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Spatial Analyses of the Meat Marketing Sector in 1955 and 1960

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SPATIAL STRUCTURE of the LIVESTOCK ECONOMY

I. Spatial Analyses of the Meat Marketing Sector in 1955 & 1960

Agricultural Experiment Stations of
Illinois
Indiana
Iowa
Kansas
Kentucky
Michigan
Minnesota
Missouri
Nebraska
North Dakota
Ohio
South Dakota
Wisconsin
and the United States Department of Agriculture, cooperating

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FOREWORD

Thirteen Agricultural Experiment Stations in the Midwest joined in a research project entitled, "Adjustments in Livestock Marketing in the North Central States to Changing Patterns of Production and Consumption." Agricultural economists, named on Regional Project Committee above, have made extensive analyses of data on the geographical movement of livestock and meat in the United States in 1955 and 1960 and have made projections for future years. This publication is one of a series eminating from these studies.

Because of the large number of farms and businesses engaged in providing the Nation's meat supply and the importance of meat in the American diet, this study should have widespread significance. In a dynamic society in which the human population is migrating from rural to metropolitan areas and in which some metropolitan areas grow more rapidly than others, there must be a continuous change in the ultimate destination of the meat supply. Likewise, as farm technology and production patterns change, there is a continuous change in the sources of supply. Businesses and industries engaged in the marketing, processing and distribution of livestock and meat must continuously adjust to these changing conditions. Studies that throw light on these changes can provide valuable information to those who must make decisions in these business operations. It is to those farmers and ranchers, marketing and transportation agencies, processors, wholesalers and retailers who are engaged in the complex livestock and meat industry that the study is addressed.

C. Peairs Wilson
Administrative Advisor

CONTENTS

I. Spatial Analyses of the Meat Marketing Sector in 1955 and 1960*

G. G. Judge, J. Havlicek and R. L. Rizek†

I. INTRODUCTION

The livestock products sector is a complex composed of the activities of production, farm marketing, slaughtering, distribution and consumption. The level of each of these activities varies spatially and thus regional imbalances are generated which make necessary product flows between the geographical areas. Within this setting this study is concerned with an interregional analysis of the livestock meat sector of the U. S. economy. Thus, spatial slaughter-consumption relations will be basic observations for this analysis. In this study regional demands are reflected by price dependent demand relations or specific estimates of consumption. Regional supplies are dressed carcass weights of livestock slaughter within the regions.

In particular for the beef, pork, veal, and lamb and mutton sectors for the years 1955 and 1960 answers will be sought to the following questions:

1. What are the levels of regional demand for each of these meat products?
2. What are the levels of regional supply for each of these products?
3. What is the aggregate interregional trade for each meat product for each year?
4. For each commodity and for each year, what regions import, export or do neither?
5. What are the levels of regional exports and imports for each region, commodity and year?
6. What is the "optimum" volume and direction of trade between all possible pairs of regions for each commodity and each year?
7. What are the optimum price differentials between regions for each commodity and year?
8. What is the total transport cost for the aggregate trade of each commodity and year?
9. What is the impact of alternative ways of estimating regional meat consumption on the interregional flows and price differentials?

In the following pages the results that are generated by these questions will be given and the implications and uses of the results will be discussed.

II. THE MODEL

A. The General Framework and Assumptions

The particular problem under study may be viewed within the general framework of equilibrium among spatially separated markets[1] and may be stated as follows: There are n regions trading a homogeneous commodity or commodities. Each region constitutes a single demand and supply for the commodity or commodities. The regions are separated but not isolated by a physical unit transport cost for each commodity. For each region the

*This is the first in a series of three North Central regional bulletins concerned with the spatial structure of the livestock marketing system. As such, the studies will be concerned with estimating the regional level and location of livestock production, slaughter and meat consumption and deriving the competitive prices and flows for four types of livestock and meat in 1955 and 1960. The titles of the three studies reported in this phase of the regional effort are: I. Spatial Analyses of the Meat Marketing Sector in 1955 and 1960. II. Spatial Analyses of the Flows of Slaughter Livestock in 1955 and 1960. III. Joint Spatial Analyses of Regional Slaughter and the Flows and Pricing of Livestock and Meat.

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[1]For a discussion of this framework, see S. Enke, "Equilibrium Among Spatially Separated Markets," *Econometrica,* 19:40-48, 1951; P. A. Samuelson, "Spatial Price Equilibrium and Linear Programming," *American Economic Review,* 42:283-303, 1952; G. G. Judge and T. D. Wallace, "Spatial Price Equilibrium Analysis of the Livestock Economy," Technical Bulletin 78, Oklahoma Experiment Station, 1959.

demand for and supply of each commodity is known, and therefore the excess demands and supplies are also known; i.e., the amount by which each region is surplus or deficit in each commodity is known. Given the regional excess demands and supplies and transport costs, the problem is to find the volume and direction of flows for each commodity between each pair of regions that will maximize returns to each supply source and permit the commodity or commodities to be distributed at a minimum total transport cost.

Within this general framework, the following restrictions and assumptions are made for the particular problem under study. Perfectly competitive behavior assumptions dictate the requirements for the regional pattern of price differentials and flows of the meat products. Thus, each regional firm is assumed to have the objective of maximizing profits and making shipment decisions that will yield the greatest per unit return; i.e., it will attempt to dispose of its supplies at the maximum prices. Also, the price of each type of meat in two different regions can differ at most by the unit cost of transportation from the region of lower price to the region of higher price.

The supply and demand sources for each geographical region are represented by a single-fixed point within the region; intraregional shipments of the meat products are not considered. It is assumed that for any particular time period regional demands for and supplies of each meat product are known or that single-valued estimates of these quantities can be derived. All regions are connected by transport costs that are independent of the volume of trade, and the flows of meat products among regions are assumed to be free of restrictions. It is further assumed that the consumers of each type of meat product are indifferent about the source of supply and that each type of meat product is homogeneous. For any time period, domestic total demands and supplies of each type of meat are assumed to be equal.

Each type of meat is produced and consumed in all regions, but meat consumed out of local production does not require transporting because each region is represented by a point. Also, obviously, there can be no negative shipments of meat. Given the profit-maximizing assumption, there is no cross-hauling of the products, and therefore, deficit regions do not export and surplus regions can export only to deficit regions.

B. The Transportation Model

The regional demand for and supply of each commodity is known, as well as the surplus and deficit regions and the quantities involved in each case. With this information plus relevant transportation costs, the determination of minimum-cost flows for each commodity may be treated as a linear programming problem.[2] In formulating this problem let:

- i,j denote regions with $i = 1,2,...,n$ and $j = 1,2,...,m$.
- a_i denote the amount of product available for export from the ith region.
- b_j denote the amount of meat demanded by the jth region.
- c_{ij} denote the unit transport cost of shipping a meat product from region i to region j.
- x_{ij} denote the amount of a meat product that flows from region i to region j.

With the symbols defined as above, the problem may be stated algebraically as finding a set of x_{ij} (flows) such that:

$$\sum_i \sum_j x_{ij} c_{ij} = \text{minimum} \qquad (1)$$

subject to

$$\sum_j x_{ij} = a_i; \quad i = 1,2,\ldots,n \qquad (2)$$

$$\sum_i x_{ij} = b_j; \quad j = 1,2,\ldots,m \qquad (3)$$

$$\sum_i a_i = \sum_j b_j \quad [3] \qquad (4)$$

and

$$x_{ij} \geq 0 \quad \text{for all } i \text{ and } j. \qquad (5)$$

There are many solutions to Equations (2) and (3) which satisfy Equations (4) and (5) and, given any feasible solution of $n + m - 1$ shipments, the simplex method provides a means of finding the optimum shipment program, i.e., the one that will satisfy Equation (1) subject to Equations (2), (3), (4), and (5).

Given the direct solution to the transportation problem (the optimum set of geographical flows), we may now consider regional price differentials, which are the prime allocators of regional distribution. As in any linear programming problem, the solution implicitly places values on the various inputs

[2] For a discussion of the linear programming transportation problem, see G. B. Dantzig, "Application of the Simplex Method to a Transportation Problem," in *Activity Analysis of Production and Allocation*, edited by T. C. Koopmans, New York, John Wiley and Sons, 1951, pp. 359-73; R. Dorfman *et al.*, *Linear Programming and Economic Analysis*, New York, McGraw-Hill Book Co., 1958, pp. 106-29; G. G. Judge and T. D. Wallace, *op. cit.*, pp. 12-16 and 49-56.

[3] Situations where total supply is not equal to total demand may be handled by introducing either a dummy surplus or deficit region.

and/or outputs. With the aid of the duality theorem of linear programming, a unique set of regional price differentials may be derived which correspond to the optimum set of flows. Thus, in a minimum-cost transportation solution, the dual problem is concerned with deriving that set of regional price differentials which is consistent with the optimum set of flows. In developing the dual formulation, let v_j be associated with the destinations and u_i be associated with the origins or supply points. The problem may then be stated algebraically as one of maximizing

$$\sum_j b_j v_j - \sum_i a_i u_i = S = \text{Maximum} \qquad (6)$$

subject to

$$v_j - u_i \leq c_{ij} \qquad (7)$$

$$u_i, v_j \geq 0 \qquad (8)$$

In Equation (6) the maximum S is equal to the total cost of transportation derived in the minimum formulation; i.e., Equation (1) is equal to Equation (6). Therefore, the maximum problem may be thought of as finding the values of u_i and v_j that will maximize the total gain in value of amounts shipped subject to nonpositive profits on each shipment. Thus, it is possible to interpret u_i as the value of the product at the supply origin i, and v_j as the value of the product delivered at destination j.

Equation (7), then, may be written as:

$$v_j \leq u_i + c_{ij} \qquad (9)$$

This relationship now states that for any supply-destination pair, the value at the destination or demand point must be no greater than the value at the supply point plus transportation cost. If some surplus region is chosen as the base, then a set of price differentials is generated subject to this choice.

In addition to providing estimates of the price differentials, u_i and v_j also provide two other types of information: (1) the values of u_i measure the comparative price advantage of the surplus regions, and (2) the values of v_j are delivered price differentials that correspond to the most economical allocation of supply from the viewpoint of minimum aggregate transportation cost. These outcomes are the competitive equilibrium solutions that would result from the efforts of firms at the supply points to dispose of their supplies at the maximum possible prices, and the solution to the value and flow problems is simultaneous and interdependent.

C. The Spatial Price Equilibrium Model

The previous model considered the case of regional demands and supplies that are fixed or predetermined. However, if information is available concerning the regional demand and/or supply relations, then the process of determining a competitive equilibrium solution becomes more complicated. Under this situation one has the task of determining the regional prices, demands and/or supplies, and the interregional flows consistent with competitive behavior. Several alternatives exist for obtaining a solution under this specification and these alternatives are discussed in a research report by Takayama and Judge.[4] Thus, it should be sufficient here to sketch the joint product model and method employed in this study. As a basis for this specification assume the following regional linear demand functions for the two products, pork and beef:

$$y_{1i} = \beta_{10i} + \beta_{12i}(y_{20} + d_i) + \beta_{13i}(y_{30} + e_i) \qquad (10)$$

$$y_{4i} = \beta_{20i} + \beta_{22i}(y_{20} + d_i) + \beta_{23i}(y_{30} + e_i) \qquad (11)$$

where y_{1i} and y_{4i} denote the regional consumption of pork and beef; y_{20} and y_{30} denote the price of pork and beef in the "base" region, and d_i and e_i denote the price differentials for pork and beef between the base region and ith region. β_{hki} denotes the estimated regional behavior coefficients. The products are assumed to be substitutes for each other and $\beta_{13i}, \beta_{22i} > 0$ and $\beta_{12i}, \beta_{23i} < 0$. The regional prices for pork and beef are $y_{2i} = y_{20} + d_i$ and $y_{3i} = y_{30} + e_i$. Equations (10) and (11) contain six unknowns which under present specifications are indeterminate. If, however, the price differentials e_i and d_i are assumed initially to be zero for all i, then the unknowns are reduced to four. By summing each demand relation over all regions, the total demand for each product $\left(\sum_i y_{1i} \text{ and } \sum_i y_{4i}\right)$ may be set equal to total supply, which is assumed known, and the resulting equations are:

$$\sum_i y_{1i} - \sum_i \beta_{10i} = y_{20} \sum_i \beta_{12i} + y_{30} \sum_i \beta_{13i} \qquad (12)$$

$$\sum_i y_{4i} - \sum_i \beta_{20i} = y_{20} \sum_i \beta_{22i} + y_{30} \sum_i \beta_{23i} \qquad (13)$$

Equations (12) and (13) contain only two unknowns and thus may be solved for equilibrium values of y_{20} and y_{30} (the regional prices). These values

[4] T. Takayama and G. G. Judge, "Non-Linear Formulations of Spatial Equilibrium Models and Methods for Obtaining Solutions," University of Illinois Research Report AERR-66, November 1963. For an application of a joint spatial price equilibrium model see: Y. H. Chuang and G. G. Judge, "Sector and Spatial Analyses of the United States Feed Economy," Illinois Experiment Station, Bulletin 699, 1964.

(prices) may then be substituted into Equations (10) and (11) and the regional demands for each product determined. By then comparing the regional demands with regional supplies, the surplus and deficit regions may be generated. Given the surplus and deficit regions and the quantitites involved along with the relevant transport costs, a transportation linear programming model may then be solved for the optimum flows for each product. The set of price differentials consistent with these flow solutions provides estimates for e_i and d_i which appear in (10) and (11). Using these estimated price differentials, $\hat{e}_i$ and $\hat{d}_i$, a new set of base region prices and demands is computed and the process of computing optimum flows and price differentials is repeated until stability is achieved in the iterative procedure in terms of flows, demands, price differentials and base regional prices. The resulting values reflect a joint product competitive equilibrium outcome for each of the market variables.

III. THE BASIC DATA

Given the conceptual framework and the specification of the type of data needed, we present in this section the basic data used in describing the spatial structure of the meat products sector in 1955 and 1960.

A. Regional Demarcation

The continental U. S. was partitioned into 26 geographically contiguous regions. States are the smallest geographical units for which data are available and thus each region is composed of one or more states. Each regional market or source of supply is represented by a point that is identified with a city near the geographical center of each area. The regional specification is given in Table 1.

