used whereby combinations of points, and the highway distance between them, were chosen from a mileage guide (Household Goods Carriers' Bureau 1962). The sample was stratified according to distance, and 60 combinations (10 per each 100-mile block) were chosen. Rates corresponding to the sample routes were then taken from Tariff 18. This generated 60 rates and corresponding highway distances which were used for regression analyses.

Linear equation (38) and quadratic equation (39) were estimated, the purpose of the latter being to check the linear hypothesis of the former:

$$(38) \quad RTRC/N = 110.63886 + 0.03566D \quad R^2 = 0.55$$

(8.40)

$$(39) \quad RTRC/N = 101.47678 + 0.05297D - 0.0000055866D^2 \quad R^2 = 0.56$$

(3.24) (1.10)

The squared term of equation (29) is significant at the 30 per cent level using a two-tail test, and each of the D coefficients are significant at the 1 per cent level. While either equation could be used with little difference in results, equation (39) appeared slightly more plausible and was used in the analysis.

The relatively low R^2 values of equations (38) and (39) reflect, in part, the aggregative nature of the primary data; in many instances the areas used for

quoting rates in Tariff 18 are entire states. Obviously, distance cannot totally explain rate variation in such a case; direction of shipment and average area temperature, neither of which is considered in the formula, might also influence rates.

Before equation (39) can be combined with equation (33) to form a total rail transfer cost function, distance must be put in units common to both equations. Refrigeration rates are now in highway

miles; the loading and shipping rates in rail miles. Because highway miles will be used in the transportation model, rail miles in equation (33) are converted by increasing the D coefficients by 8.7 per cent.²⁰

$$(40) \quad RTNRC/N = 56.37304 + 4.56936W - 0.21209D + 0.04309WD \\ - 0.00072W^2D .$$

Total rail transfer functions.—Combining equations (40) and (39) yields a total rail transfer function of

$$(41) \quad TRTC/N = 157.84982 + 4.56936W - 0.15912D + 0.04309WD \\ - 0.00072W^2D - 0.0000055866D^2 .$$

The programming model requires transfer rates in dollars per 1,000 pounds of frozen turkey shipped. All shipments are assumed to be in carload lots, and the rate is considered constant with respect to weight. Although some cars will hold more turkey, the minimum rate is allowed for 60,000 pounds (if 80,000 pounds are shipped, requiring two cars, the minimum rate is still applied). Corresponding to this, W in equation (41) is fixed at 30 tons and the coefficients revised accordingly. Also, the dependent variable is in terms of dollars *per car*. To convert to dollars per 1,000 pounds, the complete equation is divided by 60. The resulting final total rail transfer cost function is

$$(42) \quad TRTC/1,000 = 4.91553 + 0.008131D - 9.31(10)^{-8}D^2 .$$

This equation is presented in graphic form in figure 8.

Combined Transfer Functions

Transfer cost functions for both rail and truck have been estimated, but only one rate is required for each shipment in the interregional shipping model. The appropriate rate may be determined by one of two methods: (1) for each shipment use the equation yielding the lowest rate (in this case, truck rates would be used for shipments up to about 350 miles and rail rates used thereafter—see figure 8); or (2) combine the two equations based on the percentage of actual usage made of each medium for different distances.

The methods are quite different. If the

purpose of the interregional model in which the rates are to be used is prediction, selection of the appropriate rate by the first method implies that (1) each equation has correctly measured all transfer costs (to the shipper) involved, (2) the service performed for the shipper has been properly measured in each case, and (3) the shipper is a profit maximizer. The first assumption is not true in the case of rail shipments. The shipper usually either has to pay for transporting the goods to the rail station or pay for installation of a private rail spur to his plant. Neither cost is reflected in the rail rates used in this study; consequently,

²⁰ Rail distance exceeds highway distance by 8.7 per cent according to U. S. Bureau of the Census, 1959, p. 4. This percentage would vary somewhat depending on the particular shipping and destination points involved but information to make such adjustments was not available.

the estimated rail cost function probably will yield transfer costs that underestimate the true costs.

Neither does the second assumption (proper measurement of service performed) hold for this study. The product in both rail and truck shipments has been defined as weight moved per mile. However, speed, availability of service, convenience (paper work and complexity of arrangements), and safety are all a part of the service performed for the shipper. Exclusion of these factors probably resulted in an underevaluation of truck service relative to rail service, which would emerge as overestimates of truck rates relative to rail rates by using the estimated equations.

Choosing the lowest rate for each distance, then, would result in less use of trucks and more use of railroads in the transportation model than occurs, or is likely to occur, under actual conditions. Data on actual shipments support this—many shipments in excess of 350 miles are made by truck (U. S. Agricultural Marketing Service 1958, pp. 29–42).

The combined-rate method (combining rail and truck rates, weighted by actual usage data) is employed in this study because, with prediction as the objective, it is judged to produce less biased rate estimates than the least-cost method. The rail and truck functions will be combined into one transfer cost function of

$$(43) \quad TC/1,000 = (P)TTTC/1,000 + (1 - P)TRTC/1,000$$

where P is the proportion of total shipments made by truck, $P = f(D)$, and $0 \leq P \leq 1$. Although a sigmoid relationship between P and D might be hypothesized (because P probably becomes asymptotic to one when $D = 0$ and asymptotic to zero when $D \rightarrow \infty$), there is actually little *a priori* basis for specifying any particular form.

Data on dressed poultry received by truck as a percentage of total dressed poultry received in 12 major cities were collected by the Agricultural Marketing Service (1958, pp. 29–42) in its survey of 144 processors and 67 motor carriers in 1957. Average percentage data were shown for each state originating shipments. To make the data more representative of turkey shipments, states

were selected that were surplus turkey producers. To obtain a mileage figure, a representative point was chosen in each of these states, and the distance between that point and the receiving city was recorded.

Seven different equations were fitted to these percentage and mileage observations. All were polynomials of second or third order, and several were for restricted mileage blocks. Finally, the decision was made to let $P = 1$ for shipments from 0 to 300 miles as nearly all of these shipments were by truck. For shipments over 300 miles a quadratic equation was fitted, forcing it through the coordinate $P = 1, D = 300$. The result of this computation is given in the formula

$$(44) \quad P = 1.1709718 - 5.986(10)^{-4}D + 9.5687(10)^{-8}D^2$$

(6.13)
(2.39)

where P equals the fraction shipped by truck and D equals distance in highway miles. The D^2 coefficient is significant

at the 5 per cent level using a two-tail test; the D coefficient is significant at the 1 per cent level.

This equation begins to turn up when $D = 3,129$ miles, i.e., the percentage shipped by truck starts increasing. This is inconsistent with *a priori* reasoning and merely a phenomenon of the type of equation used. Hence, P is fixed at 0.235, its minimum proportion for all shipments over 3,128 miles.

Combining the rail and truck functions into combined transfer functions

yields five separate equations. These are shown below, accompanied by reasons for each mileage division. When not displaced by constants at either extreme of mileage, P represents the complete equation above; TC represents combined total cost per 1,000 pounds shipped; and $TTTC$ and $TRTC$ represent truck and rail total transfer cost *functions* per 1,000 pounds shipped, respectively.

0-300 miles (P is fixed = 1)

$$(45) \quad TC = (1) [\text{truck equation (17)}] + (0) [\text{rail equation (42)}]$$

$$TC = 2.9676 + 0.014D - 2.1912(10)^{-6}D^2.$$

301-1,450 miles (truck equation changes at 1,450 miles)

$$(46) \quad TC = (P) [\text{truck equation (17)}] + (1 - P) [\text{rail equation (42)}]$$

$$TC = 2.6346 + 0.01616947D - 6.249489(10)^{-6}D^2 + 1.8175096(10)^{-9}D^3 - 2.0076089(10)^{-13}D^4.$$

1,451-2,100 miles (truck equation changes at 2,100 miles)

$$(47) \quad TC = (P) [\text{truck equation (18)}] + (1 - P) [\text{rail equation (42)}]$$

$$TC = 4.5390 + 0.01016073D - 9.54051(10)^{-7}D^2 + 9.44032(10)^{-11}D^3 + 8.90846(10)^{-15}D^4.$$

2,101-3,128 miles (P as a function of D is not representative above 3,128 miles)

$$(48) \quad TC = (P) [\text{truck equation (19)}] + (1 - P) [\text{rail equation (42)}]$$

$$TC = 17.5283 + 0.00024192D + 1.783456(10)^{-6}D^2 - 1.735204(10)^{-10}D^3 + 8.90846(10)^{-15}D^4.$$

3,129-3,300 miles (P is fixed P 0.235)

$$(49) \quad TC = (0.2347894) [\text{truck equation (19)}] + (0.7652106) [\text{rail equation (42)}]$$

$$TC = 7.4445 + 0.007842D - 7.123(10)^{-8}D^2.$$

These functions are shown in figure 8.

Transfer Cost Matrix

Distance in highway miles was obtained for all possible 3,480 routes between the 60 producing and 58 consuming areas (Household Goods Carriers' Bureau, 1962b). The appropriate equa-

tion was then used to compute a corresponding transportation cost for every route. These transfer costs, in dollars per 1,000 pounds shipped, are presented in matrix form in table 7.

In addition to specification errors in estimation and misrepresentation of data

through sampling errors, to the extent they exist, the estimated transfer costs are subject to two restrictions: (1) rates (dollars per 1,000 pounds shipped, not total charges) are independent of the weight shipped, and (2) shipping costs are from *one* point in the producing area to *one* point in the consuming area. While the first seems limitational on the surface, it probably is not restrictive when applied to an interregional transportation model. Interstate shipments are likely of similar size because processors, not individual producers, do the shipping. Processors can ship almost exclusively in carload or truckload lots because they have storage facilities. The representation of an entire area by one point is an undesirable restriction, but necessary if the model is to remain computationally manageable.

AREA PRODUCTION AND PROCESSING COSTS

Necessary components of the long-run ex ante model include farm production costs and the processing costs in each area. These components are developed separately below, then combined into a total production and processing cost for each area.

Area Farm Production Costs

Comparative state estimates of the farm cost of producing turkey are not published. A few independent cost analyses have been made in various states, but wide differences in their date of publication and/or method of analysis limit their usefulness for this study. Thus, turkey extension specialists in all key turkey producing states were contacted in an effort to obtain primary cost data. Again, the information received was not

always comparable. Consequently, all farm production cost estimates in this study are synthesized, using secondary data.

Table 8 shows the relative importance of various components of United States farm production costs for heavy turkeys as estimated for 1961 by Rogers (1962, p. 7). Each of these components is developed in detail below, with particular emphasis on area ration costs, because feed costs constitute about two-thirds of total farm production costs for turkeys (table 8).

Ration costs.—Area ration costs are synthesized based on the following procedures and assumptions: (1) the United States is divided into eight regions with respect to feed ingredients used in turkey rations, and all areas within any one region are assumed to feed the same ingredients, (2) feed ingredient prices may differ among areas, (3) the quantity of ration fed is the same within regions but may differ among regions, (4) the energy conversion ratio (calories of metabolizable energy required to produce one pound of RTC turkey) is the same throughout the entire United States, (5) protein requirements as a percentage of ration fed are identical in all regions, (6) total cost of vitamin and mineral supplements is the same in all regions, (7) all turkey operations consist of a mixed (one-half toms and one-half hens), Broad Breasted Bronze flock raised in semiconfinement, and (8) all toms are marketed at 26 weeks weighing 27.2 liveweight pounds and hens are sold at 22 weeks weighing 15.0 pounds.

A group of rations, most of which were used in state random sample turkey meat performance tests,²¹ were selected from eight states—Iowa (Balloun, 1960,

²¹ Several states conduct such a test. Eggs are chosen at random from each breeding farm that has applied for, and been accepted in, the contest. The eggs are hatched and all poults are raised (by the state turkey commission or some other agency) under identical conditions. At the end of the contest, they are rated by participant and breed according to growth, feed conversion, yield, liveability, grade, profitability, and other factors.

TRANSFER COST MATRIX FOR

Consumption areas →														
Production areas ↓	Maine (Augusta) 1	New Hampshire (Concord) 2	Vermont (Montpelier) 3	Massachusetts (Wellesley) 4	Rhode Island (Providence) 5	W. Connecticut (Hartford) 6	S. New York N. New Jersey E. Connecticut (New York City) 7	N. New York (Syracuse) 8	S. New Jersey E. Pennsylvania N. Delaware (Philadelphia) 9	S. Delaware Washington, D.C. Maryland (Baltimore) 10	W. Pennsylvania (Pittsburgh) 11	N. Ohio (Cleveland) 12	S. Ohio (Springfield) 13	
	dollars per thousand pounds of													
1. Maine (Augusta)	2.967	4.911	5.376	5.403	5.810	6.523	8.020	8.569	9.032	10.093	11.844	12.044	13.595	
2. New Hampshire (Manchester)	5.031	3.218	4.777	3.758	4.250	4.669	6.240	6.805	7.340	8.510	10.411	10.629	12.316	
3. Vermont (St. Albans)	5.889	5.416	3.882	6.330	6.626	6.304	7.315	6.575	8.177	9.214	10.442	10.358	12.072	
4. Massachusetts (Framingham)	5.495	4.100	5.574	3.065	3.482	4.114	5.706	6.715	6.817	8.020	10.007	10.557	12.176	
5. Rhode Island (Cranston)	5.876	4.562	5.967	3.606	3.037	4.018	5.376	6.983	6.498	7.714	9.736	10.774	12.035	
6. Connecticut (Hartford)	6.523	4.911	5.601	4.209	3.950	2.967	4.629	6.097	5.771	7.009	9.112	10.050	11.397	
7. New York (Syracuse)	8.569	6.817	6.600	6.805	6.919	6.097	6.446	2.967	6.433	7.239	7.466	7.415	9.449	
8. New Jersey (New Brunswick)	8.368	6.843	7.327	6.175	5.824	5.151	3.579	6.317	3.772	5.071	7.440	8.756	9.953	
9. Pennsylvania (Reading)	9.460	8.008	8.044	7.390	7.047	6.266	4.871	6.123	3.730	4.304	6.253	7.825	8.918	
10. Delaware (Milford)	10.061	8.686	9.146	8.069	7.739	6.970	5.601	7.466	4.277	4.237	7.149	8.779	9.812	
11. Maryland (Baltimore)	10.093	8.721	9.089	8.105	7.776	7.009	5.640	7.239	4.304	2.967	5.928	7.516	8.628	
12. E. Ohio (Cohocton)	12.856	11.524	11.367	11.308	11.038	10.411	9.281	8.498	8.333	7.453	4.602	4.332	4.548	
13. W. Ohio (Lima)	13.414	12.129	11.968	12.120	12.204	11.593	10.588	9.214	9.714	8.906	6.201	5.031	3.882	
14. N. Indiana (Warsaw)	14.171	12.946	12.793	12.937	13.018	12.437	11.573	10.189	10.753	9.996	7.453	6.201	5.191	
15. S. Indiana (Washington)	15.517	14.386	14.246	14.229	14.004	13.483	12.556	11.882	11.786	11.078	8.814	8.273	6.188	
16. Illinois (Peoria)	15.808	14.695	14.558	14.687	14.760	14.237	13.422	12.242	12.693	12.025	9.801	8.756	7.415	
17. Michigan (Grand Rapids)	14.427	13.221	13.071	13.212	13.292	12.721	11.978	10.615	11.218	10.484	8.020	6.600	6.690	
18. N. Wisconsin (Eau Claire)	17.402	16.372	16.245	16.365	16.431	15.953	15.323	14.154	14.695	14.104	12.167	11.098	10.473	
19. S. Wisconsin (Madison)	16.073	14.976	14.840	14.968	15.039	14.525	13.843	12.566	13.159	12.511	10.358	9.157	8.451	
20. N. Minn. (Thief River Falls)	20.546	19.426	19.292	19.419	19.490	18.982	18.326	17.210	17.690	17.167	15.540	14.671	14.171	
21. N.C. Minnesota (Brainerd)	19.077	17.940	17.803	17.932	18.005	17.502	16.914	15.839	16.335	15.793	14.046	13.098	12.547	
22. S.C. Minnesota (Willmar)	18.846	17.706	17.573	17.698	17.771	17.296	16.703	15.617	16.118	15.571	13.801	12.838	12.279	
23. S. Minnesota (Owatonna)	17.884	16.835	16.711	16.827	16.893	16.424	15.808	14.671	15.197	14.623	12.748	11.719	11.118	
24. N.W. Iowa (Webster City)	17.690	16.659	16.535	16.652	16.718	16.245	15.625	14.476	14.984	14.410	12.501	11.475	10.804	
25. S.E. Iowa (Washington)	16.718	15.655	15.524	15.648	15.717	15.221	14.541	13.344	13.860	13.239	11.188	10.114	9.338	
26. N. Missouri (Trenton)	17.787	16.747	16.623	16.740	16.674	16.223	15.432	14.574	14.784	14.196	12.353	11.603	10.114	
27. S. Missouri (Springfield)	18.093	17.023	16.900	17.001	16.805	16.357	15.571	14.880	14.928	14.345	12.520	11.968	10.305	
28. North Dakota (Devils Lake)	21.288	20.176	20.043	20.169	20.239	19.735	19.085	17.924	18.455	17.876	16.260	15.424	14.944	
29. South Dakota (Watertown)	19.727	18.599	18.463	18.591	18.663	18.150	17.502	16.453	16.936	16.409	14.720	13.809	13.283	
30. Nebraska (Grand Island)	19.609	18.479	18.342	18.471	18.543	18.029	17.374	16.342	16.784	16.253	14.549	13.681	12.793	
31. Kansas (McPherson)	19.853	18.727	18.591	18.703	18.487	17.997	17.210	16.571	16.615	16.081	14.435	13.945	12.483	
32. Virginia (Harrisonburg)	11.680	10.442	10.515	9.888	9.560	8.906	7.640	8.428	6.369	5.098	8.918	7.603	7.947	
33. W. Virginia (Petersburg)	11.882	10.640	10.681	10.114	9.823	9.146	7.911	8.081	6.677	5.416	5.271	6.575	7.378	
34. N. Carolina (Fayetteville)	13.544	12.446	12.739	11.959	11.700	11.098	9.996	11.258	8.883	7.727	9.449	10.588	9.812	
35. S. Carolina (Camden)	14.623	13.561	13.835	13.106	12.865	12.251	11.288	12.270	10.274	9.214	9.932	10.845	9.996	
36. Georgia (Covington)	15.862	14.904	15.158	14.712	14.328	13.818	12.892	13.707	11.968	11.018	11.426	11.680	10.104	
37. Florida (Ocala)	17.587	16.703	16.936	16.320	16.118	15.655	14.824	15.617	14.004	13.168	13.733	14.394	13.422	
38. Kentucky (Winchester)	14.744	13.604	13.457	13.274	13.035	12.483	11.495	10.967	10.671	9.845	7.466	7.162	5.217	
39. Tennessee (Athens)	15.393	14.410	14.476	13.978	13.750	13.221	12.260	12.820	11.298	10.305	10.168	9.834	8.129	
40. Alabama (Gadsden)	16.498	15.571	15.632	15.166	14.952	14.460	13.570	14.087	12.684	11.777	11.397	11.158	9.471	
41. Mississippi (Tupelo)	17.601	16.718	16.776	16.335	16.133	15.671	14.840	14.768	14.020	13.186	12.129	11.834	10.125	
42. Arkansas (Fayetteville)	18.990	17.852	17.714	17.827	17.609	17.174	16.416	15.755	15.801	15.244	13.518	13.000	11.446	
43. Louisiana (Alexandria)	20.302	19.331	19.339	18.918	18.703	18.214	17.388	17.253	16.667	15.945	15.024	14.720	9.338	
44. Oklahoma (Oklahoma City)	20.349	19.228	19.093	19.240	18.990	18.503	17.666	17.030	17.073	16.549	14.944	14.468	13.053	
45. N.E. Texas (Hillsboro)	21.918	20.812	20.679	20.640	20.428	19.948	19.125	18.575	18.471	17.722	16.342	16.043	14.744	
46. S.E. Texas (San Marcos)	24.688	21.910	21.778	21.740	21.530	21.054	20.239	19.696	19.514	18.742	17.367	17.080	15.846	
47. W. Texas (Lubbock)	24.775	22.027	21.895	22.004	21.794	21.319	20.506	19.814	19.861	19.292	17.609	17.188	15.968	
48. Montana (Billings)	25.761	24.905	24.805	24.899	24.952	24.577	22.228	21.101	21.615	21.054	19.331	18.455	17.964	
49. Idaho (Caldwell)	29.162	28.186	28.071	28.179	28.240	27.810	27.267	26.335	26.736	26.278	24.940	22.515	21.825	
50. Wyoming (Casper)	24.723	21.957	21.825	21.949	22.019	21.522	20.882	19.743	20.239	19.672	17.924	17.124	16.630	
51. Colorado (Colorado Springs)	24.496	21.654	21.522	21.646	21.545	21.070	20.255	19.434	19.609	19.037	17.381	16.842	15.724	
52. New Mexico (Las Cruces)	26.614	25.724	25.620	25.706	25.541	25.172	24.560	22.159	22.205	21.646	20.003	19.537	18.214	
53. Arizona (Phoenix)	28.671	27.710	27.597	27.690	27.511	27.111	26.442	25.891	25.928	25.486	22.422	21.965	20.671	
54. Utah (Provo)	27.163	26.253	26.146	26.246	26.303	25.903	25.383	24.542	24.893	24.473	21.023	20.208	19.411	
55. Nevada (Austin)	29.726	28.732	28.616	28.726	28.788	28.349	27.776	26.845	26.845	25.841	25.401	24.781	22.352	
56. Washington (Yakima)	30.931	29.903	29.782	29.896	29.961	29.506	28.933	27.944	28.390	27.903	26.474	25.786	25.413	
57. Oregon (Salem)	32.075	31.026	30.901	31.019	31.085	30.617	30.025	29.002	29.443	28.940	27.458	26.723	26.196	
58. N. California (Yuba City)	31.654	30.609	29.854	30.602	30.668	30.204	29.598	28.609	29.023	28.526	27.065	26.398	25.767	
59. C. California (Fresno)	32.311	31.262	31.136	31.240	31.041	30.595	29.846	29.225	29.267	28.767	27.353	26.968	25.916	
60. S. California (Los Angeles)	31.277	30.240	30.118	30.219	30.025	29.309	28.864	28.261	28.301	27.816	26.449	26.077	25.065	