B. Data Relating to Regional Population and Income

1. Population

Since most basic data concerning the consumption of each type of meat is given on a per capita basis, regional population is needed to derive regional consumption estimates. Resident population by states (including armed forces stationed in the area) for 1955 and preliminary population by states for 1960 were used to obtain population estimates for the 26 regions.[5] These estimates are given in Table 2.

2. Income

In deriving some of the consumption estimates, regional adjustments were made based on regional income levels. For this purpose per capita disposable income data by states were converted to regional data by averaging the regional components. Data were available for 1955, but not for 1960.[6] To generate regional estimates for 1960, per capita personal income was reduced by the same percentage difference in personal income and disposable income as existed in 1959.[7] A population weighted average of the component states of each region was computed. The resulting regional income estimates are given in Table 2. Alternative spendable income estimates for 1960, which agree quite well with the 1960 estimates reported in Table 2, were generated by *Sales Management Magazine* by projecting 1959 spendable income figures.[8]

[5] *Statistical Abstracts of the U. S. 1961*, U. S. Dept. of Commerce, June 1961, p. 10.

[6] *Survey of Current Business*, U. S. Dept. of Commerce, August 1960, p. 12.

[7] *ibid*, August 1960 and April 1961, p. 13.

[8] "Survey of Buying Power," *Sales Management Magazine*, May 1961, pp. 71-331.

Table 1. Regional Demarcation and Demand and Supply Points

Regions	State (s)	Demand and Supply Points
1	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	Boston, Mass.
2	Delaware, Maryland, New Jersey, New York, Pennsylvania, Washington, D. C.	Philadelphia, Pa.
3	North Carolina, Virginia, West Virginia	Richmond, Va.
4	Florida	Orlando, Fla.
5	Georgia, South Carolina	Atlanta, Ga.
6	Alabama, Mississippi	Columbus, Miss.
7	Kentucky, Tennessee	Nashville, Tenn.
8	Ohio	Columbus, Ohio
9	Indiana	Indianapolis, Ind.
10	Michigan	Detroit, Mich.
11	Illinois	Chicago
12	Wisconsin	Milwaukee
13	Arkansas, Louisiana	Alexandria, La.
14	Missouri	Columbia
15	Iowa	Des Moines
16	Minnesota	St. Paul
17	Oklahoma, Texas	Ft. Worth, Texas
18	Kansas	Kansas City
19	Nebraska	Lincoln
20	North Dakota, South Dakota	Bismarck, N. D.
21	Colorado	Denver
22	Montana, Wyoming	Billings, Mont.
23	Arizona, New Mexico	Phoenix, Ariz.
24	Idaho, Nevada, Utah	Salt Lake City, Utah
25	California	Fresno
26	Oregon, Washington	Portland, Ore.

Table 2. Regional Population and Income Estimates

Region	Population 1955	Population 1960	Income 1955	Income 1960
	(000's)		(dollars per capita)	
1	9,729	10,546	1,818	2,206
2	36,236	38,596	1,883	2,309
3	9,781	10,398	1,278	1,544
4	3,670	5,000	1,505	1,784
5	5,963	6,341	1,140	1,371
6	5,170	5,453	1,006	1,201
7	6,338	6,620	1,130	1,403
8	9,021	9,739	1,850	2,144
9	4,362	4,677	1,707	1,965
10	7,248	7,848	1,916	2,101
11	9,228	10,113	2,023	2,363
12	3,666	3,964	1,588	1,926
13	4,716	5,058	1,106	1,340
14	4,222	4,331	1,596	1,962
15	2,684	2,761	1,425	1,737
16	3,188	3,426	1,513	1,813
17	10,928	11,950	1,423	1,688
18	2,080	2,178	1,506	1,861
19	1,360	1,414	1,456	1,871
20	1,301	1,316	1,214	1,612
21	1,583	1,758	1,528	1,982
22	937	1,010	1,638	1,872
23	1,771	2,276	1,423	1,703
24	1,642	1,855	1,609	1,933
25	13,156	15,850	1,982	2,424
26	4,320	4,633	1,699	2,001

C. Regional Consumption Estimates

1. Survey Data

A household food consumption survey conducted by the USDA in the months of April, May and June of 1955 provides the basic data for the regional consumption estimates for beef, pork and veal. Results of the survey were reported for the Northeast, North Central, South and West Census Regions. For reporting purposes households within each census region were grouped by urbanization and by family income.[9] The results of the survey for beef, pork and veal consumption are reported in Table 3. In general, households in the West had the highest consumption rate per person for beef. For pork, the South and North Central Regions had the highest consumption rates. The consumption of veal was much less important than that of beef and pork and except for the West, the highest rate of consumption was by the urban group. The weekly per capita quantities of each of the meats in Table 3 were converted to an annual basis and their carcass weight equivalents were then obtained.

2. Consumption Estimates for Beef, Pork and Veal Weighted by Urbanization Groups.

Since the consumption of each type of meat varied by region and urbanization group, the distribution of urban, rural nonfarm, and farm population for each of the 26 regions of this study was used as a basis for obtaining regional consumption estimates. A population weighted average of the annual carcass weight equivalent for urban, rural nonfarm and farm per capita consumption was computed for each of the 26 study regions for 1955 and 1960. These regional per capita consumption estimates are presented in Table 4.

In order to generate total regional consumption estimates for beef, pork and veal for 1955 and 1960, the per capita consumption of each meat for each region was multiplied by the population of that region for 1955 and 1960. The results were then summed and where necessary, the national totals were adjusted to agree with the total slaughter data for each of the commodities and each of the years. The resulting estimated total regional consumptions for 1955 and 1960 are reported in Tables 5 and 6.

In the food consumption survey data used, Texas and Oklahoma are classed in the Southern Census Region. Since it was thought that the consumption patterns for these two states were more closely related to those of the West than to the South, alternative estimates were made for beef and pork under this assumption.[10] These estimates appear in Table 7. This change in specification resulted in an increase in beef consumption and a decrease in pork consumption for Oklahoma and Texas relative to the estimates contained in Tables 5 and 6.

[9]For data on the states within each census region, the definition of each urbanization group, and the income classes used, see: "Food Consumption of Households in the United States and in the Northeast, North Central, South, and West," USDA, 1956.

[10]For some information on this topic see: W. F. Williams, "Marketing Potential for Feed Lot Cattle in Oklahoma and Texas," Oklahoma Processed Report P-426, 1962.

Table 3. Quantity of Meats Used at Home Per Person, by Region and Urbanization, All Households, in a Week, Spring, 1955.[a]

	Beef	Veal	Pork
		Pounds	
Northeast	**1.29**	**.12**	**.98**
Urban	1.29	.15	.95
Rural nonfarm	1.23	.06	1.01
Farm	1.54	.05	1.15
North Central	**1.51**	**.07**	**1.23**
Urban	1.52	.10	1.22
Rural nonfarm	1.43	.05	1.17
Farm	1.61	.02	1.34
South	**.85**	**.04**	**1.26**
Urban	1.09	.06	1.33
Rural nonfarm	.64	.03	1.22
Farm	.68	.10	1.18
West	**1.62**	**.07**	**1.00**
Urban	1.52	.07	1.00
Rural nonfarm	1.89	.12	1.05
Farm	1.73	.03	.89

[a]These data were taken from "A Review of 1955 Survey Data on Household Meat Consumption" AMS-340, U.S.D.A., September 1959, p. 55.

Table 4. Estimated Regional Per Capita Consumption of Beef, Pork and Veal in 1955 and 1960.[a]

Regions	1955			1960		
	Beef	Pork	Veal	Beef	Pork	Veal
	(Pounds)					
1	84.57	56.85	15.07	84.05	56.63	15.11
2	82.69	58.74	14.54	82.12	58.73	14.57
3	54.08	73.34	4.26	55.75	74.12	4.83
4	61.52	75.51	5.64	63.86	76.20	6.08
5	55.17	73.49	4.31	57.05	74.43	5.00
6	53.99	72.96	3.92	56.62	74.18	4.81
7	54.83	73.36	4.21	56.81	74.23	4.83
8	99.22	71.68	9.62	98.78	71.25	10.00
9	99.34	71.99	8.80	98.72	71.42	9.17
10	99.27	71.71	9.64	98.82	71.27	9.98
11	99.42	71.70	10.12	99.23	71.47	10.42
12	99.72	72.35	8.53	99.23	71.82	9.13
13	56.28	73.74	4.44	58.82	74.83	5.24
14	100.02	72.53	8.72	99.23	71.76	9.35
15	100.15	72.93	7.63	99.78	72.50	8.15
16	99.95	72.62	8.20	99.51	72.08	8.91
17	60.21	74.93	5.21	63.64	75.99	5.89
18	99.65	72.41	8.12	99.15	71.82	8.95
19	100.06	72.87	7.59	99.59	72.32	8.29
20	100.30	73.41	6.23	99.69	72.75	6.96
21	107.18	58.50	8.84	105.32	58.93	9.01
22	110.59	58.29	9.11	109.72	58.78	9.46
23	109.59	58.78	9.45	106.28	59.23	9.44
24	108.67	58.40	8.95	107.31	58.91	9.26
25	103.83	58.93	8.80	102.79	59.08	8.81
26	108.17	58.77	9.24	107.31	59.21	9.55

[a]Weighted by the urbanization characteristics of each region.

3. Regional Consumption Estimates for Lamb and Mutton

In 1954 the USDA conducted a study relative to the distribution and consumption of lamb and mutton.[11] Since the data from this study were considered more complete than that from the Household Food Consumption Survey, it was used as a basis for generating regional consumption estimates for lamb and mutton. Regional per capita consumption estimates were obtained by combining state data weighted by population. The regional per capita estimates are given in Table 8 and the regional total consumption estimates are given in Tables 5 and 6.

4. Alternative Consumption Estimates

a. Regional beef consumption adjusted by income

The results of several econometric studies suggest that the level of disposable income conditions the level of beef consumption. Therefore, alternative regional consumption estimates were obtained by (1) estimating income-consumption relations for each census region from the Household Food Consumption Survey and (2) using these income-consumption response coefficients for adjusting per capita consump-

[11]"Distribution of Lamb and Mutton for Consumption in the U. S.," AMS-93, USDA, 1956.

Table 5. Estimated Regional Consumption for Beef, Veal, Pork, and Lamb and Mutton in 1955

Region	Beef[a]	Veal[a]	Pork[a]	Lamb and Mutton
	(Pounds)			
1	815,907,512	148,938,480	543,724,989	85,448,800
2	2,970,212,037	535,059,323	2,096,326,780	289,324,580
3	534,278,731	45,098,970	710,312,163	6,833,393
4	228,853,718	21,817,910	274,202,895	11,721,175
5	332,811,801	28,160,086	434,393,652	3,570,846
6	284,412,434	22,894,136	374,639,062	1,547,986
7	351,913,321	29,062,980	460,681,668	4,427,977
8	888,348,793	89,778,670	634,994,318	19,807,627
9	429,680,930	39,760,626	308,075,286	6,094,931
10	714,075,907	72,133,444	510,370,120	33,276,000
11	911,716,467	96,145,177	650,655,902	46,050,323
12	362,743,841	32,839,962	260,290,982	5,488,312
13	269,968,295	23,156,272	345,061,640	1,882,734
14	418,388,947	38,698,654	300,017,249	5,056,553
15	266,884,973	21,483,696	192,233,148	3,750,297
16	316,255,270	27,668,639	227,184,452	6,681,788
17	673,132,161	61,529,466	812,230,410	13,088,113
18	205,656,935	18,010,109	147,744,289	3,113,936
19	135,042,934	10,954,912	97,245,021	6,108,105
20	129,404,453	8,704,455	93,647,803	649,236
21	167,302,909	14,333,050	91,548,607	6,951,663
22	102,668,554	8,826,143	54,022,785	2,057,394
23	190,140,441	16,969,537	102,926,957	8,661,034
24	176,380,404	15,167,101	94,863,676	9,668,971
25	1,351,947,620	117,517,542	764,600,254	161,504,293
26	462,971,607	41,174,659	251,005,883	15,952,934
Total	13,691,100,995	1,585,883,999	10,832,999,991	758,719,001

[a]Weighted by the urbanization characteristics of each region.

Table 6. Estimated Regional Consumption for Beef, Veal, Pork, and Lamb and Mutton in 1960.

Region	Beef[a]	Veal[a]	Pork[a]	Lamb and Mutton
	(Pounds)			
1	875,527,724	102,582,741	575,762,920	85,271,568
2	3,130,658,212	362,012,793	2,185,303,002	283,704,414
3	572,583,861	32,330,991	743,009,878	6,687,775
4	315,386,672	19,570,218	367,311,342	14,701,234
5	357,320,407	20,410,321	455,003,918	3,495,770
6	304,964,846	16,885,061	389,970,442	1,503,109
7	371,472,952	20,583,878	473,747,372	4,257,845
8	950,227,961	62,695,509	668,973,013	19,686,606
9	456,054,699	27,609,515	322,030,184	6,016,296
10	766,034,381	50,421,017	539,231,330	33,170,394
11	991,213,975	67,837,494	696,808,040	46,460,494
12	388,526,866	23,298,421	274,465,910	5,463,346
13	293,865,270	17,062,088	364,891,657	1,858,971
14	424,497,946	26,068,849	299,626,332	4,775,328
15	272,116,154	14,485,920	192,980,655	3,551,634
16	336,742,943	19,651,112	238,073,743	6,610,594
17	751,177,367	45,311,169	875,454,770	13,175,981
18	213,302,041	12,548,823	150,803,923	3,001,808
19	139,094,373	7,546,160	98,586,441	5,846,497
20	129,584,156	5,896,404	92,299,267	604,588
21	182,883,338	10,196,843	99,876,813	7,107,312
22	109,459,029	6,150,842	57,234,820	2,041,634
23	238,928,646	13,831,406	129,964,085	10,247,128
24	196,620,378	11,058,010	105,351,883	10,056,103
25	1,609,253,826	89,893,283	902,774,154	179,129,943
26	491,073,968	28,483,132	264,464,099	15,750,626
Total	14,868,571,991	1,114,422,000	11,563,999,993	774,176,998

[a]Weighted by the urbanization characteristics of each region.

tion rates, unweighted by urbanization groups, for variation in income among the 26 regions. The estimated income-consumption relations are given in Table 9. There are only minor differences in the estimated income elasticities depending on whether variables linear in natural or logarithmic units are used. There are, however, discernable differences in the estimates of the regional income elasticities. For example, the estimate of income elasticity for the Southern Region is considerably larger than for the other regions.

Using the two different sets of elasticity estimates, regional income adjusted consumption was calculated with the following relationship:

$$C_{ij}y = C_{ij} + E_i \left(\frac{C_{ij}}{Y_i}\right)(Y_{ij} - Y_i)$$

where $C_{ij}y$ denotes unurbanized per capita consumption adjusted for income for the jth subregion of the ith census region. C_{ij} denotes unurbanized per capita consumption of the jth subregion of the ith census region. E_i denotes income elasticity of the ith census region. Y_i denotes per capita income of the ith census region. Y_{ij} denotes income of the jth subregion of the ith census region.

Table 7. Estimated Regional Beef and Pork Consumption Assuming Oklahoma and Texas in the Western Census Region.

Region	Beef[a]		Pork[a]	
	1955	1960	1955	1960
	(Pounds)			
1	788,031,170	847,362,371	553,005,520	585,735,623
2	2,868,731,603	3,029,946,274	2,132,107,784	2,223,154,306
3	516,024,534	554,164,083	722,436,075	755,879,440
4	221,034,689	305,240,817	278,883,107	373,673,487
5	321,440,934	345,825,562	441,808,069	462,884,972
6	274,695,182	295,154,257	381,033,562	396,725,061
7	339,889,830	359,522,825	468,544,780	481,953,079
8	857,997,417	919,659,533	645,832,673	680,560,194
9	415,000,427	441,383,614	313,333,647	327,608,020
10	689,678,749	741,391,382	519,081,336	548,571,274
11	880,566,710	959,327,045	661,761,576	708,877,347
12	350,350,314	376,028,123	264,733,740	279,219,893
13	260,744,543	284,411,750	350,951,300	371,211,891
14	404,094,246	410,842,028	305,138,072	304,816,114
15	257,766,565	263,362,293	195,514,266	196,323,244
16	305,450,074	325,910,066	231,062,134	242,197,383
17	1,117,904,828	1,205,327,923	641,191,626	690,320,084
18	198,630,448	206,440,206	150,266,051	153,415,975
19	130,429,050	134,619,766	98,904,841	100,294,042
20	124,983,213	125,415,489	95,246,224	93,897,968
21	161,586,828	177,000,059	93,111,197	101,606,764
22	99,160,774	105,937,779	54,944,869	58,226,175
23	183,644,092	231,242,413	104,683,759	132,215,174
24	170,354,181	190,295,184	96,482,850	107,176,667
25	1,305,756,900	1,557,484,818	777,650,779	918,410,969
26	447,153,692	475,276,328	255,290,160	269,044,842
Total	13,691,100,993	14,868,571,988	10,832,999,999	11,563,999,988

[a]Weighted by urbanization characteristics of each region.

Table 8. Per Capita Lamb and Mutton Consumption by Regions, 1954

Region	Consumption per capita (pounds)	Region	Consumption per capita (pounds)
1	8.8	14	1.2
2	8.0	15	1.4
3	.7	16	2.1
4	3.2	17	1.2
5	.6	18	1.5
6	.3	19	4.5
7	.7	20	.5
8	2.2	21	4.4
9	1.4	22	2.2
10	4.6	23	4.9
11	5.0	24	5.9
12	1.5	25	12.3
13	.4	26	3.7

Table 9. Estimated Income-Consumption Relations for Beef[a]

Linear in Natural Units

United States

$C = .0145Y + 45.93$; $r = .87$
(.0032)
Mean Elasticity = .2877;
Income-group weighted elasticity = .2358

Northeast

$C = .00743Y + 53.65$; $r = .72$
(.0027)
Mean Elasticity = .1492;
Income-group weighted elasticity = .1353

North central

$C = .0063Y + 67.71$; $r = .77$
(.0020)
Mean Elasticity = .1072;
Income-group weighted elasticity = .0991

South

$C = .0181Y + 31.66$; $r = .92$
(.0029)
Mean Elasticity = .4179;
Income-group weighted elasticity = .2733

West

$C = .0126Y + 66.39$; $r = .82$
(.0036)
Mean Elasticity = .2307;
Income-group weighted elasticity = .1923

Linear in Logs

United States

$\text{Log } C = .2948 \log Y + .92$; $r = .98$
(.0217)

North central

$\text{Log } C = .1127 \log Y + 1.54$; $r = .92$
(.0184)

South

$\text{Log } C = .3987 \log Y + .536$; $r = .98$
(.0311)

West

$\text{Log } C = .2715 \log Y + 1.085$; $r = .87$
(.0632)

Northeast

$\text{Log } C = .1549 \log Y + 1.34$; $r = .88$
(.0310)

[a]C refers to the per capita consumption of beef in pounds and Y refers to per capita income in dollars. Standard errors appear in parentheses below the coefficient.

The C_{ijy} relationship was then used to generate two per capita consumption estimates for each region and year: one based on the natural unit relationship and one on the log relationship.

To generate income adjusted total consumption estimates, the population of each region was multiplied by its per capita consumption estimate. The percentage difference between the sum of these regional, total consumption estimates and the actual, (U.S.) total slaughter was calculated. The regional total estimates were then adjusted by this percentage so their sum was equal to actual total slaughter. This procedure was followed for 1955 and 1960 using both natural and log-unit functions and the results are given in Table 10.

b. Beef consumption adjusted for income with Oklahoma and Texas considered as part of the Western Census Region.

Since it was thought that beef consumption in Oklahoma and Texas might correspond more closely to that of the Western Census Region than to that of the Southern, alternative calculations satisfying this condition were made.[12]

The income-consumption relationships and the weighted elasticities could not be altered because the original data were provided on a basis of census regions; however, different per capita disposable income figures for the adjusted regions were calculated for 1955 and 1960. Using these new disposable income figures for the Southern and Western Census Regions and the unurbanized per capita consumption estimate of the Western Census Region for Oklahoma and Texas, new consumption figures for the effected regions were calculated and are given in Table 11. Given the relatively high level of beef consumption in the Western Census Region, this modification generated a significant increase in the estimated beef consumption for Oklahoma and Texas.

c. Regional demand relations.

To provide an alternative set of regional demands for pork and beef, regional demand relations were developed. Since there are no adequate data on beef and pork consumption by state, the regional demand relations were derived from an aggregate study involving all of the United States. The aggregate relations used were:[13]

$$(1)\quad Y_1 = -.9705\ P_b + .2261\ P_p + .0326\ I + \alpha_{10}$$

$$(2)\quad Y_2 = .3890\ P_b - .8551\ P_p + .0061\ I + \alpha_{20}$$

[12]Williams, *op. cit.*

[13]Hans Konrad Larsen, "Econometric Analysis of the Demand for Beef, Pork and Broilers," Unpublished University of Illinois Master's Thesis, Equations 2 and 25, pages 37 and 59, July, 1962.

Table 10. Estimated Income Adjusted Regional Total Beef Consumption Assuming Oklahoma and Texas in the Southern Census Region

Region	1955 Natural	1955 Log	1960 Natural	1960 Log
	(Pounds)			
1	822,258,219	821,768,873	885,777,298	885,114,657
2	2,990,478,477	3,002,847,804	3,167,352,266	3,181,504,075
3	545,437,792	544,651,445	576,242,546	575,287,979
4	214,534,902	218,773,043	288,777,917	293,711,361
5	322,766,065	317,855,386	340,833,465	335,375,591
6	271,691,199	263,695,432	284,062,473	275,284,893
7	342,300,336	336,698,947	357,813,366	353,040,856
8	901,388,591	902,112,406	966,421,830	966,971,883
9	432,351,636	432,219,782	460,138,393	459,842,187
10	726,921,523	727,867,009	777,206,269	777,414,446
11	931,061,313	933,006,444	1,014,139,636	1,016,124,395
12	360,935,880	360,493,731	389,238,955	388,908,756
13	253,373,897	248,590,324	270,305,298	265,244,608
14	415,846,432	415,379,623	426,011,285	425,736,995
15	261,773,379	261,126,226	268,630,496	268,042,137
16	312,529,782	311,953,196	334,563,204	334,004,166
17	628,166,258	635,957,330	679,080,022	685,739,630
18	203,825,465	203,428,385	213,191,089	212,900,930
19	132,888,085	132,573,826	138,478,414	138,304,156
20	125,346,238	124,823,508	127,251,160	126,865,611
21	163,564,246	161,449,780	182,684,516	181,150,741
22	97,992,189	97,211,088	103,926,393	102,631,698
23	180,890,812	177,653,769	230,648,535	226,276,391
24	171,177,483	169,577,829	191,912,176	189,960,345
25	1,426,861,807	1,437,033,340	1,711,655,075	1,724,575,542
26	454,738,993	452,352,475	482,229,919	478,557,962
Total	13,691,100,999	13,691,101,001	14,868,571,996	14,868,571,991

Table 11. Estimated Income Adjusted Regional Beef Consumption Assuming Oklahoma and Texas in Western Census Region

Region	1955 Relations Natural	1955 Relations Log	1960 Relations Natural	1960 Relations Log
	(Pounds)			
1	790,341,479	789,850,277	851,341,958	850,387,370
2	2,876,498,804	2,889,710,794	3,046,441,642	3,059,641,050
3	528,231,377	529,349,800	557,234,139	557,605,326
4	207,978,762	212,861,543	279,423,212	284,874,246
5	312,424,795	308,675,063	329,348,403	324,833,390
6	262,792,062	255,848,455	274,380,213	266,420,036
7	331,277,196	326,985,792	345,872,951	342,047,710
8	866,400,329	867,073,161	928,851,365	929,032,946
9	415,569,494	415,431,791	442,250,125	441,800,376
10	698,705,368	699,595,587	746,991,719	746,912,754
11	894,921,276	896,767,233	974,714,102	976,256,969
12	346,925,808	346,491,675	374,106,962	373,650,003
13	245,177,714	241,392,828	261,156,383	256,876,106
14	399,704,954	399,245,726	409,449,737	409,033,294
15	251,612,394	250,983,736	258,187,259	257,525,560
16	300,398,639	299,836,519	321,556,777	320,899,583
17	1,085,417,717	1,071,359,136	1,175,971,449	1,158,407,202
18	195,913,784	195,526,956	204,903,105	204,547,807
19	127,729,906	127,424,482	133,094,949	132,877,822
20	120,480,804	119,975,197	122,304,164	121,888,066
21	159,171,176	157,929,170	177,928,101	177,366,313
22	95,427,613	95,189,848	101,156,194	100,407,473
23	175,903,622	173,625,277	224,303,523	220,870,746
24	166,656,891	166,002,512	186,873,032	185,924,630
25	1,392,429,918	1,410,804,584	1,670,977,204	1,693,411,398
26	443,009,107	443,163,752	469,753,317	475,073,822
Total	13,691,100,989	13,691,100,994	14,868,571,985	14,868,571,998

where Y_1 denotes per capita consumption of beef in pounds, Y_2 denotes per capita consumption of pork in pounds, P_b denotes price of beef cents per pound, P_p denotes price of pork cents per pound, I denotes income in dollars, α_{10} denotes beef equation constant, and α_{20} denotes pork equation constant.

Given these relations it was assumed that the price and income coefficients were the same for each region and for each time period. To take account of the fact that regional consumption varies over and above the price and income effects, information from the Household Food Consumption Survey was used in specifying the census region differences. Using the 1955 and 1960 observed values of regional incomes, the following regional demand relations were derived:

$$(3) \quad Y_{1i} = -.9705\ P_{bi} + .2261\ P_{pi} + \alpha_{1i}$$

$$(4) \quad Y_{2i} = .3890\ P_{bi} - .8551\ P_{pi} + \alpha_{2i}$$

where $i=1,2,\ldots,26$

The resulting constants α_{1i} and α_{2i} are given in Table 13. Thus, combining the estimated equation constants of Table 12 with equations (3) and (4), four sets of 26 regional demand relations were derived. Using these demand relations along with regional supplies and an appropriate set of regional price differentials, a joint spatial model was solved for regional beef and pork consumption estimates for 1955 and 1960.[14] These regional consumption estimates are given in Table 13.

D. Transportation Rates.

Since the structure of transport rates for meat products are basic to the spatial solutions, it is necessary to obtain estimates of these costs between the points that represent each pair of regions. As a basis for determining these rates, transport cost functions were estimated from samples of truck and rail rates and the resulting cost functions were then used to estimate the point-to-point rate structure.

1. The 1955 Transport Rates

Truck and rail transport cost functions derived by Judge and Wallace[15] were used for generating the 1955 transport rate structure. They obtained a sample of rail rates from the Transportation and Storage Service of the USDA and a sample of truck rates were provided by Wilson and Company and Armour and Company. A square root functional form was postulated for the transport cost functions and the least squares procedure using moments about zero was used to estimate the parameters of the function. The resulting cost functions were as follows:

[14]For the procedure used in solving the joint beef and pork model for regional consumption estimates see: Y. A. Chuang and G. G. Judge, "Sector and Spatial Analyses of the United States Feed Economy," Illinois Experiment Station Bulletin, Number 699, 1964.