SHIPPING FROZEN TURKEY

S.E. Michigan (Detroit) 14	S.W. Michigan (Lansing) 15	S. Indiana (Indianapolis) 16	N.W. Indiana N.E. Illinois (Chicago) 17	Central Illinois (Peoria) 18	S. Illinois E. Missouri (St. Louis) 19	W. Missouri E. Kansas (Kansas City) 20	W. Kansas (Salina) 21	N. Wisconsin N. Michigan N. Minnesota (Duluth) 22	W. Wisconsin S. Minnesota (Minneapolis) 23	S.E. Wisconsin (Madison) 24	E. Iowa (Cedar Rapids) 25	E. Nebraska W. Iowa (Omaha) 26	E. South Dakota (Huron) 27	North Dakota (Bismarck) 28	Virginia (Richmond) 29
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frozen ready-to-cook turkey shipped

13.544 12.660 12.016 12.446 12.195 12.391	13.936 12.684 12.446 12.621 12.811	14.623 13.422 13.195 13.344 13.124	14.968 13.792 13.570 13.733 13.911	15.808 14.687 14.476 14.631 14.760	16.453 15.369 15.166 15.299 15.103	18.334 17.210 17.023 17.145 16.965	19.688 18.551 18.342 18.479 18.278	18.655 17.516 17.331 17.466 17.617	18.093 17.016 16.827 16.965 17.116	16.073 14.968 14.760 14.912 15.079	16.667 15.594 15.393 15.540 15.701	18.527 17.402 17.217 17.503 17.802	20.019 18.886 18.679 18.830 18.998	21.475 20.357 20.153 20.302 20.467	11.603 10.168 10.804 9.725 9.449
11.738 9.382 10.578 9.626 10.484	12.176 9.898 11.288 10.125 10.957	12.621 10.763 11.288 10.337 11.058	13.318 11.198 12.251 11.387 12.063	14.237 12.242 13.106 12.260 12.901	14.655 13.026 13.483 12.657 13.283	16.557 15.095 15.501 14.768 15.323	17.827 16.416 16.798 16.111 16.630	17.124 15.432 16.260 15.578 16.111	16.615 14.880 15.732 15.031 15.578	14.525 12.566 13.555 12.739 13.361	15.166 13.283 14.212 13.422 14.020	17.008 15.307 16.118 15.408 15.945	18.447 16.725 17.509 16.864 17.819	19.924 18.117 18.990 18.270 18.830	8.814 8.998 6.996 6.266 5.758
9.349 5.797 4.857 5.679 8.057	9.856 6.395 5.124 5.058 7.052	10.072 6.253 4.938 4.521 4.481	11.138 7.028 5.915 4.535 6.278	12.025 8.674 7.034 6.019 6.097	12.428 9.157 7.984 7.453 5.297	14.566 11.738 10.743 10.429 8.087	15.922 13.327 12.748 12.428 11.786	15.385 12.748 11.485 10.432 11.757	14.832 12.101 10.784 9.681 11.068	12.511 9.315 7.739 6.420 8.081	13.204 10.114 8.616 7.352 8.333	15.213 12.511 11.228 10.157 10.411	16.681 14.237 13.089 12.138 13.018	18.069 15.717 14.663 13.801 14.888	4.991 8.380 9.834 10.866 11.208
8.189 4.964 10.348 8.309 13.266	7.516 3.827 9.747 7.628 13.300	5.824 6.240 9.471 7.315 13.379	5.044 5.271 7.289 4.924 11.690	2.967 7.009 7.788 5.587 11.892	5.284 8.674 9.438 7.727 13.026	7.603 10.967 9.637 9.214 11.661	9.626 12.630 10.987 11.008 11.834	9.637 10.967 5.191 7.491 6.240	8.557 10.274 5.443 6.600 7.162	5.587 7.124 5.443 2.967 10.242	5.390 8.117 6.369 5.244 10.274	7.874 10.855 8.721 4.863 9.492	10.886 12.648 7.800 9.516 7.751	12.937 14.262 9.560 11.456 17.034	12.575 11.377 14.816 13.292 17.111
12.437 12.167 10.997 10.421 10.753 9.326	11.911 11.632 10.421 10.157 10.168 8.698	11.671 11.387 10.157 7.751	9.780 9.460 8.069 7.776 6.123	9.975 9.626 7.898 7.162 4.804	11.248 10.855 9.236 8.237 6.510	10.253 9.146 8.321 6.651 6.690	10.947 9.670 10.061 8.392 8.756	4.548 5.758 5.941 7.528 9.021	4.696 4.264 3.895 6.084 7.302	8.141 7.788 6.266 6.728 5.928	8.141 7.690 5.732 4.938 3.799	8.674 7.200 6.562 5.403 6.304	7.226 5.706 6.562 7.428 9.360	7.378 7.665 9.315 10.473 12.204	16.446 16.231 15.315 15.079 13.903
11.168 11.796 14.776 13.177 13.053	10.578 11.456 14.279 12.675 12.565	8.674 8.883 14.187 12.446 11.632	8.380 9.494 12.584 10.650 10.536	6.575 8.057 12.721 10.526 9.449	6.459 5.941 13.801 11.593 10.007	4.205 5.363 12.353 9.338 7.086	6.639 7.428 11.709 8.860 5.535	9.549 11.940 7.702 7.200 10.421	7.764 10.411 8.261 5.745 8.709	8.141 10.242 11.218 9.100 9.975	6.032 4.839 11.188 8.651 8.069	5.784 7.984 10.358 6.906 4.301	9.427 11.238 6.881 4.209 6.703	12.260 13.826 5.416 6.919 9.626	14.566 14.695 18.575 17.044 16.681
13.673 9.293 8.416 11.524 11.000	13.195 9.801 8.952 12.910 12.140	11.248 9.371 8.848 10.997 10.484	11.417 10.916 8.327 12.501 12.298	9.878 11.544 11.088 12.973 12.547	8.756 11.825 11.377 12.721 12.035	5.627 14.037 13.647 14.864 14.262	3.482 15.432 15.071 16.201 15.640	12.474 15.213 14.760 16.461 16.298	10.997 14.655 14.187 15.937 15.770	11.288 12.307 11.767 13.767 13.578	9.538 12.973 12.455 14.378 15.655	6.626 14.824 14.851 16.013 15.655	9.078 16.520 16.096 17.714 17.544	11.825 17.892 17.452 19.204 19.029	16.416 4.535 5.693 5.837 7.440
11.959 14.816 7.590 10.210 11.397	12.091 15.095 8.057 10.358 11.367	9.834 13.239 5.535 7.911 8.883	11.719 14.784 7.886 10.018 10.753	11.426 14.500 8.213 10.168 10.327	10.567 13.630 7.714 9.055 9.032	12.820 15.509 10.567 11.700 11.534	14.312 16.711 12.270 13.292 13.124	15.808 18.398 12.937 14.541 14.968	15.181 17.747 12.298 13.962 14.312	13.009 15.831 9.538 11.505 12.016	13.089 15.900 10.221 11.978 12.025	14.549 17.037 12.157 13.544 13.405	16.645 19.276 14.410 15.747 15.701	18.423 21.140 15.877 17.473 17.558	9.582 11.806 9.202 9.202 10.722
11.882 12.838 14.663 14.320 15.907	11.603 10.125 12.620 14.029 15.659	8.986 10.125 12.260 11.863 13.681	10.337 10.691 13.186 12.372 14.154	9.371 9.360 12.307 11.178 13.089	7.776 7.378 10.640 9.416 11.534	10.082 6.240 11.198 7.565 10.039	11.709 7.850 11.796 6.459 9.780	14.295 12.847 16.111 13.809 15.540	13.431 11.407 14.928 12.446 14.320	11.228 11.387 13.936 12.721 14.558	10.987 9.714 13.239 11.128 13.142	12.138 8.779 13.026 8.998 11.641	14.712 11.892 15.501 11.436 13.877	16.813 14.386 17.481 13.835 15.846	12.270 15.338 15.158 16.696 16.987
16.951 17.059 17.868 21.949 16.933	16.740 16.805 17.438 21.514 16.178	14.848 14.968 17.224 20.859 15.709	15.463 15.393 15.907 19.885 14.558	14.476 14.369 15.663 19.204 14.020	13.053 12.973 16.298 19.474 14.468	11.700 11.208 14.451 17.488 12.888	11.377 9.769 13.570 16.461 10.967	16.762 16.163 13.080 18.085 13.621	15.617 14.968 12.693 17.738 12.621	15.839 15.455 14.928 19.339 13.987	14.525 14.112 14.312 18.117 12.648	13.151 12.157 12.684 16.365 10.557	15.205 13.526 10.327 15.960 9.921	17.052 14.736 8.616 14.760 9.845	17.924 18.870 21.732 26.704 20.326
16.461 19.300 21.716 19.670 22.547	16.051 18.862 21.288 19.204 22.151	14.712 17.224 19.656 18.415 21.389	14.427 17.360 19.790 17.551 20.538	13.414 16.275 18.607 16.827 19.743	12.802 15.463 17.803 16.856 19.869	10.348 13.475 15.960 14.944 17.860	8.569 12.044 14.728 13.621 16.645	14.361 17.811 20.263 17.016 19.355	13.035 16.674 19.037 16.186 19.053	14.004 17.267 19.688 17.174 20.121	12.538 16.043 18.358 15.945 18.798	10.018 14.138 16.542 13.936 16.864	11.338 15.362 17.580 14.037 16.951	11.940 16.461 18.005 13.978 16.849	19.395 21.607 25.737 24.811 27.143
25.341 26.297 25.947 26.761 25.878	25.005 25.947 25.608 26.411 25.541	24.858 25.431 25.017 25.130 22.507	21.810 24.693 22.600 25.232 22.639	21.600 22.352 21.817 22.569 21.483	22.112 22.616 22.081 21.794 20.702	20.161 20.671 20.129 19.838 18.727	16.037 19.553 18.910 18.583 17.473	18.687 20.169 21.724 24.664 22.352	18.551 20.035 21.140 22.314 21.475	20.694 22.151 22.190 24.952 22.523	20.271 21.296 20.890 22.066 21.226	18.782 19.450 18.902 20.098 19.244	16.929 18.350 18.998 20.192 19.339	15.354 16.762 18.262 19.553 19.284	28.492 29.408 28.926 29.044 28.085

TABLE 7-

Consumption areas →	West Virginia (Charleston)	North Carolina (Greensboro)	South Carolina (Columbia)	Georgia (Atlanta)	N. Florida (Gainesville)	S. Florida (ft. Lauderdale)	Kentucky (Lexington)	Tennessee (Nashville)	Alabama (Birmingham)	Mississippi (Jackson)	Arkansas (Little Rock)	Louisiana (Alexandria)	Oklahoma (Oklahoma City)
	30	31	32	33	34	35	36	37	38	39	40	41	42
Production areas ↓	dollars per thousand pounds of ₁												
1. Maine (Augusta).....	15.063	13.256	14.776	16.028	17.381	19.474	14.744	16.439	16.900	18.806	18.934	20.302	20.34
2. New Hampshire (Manchester).....	12.270	11.968	13.604	14.936	16.357	18.350	13.570	15.362	15.854	17.674	17.787	19.188	19.220
3. Vermont (St. Albans).....	12.511	12.538	14.121	15.416	16.805	18.838	13.370	15.158	16.133	17.973	17.580	19.260	19.014
4. Massachusetts (Framingham).....	11.882	11.573	13.248	14.606	16.051	18.029	13.212	15.047	15.540	17.374	17.565	18.862	19.149
5. Rhode Island (Cranston).....	11.641	11.328	13.026	14.402	15.862	17.827	12.991	14.848	15.346	17.195	17.388	18.663	18.950
6. Connecticut (Hartford).....	11.088	10.763	12.520	13.936	15.432	17.395	12.483	14.394	14.904	16.791	16.987	18.214	18.503
7. New York (Syracuse).....	10.007	10.660	12.428	13.826	15.393	17.410	10.967	13.018	14.541	16.133	15.701	17.253	17.030
8. New Jersey (New Brunswick).....	9.615	9.157	11.088	12.630	14.237	16.313	11.138	13.133	13.743	15.678	15.953	17.080	17.402
9. Pennsylvania (Reading).....	8.557	8.451	10.463	12.063	13.758	15.884	10.178	12.363	12.964	15.047	15.236	16.490	16.733
10. Delaware (Milford).....	8.848	8.093	9.791	11.777	13.115	15.323	10.722	12.307	12.874	14.968	15.369	16.416	17.238
11. Maryland (Baltimore).....	8.069	7.315	9.460	11.158	12.910	15.134	9.867	11.709	12.298	14.460	14.872	15.945	16.540
12. E. Ohio (Coshocton).....	5.297	8.487	10.018	10.588	13.405	15.625	6.201	8.918	10.896	12.883	12.391	14.212	14.046
13. W. Ohio (Lima).....	6.330	9.393	10.712	10.337	13.621	15.869	5.824	8.428	10.473	12.288	11.524	13.552	13.186
14. N. Indiana (Warsaw).....	7.565	10.442	11.475	10.588	13.826	16.178	6.575	8.201	10.295	11.997	11.188	13.283	12.802
15. S. Indiana (Washington).....	7.764	10.104	10.327	8.906	12.418	14.984	5.231	5.719	8.309	9.769	8.998	11.238	11.218
16. Illinois (Peoria).....	9.516	12.091	12.529	11.088	14.196	16.527	7.996	8.285	10.567	11.088	9.626	12.307	11.178
17. Michigan (Grand Rapids).....	8.918	11.583	12.657	11.901	14.912	17.131	8.117	9.714	11.632	13.133	12.335	14.320	13.690
18. N. Wisconsin (Eau Claire).....	12.288	14.484	15.063	14.279	16.907	19.220	11.268	12.016	13.852	14.270	12.955	15.174	13.062
19. S. Wisconsin (Madison).....	10.494	12.928	13.561	12.703	15.548	17.438	9.349	10.189	12.232	12.766	11.593	13.936	12.721
20. N. Minn. (Thief River Falls).....	15.640	17.495	18.061	17.281	19.964	22.298	14.808	15.377	16.805	17.052	15.181	17.188	13.953
21. N.C. Minnesota (Brainerd).....	14.154	16.141	16.674	15.892	18.463	20.827	13.248	13.843	15.385	15.648	13.758	15.907	13.177
22. S.C. Minnesota (Willmar).....	13.911	15.922	16.461	15.648	18.206	20.569	12.991	13.570	15.071	15.213	13.186	15.400	12.072
23. S. Minnesota (Owatonna).....	12.865	14.992	15.555	14.468	17.073	19.403	11.882	12.232	13.869	14.129	12.204	14.541	12.006
24. N.W. Iowa (Webster City).....	12.593	14.752	15.205	13.843	16.512	18.806	11.446	11.515	13.098	13.239	10.862	13.414	10.681
25. S.E. Iowa (Washington).....	11.108	13.457	13.869	12.483	15.362	17.573	9.736	9.932	11.786	12.082	10.390	12.829	10.712
26. N. Missouri (Trenton).....	11.892	14.079	14.246	12.584	15.408	17.488	10.379	10.050	11.748	11.564	8.941	11.757	8.791
27. S. Missouri (Springfield).....	11.978	13.405	13.000	10.957	13.792	16.305	10.039	8.825	9.703	9.202	6.058	9.338	6.766
28. North Dakota (Devils Lake).....	16.357	18.246	18.822	17.956	20.663	24.670	15.555	16.058	17.445	17.625	15.747	17.658	14.046
29. South Dakota (Watertown).....	14.824	16.747	17.267	16.283	18.878	21.234	13.953	14.279	15.648	15.439	13.335	15.470	11.612
30. Nebraska (Grand Island).....	14.328	16.298	16.564	15.111	17.523	20.035	13.212	12.964	14.295	13.919	11.603	13.518	8.791
31. Kansas (McPherson).....	13.995	15.632	15.486	13.741	16.186	18.575	12.298	11.921	12.693	12.054	9.427	11.436	5.980
32. Virginia (Harrisonburg).....	6.188	6.266	8.069	9.823	11.844	14.262	8.581	10.136	10.784	13.142	14.146	14.736	16.073
33. W. Virginia (Petersburg).....	5.928	6.664	8.762	10.546	12.483	14.816	8.129	10.588	11.436	13.707	13.758	15.252	15.724
34. N. Carolina (Fayetteville).....	7.578	4.304	5.111	7.874	9.326	12.054	9.349	10.029	9.637	12.157	13.080	13.843	15.862
35. S. Carolina (Camden).....	7.862	5.138	3.413	6.291	8.008	10.702	8.639	8.906	8.201	10.937	11.968	12.748	14.920
36. Georgia (Covington).....	9.293	7.327	5.679	3.441	7.327	10.753	8.356	6.843	5.495	8.616	9.801	10.691	13.133
37. Florida (Ocala).....	12.120	10.039	7.972	8.008	3.482	6.881	12.054	10.804	8.941	10.463	12.793	11.892	15.555
38. Kentucky (Winchester).....	9.703	8.020	8.557	7.886	11.651	14.279	3.218	6.149	8.333	10.753	10.200	12.270	12.991
39. Tennessee (Athens).....	7.886	7.149	6.970	4.938	9.259	12.279	6.188	5.284	5.732	8.825	9.483	10.876	12.874
40. Alabama (Gadsden).....	9.582	8.628	7.251	4.440	8.581	11.873	7.652	5.443	3.813	7.086	8.189	9.349	11.834
41. Mississippi (Tupelo).....	10.671	10.526	9.304	6.703	10.093	13.168	8.569	5.810	4.898	5.548	6.266	7.911	10.295
42. Arkansas (Fayetteville).....	13.009	14.079	13.230	11.218	14.012	16.498	11.198	9.604	9.986	8.733	5.522	8.581	6.019
43. Louisiana (Alexandria).....	13.818	13.587	12.455	10.337	11.632	14.476	12.101	10.125	8.651	5.561	6.562	2.967	9.236
44. Oklahoma (Oklahoma City).....	14.476	15.524	14.663	12.829	15.330	17.714	12.829	11.475	11.719	10.221	7.590	9.236	2.967
45. N.E. Texas (Hillsboro).....	14.960	15.571	14.566	12.721	14.312	16.711	13.647	11.863	11.278	8.628	7.972	7.302	6.677
46. S.E. Texas (San Marcos).....	16.298	16.512	15.555	13.818	14.598	17.037	14.816	13.159	12.474	10.029	9.604	8.069	8.581
47. W. Texas (Lubbock).....	17.052	17.617	16.740	15.111	16.527	18.974	15.625	14.046	13.869	11.757	10.702	10.804	7.690
48. Montana (Billings).....	19.434	21.413	21.934	20.608	24.846	26.716	18.551	18.583	19.909	19.553	17.516	19.220	15.494
49. Idaho (Caldwell).....	24.834	26.373	26.493	25.310	27.346	29.492	22.143	21.841	24.705	22.244	20.561	21.498	17.852
50. Wyoming (Casper).....	17.956	19.964	20.263	18.750	21.296	25.256	16.980	16.791	17.932	17.530	15.648	16.972	13.098
51. Colorado (Colorado Springs).....	17.030	18.631	18.647	16.994	19.371	21.856	15.632	15.330	16.118	15.268	13.509	14.500	10.178
52. New Mexico (Las Cruces).....	19.545	20.334	19.931	17.609	19.006	21.522	18.013	16.754	16.512	14.614	13.936	13.818	11.098
53. Arizona (Phoenix).....	22.011	24.770	22.135	20.459	21.817	25.681	20.514	19.498	19.260	17.234	16.733	16.630	14.062
54. Utah (Provo).....	20.812	22.592	22.492	20.820	24.823	26.781	19.498	19.188	19.885	18.830	17.324	18.061	14.695
55. Nevada (Austin).....	25.238	15.594	26.569	25.238	27.156	29.302	22.531	22.205	24.336	21.778	20.279	21.031	17.516
56. Washington (Yakima).....	26.557	28.213	28.705	27.438	29.648	31.957	25.891	25.804	26.774	26.127	24.816	25.535	20.530
57. Oregon (Salem).....	27.339	29.044	29.578	27.870	30.111	32.437	26.455	26.209	27.195	26.538	25.202	25.934	21.038
58. N. California (Yuba City).....	26.890	28.568	28.588	27.150	28.719	30.997	26.021	25.780	26.385	25.041	22.345	24.479	19.616
59. C. California (Fresno).....	27.007	27.977	27.254	25.885	27.300	29.478	25.792	25.011	25.095	21.841	20.702	21.093	17.932
60. S. California (Los Angeles).....	26.115	27.052	26.354	25.035	26.134	28.220	24.946	22.352	22.337	20.420	19.601	19.664	16.893

(Continued)