[15]Judge and Wallace, *op. cit.*

Table 12. Regional Constant Terms (α_{1i} and α_{2i}) for Beef and Pork Demand Relations

Region	Beef		Pork	
	1955	1960	1955	1960
1	134.2908	145.9653	76.6938	71.5981
2	134.9730	148.0038	78.9486	73.6221
3	106.6018	118.7979	93.3673	88.3692
4	113.0892	125.0245	94.5812	89.5343
5	102.6572	114.3317	92.6292	87.5335
6	98.8430	109.9307	91.9155	86.7100
7	102.3638	115.1467	92.5743	87.6860
8	153.1118	164.8515	92.2073	87.1238
9	149.0368	160.2223	91.4448	86.2576
10	155.0026	163.7431	92.5611	86.9164
11	158.0670	170.5239	93.1345	88.1852
12	145.6464	159.2117	90.8104	86.0685
13	101.6792	113.5167	92.4462	87.3810
14	145.8746	160.1245	90.8531	86.2393
15	140.9846	154.3217	89.9381	85.1535
16	143.4948	156.2777	90.4078	85.5195
17	110.7420	122.5469	94.1420	89.0707
18	143.2992	157.5165	90.3712	85.7513
19	141.8648	157.7773	90.1028	85.8001
20	134.9536	151.0617	88.8906	84.5435
21	149.1952	163.8689	76.6172	72.0827
22	152.3574	161.0327	77.2089	71.5520
23	146.1960	156.6643	76.0560	70.7346
24	151.5098	162.5975	77.0503	71.8448
25	162.1700	175.3115	79.0450	74.2238
26	154.0852	164.3579	77.5322	72.1742

Table 13. Regional Beef and Pork Consumption Estimates Based on Regional Demand Relations

Region	Beef		Pork	
	1955	1960	1955	1960
	(000 Pounds)			
1	799,605	856,033	544,293	572,645
2	3,013,667	3,217,887	2,117,027	2,177,829
3	536,193	563,343	711,808	740,336
4	225,593	301,825	270,009	360,604
5	305,914	316,660	430,494	448,027
6	247,956	249,701	369,641	380,031
7	327,161	383,261	458,188	535,574
8	919,399	979,445	650,255	686,743
9	427,846	449,766	312,541	326,825
10	752,922	781,277	525,197	549,868
11	992,584	1,080,912	677,531	725,191
12	350,499	379,373	256,341	276,075
13	242,032	252,068	337,755	354,272
14	404,080	419,403	300,490	302,324
15	244,153	251,687	189,274	190,166
16	298,239	319,187	226,461	237,335
17	669,107	713,653	799,992	851,912
18	194,232	205,664	146,861	150,765
19	125,315	134,071	95,760	98,006
20	111,600	116,340	89,618	89,390
21	159,000	178,768	88,423	95,262
22	95,889	98,374	53,176	54,866
23	170,093	211,362	96,378	120,000
24	167,758	184,418	91,349	99,970
25	1,464,793	1,760,630	751,405	888,269
26	445,474	463,515	242,717	251,715
Total	13,691,104	14,868,623	10,832,984	11,564,000

Rail

$$C_{ij} = .0008\, x_{ij} + .0464\, x_{ij}^{\frac{1}{2}}; \quad R = .98$$

Truck

$$C_{ij} = .0015\, x_{ij} + .0226\, x_{ij}^{\frac{1}{2}}; \quad R = .98$$

where C_{ij} is the cost per pound of shipping meat from region i to region j and x_{ij} is the distance in miles between region i and region j.

Transport rates were then estimated for each of these functions and the minimum rate in each instance was employed in developing the effective rate structure. In general, the truck rate function was used for distances less than 1200 miles.

2. The 1960 Transport Rates.

In order to generate transport cost functions for 1960, samples of rail and truck rates were obtained from the Traffic Department of John Morrell and Company. Since it was thought that the transport rate might vary depending on the direction of shipment, the observations were partitioned into East and West samples. A square root functional form was postulated and the least squares method of estimation was employed with the following results:

Rail West Shipments

$$C_{ij} = -1.0021 - .00036\, x_{ij} + .1177\, x_{ij}^{\frac{1}{2}}; \quad R = .96$$

Truck West Shipments

$$C_{ij} = -.1039 + .0001\, x_{ij} + .0670\, x_{ij}^{\frac{1}{2}}; \quad R = .99$$

Rail East Shipments

$$C_{ij} = -.4345 + .00006\, x_{ij} + .0750\, x_{ij}^{\frac{1}{2}}; \quad R = .86$$

Truck East Shipments

$$C_{ij} = -.6203 - .00007\, x_{ij} + .0805\, x_{ij}^{\frac{1}{2}}; \quad R = .94$$

The definitions of C_{ij} and x_{ij} are as previously specified. Transport rates for each of the designated pairs of points were estimated for each of these functions and the minimum rate applicable was employed in developing the effective rate structure. In each case the estimated rates for the shipments moving west were higher than for the east shipments for the same mileage. As a result of the above estimated functions, truck rates were predominantly employed to reflect the rate structure.

E. Regional Livestock Slaughter.

Regional slaughter data for beef, veal, pork, and lamb and mutton for the years 1955 and 1960 consist of commercial slaughter estimates published by the USDA and estimates of farm slaughter based on reported numbers of animals slaughtered on farms. All quantities of meat are assumed to be available at the demand and supply points of the regions which are designated in the previous section on regional demarcation.

The live weight commercial slaughter for each state was converted to dressed weight by using the U. S. average dressing yield for federally inspected slaughter.[16] Regional estimates were obtained by summing the dressed weights of the component states.

Live weight of farm slaughter for each state was estimated using the product: (the number of animals slaughtered at the farm)[17] *times* (the adjusted average live weight of animals slaughtered at the farm).[18] These live weights were converted to dressed weights by using the U. S. average dressing yield for farm slaughter: (dressed weight of farm slaughter) *divided by* (live weight of farm slaughter).

The total quantities of the four types of meats available in each of the 26 regions are the sum of the regional commercial slaughter dressed weight and the regional farm slaughter dressed weight. The dressed weight of pork, commercial and farm, exclude lard. The quantities of the different types of meats available for 1955 and 1960 are presented in Tables 14 and 15.

IV. THE EMPIRICAL RESULTS

Given the model and the data relating to regional demands, supplies and transport costs, the spatial analyses for each meat product for 1955 and 1960 will now be presented. For the purpose of presentation the results will be partitioned by type of meat product.

A. Spatial Analyses for Beef.

The results of the spatial analyses for beef vary by the way in which regional consumption was estimated and by time periods. The alternative results for 1955

[16]Agricultural Marketing Service, "Commercial Livestock Slaughter," USDA Statistical Bulletin No. 231, July 1958; and Statistical Reporting Service, "Livestock Slaughter," U. S. Department of Agriculture, Mt. An 1-2-1 (61), April 1961.

[17]Agricultural Marketing Service, "Livestock and Meat Statistics," U. S. Department of Agriculture, Statistical Bulletin No. 230, Supplement for 1961; and Statistical Reporting Service, "Meat Animals," U. S. Department of Agriculture, Statistical Bulletin No. 284, May 1961.

[18]Two adjustments were actually made. First liveweight estimates of animals slaughtered at the farm were obtained in the following manner. For each state the average liveweight of animals slaughtered commercially was adjusted by the difference: (U. S. average liveweight of animals slaughtered commercially) *minus* (U. S. average liveweight of animals slaughtered at the farm). Next, the resulting estimates of average liveweight of animals slaughtered at the farm were adjusted by a constant percentage so that the sum of the products at the farm was equal to the U. S. total liveweight of slaughter at the farm.

are reported first and followed by the analyses for 1960.

1. The Beef Flow Results for 1955

a. Results based on urbanized consumption estimates.

Given the regional demands of Table 5 and the regional supplies of Table 14, the excess regional demands and supplies are given in Table 16. In Table 16 the deficit regions are given at the top of the table and the surplus regions are given along the side. Given these excess demands and supplies and the transport costs, the spatial flow pattern for beef in 1955 that would minimize the total transportation cost was derived. The flow quantities consistent with this objective are reported in the body of Table 16. A picture of these optimum geographical flows is given in Figure 1. The shaded areas represent surplus regions and the lines emanating in the surplus regions indicate the direction of beef flows. The numbers appearing on the lines indicate the quantity of flow involved in each case.

Table 14. Regional Commercial and Farm Slaughter, Dressed Weight, 1955

Regions	Beef	Veal	Pork	Lamb and Mutton
		(000 Pounds)		
1	150,846	23,405	129,322	14,301
2	1,235,573	208,997	912,487	118,842
3	199,858	40,367	416,000	1,127
4	168,245	23,760	73,425	27
5	244,165	37,192	306,281	70
6	166,313	59,785	174,547	107
7	345,922	55,806	423,257	9,250
8	630,264	31,565	564,027	10,752
9	376,884	27,999	523,314	7,562
10	453,112	69,290	225,315	38,847
11	1,144,679	96,699	963,045	38,462
12	505,547	99,675	449,294	6,351
13	139,008	82,662	93,076	261
14	537,680	39,409	550,304	31,049
15	1,088,587	72,073	1,752,925	69,087
16	841,711	56,502	860,942	46,191
17	958,213	340,719	408,268	46,202
18	645,745	48,071	377,861	24,865
19	1,053,180	12,587	572,017	55,878
20	277,343	8,744	388,192	33,656
21	474,195	13,919	93,655	42,665
22	57,559	3,651	39,158	1,539
23	81,870	10,157	28,136	6,785
24	183,896	10,124	58,483	23,028
25	1,337,570	87,623	294,964	112,749
26	393,136	25,103	154,705	19,066
Total	13,691,101	1,585,884	10,833,000	758,719

Table 15. Regional Commercial and Farm Slaughter, Dressed Weight, 1960

Regions	Beef	Veal	Pork	Lamb and Mutton
		(000 Pounds)		
1	124,440	20,909	86,829	12,678
2	1,229,572	152,202	889,250	106,359
3	212,875	37,093	537,097	1,366
4	162,230	27,388	79,009	47
5	195,606	29,567	349,711	102
6	250,723	49,047	239,103	165
7	300,557	34,175	590,268	12,205
8	687,202	16,917	599,699	7,823
9	389,070	16,256	726,136	9,720
10	430,546	40,580	217,176	35,269
11	873,676	37,234	784,007	22,147
12	621,105	79,695	493,922	9,096
13	144,024	61,843	93,357	255
14	645,885	15,771	581,552	28,917
15	1,562,092	47,724	2,095,348	72,463
16	886,542	29,267	817,037	52,810
17	928,628	292,367	367,767	57,433
18	681,667	27,080	418,430	14,313
19	1,280,118	4,997	609,234	54,081
20	286,365	3,427	352,879	28,763
21	624,637	4,795	92,072	75,039
22	78,729	2,440	46,695	1,776
23	120,347	6,068	36,109	7,425
24	264,817	6,228	68,839	21,011
25	1,462,486	58,296	225,218	123,180
26	424,633	13,056	167,256	19,734
Total	14,868,572	1,114,422	11,564,000	774,177

Table 16. Excess Demand and Supplies and Optimum Shipment Pattern and Price Differentials, Urbanized Model, Beef, 1955

	Destinations															Excess supplies	
Origins	1	2	3	4	5	6	7	8	9	10	13	22	23	25	26	(100,000 lbs.)	U_i [a]
11										2330						2330	0
12	1148									280						1428	– .18
14								1193								1193	– .40
15	3255	4434							528							8217	– .65
16		5254														5254	– .75
17				607		934					1310					2851	– .55
18			3207		886	247	60									4400	– .66
19		7658	137					1387								9182	– .91
20	1028											451				1479	–1.47
21	1220												1082	143	624	3069	–1.70
24															75	75	– .82
Excess Demands	6651	17346	3344	607	886	1181	60	2580	528	2610	1310	451	1082	143	699	39478	
V_j [a]	2.15	1.75	1.74	1.90	1.20	.87	.71	.92	.54	.83	.39	–.33	.18	1.05	1.03		

[a] The U_i and V_j are given in terms of cents per pound.

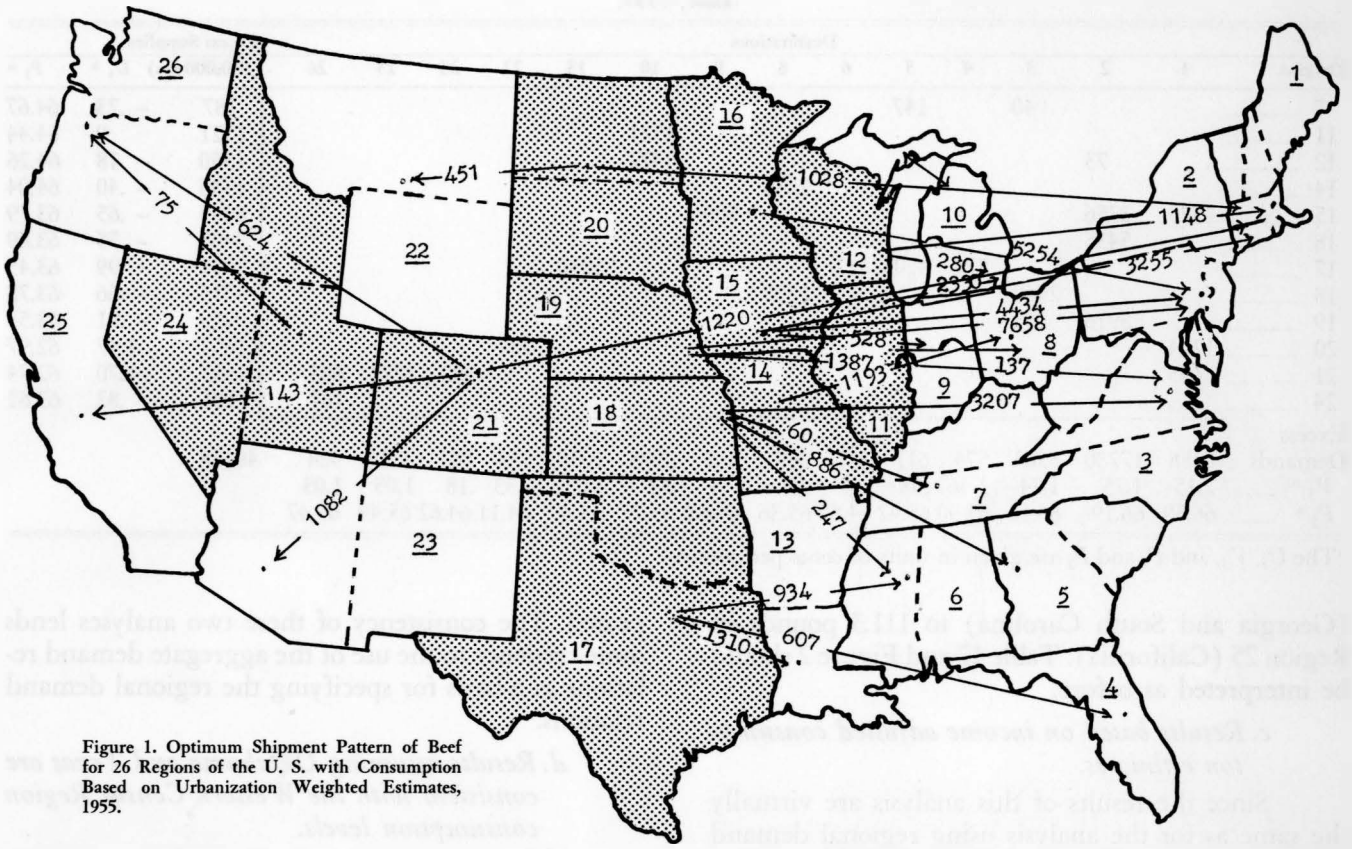


Figure 1. Optimum Shipment Pattern of Beef for 26 Regions of the U. S. with Consumption Based on Urbanization Weighted Estimates, 1955.

For the urbanized consumption estimates, the Cornbelt was the dominant surplus area and the East Coast the dominating deficit area. The major flows were Regions 11 (Illinois), 12 (Wisconsin), and 14 (Missouri) to 19 (Nebraska) shipping to the East; Regions 20 (North and South Dakota) and 21 (Colorado) shipping both east and west; and Region 24 (Idaho, Nevada and Utah) shipping to the west. The total shipments involved are 3,947.8 million pounds. Thus, it is estimated that approximately 28 percent of the total supply of meat is involved in interregional trade. The total transportation cost for these shipments was estimated to be 90.3 million dollars.

The set of regional price differentials consistent with this optimum flow pattern is given in the last column (u_i) and last row (v_j) of Table 16. Region 11 (Illinois) was chosen as the base region and all price differentials are computed relative to this base. The price differentials for the surplus regions measure the comparative price advantages of these regions relative to Region 11 (Illinois). For example, beef is worth 91 cents per hundred more in Region 11 than in Region 19 (Nebraska) because of its proximity to the deficit regions of the East. Therefore, Region 11 has a comparative price advantage of 91 cents per one hundred pounds over Region 19. The price differentials for the deficit regions give the delivered price differentials relative to Region 11. For example, the price of beef is $2.15 higher in Region 1 (New England) than in Region 11. The resulting price differentials are the competitive equilibrium differentials that would exist if the surplus regions sold their excess supplies to the deficit regions at the maximum possible gain. These estimated price differentials suggest that beef prices will be highest on the East and West Coasts and lowest in the Great Plains. The estimated per capita consumption of beef varied from a low of 54.6 pounds in Region 3 (North Carolina, Virginia and West Virginia) to a high of 109.5 pounds in Region 22 (Montana and Wyoming).

b. Results based on regional demand relations.

The results for beef analysis using the estimated regional demand relations are given in Table 17 and Figure 2. The total shipments for this analysis was 4,012.8 million pounds and the transportation cost was 92.5 million dollars.

Except for Region 7 (Kentucky and Tennessee), which in this analysis became a surplus region shipping to the southeast, the basic flow pattern remained the same as in the previous model. The regional prices (p_i, p_j) that resulted from this model are given in the last row and column of Table 17. The estimated per capita beef consumption for this analysis ranged from a low of 51.3 pounds in Region 5

Table 17. Excess Demand and Supplies, Optimum Shipment Pattern, Prices and Price Differentials, Demand Relation Model, Beef, 1955.

Origins	Destinations 1	2	3	4	5	6	8	9	10	13	22	23	25	26	Excess Supplies (100,000 lbs)	U_i [a]	P_i [a]
7			40		147										187	- .23	64.67
11									1521						1521	0	64.44
12		73							1477						1550	- .18	64.26
14							1336								1336	- .40	64.04
15	4579	3356						509							8444	- .65	63.79
16		5435													5435	- .75	63.69
17				574	470	817				1030					2891	- .99	63.45
18			2960				1555								4515	- .66	63.78
19		8916	363												9279	- .91	63.53
20	1274										383				1657	-1.47	62.97
21	635											882	1272	363	3152	-1.70	62.74
24														161	161	- .82	63.62
Excess Demands	6488	17780	3363	574	617	817	2891	509	2998	1030	383	882	1272	524	40128		
V_j [a]	2.15	1.75	1.74	1.46	.98	.43	.92	.54	.83	-.05	-.33	.18	1.05	1.03			
P_j [a]	66.59	66.19	66.18	65.90	65.42	64.87	65.36	64.98	65.27	64.39	64.11	64.62	65.49	65.47			

[a]The U_i, V_j, and P_i and P_j are given in units of cents per pound.

(Georgia and South Carolina) to 111.3 pounds in Region 25 (California). Table 17 and Figure 2 should be interpreted as before.

c. Results based on income adjusted consumpton estimates.

Since the results of this analysis are virtually the same as for the analysis using regional demand relations, the flow table and diagram will not be repeated. The consistency of these two analyses lends some credence to the use of the aggregate demand relations as a basis for specifying the regional demand relations.

d. Results assuming Oklahoma and Texas are consistent with the Western Census Region consumption levels.

The results based on **urbanized** consumption

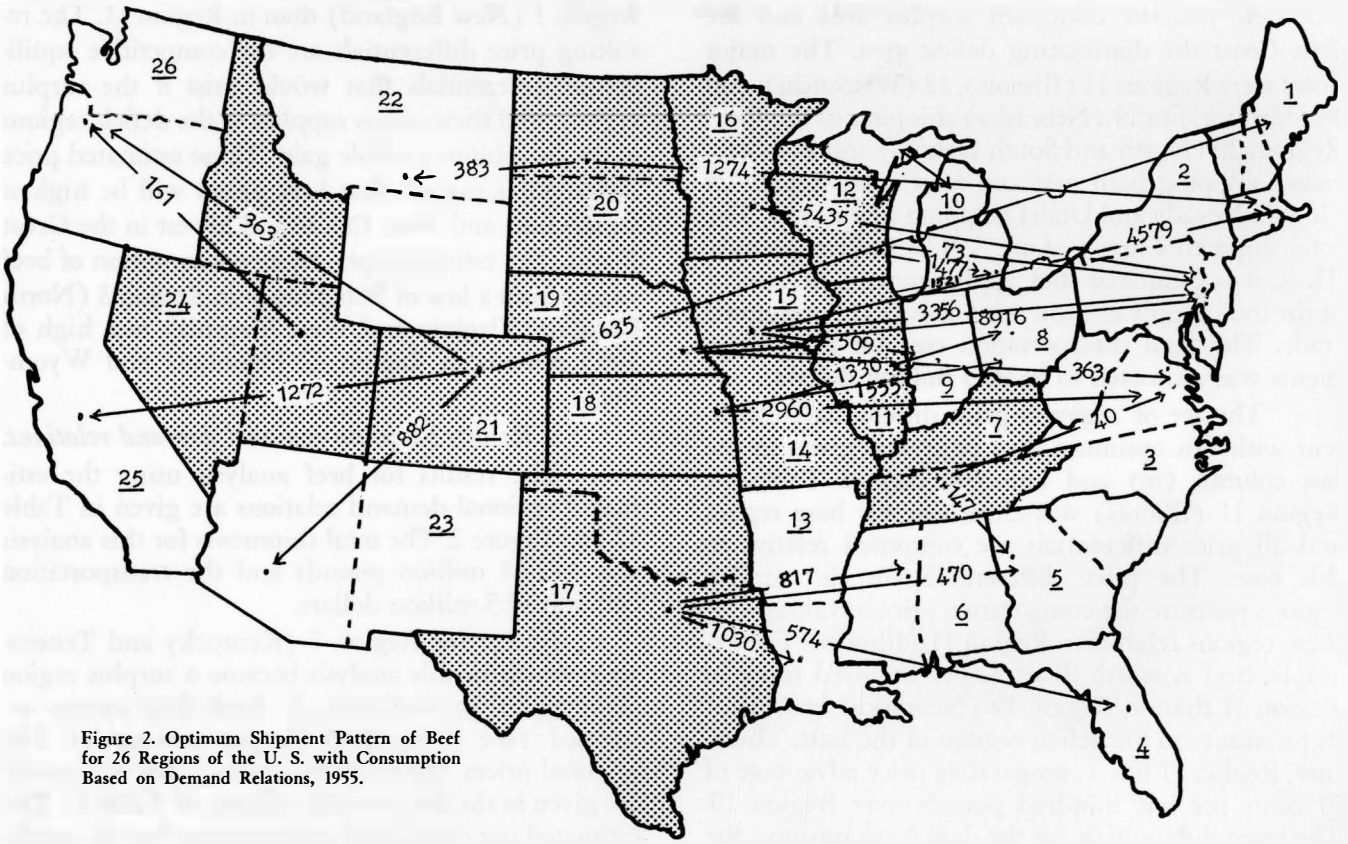


Figure 2. Optimum Shipment Pattern of Beef for 26 Regions of the U. S. with Consumption Based on Demand Relations, 1955.

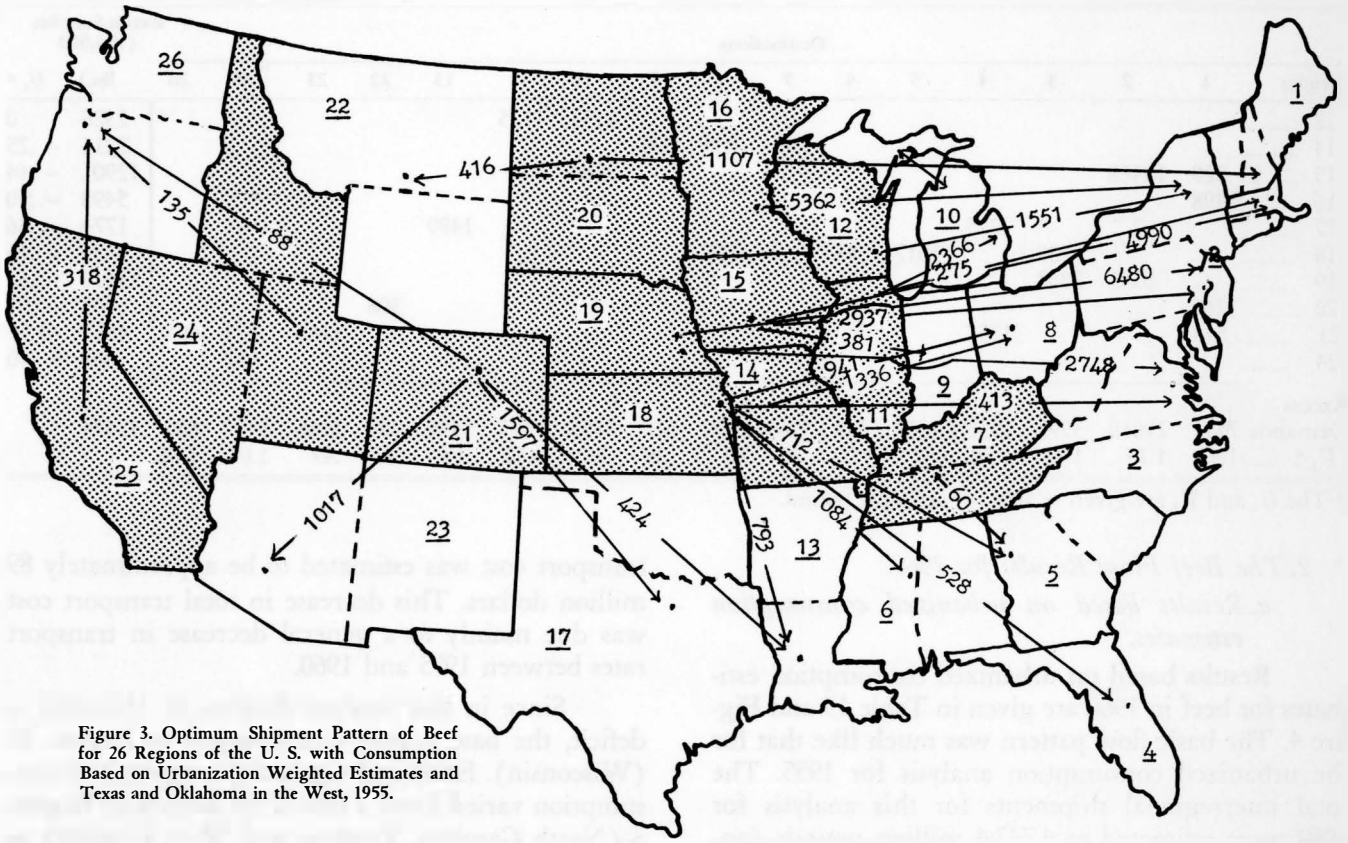


Figure 3. Optimum Shipment Pattern of Beef for 26 Regions of the U. S. with Consumption Based on Urbanization Weighted Estimates and Texas and Oklahoma in the West, 1955.

estimates with Oklahoma and Texas grouped in the Western Census Region are given in Table 18 and Figure 3. Associating Region 17 (Texas and Oklahoma), with the West resulted in a large increase in consumption and shifted this regon to the deficit category. Regions 7 (Kentucky and Tennessee) and 25 (California) became minor surplus regions due to the large increase in the level consumption in Region 17. The total beef flows are approximately 150 million pounds less than for the previous analyses and the total transport cost is reduced over four million dollars.

When the income adjusted consumption estimates, with Region 17 assumed in the Western Census Region, were used, the only basic change which occurred was that Region 25 again became a deficit region.

Table 18. Excess Demands and Supplies, Optimum Flows and Price Differentials, Urbanization Model with Texas and Oklahoma in West, Beef, 1955.

	Destinations														Excess Supplies	
Origins	1	2	3	4	5	6	8	9	10	13	17	22	23	26	(100,000 lbs.)	U_i [a]
7					60										60	.46
11	275								2366						2641	0
12		1551													1551	– .17
14							1336								1336	– .39
15	4990	2937						381							8308	– .64
16		5362													5362	– .74
18			413	528	712	1084	941			793					4471	– .65
19		6480	2748												9228	– .90
20	1107											416			1523	–1.46
21										424	1597		1017	88	3126	–1.43
24														135	135	– .55
25														318	318	– .49
Excess Demands	6372	16330	3161	528	772	1084	2277	381	2366	1217	1597	416	1017	541	38059	
V_j [a]	2.16	1.75	1.75	2.05	1.21	.88	.93	.55	.83	.96	.33	–.32	.45	1.30		

[a] The U_i and V_j are given in terms of cents per pound.

Table 19. Excess Demands and Supplies, Optimum Flows and Price Differentials, Urbanization Model, Beef, 1960.

Origins	Destinations 1	2	3	4	5	6	7	8	9	10	11	13	22	23	25	26	Excess Supplies (100,000 lbs.)	U_i [a]
12										1151	1175						2326	0
14							709	835	670								2214	– .25
15	229	10468								2204							12901	– .44
16	5498																5498	– .50
17				275								1499					1774	– .36
18			729		1617	543		1795									4684	– .45
19		8542	2868														11410	– .61
20	1260												308				1568	– .91
21	524			1257										1186	785	665	4417	–1.07
24															682		682	+ .10
Excess Demands	7511	19010	3597	1532	1617	543	709	2630	670	3355	1175	1499	308	1186	1467	665	47474	
V_j [a]	1.42	1.19	1.17	1.30	.82	.57	.45	.61	.28	.58	–.17	.15	.06	.49	1.04	1.03		

[a] The U_i and V_j are given in units of cents per pound.