N.E. Texas (Dallas) 43	S.E. Texas (Houston) 44	S. Texas (San Antonio) 45	W. Texas (Lubbock) 46	Montana (Helena) 47	Idaho (Boise) 48	W. South Dakota W. Nebraska Wyoming (Casper) 49	Colorado (Denver) 50	New Mexico (Albuquerque) 51	Arizona (Phoenix) 52	Utah (Salt Lake City) 53	Nevada (Tonopah) 54	Washington (Seattle) 55	Oregon (Salem) 56	N. California (Oakland) 57	S. California (Los Angeles) 58
frozen ready-to-cook turkey shipped															
21.452	22.058	24.970	24.775	27.169	28.988	24.723	22.716	25.823	28.871	27.052	29.868	31.440	32.075	32.289	31.277
20.384	20.900	22.275	22.019	26.253	28.011	21.949	21.607	24.958	27.703	26.140	28.864	30.392	31.019	31.232	30.233
20.129	20.945	22.073	21.817	26.090	27.836	21.747	21.405	24.805	27.531	25.978	28.684	30.204	30.828	31.041	30.046
20.153	20.640	22.058	21.949	26.209	27.964	21.895	21.553	24.905	27.643	26.096	28.815	30.341	30.967	31.181	30.168
19.956	20.444	21.864	21.755	26.341	28.105	22.058	21.467	24.758	27.478	26.228	28.961	30.493	31.122	31.336	29.989
19.514	20.003	21.428	21.319	25.909	27.643	21.522	21.031	22.670	27.111	25.798	28.485	29.996	30.617	30.828	29.591
18.093	18.926	20.074	19.814	24.548	26.177	19.743	19.395	21.179	25.891	22.685	26.974	28.410	29.002	29.204	28.261
18.398	18.822	20.294	20.224	25.190	26.632	20.600	19.932	21.584	26.215	25.065	27.670	29.162	29.768	29.953	28.616
17.650	18.174	19.601	19.490	24.658	26.278	19.869	19.196	20.859	25.638	24.519	27.059	28.540	29.114	29.295	27.984
17.787	18.093	19.577	20.043	25.071	26.404	20.420	19.751	21.405	26.071	24.928	27.517	28.523	29.605	29.789	28.458
17.317	17.587	19.077	19.292	24.513	26.121	19.672	18.998	20.663	25.486	22.592	26.897	28.369	28.940	29.121	27.816
15.158	15.907	16.994	16.820	20.326	22.376	17.174	16.549	18.125	21.568	20.106	24.923	26.303	26.806	26.974	25.761
14.386	15.307	16.327	16.081	19.268	21.335	16.933	15.755	17.353	20.788	19.045	22.283	25.474	25.959	26.121	25.154
14.029	15.063	16.073	15.755	18.439	20.522	15.400	15.079	16.878	20.271	18.214	21.475	24.852	25.323	25.480	24.764
12.288	13.239	14.419	14.435	19.101	20.624	15.808	14.394	15.846	19.173	18.246	21.366	25.347	25.401	25.504	22.035
12.529	13.869	14.864	14.369	17.338	19.006	14.020	13.318	15.299	18.607	16.703	19.901	22.135	22.352	22.484	21.483
14.856	16.005	16.929	16.512	18.878	21.007	15.877	15.602	17.523	20.976	18.750	21.996	25.178	25.700	25.891	25.298
14.361	16.260	16.483	15.632	15.111	18.254	13.379	13.544	16.357	19.711	16.689	19.885	19.806	20.734	22.469	22.135
14.046	15.408	16.201	15.455	16.498	19.141	13.987	13.826	16.335	19.688	17.052	20.279	21.234	22.151	24.571	22.523
15.648	17.438	17.495	16.216	13.449	19.893	12.883	13.995	16.922	20.318	16.253	19.363	17.860	18.806	21.350	21.677
14.816	16.674	16.849	15.602	13.860	17.088	12.730	13.509	16.327	19.680	16.148	19.308	18.382	19.323	21.561	21.568
13.953	15.892	15.953	14.647	13.604	16.871	11.748	12.409	15.408	18.719	15.346	18.471	18.350	19.292	21.085	20.749
13.388	15.385	15.617	14.679	14.744	17.625	12.316	12.465	15.439	18.750	15.808	18.950	19.442	20.373	21.553	21.218
12.176	14.312	14.558	13.733	15.071	17.080	11.593	11.505	14.558	17.860	15.134	18.254	17.967	20.420	20.874	20.538
12.204	14.262	14.582	13.767	16.298	18.021	12.892	12.307	14.728	18.029	15.785	18.926	21.023	21.397	21.530	20.921
10.463	12.820	13.089	12.195	16.245	17.452	12.409	10.957	13.248	16.718	15.221	18.382	20.968	20.827	20.960	19.537
8.510	10.866	11.446	10.876	17.502	18.687	13.852	11.968	12.684	16.253	16.148	18.814	22.314	22.042	21.506	19.037
15.763	17.551	17.573	15.709	12.120	15.945	11.690	12.982	16.260	19.434	15.299	18.342	16.776	17.625	20.349	20.702
13.578	15.563	15.586	13.995	12.829	16.118	10.629	11.573	14.784	18.085	14.451	17.573	17.641	18.591	20.208	19.869
11.108	13.388	13.370	11.028	13.911	15.134	9.236	8.261	11.968	15.671	12.593	16.005	18.639	18.366	18.503	18.158
8.663	11.288	11.318	9.703	15.709	16.476	11.328	8.848	10.557	14.549	13.886	16.689	20.381	19.767	19.529	17.253
16.186	16.468	17.835	18.439	22.608	25.860	19.466	18.487	20.161	25.101	22.197	26.569	28.220	28.650	28.767	26.742
16.335	16.943	18.158	18.415	22.166	25.577	19.014	18.398	19.798	24.828	21.841	26.278	27.910	28.335	28.451	26.449
15.866	15.655	17.037	17.900	25.353	26.826	20.718	19.506	20.098	24.946	24.970	27.313	29.351	29.718	29.478	27.339
14.598	16.571	16.118	16.972	25.220	26.398	20.341	18.918	19.141	22.383	24.577	26.506	29.197	29.246	28.609	26.557
12.775	12.856	14.451	15.377	22.639	25.365	19.021	17.488	10.691	20.726	21.428	25.214	28.247	28.098	27.208	25.238
14.221	13.431	15.087	16.725	26.455	27.418	21.576	19.932	19.157	22.027	25.304	26.544	30.624	30.370	28.650	26.303
13.227	14.154	15.338	15.763	20.491	22.089	17.109	15.877	17.231	20.655	19.743	24.548	26.436	26.569	26.678	25.053
12.739	13.018	14.598	15.252	21.708	24.653	18.061	16.718	17.246	20.671	20.632	25.041	27.445	27.300	27.020	25.065
11.603	11.690	13.396	14.353	21.662	24.560	17.932	16.468	16.431	19.743	20.326	22.608	27.405	27.195	26.303	22.639
9.932	10.567	12.063	12.910	20.585	21.747	16.885	15.307	15.268	18.447	19.117	21.421	26.512	26.291	25.359	21.452
7.302	9.758	10.442	10.104	18.029	19.014	14.287	12.288	12.148	15.816	16.402	18.543	24.554	22.360	21.054	18.575
7.111	6.175	8.428	10.804	21.007	21.304	16.972	14.944	13.750	16.630	18.415	19.964	26.423	25.934	22.445	19.664
5.876	8.906	9.021	7.690	17.181	17.650	13.098	10.609	9.932	14.062	15.047	16.864	21.646	21.038	19.323	16.893
3.827	5.902	5.824	7.565	18.870	19.045	12.920	12.575	11.098	14.410	16.253	17.674	24.676	22.391	20.176	17.260
6.006	5.178	3.634	8.309	19.822	19.529	15.854	13.638	11.700	14.121	16.630	17.956	24.976	24.519	20.231	17.145
7.264	9.516	8.165	2.967	16.754	16.394	12.566	9.845	7.175	11.524	13.475	15.087	20.294	19.680	17.459	14.976
16.871	18.727	18.013	15.031	6.032	10.588	6.843	10.082	14.012	15.945	10.082	13.595	12.766	13.801	15.648	16.387
19.053	20.553	19.632	16.579	10.168	3.316	11.367	13.026	21.498	14.196	8.105	9.801	9.146	8.237	10.650	12.730
14.655	16.520	15.854	12.566	9.560	11.118	2.967	6.651	11.377	14.558	8.416	12.693	15.205	14.920	15.463	15.126
11.748	13.928	13.071	9.100	12.937	13.379	7.478	3.895	7.677	12.260	10.210	13.621	17.324	16.762	16.535	15.205
10.937	12.391	10.567	7.578	16.711	15.709	13.405	10.835	5.954	7.702	12.666	12.955	19.577	18.711	15.338	11.959
14.212	15.416	13.911	11.524	15.524	13.987	14.558	12.584	8.848	2.967	11.158	9.382	17.601	15.998	12.298	8.129
15.740	17.145	16.290	13.089	9.866	8.333	8.616	9.270	10.104	10.712	3.579	8.380	13.449	12.577	12.251	11.308
18.575	20.082	19.141	16.058	12.167	8.249	12.511	13.133	13.681	10.732	8.141	4.696	12.693	10.757	8.069	9.527
21.701	24.811	22.267	19.165	9.834	7.751	14.394	15.793	16.798	16.703	11.738	12.648	4.924	6.084	11.757	14.663
22.205	25.196	24.508	19.680	11.748	8.534	14.920	16.283	17.267	15.998	12.353	11.757	5.967	2.967	10.463	13.587
20.310	21.778	20.326	17.738	14.451	10.007	14.784	15.532	15.393	12.639	11.058	7.850	11.641	9.349	4.508	8.581
18.639	20.129	18.655	16.193	15.732	11.661	15.960	16.036	13.673	10.588	12.611	8.721	13.587	11.573	5.337	5.941
17.224	18.382	16.965	14.976	15.975	12.928	15.126	15.205	12.428	8.129	11.738	8.069	15.385	13.587	8.141	2.967

Fig. 9. Eight major areas for which rations are assumed equivalent to that of a representative state.

TABLE 8
ESTIMATED AVERAGE FARM COST OF
PRODUCING HEAVY TURKEYS IN
THE UNITED STATES, 1961

Item	Cost per 1,000 liveweight pounds produced	Cost per 1,000 RTC pounds produced	Percentage of total farm pro- duction costs
	<i>dollars</i>		<i>per cent</i>
Feed.....	142.00	177.50	66.05
Poults.....	33.00	41.25	15.35
Labor.....	19.00	23.75	8.84
Overhead*.....	6.40	8.00	2.98
Miscellaneous†....	14.60	18.25	6.79
Total.....	215.00	268.75	100.01

* Includes property taxes and cost of land, buildings, and equipment.

† Includes interest on operating capital, medication, veterinary expense, and cost of heat, water, litter, and other small items.

Sources:

Column 1: George B. Rogers (1962, p. 7).

Column 2: Column 1 + .80 (the average 1961 dressing percentage).

pp. 3-7), Texas,²² California (Calif. Poultry Improvement Commission, 1961, p. 8) North Dakota,²³ Minnesota,²⁴ Kansas,²⁵ North Carolina,²⁶ and New York (N. Y. State Dept. of Agri., 1962, pp. 12-17). These rations were assumed to represent those fed in the larger, multi-state regions (named for the states whose rations were selected) shown on the map in figure 9.

The feeding period is divided into five growth stages according to the turkey's age, and standards for percentage of protein in the ration established for each stage:

Age of turkey	Protein level
<i>weeks</i>	<i>per cent</i>
0- 8	28
9-12	22
13-16	19
17-20	16
More than 20	14

The procedure for synthesizing the eight regional rations is as follows: (1) alter the ingredient proportions in each of the eight rations, forcing the protein content in each growth period to conform to the above standard, (2) convert each ration to calories of metabolizable energy (Hill, 1961, p. 1), (3) arbitrarily select one ration as the base ration, (4) equate all rations with the base ration on a calorie basis by adjusting total ration quantity, (5) convert rations back to pounds, (6) calculate the pounds of feed required to produce 1,000 RTC pounds of turkey using the base ration (Scott, 1962, pp. 36-37), and (7) calculate the pounds of feed required to produce 1,000 RTC pounds of turkey using the other seven rations (employing the quantity ratio between each ration and the base ration as derived in step (5) above). The summary of these extensive calculations, showing only the final ingredients and amounts fed, assuming no death loss, are given in table 9.

²² Letter from B. C. Wormell, Poultry Husbandry Department, Texas A & M College, College Station, Texas, September 24, 1962.

²³ Ration used in 1961 North Dakota random sample turkey meat production tests; copy received from David Dickens of the North Dakota Poultry Improvement Board, Bismarck, North Dakota.

²⁴ Letter from Roy D. Carlson, Director of Division of Poultry Industries, Minnesota Department of Agriculture, St. Paul, Minnesota, December 7, 1962. Ration is that used in the 1961 Minnesota random sample test.

²⁵ Letter from Thomas B. Avery, Head of Department of Poultry Husbandry, Kansas State University, Manhattan, Kansas, January 2, 1963. Ration is that used in the Kansas random sample test.

²⁶ Letter from G. A. Martin, Project Leader, North Carolina Random Sample Poultry Tests, North Carolina State College, State College Station, North Carolina, January 30, 1963.

TABLE 9
REGIONAL RATION INGREDIENTS AND QUANTITIES REQUIRED
ASSUMING NO DEATH LOSS

Feed component	Feed required to produce 1,000 RTC pounds of turkey with no death loss							
	California	N. Dakota	Minnesota	Kansas	Iowa	Texas	N.Carolina	New York
	pounds							
Corn.....	423.38	2,507.55	3,109.16	1,459.46	2,975.54	975.50	2,966.86	2,743.93
Barley.....	255.19	867.84	.....	.....	.....	.....	.....	548.12
Oats.....	.....	.....	218.13	94.19	.....	.....	.....	.....
Milo.....	2,850.89	.....	.....	1,828.59	.....	2,333.66	.....	.....
Wheat middlings.....	.....	.....	.....	.....	242.01	.....	210.55	.....
Flour middlings.....	.....	.....	.....	.....	.....	.....	.....	136.41
Soybean oilmeal 44%.....	.....	797.43	980.10	890.47	803.17	815.31	754.31	.....
Soybean oilmeal 50%.....	462.00	.....	.....	.....	.....	.....	.....	651.73
Cottonseed meal 41%.....	276.55	.....	.....	.....	.....	.....	.....	.....
Alfalfa meal 17%.....	174.46	135.02	116.39	221.88	121.00	241.54	117.74	180.98
Fish meal 60%.....	.....	190.25	.....	65.27	.....	26.35	31.15	46.75
Fish meal 65%.....	126.31	.....	.....	.....	70.19	.....	.....	.....
Fish solubles 32%.....	.....	82.84	65.65	.....	.....	13.17	.....	8.74
Meat-bone meal 50%.....	179.34	.....	168.40	162.46	206.69	.....	.....	227.18
Meat-bone meal 55%.....	.....	.....	.....	.....	.....	.....	235.48	.....
Poultry byproduct meal	.....	.....	.....	.....	.....	.....	.....	.....
56%.....	.....	.....	.....	.....	.....	254.72	.....	.....
Distillers solubles.....	.....	.....	.....	57.10	.....	.....	117.74	35.57
Soya oil.....	.....	55.23	.....	.....	.....	.....	.....	.....
Buttermilk 32%.....	.....	62.88	.....	.....	.....	.....	.....	.....
Dried whey.....	12.22	.....	53.50	.....	57.17	127.36	117.74	16.25
Dried yeast.....	.....	.....	.....	.....	13.66	.....	.....	24.53
Stabilized fat.....	.....	.....	.....	.....	116.62	.....	94.19	35.54
Blood meal.....	.....	.....	.....	.....	.....	.....	.....	17.15
Total.....	4,760.34	4,699.04	4,711.33	4,779.42	4,606.05	4,787.61	4,645.76	4,672.88

SOURCE: See text.

It is apparent that rations fed by individual growers in these areas may vary somewhat from those indicated in table 9, especially as to choice of protein supplements; however, the overall effect on ration cost from such changes is not substantial.

Additional feed required because of death loss is computed as follows:

S = birds started per 1,000 RTC pounds of turkey produced.

E = birds sold per 1,000 RTC pounds of turkey produced.

L = liveability.

D_i = percentage of total death loss occurring in period i .

F_i = accumulated feed consumed per bird in period i .

Then the number of birds lost in period i is:

$$(D_i)(1 - L)(S).$$

But $S = E/L$, and $E = 59.2417$ (assuming toms weigh 27.2 pounds and hens 15.0 pounds when sold, and the dressing yield is 0.80).

Thus, feed lost during the total growing period per 1,000 RTC pounds of turkey produced is

$$\sum_{i=1}^6 (D_i)(1 - L) \left(\frac{59.2417}{L} \right) (F_i).$$

From the ration synthesis, F_i is established for each four-week period. The figure and corresponding median for each period are as follows: $F_1 = 0.19$ for 1 week, $F_2 = 4.35$ for 6 weeks, $F_3 = 14.40$ for 10 weeks, $F_4 = 28.20$ for 14 weeks, $F_5 = 45.75$ for 18 weeks, and $F_6 = 65.10$

for 22 weeks. The D_i 's for each four-week period with medians corresponding to the weeks above are: $D_1 = 0.259$, $D_2 = 0.156$, $D_3 = 0.132$, $D_4 = 0.180$, $D_5 = 0.148$, and $D_6 = 0.125$ (Mortenson and Annin, 1954, p. 30). Average liveability data for 1960 and 1961 are used (U. S. Statistical Reporting Service, 1962a, p. 11). Liveability figures and the resulting feed lost through death loss, computed by the above equation, are presented below. The geographic divisions do not correspond to ration regions, but to the usual U. S. regions for which liveability figures are published. The quantity of ration fed in each region (table 9) is adjusted for feed lost through death loss according to which geographic division below encompasses that region.

Geographic divisions	Average 1960-1961 liveability	Feed lost through death loss
		<i>pounds</i>
North Atlantic	0.935	91.48
North Central	0.900	146.22
South Atlantic	0.910	130.15
South Central	0.920	114.43
Western	0.910	130.15

Area ration costs are computed by multiplying the quantities of feed ingredients in the appropriate regional ration by area prices. To check the cost estimates for price sensitivity, three sets of prices are used: (1) 1960 major ingredient prices (U. S. Statistical Reporting Service, 1961), (2) 1961 major ingredient prices (U. S. Statistical Reporting Service, 1962b), and (3) the 1960-1961 average turkey growing mash prices (U. S. Statistical Reporting Service, 1961 and 1962b). In the first two cases, minor ingredients are valued at 1961 prices.²⁷ These area ration cost

estimates are shown in columns 1-3 of table 10.

As might be expected, ration costs are very high in the East (e.g., 1961 Connecticut = \$162.82) and fairly high on the West Coast (e.g., 1961 California = \$147.90) under all three price assumptions. The South has fairly high feed costs valued by ingredient prices (e.g., Mississippi = \$143.06), and most southern states experience similar conditions under growing mash price evaluations. The exception is Arkansas which, under the latter price assumption, has the lowest feed cost of all 60 areas. The mountain and southwestern states have reasonably low feed costs in each of the three cases, but the Midwest consistently has the lowest (e.g., 1961 Minnesota = \$132.99). Using either 1960 or 1961 ingredient prices, Kansas has the lowest ration costs, followed closely by Minnesota and Nebraska. Missouri rivals Arkansas for the lowest costs using growing mash prices.

Other farm costs.—The second most costly factor of production is poults, averaging about 15 per cent of total farm costs (table 8). Estimated area poult costs for raising 1,000 pounds of RTC turkey are shown in column 4 of table 10. These estimates reflect differences in both price of poults (U. S. Statistical Reporting Service, 1962c, p. 29) and their liveability (U. S. Statistical Reporting Service, 1962a, p. 11). The North Atlantic has the least death loss, but there is little difference among all areas.

Area poult costs appear to be inversely correlated with area production. In general, large turkey producing states have low poult prices, and smaller producers have high prices. (Still, there are exceptions; for example, Louisiana produces

²⁷ Prices for all minor ingredients except soya oil from *Feedstuffs*, 1961, vol. 33, issues 1, 5, 9, 13, 18, 22, 26, 31, 35, 40, 44, and 48. Prices of soya oil from U. S. Economic Research Service, 1962d, p. 14.

TABLE 10
ESTIMATED COST OF PRODUCING AND PROCESSING 1,000 RTC POUNDS OF TURKEY BY AREA

Producing areas	Ration cost using			Cost of poults	Farm labor cost	Overhead and mis- cellaneous cost	Processing costs	Total production and processing cost using ration valued at					
	Ingredient prices		1960-61 growing mash price					1961 ingredient prices		1961 ingredient prices		Average 1960-61 turkey growing mash price	
	1960	1961						dollars	rank	dollars	rank	dollars	rank
			dollars											rank	dollars	rank
Maine	159.29	163.08	222.34	64.53	27.11	26.25	53.61	330.79	43	334.58	43	393.84	28
New Hampshire.....	158.91	162.88	218.07	64.53	27.83	26.25	53.51	331.03	44	335.00	44	390.19	25
Vermont.....	159.20	163.15	221.54	64.53	27.35	26.25	54.19	331.52	45	335.47	45	393.86	29
Massachusetts.....	159.59	163.48	224.52	64.53	29.75	26.25	56.93	337.05	47	340.94	47	401.98	39
Rhode Island.....	159.50	162.85	225.22	64.53	29.51	26.25	54.68	334.47	46	337.82	46	400.19	35
Connecticut.....	159.53	162.82	223.82	64.53	31.67	26.25	59.08	341.06	48	344.35	48	405.35	41
New York.....	146.76	151.06	223.03	64.53	27.59	26.25	58.99	324.12	42	328.43	42	400.39	36
New Jersey.....	149.18	152.75	225.02	60.70	27.83	26.25	59.57	323.53	41	327.10	41	399.47	34
Pennsylvania.....	145.65	151.55	222.34	62.24	25.67	26.25	58.70	318.51	40	324.41	39	395.20	31
Delaware.....	146.34	152.97	219.26	49.95	23.99	26.25	58.40	304.93	29	311.56	29	377.85	14
Maryland.....	144.79	149.41	226.11	57.63	24.95	26.25	58.60	312.22	34	316.84	34	393.54	27
E. Ohio.....	134.94	141.55	229.79	55.08	26.15	26.25	61.92	304.34	27	310.96	25	399.19	33
W. Ohio.....	134.94	141.55	229.79	55.08	26.15	26.25	61.92	304.34	27	310.96	25	399.19	33
N. Indiana.....	134.12	140.18	212.37	55.88	25.67	26.25	60.75	302.67	24	309.73	23	380.92	16
S. Indiana.....	134.12	140.18	212.37	55.88	25.67	26.25	60.75	302.67	24	309.73	23	380.92	16
Illinois.....	134.56	141.21	232.27	55.88	26.87	26.25	60.36	303.92	26	310.57	24	401.63	38
Michigan.....	136.10	139.69	226.03	55.88	26.15	26.25	63.10	307.48	32	311.17	28	397.41	32
N. Wisconsin.....	127.48	135.58	231.44	45.50	26.39	26.25	59.28	284.91	12	293.00	10	388.86	24
S. Wisconsin.....	127.48	135.58	231.44	45.50	26.39	26.25	59.28	284.91	12	293.00	10	388.86	24
N. Minnesota.....	117.33	132.99	209.08	46.30	26.39	26.25	59.67	275.94	1	291.61	8	367.69	3
N.C. Minnesota.....	117.33	132.99	209.08	46.30	26.39	26.25	59.67	275.94	1	291.61	8	367.69	3
S.C. Minnesota.....	117.33	132.99	209.08	46.30	26.39	26.25	59.67	275.94	1	291.61	8	367.69	3
S. Minnesota.....	117.33	132.99	209.08	46.30	26.39	26.25	59.67	275.94	1	291.61	8	367.69	3
N.W. Iowa.....	129.95	141.23	218.90	52.68	27.83	26.25	59.67	296.38	19	307.66	19	385.33	21
E. Iowa.....	129.95	141.23	218.90	52.68	27.83	26.25	59.67	296.38	19	307.66	19	385.33	21

N. Missouri.....	130.47	140.47	203.56	50.29	24.23	26.25	58.20	289.44	299.44	17	362.53	2
S. Missouri.....	130.47	140.47	203.56	50.29	24.23	26.25	58.20	289.44	299.44	17	362.53	2
North Dakota.....	123.09	138.01	222.07	51.89	24.95	26.25	56.15	282.33	297.25	15	381.31	18
South Dakota.....	120.75	134.18	229.14	51.89	25.19	26.25	56.15	280.24	293.66	13	388.62	23
Nebraska.....	119.31	131.87	213.14	53.48	27.11	26.25	56.74	282.89	295.45	14	376.72	12
Kansas.....	116.86	129.34	211.19	47.89	27.35	26.25	59.48	277.83	290.31	7	372.16	6
Virginia.....	148.97	155.28	231.19	49.74	20.15	26.25	53.80	298.91	305.22	20	381.13	17
West Virginia.....	156.07	162.04	222.90	47.36	18.71	26.25	59.97	307.36	314.33	31	376.19	8
North Carolina.....	146.12	152.20	231.23	50.53	17.27	26.25	51.16	291.33	297.41	16	376.44	11
South Carolina.....	147.50	153.83	241.28	55.26	12.71	26.25	51.45	293.17	299.50	18	386.95	22
Georgia.....	143.24	147.74	230.93	50.53	16.07	26.25	52.24	288.33	292.83	9	376.02	10
Florida.....	143.34	142.18	239.00	49.74	20.63	26.25	54.55	294.54	293.38	12	390.20	26
Kentucky.....	138.54	145.68	219.02	60.90	20.87	26.25	57.32	303.89	311.04	27	384.36	20
Tennessee.....	140.53	148.03	226.11	49.20	15.59	26.25	54.09	285.66	293.16	11	371.24	5
Alabama.....	141.27	143.65	231.56	46.85	14.63	26.25	55.27	284.27	286.65	3	374.06	7
Mississippi.....	141.23	143.06	230.27	49.20	12.71	26.25	50.96	280.35	282.18	1	369.39	4
Arkansas.....	135.69	141.55	203.21	47.63	17.51	26.25	51.45	278.53	284.39	2	346.05	1
Louisiana.....	141.10	144.44	232.85	42.95	15.83	26.25	57.42	283.45	286.89	4	375.30	9
Oklahoma.....	123.27	133.71	224.07	46.85	24.23	26.25	56.64	277.24	287.68	6	378.04	15
N.E. Texas.....	127.97	137.53	227.59	46.85	19.19	26.25	57.72	277.98	287.54	5	377.60	13
S.E. Texas.....	127.97	137.53	227.59	46.85	19.19	26.25	57.72	277.98	287.54	5	377.60	13
W. Texas.....	127.97	137.53	227.59	46.85	19.19	26.25	57.72	277.98	287.54	5	377.60	13
Montana.....	121.35	135.37	237.19	66.31	27.83	26.25	59.87	310.61	315.63	33	417.45	45
Idaho.....	137.91	147.03	245.34	63.15	28.79	26.25	58.01	314.11	323.23	37	421.54	47
Wyoming.....	134.36	141.26	237.19	63.95	27.35	26.25	60.75	312.66	319.56	36	415.49	44
Colorado.....	123.91	134.79	228.09	63.95	27.11	26.25	60.45	301.67	312.55	30	405.85	42
New Mexico.....	137.46	145.42	252.35	59.21	20.87	26.25	56.54	300.33	308.29	22	415.22	43
Arizona.....	142.90	146.18	241.16	51.32	23.75	26.25	60.36	304.58	307.86	21	402.84	40
Utah.....	144.40	147.31	210.09	55.26	29.51	26.25	61.04	316.46	319.37	35	382.15	19
Nevada.....	143.51	150.80	274.31	55.26	28.55	26.25	63.98	317.55	324.84	40	448.35	48
Washington.....	141.31	149.12	243.00	55.26	31.19	26.25	62.31	316.32	324.13	38	418.61	46
Oregon.....	142.35	150.77	234.23	43.42	29.51	26.25	61.14	302.67	310.99	26	394.55	37
N. California.....	140.88	147.90	234.85	46.58	30.47	26.25	62.31	306.49	313.51	31	400.46	30
C. California.....	140.88	147.90	234.85	46.58	30.47	26.25	62.31	306.49	313.51	31	400.46	37
S. California.....	140.88	147.90	234.85	46.58	30.47	26.25	62.31	306.49	313.51	31	400.46	37

SOURCE: See text.

TABLE 11
HOURLY FARM WAGE RATES (WITHOUT BOARD OR ROOM)
BY STATE AND REGION, 1961

State and region	Annual average	State and region	Annual average
	<i>dollars/hour</i>		<i>dollars/hour</i>
United States.....	.99	East South Central.....	.65
New England.....	1.19	Kentucky.....	.87
Maine.....	1.13	Tennessee.....	.65
New Hampshire.....	1.16	Alabama.....	.61
Vermont.....	1.14	Mississippi.....	.53
Massachusetts.....	1.24	West South Central.....	.78
Rhode Island.....	1.23	Arkansas.....	.73
Connecticut.....	1.32	Louisiana.....	.66
Middle Atlantic.....	1.13	Oklahoma.....	1.01
New York.....	1.15	Texas.....	.80
New Jersey.....	1.16	Mountain.....	1.09
Pennsylvania.....	1.07	Montana.....	1.16
East North Central.....	1.10	Idaho.....	1.20
Ohio.....	1.09	Wyoming.....	1.14
Indiana.....	1.07	Colorado.....	1.13
Illinois.....	1.12	New Mexico.....	.87
Michigan.....	1.09	Arizona.....	.99
Wisconsin.....	1.10	Utah.....	1.23
West North Central.....	1.10	Nevada.....	1.19
Minnesota.....	1.10	Pacific.....	1.27
Iowa.....	1.16	Washington.....	1.30
Missouri.....	1.01	Oregon.....	1.23
North Dakota.....	1.04	California.....	1.27
South Dakota.....	1.05		
Nebraska.....	1.13		
Kansas.....	1.14		
South Atlantic.....	.74		
Delaware.....	1.00		
Maryland.....	1.04		
Virginia.....	.84		
West Virginia.....	.78		
North Carolina.....	.72		
South Carolina.....	.53		
Georgia.....	.67		
Florida.....	.86		

SOURCE: U. S. Statistical Reporting Service, *Farm Labor* 1962, p. 15.

very few turkeys and has the lowest poult cost of any area.) This pattern can probably be attributed to economies of scale in the egg and poult hatching industries.

Labor productivity is assumed the same in all areas, but differences in wage rates are incorporated. Table 11 shows farm wage rate data (1961) on comparative farm wage rates by state and region of the United States. The Pacific region has by far the highest rate, averaging

about \$1.27 per hour. This compares with about \$1.10 per hour in the West North Central states and only \$0.65 per hour in the East South Central states. Thus, while labor costs average only about 9 per cent of total production costs (table 8), the great differences in wage rates among regions creates substantial absolute differences in labor costs as shown in column 5, table 10.

The overhead and miscellaneous cost items are assumed a constant \$26.25

among areas as shown in column 6, table 10. Items included in this category are the price and amount of land, equipment, buildings, medication, veterinary service, heat, water, litter, and the rate of interest. To estimate each of these items separately by area would be a formidable task with little prospect of an appreciable effect on the results, since in total these items bulk to less than 10 per cent of farm production costs (table 8).

Evaluation of farm production cost estimates.—Accuracy is sacrificed by assuming that turkey feeding in an entire region can be represented by one ration. A separate ration for each producing area would be much preferred, but this information is unavailable. The assumptions of equal protein levels and calorie conversion ratios are probably quite realistic. The exclusion of mineral and vitamin supplements is not serious because the difference between rations in supplements required to reach the minimum recommended levels is monetarily very small. In all, regional differences in ingredients, feed conversion ratios (on a pound basis), and prices should be adequately reflected in the feed cost estimates.

The assumptions of equal quantity and price of buildings, medication, veterinary expenses, and heat ignore weather differences between the North and South. The little data available suggest that small differences in building costs (insulation) and heat do exist, but that other costs are roughly the same. Perhaps this similarity is due to the seasonality of production. If turkey were produced the year around, costs between the North and South would likely be substantially different, but turkey is not produced in large quantity during the winter months in either region.

The assumption of invariant production practices appears, at first, to be quite limiting. It implies either the same scale of operations in all areas or a linear, homogeneous production function. In reality, scale of operations differs substantially among areas, and it would not be surprising to find significant economies due to size. Minnesota and California, for example, have a greater proportion of large-scale producers than do most of the smaller producing states. Large producers are likely to be more mechanized, using less labor and more capital per unit of output; make greater use of drylot feeding (less land); and possibly use more medication, resulting in less death loss. Unfortunately, there is insufficient information to either verify or refute this hypothesis.

Given the purpose for which these estimates are to be used, however, the assumption of identical area production practices may be an advantage. These estimates are to be used in the long-run interregional model. To assume that all areas will have similar practices in 15 years appears to be as realistic as, if not more realistic than, the alternative of assuming that the differences existing now will prevail then.

Area Processing Costs

Processing is assumed to take place near the point of production.²⁸ Consequently, in an interregional analysis conducted to evaluate the absolute advantage of areas with respect to turkey production, both production and processing costs are relevant. Shipments specified by the long-run model will be from the processor in the producing area to the wholesaler in the consuming area.

The U. S. Department of Agriculture

²⁸ A survey of 67 processing plants in 11 North Central states revealed an average hauling distance from farm to plant of 71 miles, with the longest haul being 219 miles (Mortenson, 1960, p. 13).

has published average processing cost estimates based on a survey of 25 turkey processing plants in Minnesota, Wisconsin, Kansas, California, Utah, Colorado, and Virginia (U. S. Economic Research Service, 1961c, p. 10). These are shown in table 12. Processing cost estimates by area are unavailable in any form. Excluding a special, nationwide survey of processors for this study, the only alternative is to derive area differences based on the cost breakdown in table 12. Of the

TABLE 12
AVERAGE COST OF PROCESSING
HEAVY YOUNG TURKEYS IN THE
UNITED STATES, 1960

Item	Cost per 1,000 RTC pounds of turkey
	<i>dollars</i>
Wages and salaries.....	22.70
Packaging, supplies, miscellaneous.....	19.20
Utilities, ice, freezing, storage.....	8.00
Fixed overhead.....	8.50
Total processing cost.....	58.40

SOURCE: U. S. Economic Research Service, 1961c, p. 10.

four categories shown, area information is available on only the first—wages and salaries. Hence, area processing costs are estimated by adjusting the wages and salary component of the processing costs by the area differences in hourly wages of workers in manufacturing published by the U. S. Bureau of Labor Statistics (1962, pp. 42–44). The resulting figures on area processing costs are given in column 7, table 10. Cost estimates are highest for the West and lowest for the South, reflecting the area differentials in labor costs.

Scarcity of data makes difficult the evaluation of area processing cost estimates. The survey by the U. S. Department of Agriculture did reveal substantial cost differences between the very

small plants (less than 400 birds per hour) and the larger plants. However, processing cost per bird varied only 8 per cent among the five remaining size classifications (from 400 to more than 2,000 birds per hour in capacity).

Even if cost differences due to scale could be estimated for each area (an impossible task from secondary data since average area plant size is not known), it is doubtful that these differences should be explicitly maintained among areas in the long run. Scale economies are not due to geographic location, *per se*, but to concentration of turkeys in the area. To differentiate scale costs on the basis of the present geographic distribution of turkey production would not allow for the possibility of an area which is a producer now becoming a large producer in 15 years and thereby experiencing scale economies in processing. Processing economies of scale are not primarily a *determinant* of turkey production location but rather a *result* thereof. Consequently, they are not reflected in the processing cost estimates used in the long-run interregional model.

Total Area Production and Processing Costs

Production costs and processing costs are combined and listed in columns 8, 10, and 12 of table 10. Columns 9, 11, and 13 rank the individual states from lowest to highest total costs.

Texas, Oklahoma, most Southern states, and a few North Central states experience the lowest costs in all three estimates. Among these, however, there is considerable shifting in positions, reflecting the sensitivity of the cost estimates to annual changes in feed prices. Using 1960 ingredient prices, Minnesota is first (lowest cost) and Mississippi is seventh; valued according to 1961 prices, Mississippi becomes first and Minnesota

drops to eighth place. Arkansas is the only state appearing in the top five in all three estimates. It is fifth in 1960, second in 1961, and first using the 1960–1961 growing mash price.

Using any of the three estimates, the East and West have the highest total costs, due principally to high feed and labor costs. The North Central states have about average labor costs, but very low feed costs. The South experiences slightly higher feed costs, but has the lowest labor costs. The combined costs of production and processing, then, are about equal in the Midwest and South.

These cost estimates should not be used as *absolute* standards of the average or typical production costs within areas. Rather, they should be used primarily for making *relative* cost comparisons among areas. The general level of estimated costs may be either high or low for all states, but the cost differences among areas should approximate the actual differences in existence. The reason for emphasis on relative estimation is that the long-run model solution de-

pends on relative costs, and it is independent of their absolute level.

It is difficult to judge how well these cost estimates reflect actual cost differences among areas. Farm costs represent 82 per cent of total production costs, and processing costs make up the remaining 18 per cent. Feed, poults, and farm labor constitute 90 per cent of farm cost, or 73 per cent of the total costs of producing turkey. Thus, since farm wage rates, and the quantities and prices of feed and poults have been varied among areas, the estimates should account for something more than 73 per cent of the difference in total costs among areas.

Wages and salaries represent 39 per cent of processing costs or 7 per cent of total costs. This is the processing cost item most likely to vary substantially among areas, thus the consideration of area wage rates should account for about 7 per cent of the difference in total costs. In total, then, at least 80 per cent of the variation in total production costs should be reflected in the cost estimates in table 10.

EMPIRICAL RESULTS FROM THREE INTERREGIONAL MODELS

This section of the study reports the empirical results obtained from each of the three interregional models discussed in the earlier theoretical section—namely, the short-run *ex post* model, the short-run *ex ante* model, and the long-run *ex ante* model. Because major emphasis is on prediction, interest centers mainly on the latter two models.

SHORT-RUN EX POST MODEL

The necessary components of this model are actual area production and consumption quantities for a particular past time period, and the transfer costs

among all areas. The solution yields the shipping pattern (quantity and destination of shipments from every producing area) that would have minimized total transportation cost in that year. The linear programming dual solution shows what the relative area prices would have been if the suggested shipping pattern had been followed.

Empirical Results

This model is applied to the U. S. turkey industry for 1961, the latest year for which complete data are available. Published state production figures are

Fig. 10. Major turkey shipments, 1961—short-run ex post model.

used to estimate actual area production (appendix table A-3). State consumption data are not available, and 1961 area consumption therefore is synthesized (table 6). The transfer cost matrix shown in table 7 completes the information requirements for this model.

The solution of the model provides the amounts shipped and their destinations, as shown in table 13.²⁹ The major shipments are also shown in the flow map in figure 10.³⁰ Most shipments are from west to east. More specifically, California, Utah, Minnesota, Wisconsin, Iowa, and Missouri provide most of the turkey for the large eastern markets, with some help from North Dakota, Oklahoma, and Colorado. California and Arkansas, with assistance from Texas, ship to those southern states deficient in turkey production.

The model also yields relative area prices, but their absolute level is indeterminate. To make possible a comparison between model and actual prices, the dual prices for producing areas are adjusted upwards by a constant amount so their simple average equals the simple average of actual farm prices in 1961. The adjusted prices are shown in column 2 of table 14. Prices are highest in the East, followed by the South, Midwest, and West, with California areas having the lowest prices.

Evaluation of Results

As discussed in the theoretical section, the short-run ex post model is mainly used to judge the efficiency of the actual shipping pattern by comparing it with the programmed minimum cost pattern. Unfortunately, actual shipments in the

turkey industry are not recorded,³¹ nor can they be synthesized from existing data with a desirable degree of accuracy. Hence, it is impossible to make a direct comparison of actual and cost-minimizing quantities shipped. Nevertheless, the general shipment pattern shown in table 13 and figure 10 appears to be qualitatively reasonable from what is known about the industry. Certainly, the shipment pattern from the surplus producing areas of the West and Midwest to the population centers on the eastern seaboard is consistent with expectations and general knowledge about the industry. A measure of efficiency such as (total shipping cost of the actual pattern/total shipping cost of the least-cost pattern) could, therefore, be expected to show a ratio greater than, but reasonably close to, unity.

Theoretically, an indirect index of market efficiency could be obtained from the formula

$$\frac{\sum_{i=1}^{60} \left(\frac{|PA_i - PP_i|}{PA_i} \right)}{60}$$

where PA_i = actual price in area i and PP_i = predicted price in area i . The average area price difference calculated from table 14, using this formula, is 12.3 per cent. Much of the discrepancy in prices results from a consistent underestimation of prices in the Northeast consumption areas and a consistent overestimation of prices in the Midwest producing areas. (Model prices in the South and West are quite close to actual prices.) Thus, actual area prices differ far more than the transportation cost between them.

²⁹ The Ford-Fulkerson algorithm is used to solve the problem (Ford-Fulkerson, 1956).

³⁰ This shipping pattern corresponds roughly to those shown by Hertsgaard (1961, p. 14). An exact comparison is not possible because of the dissimilarity in designated area boundaries (Hertsgaard divides the United States into 17 areas) and in the consumption estimates used.

³¹ Receipts of processed turkeys for some selected cities (varying from 1 to 12 in number) were kept for a few years, but the practice was discontinued in 1960.

TABLE 13
TURKEY SHIPMENTS—1961 SHORT-RUN EX POST MODEL

Producing area	Shipments (with destination number in parentheses)	Consuming area (for reference)
	10,000 pounds	
Maine (Augusta).....	88(1)	1. Maine (Augusta)
New Hampshire (Manchester).....	131(2)	2. New Hampshire (Concord)
Vermont (St. Albans).....	56(3)	3. Vermont (Montpelier)
Massachusetts (Framingham).....	753(4)	4. Massachusetts (Wellesley)
Rhode Island (Cranston).....	40(5)	5. Rhode Island (Providence)
Connecticut (Hartford).....	421(6)	6. N.E. Connecticut (Hartford)
New York (Syracuse).....	1,192(8)	7. N. New Jersey, S. New York, S.W. Connecticut (New York City)
New Jersey (New Brunswick).....	281(7)	8. N. New York (Syracuse)
Pennsylvania (Reading).....	2,417(9)	9. E. Pennsylvania, S. New Jersey, N. Delaware (Philadelphia)
Delaware (Milford).....	313(9)	10. S. Delaware, Maryland, Washington, D.C. (Baltimore)
Maryland (Baltimore).....	262(10)	11. W. Pennsylvania (Pittsburgh)
E. Ohio (Coshocton).....	2,326(11)	12. N. Ohio (Cleveland)
W. Ohio (Lima).....	2,541(13)	13. S. Ohio (Springfield)
N. Indiana (Warsaw).....	2,406(12)	14. S.E. Michigan (Detroit)
S. Indiana (Washington).....	2,831(16), 897(36)	15. S.W. Michigan (Lansing)
Illinois (Peoria).....	2,063(18)	16. S. Indiana (Indianapolis)
Michigan (Grand Rapids).....	2,175(15)	17. N.W. Indiana, N.E. Illinois (Chicago)
N. Wisconsin (Eau Claire).....	3,339(14), 291(15)	18. C. Illinois (Peoria)
S. Wisconsin (Madison).....	673(17), 1,357(24)	19. S. Illinois, E. Missouri (St. Louis)
N. Minnesota (Thief River Falls).....	1,447(24)	20. W. Missouri, E. Kansas (Kansas City)
N.C. Minnesota (Brainerd).....	2,023(9)	21. W. Kansas (Salina)
S.C. Minnesota (Willmar).....	1,573(6), 3,285(7)	22. N. Wisconsin, N. Michigan, N. Minnesota (Duluth)
	964(22)	23. W. Wisconsin, S. Minnesota (Minneapolis)
	477(2), 4,774(4)	24. S.E. Wisconsin (Madison)
	874(5), 398(7)	25. E. Iowa (Cedar Rapids)
	2,453(23)	26. E. Nebraska, W. Iowa (Omaha)
S. Minnesota (Owatonna).....	452(1), 5,613(7)	27. E. South Dakota (Huron)
N.W. Iowa (Webster City).....	400(1), 3,450(8)	28. North Dakota (Bismarek)
	2,924(9), 45(10)	29. Virginia (Richmond)
	272(12), 289(14)	30. West Virginia (Charleston)
	1,668(25)	31. North Carolina (Greensboro)
S.E. Iowa (Washington).....	4,806(17), 56(18)	32. South Carolina (Columbia)
		33. Georgia (Atlanta)
N. Missouri (Trenton).....	229(16), 1,709(20)	34. N. Florida (Gainesville)
S. Missouri (Springfield).....	1,186(13), 302(16)	35. S. Florida (Ft. Lauderdale)
	2,848(19), 2,011(37)	36. Kentucky (Lexington)
North Dakota (Devils Lake).....	1,343(8), 515(28)	37. Tennessee (Nashville)
South Dakota (Watertown).....	793(7), 447(27)	38. Alabama (Birmingham)
Nebraska (Grand Island).....	691(7), 1,622(26)	39. Mississippi (Jackson)
Kansas (McPherson).....	475(20), 1,234(21)	40. Arkansas (Little Rock)
Virginia (Harrisonburg).....	3,087(10), 1,566(29)	41. Louisiana (Alexandria)
West Virginia (Petersburg).....	930(10)	42. Oklahoma (Oklahoma City)
North Carolina (Fayetteville).....	1,130(29), 3,029(31)	43. N.E. Texas (Dallas)
South Carolina (Camden).....	1,389(32)	44. S.E. Texas (Houston)
Georgia (Covington).....	985(33)	45. S. Texas (San Antonio)
Florida (Ocala).....	256(34)	46. W. Texas (Lubbock)
Kentucky (Winchester).....	1,151(36)	47. Montana (Helena)
Tennessee (Athens).....	210(33)	48. Idaho (Boise)
Alabama (Gadsden).....	501(33)	49. W. South Dakota, W. Nebraska, Wyoming (Casper)
Mississippi (Tupelo).....	229(38)	50. Colorado (Denver)
Arkansas (Fayetteville).....	166(32), 944(33)	51. New Mexico (Albuquerque)
	386(37), 1,945(38)	52. Arizona (Phoenix)
	1,186(40)	53. Utah (Salt Lake City)
Louisiana (Alexandria).....	94(41)	54. Nevada (Tonopah)
Oklahoma (Oklahoma City).....	1,009(7), 30(32)	55. Washington (Seattle)
	1,594(42)	56. Oregon (Salem)
N.E. Texas (Hillsboro).....	1,423(41), 2,222(43)	57. N. California (Oakland)
	665(44), 1,565(45)	
S.E. Texas (San Marcos).....	1,007(44), 1,565(45)	
W. Texas (Lubbock).....	390(46)	
Montana (Billings).....	24(47)	

TABLE 13—Continued

Producing area	Shipments (with destination number in parentheses)	Consuming area (for reference)
	10,000 pounds	
Idaho (Caldwell).....	3,358(48)	58. S. California (Los Angeles)
Wyoming (Casper).....	15(49)	
Colorado (Colorado Springs).....	1,733(9), 1,397(50)	
New Mexico (Las Cruces).....	56(46)	
Arizona (Phoenix).....	170(52)	
Utah (Provo).....	2,301(11), 1,446(12)	
	1,209(30), 458(49)	
	720(53)	
Nevada (Austin).....	2(31)	
Washington (Yakima).....	771(55)	
Oregon (Salem).....	1,240(55), 1,451(56)	
N. California (Yuba City).....	306(3), 545(47)	
	208(48), 240(54)	
	315(55), 1,176(57)	
C. California (Fresno).....	5,385(7), 1,137(34)	
	2,137(35), 1,445(39)	
	692(41), 751(46)	
	791(51), 907(52)	
	4,280(57), 517(58)	
S. California (Los Angeles).....	6,501(58)	

Several hypotheses can be advanced to explain these large actual price differences between predominantly producing and consuming areas: (1) the published prices or/and estimated regional consumption data are in error, (2) turkey is not a homogeneous product throughout the United States, (3) model transportation costs are an underestimate of the actual costs, or (4) the price differentials exist because of a lack of knowledge and imperfect competition. The complete explanation is probably a combination of these. Published prices could easily misrepresent actual prices through sampling, aggregation, or clerical errors. Turkey is not a homogeneous product; smaller turkeys are grown in the East and they do command a higher price. Estimated transfer costs probably do not reflect all the costs involved in shipping turkeys. Shippers in various areas probably do not have complete information on prices in all other areas at all times, and, therefore, make inefficient shipments. Also, a sizable proportion of the shipments may take place

within large oligopolistic organizations whose shipments are determined by contracts or internal considerations other than relative prices.