2. The Beef Flow Results for 1960.

a. Results based on urbanized consumption estimates.

Results based on urbanized consumption estimates for beef in 1960 are given in Table 19 and Figure 4. The basic flow pattern was much like that for the urbanized consumption analysis for 1955. The total interregional shipments for this analysis for 1960 were estimated at 4,747.4 million pounds (approximately 32 percent of the total supply) and the transport cost was estimated to be approximately 89 million dollars. This decrease in total transport cost was due mainly to a general decrease in transport rates between 1955 and 1960.

Since in this analysis Region 11 (Illinois) is deficit, the base region was changed to Region 12 (Wisconsin). Estimated regional per capita beef consumption varied from a low of 55 pounds in Region 3 (North Carolina, Virginia and West Virginia) to 108.4 pounds in Region 22 (Montana and Wyoming).

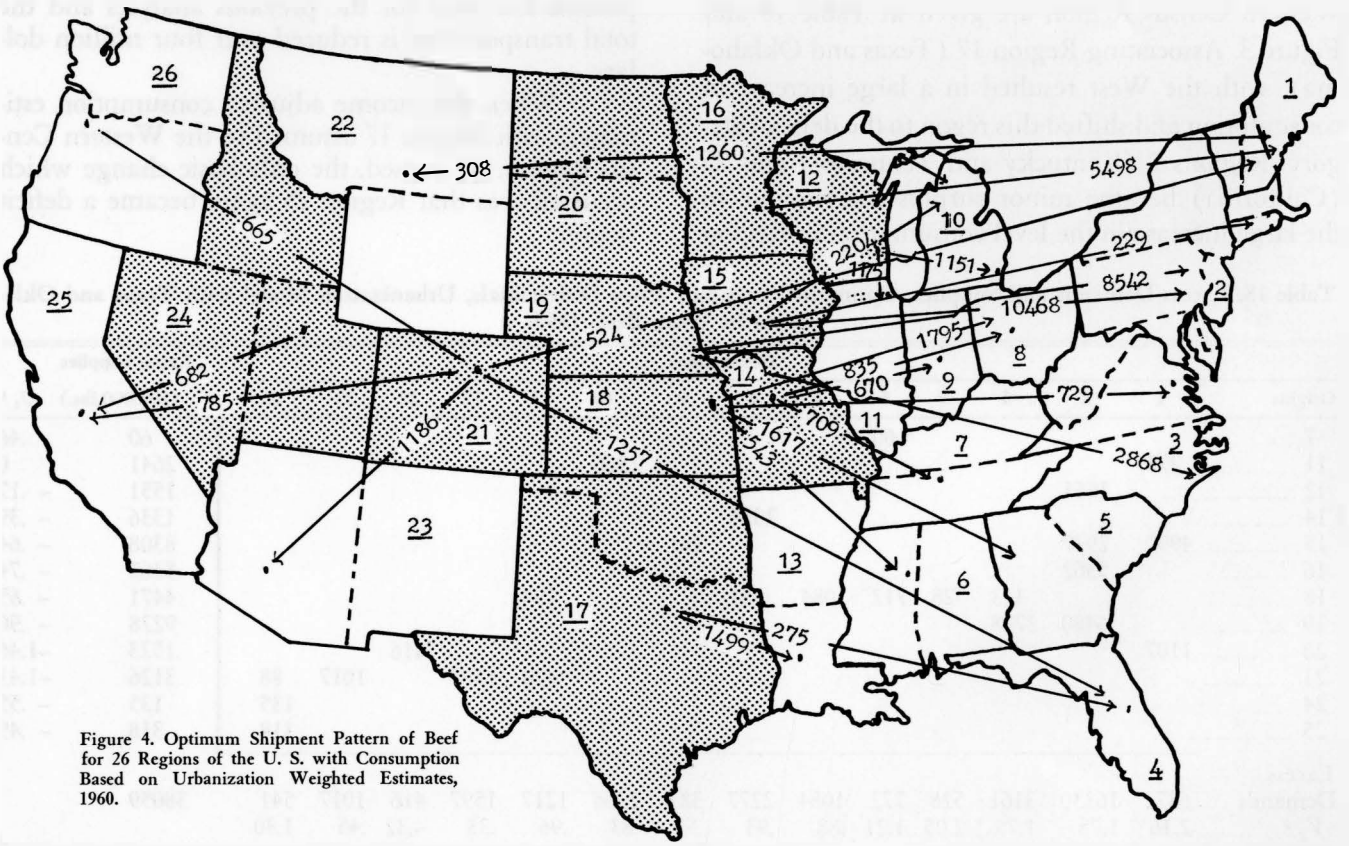


Figure 4. Optimum Shipment Pattern of Beef for 26 Regions of the U. S. with Consumption Based on Urbanization Weighted Estimates, 1960.

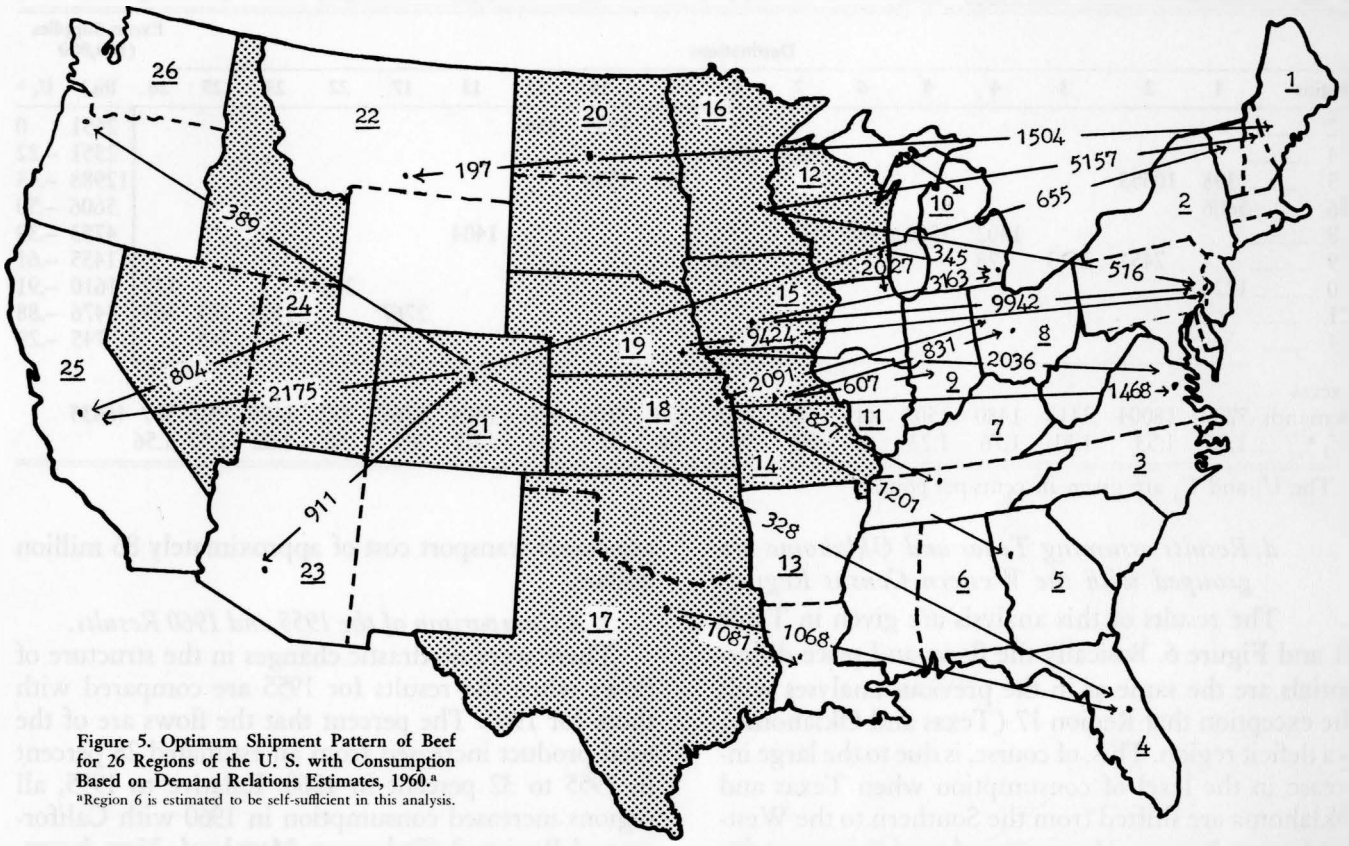


Figure 5. Optimum Shipment Pattern of Beef for 26 Regions of the U. S. with Consumption Based on Demand Relations Estimates, 1960.[a]

[a]Region 6 is estimated to be self-sufficient in this analysis.

b. Results based on regional demand relations.

The results of this analysis are given in Table 20 and Figure 5. The flow pattern changed only slightly from the previous results with the exception that Region 6 (Alabama and Mississippi) is in the self-sufficient category. The total flows were estimated to be 4,879.2 million pounds and the total transportation cost was approximately 91 million dollars. Since demand relations were used, both the estimated regional prices and price differentials are given in Table 20. The estimated per capita consumption ranged from 48 pounds in Region 6 to 111 pounds in Region 25 (California).

c. Results based on income adjusted consumption estimates.

Once again the results of the analysis using demand relations and income adjusted consumption estimates were virtually the same. Therefore, since the results add no new information, they are omitted.

Table 20. Excess Demands and Supplies, Optimum Flows, Prices and Price Differentials, Demand Relations Model, Beef, 1960.

	Destinations															Excess Supplies		
Origins	1	2	3	4	5	7	8	9	10	11	13	22	23	25	26	(100,000 lbs.) U_i [a]		P_i [a]
12									345	2072						2417	0	78.37
14						827	831	607								2265	– .25	78.12
15		9942							3163							13105	– .44	77.93
16	5157	516														5673	– .51	77.86
17				1068							1081					2149	– .37	78.00
18			1468		1201		2091									4760	– .45	78.82
19		9424	2036													11460	– .61	77.92
20	1504											197				1701	– .92	77.45
21	655			328									911	2175	389	4458	–1.08	77.29
24														804		804	+ .09	78.46
Excess Demands	7316	19882	3504	1396	1201	827	2922	607	3508	2072	1081	197	911	2979	389	48792		
V_j [a]	1.41	1.19	1.17	1.29	.82	.45	.61	.28	.58	–.17	.14	.05	.48	1.03	1.02			
P_j [a]	79.78	79.56	79.54	79.66	79.19	78.82	78.98	78.65	78.95	78.20	78.51	78.42	78.85	79.40	79.39			

[a]The U_i, V_j, and P_i and P_j are given in units of cents per pound.

Table 21. Excess Demands and Supplies, Optimum Flows, and Price Differentials, Oklahoma and Texas in West, Beef, 1960.

Origins	Destinations 1	2	3	4	5	6	7	8	9	10	11	13	17	22	23	25	26	Excess Supplies (100,000 lbs.)	U_i [a]
12										1595	856							2451	0
14							589	1762										2351	–.22
15	398	10553							523	1514								12988	–.44
16	5606																	5606	–.50
18				1402	1502	445						1404						4753	–.39
19		7451	3413	28				563										11455	–.61
20	1226													272			112	1610	–.91
21													2767		1109	205	395	4476	–.88
24																745		745	–.29
Excess Demands	7230	18004	3413	1430	1502	445	589	2325	523	3109	856	1404	2767	272	1109	950	507	46435	
V_j [a]	1.76	1.53	1.51	1.76	1.22	.97	.82	.98	.64	.92	.24	1.03	.66	.40	1.02	1.57	1.56		

[a] The U_i and V_j are given in cents per pound.

d. Results assuming Texas and Oklahoma are grouped with the Western Census Region.

The results of this analysis are given in Table 21 and Figure 6. Basically the flows and price differentials are the same as in the previous analyses with the exception that Region 17 (Texas and Oklahoma) is a deficit region. This, of course, is due to the large increase in the level of consumption when Texas and Oklahoma are shifted from the Southern to the Western Census Region. The estimated total shipments for this analysis were 4,643.5 million pounds with an associated transport cost of approximately 86 million dollars.