In addition to providing a measure of market efficiency, the other major use of the short-run ex post model discussed in the theoretical section was to predict short-run changes in the shipping pattern resulting from changes in certain exogenous variables such as transportation rates. The results discussed above seem to indicate that the actual and predicted shipment patterns are reasonably similar. Thus, this model might serve as at least an indicator of the effects of fairly major changes in the transportation rate structure in the short run. For our purposes, however, major emphasis is given to the effects of changes in the exogenous variables in the longer run. Therefore, this question is examined in more detail using the long-run ex ante model.

SHORT-RUN EX ANTE MODEL

The short-run ex ante model is developed to make forecasts of the near future

TABLE 14
COMPARISON OF ACTUAL AND ESTIMATED AREA PRICES,
1961 SHORT-RUN EX POST MODEL

Producing area	Actual price	Estimated price	Estimation error	Producing area	Actual price	Estimated price	Estimation error
	<i>dollars per 1,000 RTC pounds</i>		<i>per cent</i>		<i>dollars per 1,000 RTC pounds</i>		<i>per cent</i>
Maine.....	335.000	270.834	-19.154	Kansas.....	218.750	255.058	+16.597
New Hampshire.....	316.250	269.510	-14.779	Virginia.....	233.750	265.423	+13.549
Vermont.....	335.000	268.680	-19.797	West Virginia.....	243.750	265.105	+08.760
Massachusetts.....	358.750	269.655	-24.835	North Carolina.....	283.750	264.121	-06.918
Rhode Island.....	368.750	269.756	-26.846	South Carolina.....	270.000	265.309	-01.737
Connecticut.....	376.250	269.346	-28.413	Georgia.....	287.500	263.269	-08.428
New York.....	351.250	267.620	-23.809	Florida.....	321.250	265.697	-17.293
New Jersey.....	348.750	268.146	-23.112	Kentucky.....	233.750	262.686	+12.378
Pennsylvania.....	336.250	267.365	-20.486	Tennessee.....	265.000	261.772	-01.218
Delaware.....	261.250	266.818	+ 2.130	Alabama.....	273.750	262.270	-04.194
Maryland.....	246.250	267.554	+ 8.650	Mississippi.....	261.250	260.580	-00.256
E. Ohio.....	237.500	263.799	+11.072	Arkansas.....	235.000	255.492	+08.719
W. Ohio.....	237.500	262.694	+10.607	Louisiana.....	300.000	260.005	-13.332
N. Indiana.....	228.750	261.385	+14.266	Oklahoma.....	226.250	254.059	+12.290
S. Indiana.....	228.750	260.673	+13.954	N.E. Texas.....	245.000	255.670	+04.354
Illinois.....	238.750	259.519	+ 8.698	S.E. Texas.....	245.000	256.394	+04.650
Michigan.....	235.000	262.436	+11.674	W. Texas.....	245.000	255.105	+04.123
N. Wisconsin.....	232.500	256.516	+10.328	Montana.....	275.000	251.127	-08.681
S. Wisconsin.....	232.500	258.992	+11.393	Idaho.....	260.000	249.399	-04.077
N. Minnesota.....	220.000	253.405	+15.183	Wyoming.....	272.500	253.027	-07.146
N.C. Minnesota.....	220.000	254.811	+15.822	Colorado.....	283.750	251.486	-11.371
S.C. Minnesota.....	220.000	255.022	+15.918	New Mexico.....	242.500	250.494	+03.295
S. Minnesota.....	220.000	255.917	+16.325	Arizona.....	277.500	249.500	-10.090
N.W. Iowa.....	210.000	256.111	+21.957	Utah.....	227.500	247.378	+08.737
S.E. Iowa.....	210.000	257.682	+22.705	Nevada.....	225.000	252.831	+12.368
N. Missouri.....	197.500	256.480	+29.862	Washington.....	230.000	249.425	+08.445
S. Missouri.....	197.500	256.271	+29.756	Oregon.....	240.000	248.382	+03.492
North Dakota.....	222.500	252.663	+13.555	N. California.....	242.500	242.708	+00.085
South Dakota.....	226.250	254.223	+12.363	C. California.....	242.500	241.879	-00.256
Nebraska.....	210.000	254.351	+21.119	S. California.....	242.500	244.853	+00.969

SOURCES:

Column 1: U. S. Statistical Reporting Service (1962a, p. 7). Adjusted from liveweight to RTC pounds by dividing by .80, the dressing yield.

Column 2: Shadow prices from the short-run ex post model.

Column 3: (Column 1 minus column 2) divided by column 1.

—the next one or two time periods. Predictions can be expected to decrease rapidly in accuracy with time because errors become compounded after the first prediction.

Necessary components of the model are area supply functions, area demand functions, and the transfer costs matrix. As shown in the theoretical example presented earlier, the primal solution yields amounts produced and consumed in each area and the complete shipping

pattern (quantity and destination of shipments from every producing area). Total production equals total consumption, and area production and consumption are consistent with the area supply and demand equations. The derived shipping pattern is the one which will minimize total transportation cost within the demand and supply constraints, assuming each area can be represented by one point for trading purposes.

The dual solution shows relative area

prices under the derived shipping solution assuming prices between areas can differ by no more than the transfer cost between them. Absolute prices are obtained from the corollary solution by finding that price level at which total consumption will just equal total (fixed) production.

The model is recursive in that the required data necessary for each successive solution are either generated by the previous solution or are exogenous to the model. The model may be thought of as yielding a series of static equilibrium solutions, each being derived under conditions of a constrained optimum.

Production costs are not introduced explicitly into the model because they are reflected in the supply equations. This is done by introducing area values for the explanatory cost variables in the supply equation and by allowing the equation constant to vary among areas.

The model is applied to the turkey industry to predict total and area turkey produced and consumed, area prices, and the complete shipping patterns for 1962, 1963, and 1964. Only information known on January 1, 1962, is used in the model. The model is tested in detail for 1962 by comparing the predictions of state quantities produced and state prices with the actual values in that year. For 1963 and 1964 only the United States price and quantity predictions are tested.

Empirical Results

Total U. S. turkey supply is predicted to be 1,304,725,600 RTC pounds in 1962, 1,497,826,700 in 1963, and 1,415,255,500 in 1964. With respect to each preceding year, this represents a decrease of 13.2 per cent (1962 over 1961), an increase of 14.8 per cent (1963 over 1962), and a decrease of 5.5 per cent (1964 over 1963).

Predictions of amounts to be produced

in and shipped from each area, and the shipping destinations, are shown in table 15 for 1962, 1963, and 1964. A cursory look at this table reveals that the East, the most densely populated sector of the country, is expected to produce very little turkey. Most surplus producing areas are found on the West Coast, in the Southwest, and in the Midwest, with an occasional large producing area among the mountain and southern states. Consequently, most shipments are predicted to be from west to east, with the Midwest shipping to the east and west and Southwest shipping to both the south and east. This is better shown on the flow map in figure 11. (Only predicted area shipments in excess of ten million pounds are shown.) Direction of shipment varies little over the three-year period 1962, 1963, and 1964; changes are mainly in quantities shipped, resulting from changes in area production.

A decrease in production is predicted for every area in 1962, but the various areas are predicted to decrease in different proportions. These shifts in production among states, as a percentage of the total produced, are shown in table 16. In 1962, the model predicts that the Midwest will decrease its production relative to all other areas. The largest relative decreases are predicted in Minnesota, Iowa, and Missouri; the largest relative increases in Pennsylvania, North Carolina, Texas, Colorado, and California. These 1962 interarea shifts are fairly small and have little relation to the long-run shifts predicted in the next section by the long-run model. They reflect production response to relative area prices existing in 1961. For example, California's relative production is predicted to decrease in the long run according to the long-run model presented later, but its share of the market in 1962 is predicted to increase slightly over 1961 because of

TABLE 15

PREDICTED TURKEY SHIPMENTS IN 1962, 1963 AND 1964—SHORT-RUN EX ANTE MODEL

Producing areas	Predicted shipments (with destination numbers in parentheses)			Consuming areas (for reference)
	1962	1963	1964	
<i>ten thousand pounds</i>				
Maine (Augusta).....	83(1)	81(1)	77(1)	1. Maine (Augusta)
New Hampshire (Manchester).....	120(2)	121(2)	115(2)	2. New Hampshire (Concord)
Vermont (St. Albans).....	53(3)	53(3)	49(3)	3. Vermont (Montpelier)
Massachusetts (Framingham).....	706(4)	663(4)	629(4)	4. Massachusetts (Wellesley)
Rhode Island (Cranston).....	38(5)	35(5)	33(5)	5. Rhode Island (Providence)
Connecticut (Hartford).....	403(6)	369(6)	350(6)	6. N.E. Connecticut (Hartford)
New York (Syracuse).....	1,147(8)	1,086(8)	1,029(8)	7. N. New Jersey, S. New York, S.W. Connecticut (New York City)
New Jersey (New Brunswick).....	269(7)	256(7)	242(7)	8. N. New York (Syracuse)
Pennsylvania (Reading).....	2,287(9)	2,216(9)	2,100(9)	9. E. Pennsylvania, S. New Jersey, N. Delaware (Philadelphia)
Delaware (Milford).....	273(9)	303(9)	287(9)	10. S. Delaware, Maryland, Washington, D.C. (Baltimore)
Maryland (Baltimore).....	223(10)	255(10)	242(10)	11. W. Pennsylvania (Pittsburgh)
E. Ohio (Coshocton).....	2,016(11)	2,340(11)	2,216(11)	12. N. Ohio (Cleveland)
W. Ohio (Lima).....	2,202(13)	2,551(13)	2,415(13)	13. S. Ohio (Springfield)
N. Indiana (Warsaw).....	2,088(12)	2,463(12)	2,331(12)	14. S.E. Michigan (Detroit)
S. Indiana (Washington).....	2,227(16)	2,694(16)	2,554(16)	15. S. W. Michigan (Lansing)
	481(36)	530(36)	500(36)	16. S. Indiana (Indianapolis)
Illinois (Peoria).....	21(13),	158(13),	162(13),	17. N.W. Indiana, N.E. Illinois (Chicago)
	1,597(18)	1,835(18)	1,733(18)	18. C. Illinois (Peoria)
Michigan (Grand Rapids).....	118(14),	166(14),	160(14),	19. S. Illinois, E. Missouri (St. Louis)
N. Wisconsin (Eau Claire).....	1,607(8),	2,261(8),	2,151(8),	20. W. Missouri, E. Kansas (Kansas City)
	2,490(14)	2,515(14)	2,367(14)	21. W. Kansas (Salina)
	804(24)	905(24)	852(24)	22. N. Wisconsin, N. Michigan, N. Minnesota (Duluth)
S. Wisconsin (Madison).....	1,253(24)	1,459(24)	1,380(24)	23. W. Wisconsin, S. Minnesota (Minneapolis)
N. Minnesota (Thief River Falls).....	1,693(7)	2,011(7)	1,899(7)	24. S.E. Wisconsin (Madison)
N.C. Minnesota (Brainerd).....	76(4),	2,237(6),	2,137(6),	25. E. Iowa (Cedar Rapids)
	2,204(7),	2,738(7)	2,584(7)	26. E. Nebraska, W. Iowa (Omaha)
S.C. Minnesota (Willmar).....	469(2),	807(22)	761(22)	27. E. South Dakota (Huron)
	1,762(23)	553(2),	523(2),	28. North Dakota (Bismarck)
S. Minnesota (Owatonna).....	992(5),	95(5),	80(5),	29. Virginia (Richmond)
N.W. Iowa (Webster City).....	877(1),	1,048(5),	1,002(5),	30. West Virginia (Charleston)
	2,463(8),	1,017(1),	963(1),	31. North Carolina (Greensboro)
	1,837(9)	2,576(8),	2,427(8),	32. South Carolina (Columbia)
	1,104(25)	2,330(9)	1,198(25)	33. Georgia (Atlanta)
S.E. Iowa (Washington).....	36(14),	1,269(25)	1,198(25)	34. N. Florida (Gainesville)
N. Missouri (Trenton).....	235(9),	4,610(17)	4,353(17)	
	528(13)	674(9),	658(9),	
	801(20)	857(20)	801(20)	

S. Missouri (Springfield).....	1908-9	1909-10	2, 832(9)	2, 811(9)	1909-10	1910-11	1911-12	1912-13
North Dakota (Devils Lake).....	1, 271(37)	364(28)	1, 606(37)	420(28)	1, 513(37)	395(28)	37, Tennessee (Nashville)	
South Dakota (Watertown).....	1, 253(8)	322(27)	833(7)	788(7)	1, 405(8)	350(27)	38. Alabama (Birmingham)	
Nebraska (Grand Island).....	844(7)	1, 077(26)	791(20)	989(21)	1, 044(7)	1, 170(26)	39. Mississippi (Jackson)	
Kansas (McPherson).....	631(20)	859(21)	734(9)	1, 287(39)	1, 047(7)	1, 170(26)	40. Arkansas (Little Rock)	
Virginia (Harrisonburg).....	116(9)	3, 127(10)	3, 384(10)	1, 287(39)	749(20)	933(21)	41. Louisiana (Alexandria)	
West Virginia (Petersburg).....	812(9)	2, 668(31)	737(29)	3, 060(31)	3, 216(10)	1, 209(29)	42. Oklahoma (Oklahoma City)	
North Carolina (Fayetteville).....	64(32)	1, 261(32)	1, 369(32)	970(33)	710(9)	172(10)	43. N.E. Texas (Dallas)	
South Carolina (Camden).....	927(33)	234(34)	234(34)	1, 012(36)	894(29)	2, 894(31)	44. S.E. Texas (Houston)	
Georgia (Covington).....	1, 012(36)	196(33)	213(33)	505(33)	140(32)	127(32)	45. S. Texas (San Antonio)	
Florida (Ocala).....	204(38)	771(33)	714(37)	879(40)	1, 207(32)	918(33)	46. W. Texas (Lubbock)	
Kentucky (Winchester).....	1, 657(38)	89(41)	1, 155(42)	2, 004(41)	222(34)	222(34)	47. Montana (Helena)	
Tennessee (Athens).....	1, 734(43)	161(44)	239(44)	1, 992(43)	1, 120(36)	1, 230(36)	48. Idaho (Boise)	
Alabama (Gadsden).....	471(33)	1, 133(44)	1, 247(44)	1, 400(45)	202(33)	478(33)	49. W. South Dakota, W. Nebraska, Wyoming (Casper)	
Mississippi (Tupelo).....	204(38)	771(33)	714(37)	879(40)	211(38)	211(38)	50. Colorado (Denver)	
Arkansas (Fayetteville).....	1, 657(38)	89(41)	1, 155(42)	2, 004(41)	1, 026(33)	675(37)	51. New Mexico (Albuquerque)	
Louisiana (Alexandria).....	1, 734(43)	161(44)	239(44)	1, 992(43)	1, 080(38)	955(40)	52. Arizona (Phoenix)	
Oklahoma (Oklahoma City)	1, 142(7)	1, 155(42)	1, 360(41)	1, 992(43)	53. Utah (Salt Lake City)	642(37)	53. Utah (Salt Lake City)	
N.E. Texas (Hillsboro)	1, 734(43)	161(44)	239(44)	1, 992(43)	54. Nevada (Tonopah)	55. Washington (Seattle)	54. Nevada (Tonopah)	
S.E. Texas (San Marcos).....	1, 133(44)	1, 219(45)	1, 247(44)	1, 400(45)	85(41)	1, 254(42)	56. Oregon (Salem)	
W. Texas (Lubbock).....	357(46)	23(47)	401(46)	24(46)	1, 287(7)	1, 287(7)	57. N. California (Oakland)	
Montana (Billings).....	23(47)	357(46)	401(46)	24(46)	2, 094(41)	1, 879(43)	58. S. California (Los Angeles)	
Idaho (Caldwell).....	328(48)	14(49)	354(48)	15(49)	1, 184(43)	1, 321(45)		
Wyoming (Casper).....	1, 663(9)	1, 279(50)	1, 561(9)	1, 475(50)	379(46)	23(47)		
Colorado (Colorado Springs).....	48(46)	163(52)	169(52)	160(52)	234(48)	334(48)		
Arizona (Phoenix).....	2, 808(11)	945(12)	3, 193(11)	1, 017(12)	14(49)	1, 390(50)		
Utah (Provo).....	383(30)	348(49)	399(49)	617(53)	51(46)	1, 476(9)		
Nevada (Austin).....	1(31)	150(47)	78(47)	683(55)	3, 015(11)	959(12)		
Washington (Yakima).....	1, 221(56)	318(3)	1, 222(55)	1, 323(56)	436(30)	443(47)		
Oregon (Salem).....	318(3)	1, 806(57)	373(3)	199(48)	376(49)	581(53)		
N. California (Yuba City).....	7, 011(7)	1, 147(34)	6, 647(7)	1, 352(34)	1, 248(55)	1, 245(56)		
C. California (Fresno).....	2, 108(35)	1, 141(39)	2, 417(35)	1, 361(39)	353(3)	186(48)		
S. California (Los Angeles).....	52(46)	615(51)	110(41)	623(46)	192(54)	1, 819(57)		
	729(52)	2, 564(57)	710(51)	955(52)	6, 281(7)	1, 278(34)		
	82(52)	5, 628(58)	3, 128(57)	173(58)	2, 286(35)	1, 285(39)		
			6, 328(58)		88(41)	587(46)		
					669(51)	898(52)		
					2, 937(57)	146(58)		
					5, 967(58)

Fig. 11. Major turkey shipments, 1962—short-run ex ante model.

TABLE 16
PROPORTIONAL TURKEY PRODUCTION BY STATE, 1961 AND 1962

State	Percentage of total U. S. turkey production		Change	State	Percentage of total U. S. turkey production		Change
	Actual 1961	Predicted 1962			Actual 1961	Predicted 1962	
	per cent				per cent		
Maine.....	.058	.063	+ .005	North Carolina.....	2.767	3.015	+ .248
New Hampshire.....	.087	.092	+ .005	South Carolina.....	.924	.966	+ .042
Vermont.....	.038	.041	+ .003	Georgia.....	.655	.710	+ .055
Massachusetts.....	.501	.541	+ .040	Florida.....	.170	.181	+ .011
Rhode Island.....	.027	.029	+ .002	Kentucky.....	.766	.776	+ .010
Connecticut.....	.280	.309	+ .029	Tennessee.....	.140	.150	+ .010
New York.....	.793	.879	+ .086	Alabama.....	.334	.361	+ .027
New Jersey.....	.187	.206	+ .019	Mississippi.....	.152	.156	+ .004
Pennsylvania.....	1.609	1.753	+ .144	Arkansas.....	3.079	3.082	+ .003
Delaware.....	.208	.209	+ .001	Louisiana.....	.062	.068	+ .006
Maryland.....	.174	.171	— .003	Oklahoma.....	1.752	1.760	+ .008
Ohio.....	3.239	3.233	— .006	Texas.....	4.839	5.098	+ .259
Indiana.....	4.082	4.079	— .003	Montana.....	.016	.018	+ .002
Illinois.....	1.373	1.371	— .002	Idaho.....	.239	.252	+ .013
Michigan.....	1.448	1.474	+ .026	Wyoming.....	.010	.011	+ .001
Wisconsin.....	4.729	4.716	— .013	Colorado.....	2.083	2.255	+ .172
Minnesota.....	15.230	14.681	— .549	New Mexico.....	.037	.037	.000
Iowa.....	9.256	8.873	— .383	Arizona.....	.113	.125	+ .012
Missouri.....	5.513	5.125	— .388	Utah.....	4.082	4.095	+ .013
North Dakota.....	1.237	1.239	+ .002	Nevada.....	.001	.001	.000
South Dakota.....	.825	.788	— .037	Washington.....	.513	.509	— .004
Nebraska.....	1.539	1.472	— .067	Oregon.....	1.791	1.813	+ .022
Kansas.....	1.137	1.142	+ .005	California.....	18.189	18.400	+ .211
Virginia.....	3.096	3.052	— .044				
West Virginia.....	.619	.623	+ .004				

response to the relatively high 1961 price of turkey in the state.