3. A Comparison of the 1955 and 1960 Results.

There were no drastic changes in the structure of flows when the results for 1955 are compared with those for 1960. The percent that the flows are of the total product increased from an estimated 28 percent in 1955 to 32 percent in 1960. Relative to 1955, all regions increased consumption in 1960 with California and Region 2 (Delaware, Maryland, New Jersey, New York, Pennsylvania, Washington D.C.) leading

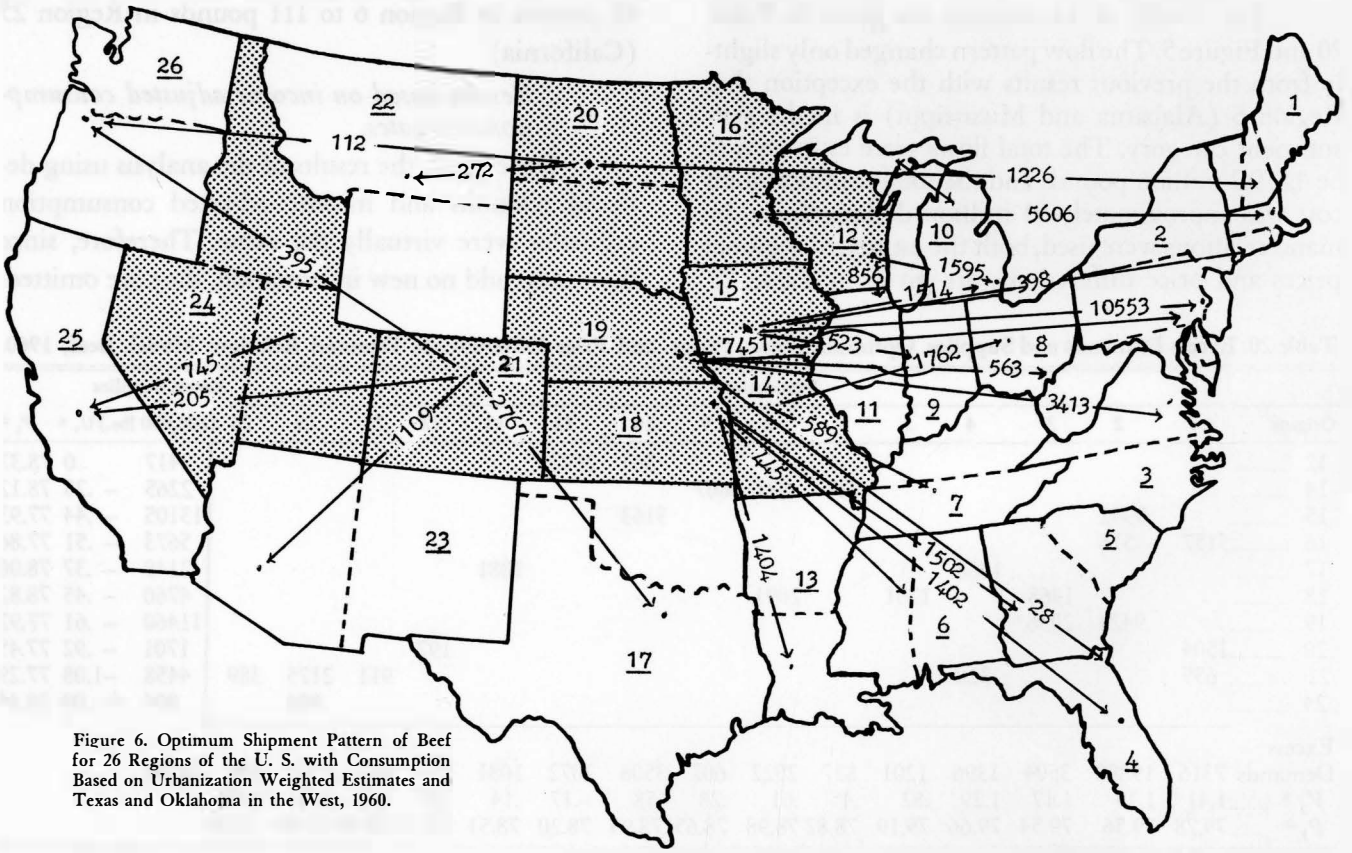


Figure 6. Optimum Shipment Pattern of Beef for 26 Regions of the U. S. with Consumption Based on Urbanization Weighted Estimates and Texas and Oklahoma in the West, 1960.

all regions. Relative to 1955 all regions west of the Mississippi River increased their supplies in 1960. Of these regions Iowa and Nebraska experienced increases of 473 and 227 million pounds, respectively. Illinois led the decreases in supply with a reduction of 271 million pounds. Increases or decreases in regional slaughtering facilities were the main reasons for these supply changes. The changes in regional consumption and supply are given in Table 22.

B. Spatial Analyses for Veal

As in the case of beef, spatial analyses for veal were completed for the years 1955 and 1960. However, for veal only the urbanization weighted regional consumption estimates were generated for each year.

1. The Results for 1955.

Using the urbanized regional consumption estimates, the excess demands and supplies and optimum geographical flows and price differentials are given in Table 23 and Figure 7. In 1955 the West and Northeast were estimated to be the deficit regions for veal. There were 14 surplus and 12 deficit regions and Regions 16 (Minnesota) and 17 (Texas and Oklahoma) provided the connecting links between shipments east and west. The total interregional flow of veal was estimated to be 592.56 million pounds (approximately 38 percent of the total supply) and the estimated total transport cost was 16.1 million dollars.

Table 22. Estimated Changes in Regional Consumption and Supply (Slaughter Volume) from 1955 to 1960 for Beef and Pork.

Region	Beef Changes[a]		Pork Changes[a]	
	Supply	Consumption	Supply	Consumption
	(000 Pounds)			
1	— 26,406	+ 59,620	— 42,493	+ 32,038
2	— 6,001	+160,446	— 23,237	+ 88,977
3	+ 13,017	+ 38,305	+121,097	+ 32,697
4	— 6,015	+ 86,533	+ 5,584	+ 93,109
5	— 48,559	+ 24,509	+ 43,430	+ 20,610
6	+ 84,410	+ 20,552	+ 64,556	+ 15,331
7	— 45,365	+ 19,559	+167,011	+ 13,066
8	+ 56,938	+ 61,879	+ 35,672	+ 33,979
9	+ 12,186	+ 26,374	+202,822	+ 13,955
10	— 22,566	+ 51,959	— 8,139	+ 28,861
11	—271,003	+ 79,497	—179,038	+ 46,153
12	+115,558	+ 25,783	+ 44,628	+ 14,175
13	+ 5,016	+ 23,897	+ 281	+ 19,830
14	+108,205	+ 6,109	+ 31,248	— 391
15	+473,505	+ 5,232	+342,423	+ 747
16	+ 44,831	+ 20,487	— 43,905	+ 10,889
17	— 29,585	+ 78,045	— 40,501	+ 63,224
18	+ 35,922	+ 7,646	+ 40,569	+ 3,059
19	+226,938	+ 4,052	+ 37,217	+ 1,341
20	+ 9,022	+ 180	— 35,313	— 1,348
21	+150,442	+ 15,581	— 1,583	+ 8,328
22	+ 21,170	+ 6,791	+ 7,537	+ 3,212
23	+ 38,477	+ 48,788	+ 7,973	+ 27,038
24	+ 80,921	+ 20,240	+ 10,356	+ 10,488
25	+124,916	+257,306	— 69,746	+138,174
26	+ 31,497	+ 28,102	+ 12,551	+ 13,459

[a] A plus sign indicates an increase from 1955 to 1960.

The price differentials relative to Region 11 (Illinois) varied from a low of –1.47 cents per pound in Region 17 to a high of 2.43 cents per pound in Region 26 (Washington and Oregon). Per capita consumption varied from 4.43 pounds in Region 6 (Alabama and Mississippi) to 15.31 in Region 1 (New England).

2. The Results for 1960.

Since there was a considerable reduction in veal supplies from 1955 to 1960, major changes occurred in the estimated flow pattern for 1960 (Table 24 and Figure 8). Regions 11 (Illinois), 14 (Missouri), 19 (Nebraska) and 20 (North and South Dakota) shifted from surplus to deficit regions, while Region 3 (North Carolina, Virginia, West Virginia) shifted to a surplus region. The total estimated flows for 1960 were 473.09 million pounds (over 42 percent of total supply) and the total estimated shipment cost was 9.5 million dollars. The price differentials varied from –.90 cents per pound in Region 17 (Texas and Oklahoma) to 1.75 cents per pound in Region 26 (Washington and Oregon). Per capita consumpton varied from an estimated 3.10 pounds in Region 6 (Alabama and Mississippi) to 9.73 pounds in Region 1 (New England).

C. Spatial Analyses for Pork

As in the case for beef, several alternative regional consumption estimates were generated for each time period. The results for each type of consumption estimate will now be presented and compared.

1. The Results for 1955.

a. Results based on urbanized consumption estimates.

The results for pork when regional consumption estimates weighted by urbanization groups are used are given in Table 25 and Figure 9. As might be expected, the regions in the Cornbelt are surplus and this pool of excess supplies is used to satisfy the excess demand requirements of the East, South and West.

Region 15 (Iowa) which shipped pork both south and east and Region 19 (Nebraska) which shipped pork both south and west acted as the connecting links in the flow pattern. The estimated total interregional flows of pork were 4,162.9 million pounds (approximately 40 percent of total supply) and the total estimated shipment cost was $92,522,196. The price differentials ranged from –.74 cents per pound in Region 16 (Minnesota) to 3.07 cents per pound in Region 25 (California). Per capita regional consumption varied from 55.9 pounds in Region 1 (New England) to 74.7 pounds in Region 4 (Florida).

Table 23. Excess Demands and Supplies, Geographical Flows and Price Differentials, Veal, 1955.

Origins	Destinations 1	2	3	8	9	10	21	22	23	24	25	26	Excess Supplies (10,000 lbs.)	U_i [a]
4		194											194	− .55
5		430	473										903	− .05
6		3690											3690	− .52
7		2675											2675	− .15
11						55							55	0
12	6455					229							6684	− .18
13		3134		2816									5950	−1.21
14					71								71	− .42
15	3954				1105								5059	− .65
16	2144	389						350					2883	− .76
17		22094					41		681	505	2990	1607	27918	−1.47
18				3006									3006	− .67
19								164					164	− .81
20								4					4	+ .03
Excess Demands	12553	32606	473	5822	1176	284	41	518	681	505	2990	1607	59256	
V_j [a]	2.15	1.74	1.26	.90	.54	.83	.29	1.17	.76	1.15	1.79	2.43		

[a] The U_i and V_j are given in cents per pound.

b. Results based on regional demand relations. The excess demands and supplies, geographical flows and prices, and price differentials that result when regional demand relations are employed are given in Table 26 and Figure 10. The surplus and deficit regions were the same as in the previous analysis and there were only minor differences in the direction and volume of flows. The total estimated interregional shipments were 4,148.2 million pounds and the associated transport costs $91,973,093. Since demand relations were employed, equilibrium regional prices (p_i, p_j) were computed and are given in Table 24. The estimated regional per capita consumption ranged from 54.4 pounds in Region 23 (Arizona and New Mexico) to 73.57 pounds in Region 4 (Florida).

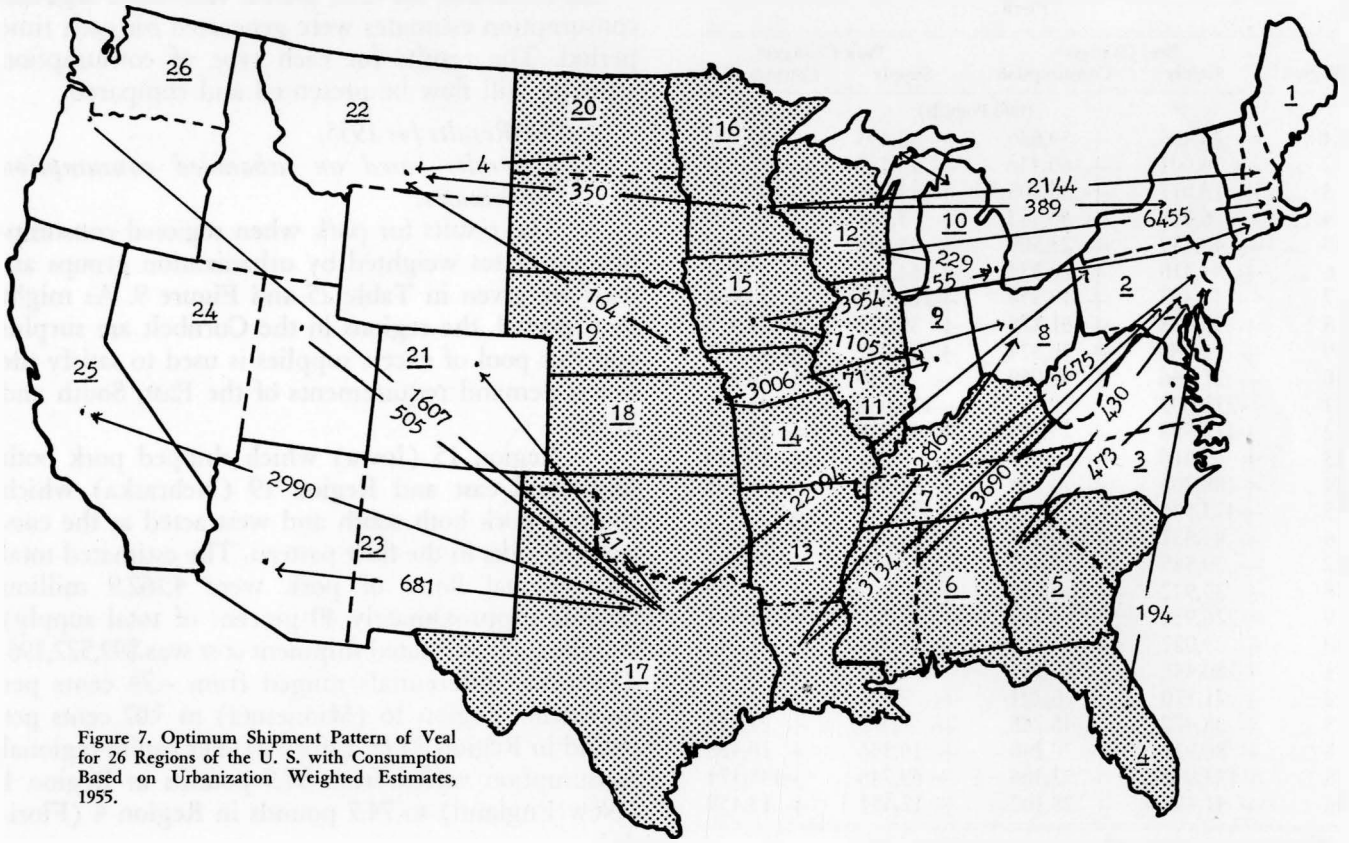


Figure 7. Optimum Shipment Pattern of Veal for 26 Regions of the U. S. with Consumption Based on Urbanization Weighted Estimates, 1955.