Forecasts of average (unweighted) farm price of turkey in the United States are \$298.36 per 1,000 RTC pounds in 1962, \$261.39 in 1963, and \$283.26 in 1964. These represent, over the previous year, an increase of 15.4 per cent (1962 over 1961), a decrease of 12.4 per cent (1963 over 1962), and an increase of 8.4 per cent (1964 over 1963). Because the United States price elasticity of demand for turkey is close to unity (-0.924), these fluctuations are in the opposite direction of, and roughly in the same proportion as, the changes in total United States production.

Predictions of area farm prices for all

three years are shown in table 17. Prices are highest in the East and South, lowest in the West and Midwest. As a condition of the model solution, no prices differ by more than the transportation cost between any pair of areas. Because the shipping pattern is nearly the same for all three years, so are the relative prices.

The aggregate solutions—total quantities produced and average United States prices—for the three years display a cobweb effect. As the price elasticity of demand (-0.924) exceeds, in absolute terms, the price elasticity of supply (0.539), the usual condition for converging fluctuations is met. However, both the demand and supply functions are shifted to the right in each time

TABLE 17
PREDICTED FARM PRICE OF TURKEY BY AREA

Producing area	Predicted farm price of turkey			Producing area	Predicted farm price of turkey		
	1962	1963	1964		1962	1963	1964
<i>dollars per 1,000 RTC pounds</i>				<i>dollars per 1,000 RTC pounds</i>			
Maine.....	310.93	273.93	295.79	Kansas.....	295.92	257.99	279.85
New Hampshire.....	309.64	272.63	294.49	Virginia.....	304.82	267.83	289.69
Vermont.....	308.79	271.79	293.65	West Virginia.....	304.51	267.51	289.37
Massachusetts.....	309.79	272.78	294.64	North Carolina.....	303.52	266.53	288.39
Rhode Island.....	309.88	272.88	294.74	South Carolina.....	305.22	268.23	290.09
Connecticut.....	309.45	272.45	294.31	Georgia.....	303.26	266.26	288.12
New York.....	307.72	270.72	292.58	Florida.....	305.80	268.80	290.66
New Jersey.....	308.25	271.25	293.11	Kentucky.....	302.46	265.46	287.32
Pennsylvania.....	307.46	270.46	292.32	Tennessee.....	301.76	264.76	286.62
Delaware.....	306.91	269.91	291.77	Alabama.....	302.26	265.26	287.12
Maryland.....	306.95	269.96	291.82	Mississippi.....	300.57	263.57	285.43
E. Ohio.....	303.82	266.82	288.68	Arkansas.....	295.48	258.48	280.34
W. Ohio.....	302.64	265.64	287.50	Louisiana.....	299.53	263.11	284.97
N. Indiana.....	301.41	264.41	286.27	Oklahoma.....	294.17	257.17	279.03
S. Indiana.....	300.45	263.45	285.31	N.E. Texas.....	295.20	258.78	280.64
Illinois.....	299.11	262.11	283.97	S.E. Texas.....	295.92	259.50	281.36
Michigan.....	301.91	264.91	286.77	W. Texas.....	295.21	258.21	280.07
N. Wisconsin.....	296.53	259.53	281.39	Montana.....	291.23	254.23	276.09
S. Wisconsin.....	299.01	262.01	283.87	Idaho.....	289.51	252.51	274.37
N. Minnesota.....	293.51	256.51	278.37	Wyoming.....	293.05	256.05	277.91
N.C. Minnesota.....	294.92	257.92	279.78	Colorado.....	291.58	254.58	276.44
S.C. Minnesota.....	295.15	258.15	280.01	New Mexico.....	290.60	253.60	275.46
S. Minnesota.....	296.02	259.02	280.88	Arizona.....	289.61	252.61	274.47
N.W. Iowa.....	296.21	259.21	281.07	Utah.....	287.40	250.40	272.26
S.E. Iowa.....	297.55	260.55	282.41	Nevada.....	292.23	255.24	277.10
N. Missouri.....	296.41	259.41	281.27	Washington.....	287.42	250.42	272.28
S. Missouri.....	296.26	259.26	281.12	Oregon.....	286.38	249.38	271.24
North Dakota.....	292.76	255.76	277.62	N. California.....	282.82	245.82	267.68
South Dakota.....	294.33	257.33	279.19	C. California.....	281.99	244.99	266.85
Nebraska.....	294.46	257.46	279.32	S. California.....	284.45	247.96	269.82

period by exogenous variables (population and income represented by time in the demand equation, and technological change represented by time in the supply equation); consequently, the convergence of the solution depends on the rates of shift as well as the shapes of the curves. Since short-run prediction is the primary purpose of this model, its long-run convergence properties are not examined in any detail here.

Evaluation of Results

The 1962, 1963, and 1964 predictions from the short-run ex ante model were

made with the information available on January 1, 1962. The forecasts for these years now can be evaluated against what actually took place in the turkey industry in those years.

Table 18 provides an overall comparison of the actual and predicted quantities produced and prices of turkey in the United States in the three years 1962, 1963, and 1964. The model predicts total production in 1962 with reasonable accuracy; the prediction error is less than one-tenth of 1 per cent. This is attributed largely to the area supply functions; the remainder of the model (de-

TABLE 18
COMPARISON OF ACTUAL AND PREDICTED U. S. QUANTITIES
AND PRICES OF TURKEY

Year	U. S. quantity produced			U. S. price		
	Actual	Predicted	Error	Actual	Predicted	Error
	thousand RTC pounds		per cent	dollars per 1,000 RTC pounds		per cent
1962.....	1,303,865	1,304,726	0.07	294.06	298.36	1.46
1963.....	1,355,195	1,497,827	10.52	294.93	261.39	-11.37
1964.....	1,454,104	1,415,256	-2.67	283.50	283.26	-.08

SOURCES:
Actual production: U. S. Statistical Reporting Service (1964, p. 5) and (1965, pp. 5, 7). Converted to RTC basis by multiplying by the yield (.80 for 1962, .81 for 1963 and 1964).
Actual prices: *Ibid.* Simple average of state prices; converted to RTC basis by dividing by the yield.
Predicted data: Short-Run Ex Ante Model.

mand functions and transfer costs) played no part in the forecast because the first supply prediction (for 1962) was based on *actual* 1961 prices, not prices that were the product of a previous solution.

The average price prediction for 1962 is also quite close, being about 1½ per cent too high. An overprediction was expected because the demand functions ignore changes in cold storage holdings, and frozen turkey inventories, at an all-time high at the beginning of 1962, declined some 60 million pounds during the year. This resulted in a net addition of 4½ per cent to the effective quantity of turkey consumed; hence with an elasticity of -0.924, price would be expected to fall by about 4 per cent more than if there were no change in inventories. An overprediction by the model of 4 per cent rather than 1½ per cent might therefore be expected.

While aggregate production and price forecasts for 1962 were close to actual, individual *area* predictions were not so accurate. This could be expected since both demand and supply functions were

estimated for the entire United States, with area functions derived from them under the assumption of constant elasticities among all areas.

A comparison of the actual and predicted turkey production by states for 1962 is shown in Table 19. A weighted average of the absolute prediction errors shown in column 3 is calculated as follows:

$$\frac{\sum_{i=1}^{48} |QA_i - QP_i|}{\sum_{i=1}^{48} QA_i}$$

where *QA* = actual quantity produced, *QP* = quantity predicted, and *i* represents the state. The weighted average error is 8.9 per cent.³² The supply function is most accurate for the midwestern states which constitute the largest single producing area. The results indicate that estimation of separate supply functions by (at least) major subregions of the United States would be desirable and, in fact, necessary where state estimates are a matter of major concern.

Area price predictions are compared

³² This is roughly comparable to Henderson's efficiency measure (Henderson, 1959, pp. 80-83). His measure is 1 - C/2 where C represents the above measure but in the unweighted form. (His reason for dividing by 2 is that if one area is off X per cent, another area must also be off X per cent in the other direction to compensate for it.) By this criterion our predictions are 95.55 per cent accurate.

TABLE 19
COMPARISON OF ACTUAL AND PREDICTED STATE TURKEY PRODUCTION,
1962

State	Actual production	Predicted production	Prediction error	State	Actual production	Predicted production	Prediction error
	<i>1,000 RTC pounds of turkey</i>		<i>per cent</i>		<i>1,000 RTC pounds of turkey</i>		<i>per cent</i>
Maine.....	427.200	826.474	+ 93.463	West Virginia.....	10,056.000	8,121.898	- 19.233
New Hampshire.....	1,057.600	1,203.008	+ 13.749	North Carolina.....	36,300.800	39,338.886	+ 8.369
Vermont.....	384.000	530.534	+ 38.160	South Carolina.....	9,828.000	12,606.587	+ 28.272
Massachusetts.....	5,254.400	7,061.919	+ 34.400	Georgia.....	9,639.200	9,267.444	- 3.857
Rhode Island.....	695.200	379.091	- 45.470	Florida.....	2,484.000	2,366.696	- 4.722
Connecticut.....	3,352.000	4,032.088	+ 20.289	Kentucky.....	12,736.000	10,124.029	- 20.509
New York.....	9,295.200	11,466.516	+ 23.360	Tennessee.....	1,753.600	1,957.573	+ 11.632
New Jersey.....	2,484.000	2,686.156	+ 8.138	Alabama.....	3,436.000	4,709.305	+ 37.058
Pennsylvania.....	21,200.000	22,869.552	+ 7.875	Mississippi.....	2,460.000	2,037.095	- 17.191
Delaware.....	1,969.600	2,730.539	+ 38.634	Arkansas.....	35,412.800	40,214.140	+ 13.558
Maryland.....	3,526.400	2,227.768	- 36.826	Louisiana.....	725.600	885.020	+ 21.971
Ohio.....	47,072.800	42,177.495	- 10.399	Oklahoma.....	19,573.600	22,967.687	+ 17.340
Indiana.....	51,573.600	53,222.763	+ 3.198	Texas.....	63,880.000	66,505.276	+ 4.110
Illinois.....	17,168.000	17,890.892	+ 4.211	Montana.....	3,885.600	3,512.522	- 9.602
Michigan.....	17,194.400	19,238.309	+ 11.887	Idaho.....	3,885.600	3,512.522	- 9.602
Wisconsin.....	59,142.400	61,538.899	+ 4.052	Wyoming.....	58.400	140.530	+140.634
Minnesota.....	185,835.200	191,541.770	+ 3.071	Colorado.....	26,227.200	29,423.446	+ 12.187
Iowa.....	112,684.000	115,770.400	+ 2.739	New Mexico.....	419.200	484.265	+ 15.521
Missouri.....	61,932.000	66,858.997	+ 7.955	Arizona.....	2,836.800	1,625.968	- 42.683
North Dakota.....	14,200.000	16,171.678	+ 13.885	Utah.....	56,656.800	53,426.979	- 5.701
South Dakota.....	10,412.000	10,279.519	- 1.272	Nevada.....	16.000	13.384	- 16.350
Nebraska.....	17,556.800	19,207.512	+ 9.402	Washington.....	8,044.800	6,641.508	- 17.443
Kansas.....	12,298.400	14,903.734	+ 21.184	Oregon.....	22,347.200	23,651.129	+ 5.835
Virginia.....	39,381.600	39,814.454	+ 1.099	California.....	278,990.400	240,074.540	- 13.949

SOURCES:

Column 1: U. S. Statistical Reporting Service (1964, p. 5). Adjusted from liveweight to RTC pounds by multiplying by .80, the dressing yield.

Column 2: Predicted by the Short-Run Ex Ante Model.

Column 3: (Column 2 minus column 1) divided by column 1.

with actual prices in table 20 in a manner similar to the supply comparison shown above. The comparison is an average of the absolute percentage difference between area prices from the linear programming dual solution and the corresponding actual prices (two or more areas in one state are assumed to have the same actual price):

$$\frac{\sum_{i=1}^{60} \frac{|PA_i - PP_i|}{PA_i}}{60}$$

where PA is actual price, PP is predicted price, and i the area. The average

price difference weighted by area turkey produced is 10.5 per cent.

As in the previous short-run ex post model, table 20 shows that prices in the northeastern areas are underestimated, and most other prices are overestimated. Actual area prices differ far more than the transportation cost between them, while predicted prices are allowed to vary by no more than this amount. For example, Maine and New Hampshire prices differ by \$18.75. The maximum possible shipping distance (from northern Maine to southern New Hampshire) is about 450 miles—an estimated trans-

TABLE 20
COMPARISON OF ACTUAL AND PREDICTED AREA TURKEY PRICE, 1962

Producing area	Actual price	Estimated price	Estimation error	Producing area	Actual price	Estimated price	Estimation error
	<i>dollars per 1,000 RTC pounds</i>		<i>per cent</i>		<i>dollars per 1,000 RTC pounds</i>		<i>per cent</i>
Maine.....	366.250	310.930	-15.104	Kansas.....	257.500	294.985	+14.556
New Hampshire.....	355.000	309.640	-12.777	Virginia.....	292.500	304.822	+ 4.212
Vermont.....	366.250	308.787	-15.690	West Virginia.....	268.750	304.514	+13.307
Massachusetts.....	393.750	309.785	-21.324	North Carolina.....	271.250	303.520	+11.896
Rhode Island.....	405.250	309.880	-23.722	South Carolina.....	276.250	305.218	+10.485
Connecticut.....	403.750	309.453	-23.355	Georgia.....	285.000	303.261	+ 6.406
New York.....	377.500	307.716	-18.486	Florida.....	327.500	305.804	- 6.625
New Jersey.....	341.250	308.253	- 9.669	Kentucky.....	263.750	302.462	+14.677
Pennsylvania.....	345.000	307.461	-10.881	Tennessee.....	278.750	301.764	+ 8.255
Delaware.....	296.250	306.914	+ 3.599	Alabama.....	272.500	302.262	+10.921
Maryland.....	293.750	306.953	+ 4.494	Mississippi.....	276.250	300.572	+ 8.803
E. Ohio.....	282.500	303.822	+ 7.547	Arkansas.....	268.750	295.484	+ 9.947
W. Ohio.....	282.500	302.639	+ 7.128	Louisiana.....	306.250	299.534	- 2.193
N. Indiana.....	273.750	301.408	+10.102	Oklahoma.....	267.500	294.166	+ 9.968
S. Indiana.....	273.750	300.449	+ 9.752	N.E. Texas.....	265.000	295.199	+11.395
Illinois.....	278.750	299.106	+ 7.302	S.E. Texas.....	265.000	295.923	+11.668
Michigan.....	283.750	301.913	+ 6.400	W. Texas.....	265.000	295.212	+11.400
N. Wisconsin.....	263.750	296.529	+12.427	Montana.....	273.750	291.225	+ 4.474
S. Wisconsin.....	263.750	299.005	+13.366	Idaho.....	278.750	289.506	+ 3.858
Minnesota.....	263.750	293.506	+11.281	Wyoming.....	280.000	293.050	+ 4.660
N.C. Minnesota.....	263.750	294.918	+11.816	Colorado.....	291.250	291.582	+ .113
S.C. Minnesota.....	263.750	295.152	+11.905	New Mexico.....	251.250	290.601	+15.661
S. Minnesota.....	263.750	296.024	+12.236	Arizona.....	322.500	289.607	-10.199
N.W. Iowa.....	271.250	296.207	+ 9.200	Utah.....	262.500	287.401	+ 9.485
S.E. Iowa.....	271.250	297.551	+ 9.695	Nevada.....	281.250	292.230	+ 3.903
N. Missouri.....	256.250	296.407	+15.670	Washington.....	251.250	287.423	+14.396
S. Missouri.....	256.250	296.263	+15.614	Oregon.....	276.250	286.380	+ 3.666
North Dakota.....	266.250	292.759	+ 9.955	N. California.....	256.250	282.815	+10.366
South Dakota.....	263.750	294.330	+11.593	C. California.....	256.250	281.386	+10.042
Nebraska.....	258.750	294.458	+13.799	S. California.....	256.250	284.445	+11.002

SOURCES:

Column 1: U. S. Economic Research Service (1963a, p. 54). Adjusted from liveweight to RTC pounds by dividing by .80, the dressing yield.

Column 2: Predicted by the Short-Run Ex Ante Model.

Column 3: (Column 2 minus column 1) divided by column 1.

portation cost of \$9.00. Even greater diversity is shown between Rhode Island, the highest actual area price, and New Mexico or Washington, the two lowest. The price difference is a prodigious \$155.00. The longest possible shipment within the 48 states (about 3,400 miles) is estimated to cost less than \$40.00 by truck, and only about \$34.00 using the combined transfer function. The possible reasons for such large price differences advanced in the discussion of

the previous model—primarily underestimation of total transfer and distribution costs, incomplete or inaccurate information, and imperfect competition—need not be restated in detail here.

Using the recursive solution procedure discussed earlier, the prices predicted for 1962 become independent variables in the area supply functions for 1963. Since the aggregate price prediction for 1962 was fairly accurate, 1963 production forecasts were expected to be reasonably

close. Instead, the total supply prediction exceeded actual total production by $10\frac{1}{2}$ per cent (table 18). In part, this overprediction can be attributed to the particular area pattern of prices predicted for 1962. All underpredictions of price were for minor producing areas (principally in the Northeast) while prices in major producing areas were grossly overpredicted (e.g., California and the midwestern states). This would naturally result in some overprediction of total production in 1963. But some of the responsibility for failing to accurately predict total 1963 production rests with the area supply functions themselves. Because the increase in production in 1961 following favorable prices in 1960 proved quite costly to producers, it is probable that they were not as responsive to the relatively high prices in 1962 as they had been during the 15 year period (1947–61) upon which the supply response elasticities were based. The supply equations as formulated would not reflect this change in attitude by producers.

With an overestimate of $10\frac{1}{2}$ per cent in production and a price elasticity of demand close to unity, it is not surprising that the 1963 price prediction fell about 11 per cent below the actual average area price. Changes in cold storage holdings were not an important factor in 1963 or 1964.

Following the recursive procedure, 1963 price forecasts are used in the supply functions for 1964. The 1964 predictions, both price and supply, are reasonably accurate. *Area* price and production forecasts for both 1963 and 1964, not shown, display a similar regional pattern to those for 1962.

In summary, the model proved fairly accurate in its first year predictions, but partly because of compounding errors resulting from the assumption of equal

elasticities in all areas and from inaccurate predictions of area price differentials, ensuing forecasts were less reliable.

LONG-RUN EX ANTE MODEL

The necessary components of this model are: future area production costs, future area consumption estimates, and future transfer costs among all areas. The sum of future production and transportation costs is minimized to solve the problem, and the dual solution yields relative area prices.

The model attempts to show production location and shipments which will tend to occur after a length of time in the future sufficient for all factors of production to become variable. The intent is to assess the absolute comparative advantage of every area, taking into consideration area production and processing costs, consumption location, and transfer costs.

Empirical Results

The year 1976 is chosen for the long-run model estimates of the turkey industry because it coincides with published state population projections, and allows sufficient time for all or most factors of production to become variable. Future area production and processing cost estimates are assumed to be equal to present costs as developed in table 10. A separate long-run interregional model is solved for each of the three alternative production and processing cost estimates made in table 10. A perfectly elastic supply assumes constant factor prices and non-limiting factor supplies regardless of regional shifts occurring in turkey production. The transfer costs in table 7 are used, implying that relative transfer costs will remain constant through time. Area consumption in 1976 shown in table 21 is assumed to be pre-

determined, based on 1976 population projections and current per capita consumption. All other factors influencing demand are assumed to remain constant.

Area production estimates yielded by the three long-run models are shown in table 22. Actual 1961 production is also listed for comparative purposes. The first solution (with production cost estimates based on 1960 ingredient prices) shows 11 areas supplying all of the turkey. Three of these areas supply only one consuming area: Arkansas supplies itself (40),³³ as does Oklahoma (42), and north central Minnesota ships to the tri-state area of northern Wisconsin, Michigan, and Minnesota (22). Two other areas support only two consuming areas each: northeastern Texas supplies Louisiana (41) and itself (43); southeastern Texas supplies southern Texas (45) and itself (44). Kansas ships to Colorado (50), western Kansas (21), and the western Missouri-eastern Kansas area (20). Northern Minnesota ships west to four areas—North Dakota (28), Montana (47), Washington (55), and Oregon (56)—while south central Minnesota ships southwest to five—Utah (53), western South Dakota-western Nebraska-Wyoming (49), Idaho (48), eastern South Dakota (27), and eastern Nebraska-western Iowa (26). Western Texas ships to the remaining western states: both California areas (57, 58), Nevada (54), Arizona (52), New Mexico (51), and itself (46). Mississippi supports eight southern states: North Carolina (31), South Carolina (32), Georgia (33), both Florida areas (34, 35), Tennessee (37), Alabama (38), and itself (39). Southern Minnesota supplies the other 25 areas, comprising about 60 per cent of the total turkey consumed. This includes all the northeastern areas (1–11),

most of those in the Midwest (12–19, 23–25), and Virginia (29), West Virginia (30), and Kentucky (36).

If ration costs are based on 1961 ingredient prices, only nine areas, eight of which are included in the above solution, supply all of the turkey (column 3, table 22). Louisiana is the new area; Kansas, south central Minnesota, and Oklahoma are excluded. The amounts produced in each area have changed considerably. Mississippi is now the largest producer, supplying over 70 per cent of the total turkey consumed. Five of the nine areas supply only one consuming area: northern Minnesota ships to North Dakota (28); north central Minnesota supplies the tri-state area of northern Wisconsin, Minnesota, and Michigan (22); southern Minnesota supports the western Wisconsin-southern Minnesota area (23); and Louisiana and northeast Texas supply themselves (41, 43). Southeast Texas supplies two areas—southeast and south Texas (44, 45). West Texas ships to the California areas (57, 58), Washington (55), Nevada (54), Arizona (52), New Mexico (51), and itself (46). Arkansas supplies 11 consuming areas, none of which are in the South. The areas are Oregon (56), Utah (53), Colorado (50), Idaho (48), Montana (47), Oklahoma (42), and the five areas comprising various sections of South Dakota, Wyoming, Nebraska, Iowa, Kansas, and Missouri (20, 21, 26, 27, 49). Mississippi supplies the remaining 33 areas, including all of the Northeast (1–11), most of the Midwest (12–19, 24, 25), and the South (29–40).

If the ration cost is based on the 1960–1961 average of the turkey growing mash price (purported to be the average price paid by producers for the mash combination most common to their region),

³³ Numbers in parentheses correspond to the numbers assigned to consuming areas in table 4.

TABLE 21
AREA TURKEY CONSUMPTION PROJECTIONS FOR 1976

Consumption area	1976 area population	1961 per capita turkey consumption	1976 area turkey consumption
	<i>thousands</i>	<i>RTC pounds</i>	<i>1,000 RTC pounds</i>
Maine.....	1,069	9.057	9,681.933
New Hampshire.....	710	9.215	6,542.650
Vermont.....	377	8.702	3,280.654
Massachusetts.....	5,487	9.924	54,452.988
Rhode Island.....	1,056	10.002	10,562.112
N.E. Connecticut.....	2,332	9.687	22,590.084
S. New York, N. New Jersey, S.W. Connecticut.....	19,296	10.239	197,571.744
N. New York.....	6,941	9.411	65,321.751
E. Pennsylvania, S. New Jersey, N. Delaware.....	10,728	9.927	104,351.256
S. Delaware, Maryland, Washington, D.C.....	5,733	9.687	55,535.571
W. Pennsylvania.....	5,218	9.372	49,493.532
N. Ohio.....	6,770	7.283	49,305.910
S. Ohio.....	6,132	7.283	44,659.356
S.E. Michigan.....	6,676	7.283	48,621.308
S.W. Michigan.....	4,486	7.322	32,846.492
S. Indiana.....	5,530	7.322	40,490.660
N.W. Indiana, N.E. Illinois.....	8,751	7.243	63,383.493
C. Illinois.....	3,347	7.322	24,506.734
S. Illinois, E. Missouri.....	4,566	7.283	33,254.178
W. Missouri, E. Kansas.....	3,124	7.322	22,873.928
W. Kansas.....	1,809	7.322	13,245.498
N. Wisconsin, N. Michigan, N. Minnesota.....	1,673	7.322	12,249.706
W. Wisconsin, S. Minnesota.....	3,859	7.283	28,105.097
S.E. Wisconsin.....	4,478	7.283	32,613.274
E. Iowa.....	2,439	7.283	17,763.237
E. Nebraska, W. Iowa.....	2,397	7.322	17,550.834
E. South Dakota.....	650	7.362	4,785.300
North Dakota.....	695	7.362	5,116.590
Virginia.....	5,351	6.140	32,855.140
West Virginia.....	1,905	6.100	11,620.500
North Carolina.....	5,598	6.100	34,147.800
South Carolina.....	2,969	6.100	18,110.900
Georgia.....	4,659	6.139	28,601.601
N. Florida.....	5,137	6.179	31,741.523
S. Florida.....	3,248	6.258	20,325.984
Kentucky.....	3,363	6.140	20,648.820
Tennessee.....	3,943	6.140	24,210.020
Alabama.....	3,575	6.140	21,950.500
Mississippi.....	2,169	6.100	13,230.900
Arkansas.....	1,406	6.100	8,576.600
Louisiana.....	4,114	6.179	25,420.406
Oklahoma.....	2,341	6.179	14,465.039
N.E. Texas.....	4,484	6.179	27,706.636
S.E. Texas.....	3,300	6.218	20,519.400
S. Texas.....	3,130	6.218	19,462.340
W. Texas.....	2,365	6.218	14,705.570
Montana.....	908	7.677	6,970.716
Idaho.....	828	7.716	6,388.848
W. South Dakota, W. Nebraska, Wyoming.....	672	7.598	5,105.856
Colorado.....	2,580	7.167	18,490.860

TABLE 21—*Continued*

Consumption area	1976 area population	1961 per capita turkey consumption	1976 area turkey consumption
	<i>thousands</i>	<i>RTC pounds</i>	<i>1,000 RTC pounds</i>
New Mexico.....	1,255	7.322	9,189.110
Arizona.....	2,144	7.125	15,276.000
Utah.....	1,297	7.125	9,241.125
Nevada.....	523	7.204	3,767.692
Washington.....	3,844	7.233	27,995.852
Oregon.....	2,415	7.401	17,873.415
N. California.....	10,110	7.086	71,639.460
S. California.....	13,636	6.731	91,783.916
48 states.....	229,598	7.624	1,750,455.152

SOURCES:

Column 1: U. S. Outdoor Recreation Resources Review Committee (1962, pp. 15-16). Populations of consuming areas comprising more than one state are assumed to increase in proportion to the average increase of the total population of the composite states.

Column 2: Bawden (1964b, p. 122). Table C.V.2, column 11.

Column 3: Column 1 multiplied by column 2.

the long-run solution shows Arkansas producing all of the turkey for the United States (column 4, table 22).

Evaluation of Results

The long-run models do not purport to predict exact production location or shipping patterns in the future. Rather, their purpose is to show which areas are likely to have a comparative advantage, from which tentative conclusions can be derived about the direction of future shifts in the location of turkey production. It is reasonable to suppose that cost differences among producers in any one area are as large as, or larger than, average cost differences among areas. Assuming that this within-area variability will continue to exist, it is likely that some turkey will continue to be produced in every area. The importance of long-run interregional models is to indicate where concentrations of production will probably exist.

Interpreted in this light, the three solutions appear quite reasonable. While locational emphasis varies depending on the particular feed prices used, the models suggest that turkey production

will concentrate either in the Midwest (mainly Minnesota) and the South, or both. Production in the Northeast and West is excluded, regardless of the particular feed prices chosen. The advantage of the Midwest is primarily in cheaper feed, while the advantage of the South lies mainly in lower labor cost. The West is at a disadvantage to the South and Midwest both in labor and feed costs. Production costs in the Northeast are so high that this is not likely to be an important supply area under any expected economic conditions.

Very small cost changes tend to shift production between the Midwest and South however. The Midwest outproduces the South using 1960 ration ingredient prices, while the situation is just reversed using 1961 ingredient prices. In the latter solution, Mississippi produces 70 per cent of all turkey; yet an increase of 7 per cent in its ration cost would completely eliminate it as a producer, and an increase of 3 per cent would reduce its production to a negligible amount. Using the turkey growing mash price statistics, Arkansas has an advantage over every other area. If the Arkansas

TABLE 22
 ACTUAL 1961 TURKEY PRODUCTION AND 1976 PRODUCTION ESTIMATED BY
 THE THREE LONG-RUN INTERREGIONAL MODELS, BY AREA

Production area	Actual 1961 turkey production	1976 turkey production estimated by the long-run model using ration costs based on		
		1960 ingredient prices	1961 ingredient prices	1960-1961 growing mash price
	10,000 RTC pounds of turkey			
Maine.....	88	0	0	0
New Hampshire.....	131	0	0	0
Vermont.....	56	0	0	0
Massachusetts.....	753	0	0	0
Rhode Island.....	40	0	0	0
Connecticut.....	421	0	0	0
New York.....	1,192	0	0	0
New Jersey.....	281	0	0	0
Pennsylvania.....	2,417	0	0	0
Delaware.....	313	0	0	0
Maryland.....	262	0	0	0
E. Ohio.....	2,326	0	0	0
W. Ohio.....	2,541	0	0	0
N. Indiana.....	2,406	0	0	0
S. Indiana.....	3,728	0	0	0
Illinois.....	2,063	0	0	0
Michigan.....	2,175	0	0	0
N. Wisconsin.....	5,660	0	0	0
S. Wisconsin.....	1,447	0	0	0
N. Minnesota.....	2,023	5,796	512	0
N.C. Minnesota.....	5,822	1,225	1,225	0
S.C. Minnesota.....	8,976	4,308	0	0
S. Minnesota.....	6,065	106,005	2,811	0
N.W. Iowa.....	9,048	0	0	0
S.E. Iowa.....	4,862	0	0	0
N. Missouri.....	1,938	0	0	0
S. Missouri.....	6,347	0	0	0
North Dakota.....	1,858	0	0	0
South Dakota.....	1,240	0	0	0
Nebraska.....	2,313	0	0	0
Kansas.....	1,709	5,461	0	0
Virginia.....	4,653	0	0	0
West Virginia.....	930	0	0	0
North Carolina.....	4,159	0	0	0
South Carolina.....	1,389	0	0	0
Georgia.....	985	0	0	0
Florida.....	256	0	0	0
Kentucky.....	1,151	0	0	0
Tennessee.....	210	0	0	0
Alabama.....	501	0	0	0
Mississippi.....	229	19,232	123,284	0
Arkansas.....	4,627	858	13,700	174,280
Louisiana.....	94	0	2,542	0
Oklahoma.....	2,633	1,447	0	0
N.E. Texas.....	4,310	5,313	2,771	0

TABLE 22—Continued

Production area	Actual 1961 turkey production	1976 turkey production estimated by the long-run model using ration costs based on		
		1960 ingredient prices	1961 ingredient prices	1960-1961 growing mash price
	10,000 RTC pounds of turkey			
S.E. Texas.....	2,572	3,998	3,998	0
W. Texas.....	390	20,637	23,437	0
Montana.....	24	0	0	0
Idaho.....	358	0	0	0
Wyoming.....	15	0	0	0
Colorado.....	3,130	0	0	0
New Mexico.....	56	0	0	0
Arizona.....	170	0	0	0
Utah.....	6,134	0	0	0
Nevada.....	2	0	0	0
Washington.....	771	0	0	0
Oregon.....	2,691	0	0	0
N. California.....	2,790	0	0	0
C. California.....	18,042	0	0	0
S. California.....	6,501	0	0	0

SOURCES:

Column 1: Bawden (1964b, p. 74). Table IV.A.1, column 3.
Columns 2-4: Long-run model solutions.

mash price is raised about 5 per cent, however, Missouri and Minnesota become substantial suppliers.

There is some question as to the reliability of the third solution. Evaluating the ration according to the turkey growing mash price has considerable appeal because it represents the price of the most common ration sold in the area. The extremely low ration cost in Arkansas, however, makes its price statistic suspect.

In terms of effects on particular production areas, the major changes in the long run compared with the present appear to be concentrated in the West and the South. Some of the economic pressures on Western producers are in fact now being felt, with the result that California interests have brought forward several policy proposals to increase the competitive advantage of the West. These policies, aimed at feed and labor

costs, are analyzed in detail in the next section.

The South is shown to be a large producer of turkeys in the model; yet, at present, it is a deficit producer. For turkey production to develop to the extent indicated in this area, processing and other auxiliary facilities must develop. The fact that California is able to compete reasonably effectively at the present time is probably due largely to the existence of sizable external economies of scale represented by the processing and other service industries which have been developed in the state over a long period of time.

If these external economies are important, the model's assumptions of constant costs of several factors (veterinary expense, equipment costs, medication, etc.) and identical technology in all areas would result in an overestimation of production costs in large producing

areas such as California and an underestimation of costs in small producing areas such as the South. These economies are not peculiar to any one area, however, but occur wherever turkey produc-

tion is concentrated. Therefore, their long-run effect is more likely to lengthen the time required to shift production geographically rather than to alter the final production pattern.

APPLICATIONS OF INTERREGIONAL MODELS TO SOME POLICY ISSUES

In recent years, rapidly expanding turkey output and low prices in the United States have created strong political pressures within the turkey industry. By and large, these pressures have taken the form either of (1) demands by the interests in a given region for measures which would improve their relative competitive position at the expense of other regions, or (2) demands for some overall United States agricultural policy which would attempt to improve the economic position of all regions and segments of the turkey industry. The following analysis, therefore, is divided into two parts: The first deals with policy proposals designed to improve the long-run competitive position of California, a major turkey area which—according to the preceding analysis—cannot compete effectively without revisions in relative costs. The second part of the analysis touches on some of the issues raised in a national marketing order for turkeys.

EVALUATION OF POLICIES DESIGNED TO IMPROVE THE COMPETITIVE POSITION OF CALIFORNIA

The results of the preceding long-run ex ante model suggest that California is in a weak competitive position in the long run due to relatively high wages, high feed costs, and high transportation costs on dressed meat shipped to the large consumption centers in the North-

east. The influence of these factors is already being felt in California, resulting in various policy proposals—made both formally and informally—designed to improve California's competitive position. Not surprisingly, these include a proposed national minimum wage law to help equalize labor costs, reductions in transportation rates for dressed turkey meat on West-to-East routes, and reductions in transportation rates for feed grains on Midwest-to-West routes. The long-run ex ante model is used to evaluate these proposals.

A Minimum Wage Law for U. S. Agriculture

Table 11 presented earlier shows that farm wage rates in California are twice those of some southern states and nearly 20 per cent higher than those in the Midwest. Thus, a minimum wage law for agriculture would tend to equalize wages and production costs in various regions. The question and hypothesis to be tested is whether such a law would, in itself, be sufficient to make California a competitive turkey producer in the long run.

To test this hypothesis, the solution to the long-run model was recalculated for each of the three ration costs, assuming a minimum wage rate first of \$1.00 per hour and then \$1.25 per hour. The general nature of the solutions can be indicated without formal presentation of the results in tabular form. All of the

solutions showed that even with a minimum wage law, California was an ineffective competitor in the eastern markets; in fact, other exporting areas continued to ship to California in all cases, so that California was an importer of all its own consumption requirements. Obviously, if the synthesized cost estimates are correct, California's comparative disadvantage cannot be attributed solely to high labor costs, for a minimum wage of \$1.25 per hour raises wage rates both in the South and Midwest to a level nearly identical to that in California. Of course, such a wage structure probably is unrealistically favorable to California in that some of the existing large differentials among areas are likely to continue even with a minimum wage law; if wages in the South were forced to \$1.25 per hour, wages in California would likely rise above current rates.

Although all solutions with a minimum wage indicated that no turkey would be produced in California in the long run, there were differences in the exact location pattern of industry production, depending on which of the three basic ration costs were used. When growing mash prices were used, Arkansas remained the sole producer just as at the original wage rates. However, changes in the wage rates did affect the solution when the ration was based on 1960 or 1961 feed ingredient prices. Using 1960 ingredient prices, a minimum wage rate of \$1.00 induced a shift in production from Texas to Oklahoma and from Arkansas and Mississippi to both Oklahoma and Minnesota. Kansas, the only other supplier, maintained its previous production. With the minimum wage raised to \$1.25 per hour at 1960 ingredient prices, area production changes were similar to those above, but with most of the increased production transferred to Kansas rather than to Oklahoma.

Using 1961 ingredient prices, the production pattern changed from the original solution with present wages but remained the same for a minimum wage of either \$1.00 or \$1.25 per hour. In this solution, Oklahoma becomes a major producer. Wisconsin also increases production, while Texas, Mississippi, and Arkansas supply the rest of United States production. California, with no

TABLE 23
TRANSPORTATION COSTS FOR
DRESSED TURKEY FROM TEXAS AND
CALIFORNIA PRODUCING AREAS TO
NORTHERN AND SOUTHERN
CALIFORNIA CONSUMING AREAS

Production area	Consumption area	
	N. California	S. California
	<i>dollars per 1,000 RTC pounds</i>	
W. Texas.....	17.46	14.98
N. California.....	4.51	8.58
C. California.....	5.34	5.94
S. California.....	8.14	2.97

SOURCE: Table 7.

production, is supplied by shipments from west Texas. Based on 1961 prices for the ration ingredients and present wages, total production and processing costs in west Texas are \$287.54 compared to \$313.51 in California. Increasing wages to \$1.25 in west Texas would increase production and processing costs by \$11.28 to \$298.82. Still, given the transportation costs shown in table 23, west Texas can still reach northern and southern California consumption markets at total costs of \$2.00-\$3.00 less than the lowest cost California producing area (table 24). Of course, given the imperfections in the basic data, the \$2.00-\$3.00 margin is probably not very significant and California would probably continue to produce some turkey. From California's viewpoint, a minimum

wage law of \$1.25 per hour would, at best, allow California producers to remain nearly competitive for the California consumption market. Since California is now a heavy exporter, however, complete self-sufficiency with no exports would still imply a substantial reduction in the size of the California turkey industry. Annual production would have to be reduced from about 275 million

sition was put to test by re-solving the long-run model assuming reductions in freight rates on California turkey exports by 10, 25, and 50 per cent.

Regardless of the amount of freight rate reduction up to 50 per cent (and again using production costs based in turn on each of the three ration alternatives), the solutions indicated that not only was California unable to compete for the eastern market but that California could import turkey cheaper than it could produce its own. In fact, even if transportation of dressed meat from California were costless, California would remain a nonproducer because of the magnitude by which its farm production costs exceed those of the South and Midwest. Thus, the conclusion again is that a reduction in transportation rates on turkey meat alone is not sufficient to substantially improve California's position.³⁴

Changes in Transportation Rates on Feed Grains³⁵

California is a deficit region with respect to feed grain production. Thus, states in or near the large feed grain-producing areas of the United States maintain a substantial feed cost advantage over California. To illustrate, figure 12 shows the price per 100 pounds of turkey grower mash for California, Minnesota, and Arkansas. California mash prices for the period January 1959 through June 1964 have been consistently higher than those in either of the other two states. Since approximately 66 per cent of the total cost of producing heavy turkeys is composed of feed costs, the effect of these higher feed prices could be substantial.

TABLE 24
TOTAL COSTS OF PRODUCING,
PROCESSING, AND SHIPPING
DRESSED TURKEY FROM TEXAS AND
CALIFORNIA PRODUCING AREAS TO
NORTHERN AND SOUTHERN
CALIFORNIA CONSUMING AREAS

Production area	Consumption area	
	N. California	S. California
	<i>dollars per 1,000 RTC pounds</i>	
W. Texas.....	316.28	313.80
N. California.....	318.02	322.09
C. California.....	318.85	319.45
S. California.....	321.65	316.48

SOURCE: Tables 7 and 10.

RTC pounds in 1961-1962 to about 163 million RTC pounds in 1976, a reduction of about 40 per cent.

Changes in Transportation Rates on Turkey Meat

Of all major producing areas in the United States, California has by far the highest transportation rates for dressed turkey meat shipments to the principal consuming markets in the East. This situation has led to the suggestion that California could compete effectively if West-to-East transportation rates on dressed meat were lowered. This propo-

³⁴ Another model, in which a 50 per cent reduction in transportation rates on dressed turkey from California was combined with a \$1.25 per hour minimum wage law for United States agriculture, still showed California to be a turkey importer, although the margin was extremely close.

³⁵ This section is based on a special study by Logan and Dean (1964), prepared at the request of the California State Department of Agriculture.

Fig. 12. Price paid per 100 pounds, turkey growing mash, monthly, January 1959–June 1964.
Source: U.S. Statistical Reporting Service, Agricultural Prices.

Under competitive conditions, the price paid by California feed buyers includes the transportation charges from point of origin. The major components of the California turkey ration which inherently include a transportation charge are feed grains and soybean oilmeal.³⁶ Figure 13 indicates the major areas west of the Mississippi River for which different freight rates would apply to shipments to California (South Pacific Coast Territory).³⁷ The majority of feed grain and soybean oilmeal shipments coming

into California, according to railway officials, originate in areas F (Kansas City and surrounding area), G (Nebraska-Kansas), and H (central Texas-Oklahoma). Table 25 shows that the rates per 100 pounds for shipping feed grains or soybean meal to California from these three areas differ very little with the exception of shipments falling into the 80,000-pound minimum class. Feed grain shipments into California typically originate in area G and fall under the 80,000-pound minimum rate of \$0.87 per 100

³⁶ The ration used to estimate feed costs for California producers was as follows (pounds required to produce 1,000 pounds dressed turkey): corn, 423.38; barley 255.19; milo, 2,850.89; soybean oilmeal (50 per cent), 462.00; cottonseed meal (41 per cent), 276.55; alfalfa meal (17 per cent), 174.46; fish meal (65 per cent), 126.31; meat-bone meal (50 per cent), 179.34; dried whey, 12.22, for a total of 4,760.34 pounds.

³⁷ Detailed transportation rates were obtained from all the major railroad companies. However, because interstate rail rates are regulated by the Interstate Commerce Commission, the rates obtained from the various railroads were identical.

Fig. 13. Rate group areas for railroad shipments west of the Mississippi River. Source: Atchison, Topeka, and Santa Fe Railway System. "Trans-Continental Territorial Rate Group Map."

TABLE 25
RAIL RATES PER 100 POUNDS OF SHIPPING FEED GRAINS AND SOYBEAN MEAL
TO CALIFORNIA FROM THREE MIDWEST REGIONS

Origin (see figure 13)	Feed grains			Soybean meal	
	Minimum shipments of			Minimum shipments of	
	40,000 pounds	80,000 pounds	110,000 pounds	40,000 pounds	50,000 pounds
	<i>dollars</i>				
Group F.....	1.34	0.97	0.80	1.645	1.34
Group G.....	1.34	0.87	0.80	1.645	1.34
Group H.....	1.34	0.815	0.80	1.645	1.34

SOURCE: Atchison, Topeka, and Santa Fe Railway System.

pounds, whereas the soybean meal shipments typically originate in area F and fall under the 50,000-pound minimum rate of \$1.34 per 100 pounds. Using these typical (August 1964) freight rates on grain and soybean meal from the Midwest to California, the total freight charges for the ration quantities of corn, barley, milo, and soybean meal are \$36.89 per 1,000 RTC pounds of turkey. These transportation charges would equal about 25 per cent of the total California ration costs or about 12 per cent of the total California production costs.

The analysis indicates that for California to remain self-sufficient in turkey production, the combined costs of *all* inputs must be reduced by from 4 to 6 per cent. If the entire cost differential is to come entirely from lowering transportation costs on feeds, a reduction of from 35 to 38 per cent would be required for California to remain self-sufficient. Such a reduction would be quite substantial and perhaps unlikely in view of the up-trend in volume of feed shipments to California at present rates, primarily as a result of increases in beef and milk production in the state.

The more ambitious goal of California to remain a substantial net exporter of

turkey would be impossible to achieve through reduction in freight rates on feeds alone. In the long run, no reduction in freight costs on feed alone would allow California to compete with Mississippi and Minnesota in the eastern markets.

RELEVANCE OF INTERREGIONAL MODELS TO A NATIONAL MARKETING ORDER

At the national level, the serious economic difficulty of the turkey industry in 1961 led to the development of a proposed nationwide marketing order for turkeys. This proposal was brought to a referendum vote of turkey producers in June 1962 but was defeated. A complete analysis of this proposal would require a separate study, for there would be both short- and long-run consequences for every level of the turkey industry—egg producers, hatchers, growers, processors, shippers, and retailers.³⁸ The more modest purpose of this section is to describe briefly the 1962 order and then to indicate where and how the models developed in this study could be used to aid in the economic evaluation and administration of such an order.

³⁸ Henry and Stemberger (1962) provide a complete discussion of all phases of the marketing order and show an appreciation of the many aspects involved in such an evaluation.

Brief Description of the 1962 Turkey Marketing Order

Actually, two marketing orders were considered in 1962—one for hatching eggs, the other for turkey meat production. Only the latter is considered here. The turkey meat order would have allowed two types of regulation: (1) allocating production among markets seasonally (e.g., by restricting supply during the holiday season when demand is less elastic and increasing supply in the off-season market), and (2) restricting total turkey production.

Much of the debate surrounding the order centered on the method and possible effectiveness of restricting total turkey meat production. The order proposed that the desired number of turkeys to market would be established by the Secretary of Agriculture. Given this total marketing quota, individuals would be assigned production allotments on the basis of their production record during the three-year period 1959–1961 (with exceptions made for cases requiring special consideration). Production allotments would be assigned to individuals, and these could be passed on to members of the family or to others purchasing those production facilities. Allotments relinquished voluntarily or involuntarily (e.g., due to bankruptcy) might be transferred by the Secretary to persons not having an original production base if the new producer could “establish an ability to produce,” with ability defined as “having the availability of resources of production, either potential or in fact.”

Evaluation of Aspects of the Order

One of the stated objectives of the order was to raise incomes to producers. A price elasticity of demand of less than

unity (an inelastic demand) is a necessary condition for a supply control program which would result in a larger gross income for growers as production is restricted. Since the farm price elasticity of demand for turkey estimated by Brandow (1961) and used in this study, has a numerical value of -0.924 , this condition is met. However, the elasticity value is sufficiently close to unity to raise the question of whether the quantitative impact on grower gross and net incomes would be significant. In a closely related study, Eidman (1964) has investigated this question in more detail and found that restrictions of 10 and 20 per cent in turkey produced would lead to price increases of about 12 and 27 per cent, respectively; or increases in aggregate gross income of about 1 and 2 per cent, respectively. However, the order would significantly raise individual grower's net incomes since a reduction in output would give essentially the same gross income but with lower total variable costs. Eidman (1964) calculates that, for typical California producers operating under a grower allotment system, the return to fixed factors would increase by three or four times with a 10 per cent reduction in aggregate and individual production, and by five to eight times with a 20 per cent reduction. While specific results would undoubtedly vary for other areas of the United States, these data from California may indicate the possible effects on growers returns. If desired, more exact calculations could be obtained for each of the 60 producing regions in this study using the aggregate demand elasticity and the relevant regional production cost data developed in the present study.

While the allocation of production quotas mentioned above does embody some flexibility, such a marketing order would tend to freeze production geo-

graphically through time. If the order were successful in its stated objective of raising producers' incomes, the economic advantage to the producer would be capitalized in his allotment base. Therefore, it is improbable that many allotments would be voluntarily relinquished, from which new production bases could be assigned. One objection to government programs of this type is that freezing production by allotment prevents adjustments among areas to changing economic conditions, resulting in an inefficient location pattern. A measure of the possible inefficiency generated by the turkey order can be obtained by comparing (1) the total production, processing, and transportation cost required to meet projected long-run (1976) demand assuming turkey production frozen in its present location, with (2) the corresponding cost assuming turkey production shifts to the optimum location pattern specified by the long-run ex ante model. If production were frozen in the 1961 pattern, the total cost would exceed \$471,387,000, while the total cost for the optimum pattern would be only \$413,338,000—a reduction of about 14 per cent. Thus, the possible inefficiency resulting from freezing supply according to the historical pattern is far from negligible and should be a consideration in policy formation.

A reason often advanced for the program controlling turkey production was that the industry could not adjust supply rapidly enough in response to adverse conditions. The supply function estimated in this study did show inelasticity, with a numerical value of about 0.5. However, supply functions estimated individually for each region might reveal sizable differences in supply elasticities among regions. One hypothesis is that producers in the important commercial production regions do respond

rapidly to changing profit margins, but that the supply in the less commercial areas is relatively price inelastic. A marketing order which recognized regional differences in supply response might be more effective than one which did not recognize these differences.

Use of Interregional Models in Administration of a Production Control Program

The interregional models and their components might be used in various ways in administering a production control program. For example, the short-run ex post model, with supply fixed according to allotments based on historical production, could specify a set of area price differentials toward which the market would tend to move. These price differentials, together with the national absolute price level determined by the aggregate demand function, would permit area estimates of absolute price levels. These estimated prices could be disseminated by the government to aid producers and shippers toward profitable production and transportation decisions.

The long-run ex ante model would be useful to program administrators primarily as an indication of the long-term efficient location pattern of the industry. This might be useful information in reassignment of allotment bases over the long run.

The short-run ex ante model might be used in various ways. Strengthened with area supply functions, the model could trace out the expected supply response and price levels, area by area for a period of two or three years. If the industry tended to readjust rapidly to an adverse year, a control program might be deemed unnecessary. Or, if the model forecasted an oversupply and consequent low prices and income, the controls might be used

in that particular year. The quantities and prices forecast also could be used, along with the area production cost data, to see if the net income goals of producers are likely to be met. Since area forecasts are made, it might develop that

only certain areas are in economic difficulty and that the control programs might then be more specific by area, rather than an across-the-board national program affecting all producers of the industry.

SUMMARY

The turkey industry in the United States has undergone dramatic change in the past two decades. This study concentrates on attempting to predict the future locational changes of the industry, both in the short and long run. Although the study is national in scope, particular attention is given to the competitive position of California.

Three spatial equilibrium models, including 60 producing regions and 58 consuming regions, are developed. The components of the various models include regional production and processing costs, regional demand and supply functions, and transportation costs.

The short-run *ex post* model suggested that, given the present location of production and consumption in the United States, the transportation of turkey follows reasonably efficient shipment patterns. The short-run *ex ante* model predicted prices, quantities, and shipments by region recursively for the three-year period 1962-1963-1964, based on data available in 1961. Predictions for the first year were reasonably accurate, but errors tended to accumulate beyond this. The long-run *ex ante* model predicted a long-run relocation of the industry, with concentrations of production in the Midwest and South, with the West (including California) dropping out of turkey production. Of course, the results of the long-run programming solutions cannot be interpreted literally. Obviously, some turkeys would be pro-

duced in California even under the cost conditions assumed, due to the particular management skills and efficiency of certain operators. Very likely the cost differences among producers in any one area are as large as, or larger than, average cost differences among areas.

Various policies designed to improve California's long-run competitive position were examined using the interregional models. Neither a uniform United States minimum wage of up to \$1.25 per hour nor a 50 per cent reduction in transportation rates on dressed turkey exports from California would prevent the state from being a net importer of turkey. Transportation rates on feed in shipments would need to be reduced nearly 40 per cent for California to remain self-sufficient in the turkey production of the state.

The interregional models also were used to examine certain aspects of the 1962 turkey marketing order. Freezing production location by historical allotment could increase the aggregate production and processing cost of meeting long-run demand by up to 14 per cent. Interregional models of the general type developed here would seem to be valuable analytical tools in assessing the effects of various types and levels of production control. Adapted to the specific case, and supplemented with judgment and political considerations, the models could be useful in the administration of such programs.

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APPENDIX A

COMPARISON OF ALTERNATIVE U. S. SUPPLY EQUATIONS

Most of the supply equations estimated have a profit statistic as one of the independent variables. The profit variable has three components:

(1) Price per pound of ready-to-cook (RTC) turkey—liveweight price is converted to RTC price by correcting for the average U. S. yield (dressing percentage).

(2) Feed cost per RTC pound—feed price (as measured by the average price paid by farmers for turkey growing mash) and the feed conversion ratio (pounds of feed concentrate to produce one RTC pound of turkey) are both incorporated in this statistic.

(3) Poult cost per RTC pound—poult prices, average weight per bird, and average death loss are all reflected in this statistic. Three alternative profit variables are used in the equations:

(a) A profit index (revenue divided by cost) with feed cost based on the U. S. Department of Agriculture's feed conversion ratio (FCR) data.³⁹

(b) A profit index with feed cost based on regression estimates of the FCR's (regressing the actual FCR's against time and using FCR).

(c) An absolute profit figure (turkey revenue minus poult and feed cost) using the actual FCR data and deflated by the index of prices received by farmers for all farm products.

Table A-1 presents the parameters, t levels, R^2 and d (Durbin-Watson) statistic for each of the 25 supply equations estimated. Since the equations are difficult to compare because of differences in form and included variables, elasticities are derived for selected variables (using the means of the observations when necessary) and listed in table A-2. As all equations do not have a profit variable, and because the profit coefficients are not comparable when the turkey-broiler price ratio is also included in the equation, profit coefficients are converted to price of turkey elasticities.

Without reviewing the complete selection process it might be noted that equations A-9, A-10, A-13 (the one selected and identified as equation (1) in the text), A-18 and A-22 were considered as "finalists." The first difference equation (A-22) has considerable appeal because time trends are eliminated in part from the data, but it is not suited for easy integration into a transportation problem. Were the results far superior to other formulations, the first-difference equation would have been given further consideration.

The linear form (A-18) is the easiest to combine with a transportation problem, but it is less appealing on *a priori* grounds because it implies a constant rate of change. The coefficient of determination (0.85) is also considerably lower than those for the log equations. The profit coefficient of equation A-18 is

³⁹ Letter from Earl F. Hodges, Agricultural Economist, Farm Economics Division, Economic Research Service, U. S. Department of Agriculture, Washington 25, D.C., November 14, 1962. These estimates differ slightly from those published by Ralph D. Jennings (1958, p. 110). Since 1956 an alternative method has been used in estimating the feed consumption statistic. Jennings' figures have been corrected to reflect this changed procedure.

negative, but this is because the price of turkey appears twice—in the profit variable and in the turkey-broiler price ratio. The derived turkey price elasticity is actually +1.101 (see table A-2)⁴⁰.

Equation A-9 differs from equation A-10 only by the exclusion of the time variable. Although technological changes are incorporated in the equation in several ways (FCR's, yields, bird weights, death losses), some technical trends are excluded. Other relevant factors felt to be correlated with time (management ability, asset inflexibility, capital limitations) were left out as well. The time variable was considered essential to represent these.

Equations A-13 and A-10 differed in only one respect. The profit variable in equation A-13 is based on the actual feed

conversion ratio (FCR) data received from the U. S. Department of Agriculture; in equation A-10 the FCR's are predictions from a regression of this data against time. The purpose of this regression was to smooth out the annual FCR fluctuations because no explanation could be found for their movements. However, when equation A-13 had a slightly higher R^2 (0.97 vs. 0.96) and coefficients of greater significance, due only to using the actual FCR data rather than the regression estimates, it was chosen as the one best suited to predict U. S. turkey supplies in the future.

Table A-3 shows the constant terms (A_i) for the 1961 area supply functions as derived from the national supply function A-13 (equation (1) in the text).

⁴⁰ The variable for tables A-1 and A-2 are defined as follows:

t = time in years

Δ = change from one year to the next

Q_T^s = turkey supplied (1,000 RTC pounds)

π = actual profit (cents per RTC pound) using actual FCR data and *deflated* by index of prices received by farmers for all farm products

π° = profit index, using actual FCR data

$\pi^{\circ\circ}$ = profit index, using regression estimates of FCRs

$^{\circ}P_T$ = price of turkey (cents per RTC pound) received by farmers, *deflated* by index of prices received by farmers for all farm products

P_{FG} = average feed grain price (cents per pound) received by farmers during *October–December*; statistic computed on basis of $\frac{1}{2}$ corn, $\frac{1}{6}$ oats, $\frac{1}{6}$ barley, and $\frac{1}{6}$ milo by weight

$^{\circ}P_{FG}$ = P_{FG} *deflated* by index of prices paid by farmers for all commodities

P_B = price of broilers (cents per liveweight pound) received by farmers

$^{\circ}P_B$ = P_B *deflated* by index of prices paid by farmers for all commodities

H = cold storage holdings (millions of RTC pounds) on January 1

$P_{T/B}$ = turkey-broiler price ratio (liveweight prices per pound received by farmers).

TABLE A-1
UNITED STATES SUPPLY EQUATION ESTIMATES

No.	Type	Data span	Coefficients										R^2	d
			$\pi^o_{(-1)}$	$\pi^{oo}_{(-1)}$	${}^oPr_{(-1)}$	$H(t)$	$Pr_{(-1)}$	${}^oPr_{(-1)}$	$P_{B(-1)}$	${}^oP_{B(-1)}$	$Pr_{B(-1)}$	t	Log constant	
A-1.....	Logarithmic	1946-61	-.741†	.....	.....	.187	-.329†	.....	.....	.....	2.361**	....	12.45042	1.56
A-2.....	Logarithmic	1946-61	-.143	.....	.....	.126	-.430*	.....	.....	.....	.870†	.246**	12.65396	§
A-3.....	Logarithmic	1946-61	.....	-.379	.....	.270†	-.375†	.....	.....	.....	2.267**	....	12.08710	§
A-4.....	Logarithmic	1946-61	1.098†	.....	.....	.033	-.174	.....	-1.475**	.....	.....	....	18.22811	1.24
A-5.....	Logarithmic	1946-61	.600†	.....	.....	.063	-.348*	.....	-.648*	.....	.....	.221**	15.17210	§
A-6.....	Logarithmic	1946-61	.....	1.344*	.....	.102	-.164	.....	-1.500**	.....	.....	....	17.96256	§
A-7.....	Logarithmic	1947-61	.....	-.573†	.....	.....	.....	-1.001**	.....	.....	.....	....	8.88987	1.48
A-8.....	Logarithmic	1947-61	.....	.929*	.....	.....	.....	.....	.....	-1.236**	.....	....	10.55162	2.21
A-9.....	Logarithmic	1947-61	.....	.686*	.....	.....	.....	-.288*	.....	-.967**	.....	....	9.86202	1.48
A-10.....	Logarithmic	1947-61	.....	.481†	.....	.....	.....	-.224*	.....	-.493*	.....	.263*	10.77799	2.02
A-11.....	Logarithmic	1947-61	.259	.....	.....	.....	.....	.....	.....	.....	.....	.573**	12.41752	1.66
A-12.....	Logarithmic	1947-61	.213	.....	.....	.....	.....	-.332*	.....	.....	.....	.439**	11.10078	1.25
A-13.....	Logarithmic	1947-61	.539*	.....	.....	.....	.....	-.239†	.....	-.475*	.....	.273*	10.72549	2.10
A-14.....	Logarithmic	1947-61	.033	.....	.....	.....	.....	-.264†	.....	.....	.517†	.395**	11.40454	1.85
A-15.....	Logarithmic	1947-61	.....	.....	-.280**	.....	.....	.....	.....	.....	.....	....	9.13234	1.50

TABLE A-2
UNITED STATES SUPPLY EQUATION ELASTICITIES

Number	Type	Elasticities			
		P $T(t-1)$	H (t)	P $B(t-1)$	t
A-1.....	Logarithmic	1.620	.187	-2.360	....
A-2.....	Logarithmic	.727	.126	- .870	.246
A-3.....	Logarithmic	1.888	.270	-2.267	....
A-4.....	Logarithmic	1.098	.033	-1.475	....
A-5.....	Logarithmic	.600	.063	- .648	.221
A-6.....	Logarithmic	1.344	.102	-1.500	....
A-7.....	Logarithmic	- .573	....	....	....
A-8.....	Logarithmic	.929	....	-1.236	....
A-9.....	Logarithmic	.686	....	- .967	....
A-10.....	Logarithmic	.481	....	- .493	.263
A-11.....	Logarithmic	.259	....	....	.573
A-12.....	Logarithmic	.213	....	....	.439
A-13.....	Logarithmic	.539	....	- .475	.273
A-14.....	Logarithmic	.550	....	- .517	.395
A-15.....	Logarithmic	- .788	....	....	....
A-16.....	Logarithmic	- .097	....	....	.386
A-17.....	Logarithmic	.368	....	- .497	.292
A-18.....	Linear	1.101	- .134	-2.590	....
A-19.....	Linear	.733	.042	.671	.524
A-20.....	Linear	1.238	- .171	-2.693	....
A-21.....	Linear F-D	.949	- .052	- .717	....
A-22.....	Linear F-D	1.033	- .030	- .721	....
A-23.....	Linear F-D	.970	- .042	.692	....
A-24.....	Linear F-D	.556	- .004	- .264	....
A-25.....	Linear F-D	1.082	.009	- .375	....

TABLE A-3
CONSTANT (A_i) FOR 1961 AREA SUPPLY FUNCTIONS

Production areas	Total turkeys raised in state in 1959	Turkey pro- duced in 1961 (liveweight)	Turkey pro- duced in 1961 (RTC)	1960 turkey price per 1,000 liveweight pounds	1960 turkey price per 1,000 RTC pounds	Supply function constant (A_i)
	<i>per cent</i>	<i>thousand pounds</i>		<i>dollars</i>		
Maine.....	100.0000	1,096	876.8	309	386.25	16.88517
New Hampshire.....	100.0000	1,637	1,309.6	306	382.50	25.35288
Vermont.....	100.0000	706	564.8	311	388.75	10.83900
Massachusetts.....	100.0000	9,412	7,529.6	334	417.50	139.04815
Rhode Island.....	100.0000	505	404.0	343	428.75	7.35445
Connecticut.....	100.0000	5,263	4,210.4	337	421.25	77.37906
New York.....	100.0000	14,900	11,920.0	312	390.00	228.35976
New Jersey.....	100.0000	3,510	2,808.0	313	391.25	53.70211
Pennsylvania.....	100.0000	30,214	24,171.2	308	385.00	466.29636
Delaware.....	100.0000	3,911	3,128.8	278	347.50	63.78672
Maryland.....	100.0000	3,275	2,620.0	275	343.75	53.72712
E. Ohio.....	47.7913	29,072	23,257.6	256	320.00	495.69694
W. Ohio.....	52.2087	31,760	25,408.0	256	320.00	541.52913
N. Indiana.....	39.2234	30,071	24,056.8	246	307.50	523.86150
S. Indiana.....	60.7766	46,596	37,276.8	246	307.50	811.74057
Illinois.....	100.0000	25,785	20,628.0	257	321.25	438.72848
Michigan.....	100.0000	27,193	21,754.4	244	305.00	475.81336
N. Wisconsin.....	79.6437	70,748	56,598.4	251	313.75	1,219.19360
S. Wisconsin.....	20.3563	18,083	14,466.4	251	313.75	311.62264
N. Minnesota.....	8.8397	25,288	20,230.4	253	316.25	433.92549

TABLE A-3 (Continued)

Production areas	Total turkeys raised in state in 1959	Turkey pro- duced in 1961 (liveweight)	Turkey pro- duced in 1961 (RTC)	1960 turkey price per 1,000 liveweight pounds	1960 turkey price per 1,000 RTC pounds	Supply function constant (A_i)
	<i>per cent</i>	<i>thousand pounds</i>		<i>dollars</i>		
N.C. Minnesota.....	25.4395	72,775	58,220.0	253	316.25	1,248.77120
S.C. Minnesota.....	39.2205	112,198	89,758.4	253	316.25	1,925.24410
S. Minnesota.....	26.5003	75,809	60,647.2	253	316.25	1,300.83270
N.W. Iowa.....	65.0460	113,094	90,475.2	244	305.00	1,978.87820
S.E. Iowa.....	34.9540	60,773	48,618.4	244	305.00	1,063.38410
N. Missouri.....	23.3910	24,223	19,378.4	243	303.75	424.78463
S. Missouri.....	76.6090	79,335	63,468.0	243	303.75	1,391.25160
North Dakota.....	100.0000	23,228	18,582.4	238	297.50	411.92626
South Dakota.....	100.0000	15,505	12,404.0	265	331.25	259.49253
Nebraska.....	100.0000	28,910	23,128.0	245	306.25	504.74288
Kansas.....	100.0000	21,358	17,086.4	233	291.25	383.12314
Virginia.....	100.0000	58,162	46,529.6	258	322.50	987.54969
West Virginia.....	100.0000	11,624	9,299.2	259	323.75	196.95621
North Carolina.....	100.0000	51,982	41,585.6	260	325.00	878.95162
South Carolina.....	100.0000	17,357	13,885.6	267	333.75	289.31286
Georgia.....	100.0000	12,310	9,848.0	265	332.50	205.60302
Florida.....	100.0000	3,199	2,559.2	307	383.75	49.45717
Kentucky.....	100.0000	14,383	11,506.4	245	306.25	251.11438
Tennessee.....	100.0000	2,622	2,097.6	249	311.25	45.37993
Alabama.....	100.0000	6,265	5,012.0	254	317.50	107.27494
Mississippi.....	100.0000	2,861	2,288.8	268	335.00	47.59220
Arkansas.....	100.0000	57,839	46,271.2	252	315.00	994.60015
Louisiana.....	100.0000	1,172	937.6	276	345.00	19.18934
Oklahoma.....	100.0000	32,915	26,332.0	241	301.25	579.78814
N.E. Texas.....	59.2656	53,870	43,096.0	239	298.75	953.17604
S.E. Texas.....	35.3654	32,146	25,716.8	239	298.75	568.79148
W. Texas.....	5.3690	4,880	3,904.0	239	298.75	86.34674
Montana.....	100.0000	302	241.6	250	312.50	5.21554
Idaho.....	100.0000	4,481	3,584.8	253	316.25	76.89102
Wyoming.....	100.0000	189	151.2	258	322.50	3.20908
Colorado.....	100.0000	39,121	31,296.8	263	328.75	657.41022
New Mexico.....	100.0000	695	556.0	259	323.75	11.77602
Arizona.....	100.0000	2,129	1,703.2	250	312.50	36.76788
Utah.....	100.0000	76,680	61,344.0	243	303.75	1,344.69240
Nevada.....	100.0000	20	16.0	259	323.75	.33887
Washington.....	100.0000	9,643	7,714.4	251	313.75	166.17691
Oregon.....	100.0000	33,633	26,906.4	252	315.00	578.35347
N. California.....	10.2088	34,880	27,904.0	255	318.75	595.98313
C. California.....	66.0084	225,530	180,424.0	255	318.75	3,853.55720
S. California.....	23.7828	81,258	65,006.4	255	318.75	1,388.42880

SOURCES:

Column 1: Turkeys produced by counties is not published. Turkey raised published by the U. S. Bureau of the Census (1961) provided the best estimate of the needed percentage figures.

Column 2: U. S. Statistical Reporting Service (1962a, p. 7). For divided states, percentage listed in column 1 was multiplied by the state total.

Column 3: Column 2 $\times .80$ (.80 is the United States average dressing yield as reported in U. S. Economic Research Service (1962a, p. 37)).

Column 4: Same as for column 2.

Column 5: Column 4 $+$.80.

Column 6: Solving for A in equation $Q_T^s = AP_{T-1}^{.539} t^{.273}$ where Q_T^s = values in column 3, P_{T-1} = values in column 5, and $t = 15$.

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