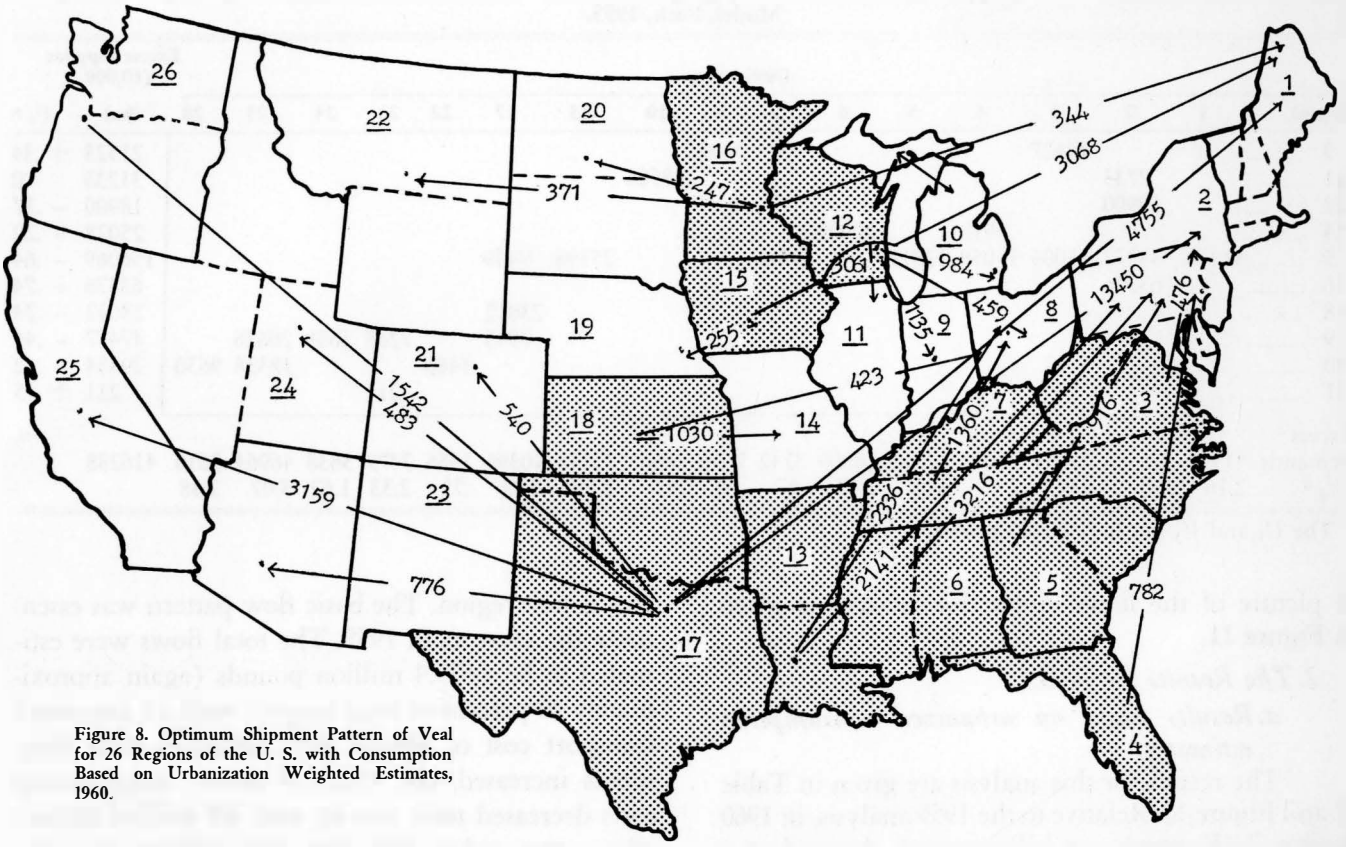


Figure 8. Optimum Shipment Pattern of Veal for 26 Regions of the U. S. with Consumption Based on Urbanization Weighted Estimates, 1960.

c. Results based on using Western Census Region consumption estimates for Oklahoma and Texas.

By considering Oklahoma and Texas in the Western Census Region, the estimated consumption decreased in Region 17 (Texas and Oklahoma) by approximately 21 percent and increased in all other regions by about 2 percent. However, even with this change in regional consumption no changes occurred in the surplus and deficit position of the regions and only very minor changes occurred in the flow pattern. Relative to the first analysis, the total estimated interregional flows decreased by about 40 million pounds and the total shipment cost increased by approximately $350,000. The increased cost resulted from the transport cost savings in shipments to Region 17 (Texas and Oklahoma) being outweighed by the additional expense of supplying the increased consumption in the other deficit regions.

Table 24. Excess Demands and Supplies and Optimum Geographical Flows and Price Differentials, Veal, 1960

	Destinations															Excess Supplies	
Origins	1	2	8	9	10	11	14	19	20	21	22	23	24	25	26	(10,000 lbs.)	U_i [a]
3		476														476	+ .94
4		782														782	- .35
5		916														916	- .01
6		3216														3216	- .33
7			1360													1360	+ .09
12			459	1135	984	3061										5639	0
13		2141	2336													4477	- .73
15	3068							255								3323	- .40
16	344								247		371					962	- .46
17	4755	13450								540		776	483	3159	1542	24705	- .90
18			423				1030									1453	- .35
Excess Demands	8167	20981	4578	1135	984	3061	1030	255	247	540	371	776	483	3159	1542	47309	
V_j [a]	1.32	1.07	.57	.20	.44	-.24	-.53	-.29	.35	.45	1.00	.76	.99	1.33	1.75		

[a] The U_i and V_j are in cents per pound.

Table 25. Excess Demands and Supplies and Optimum Geographical Flows and Price Differentials, Urbanized Consumption Model, Pork, 1955.

Origins	Destinations 1	2	3	4	5	6	7	8	10	13	17	22	23	24	25	26	Excess Supplies (10,000 lbs.)	U_i [a]
9			14427					7096									21523	+ .34
11		2733							28505								31238	0
12		18900															18900	- .17
14				5019		20009											25028	- .22
15	41440	33377	15004	15058	12811		3742			25198	9439						156069	- .64
16		63376															63376	- .74
18											23012						23012	- .24
19											7945		7268	3638	28626		47477	- .44
20												1486			18338	9630	29454	- .42
21													211				211	+ .45
Excess Demands	41440	118386	29431	20077	12811	20009	3742	7096	28505	25198	40396	1486	7479	3638	46964	9630	416288	
V_j [a]	2.16	1.76	1.82	2.28	1.39	1.12	.87	.90	.83	1.29	1.08	.72	2.33	1.62	3.07	2.38		

[a] The U_i and V_j are in cents per pound.

A picture of the flows under this analysis is given in Figure 11.

2. The Results for 1960.

a. Results based on urbanized consumption estimates.

The results for this analysis are given in Table 27 and Figure 12. Relative to the 1955 analysis, in 1960 Region 7 (Kentucky and Tennessee) changed to a surplus region and Region 21 (Colorado) changed to a deficit region. The basic flow pattern was essentially the same as in 1955. The total flows were estimated to be 4,629.4 million pounds (again approximately 40 percent of total supply) with an associated transport cost of $88,660,375. Although total shipments increased, the effect of lower tranportation costs decreased total cost by over 3.8 million dollars when compared to 1955. The price differentials, relative to Region 11 (Illinois), varied from —.58 cents

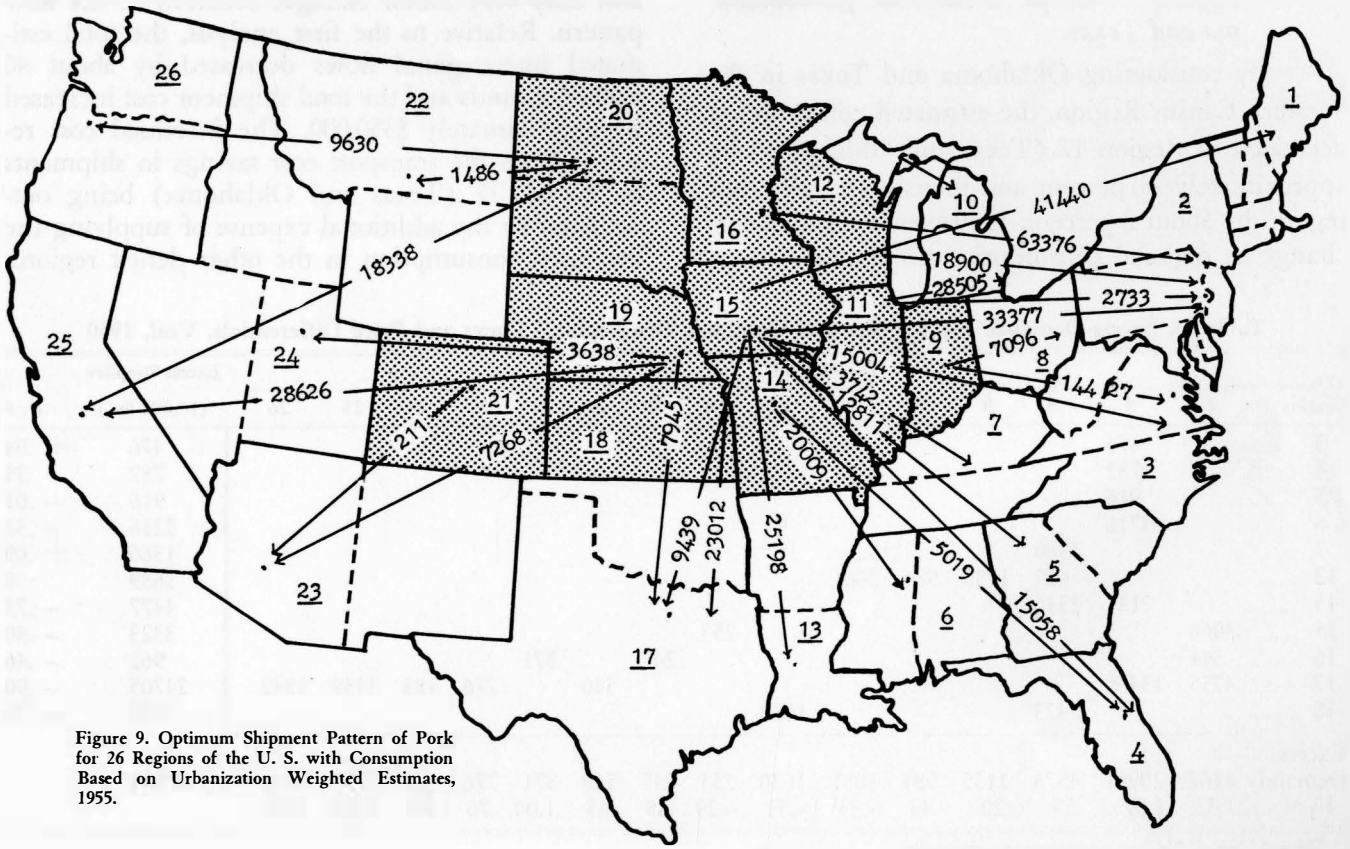


Figure 9. Optimum Shipment Pattern of Pork for 26 Regions of the U. S. with Consumption Based on Urbanization Weighted Estimates, 1955.

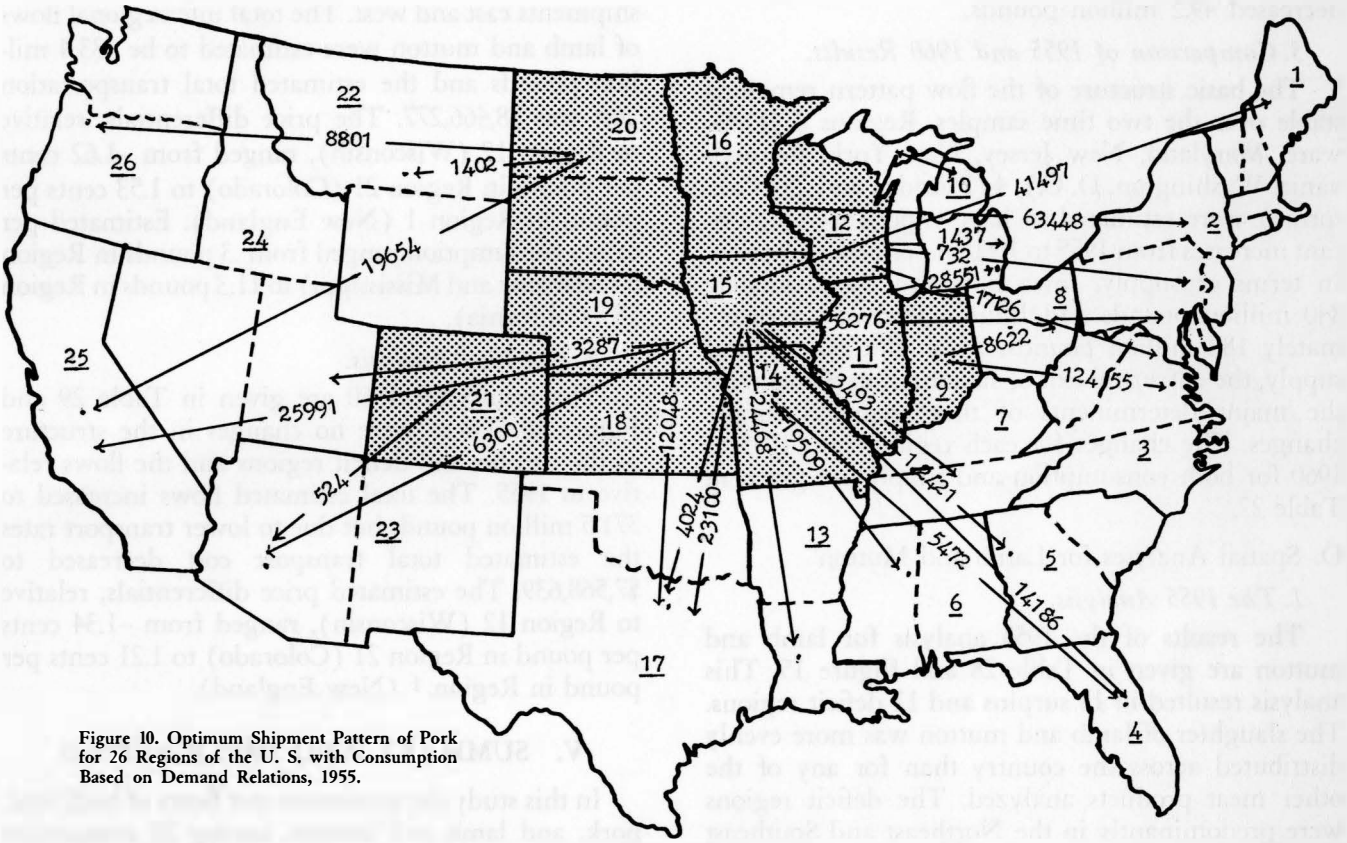


Figure 10. Optimum Shipment Pattern of Pork for 26 Regions of the U. S. with Consumption Based on Demand Relations, 1955.

per pound in Region 16 (Minnesota) to 2.54 cents per pound in Region 25 (California). Estimated per capita consumption varied from 54.6 pounds in Region 1 (New England) to 73.5 pounds in Region 4 (Florida).

b. Results based on regional demand relations. The results of this analysis agree quite closely with the previous analyses. Total estimated shipments are 4,537.1 million pounds and the total transportation cost is $87,237,580. Estimated regional per capita consumption varied from 52.7 pounds in Region 23 (Arizona and New Mexico) to 72 pounds in Region 4 (Florida). The direction and magnitude of the interregional flows for this analysis are given in Figure 13.

c. Results based on Western Census Region consumption estimates for Oklahoma and Texas.

The flow results for this analysis are given in Figure 14. No changes occurred in the structure of the surplus and deficit regions and the geographical

Table 26. Excess Demands and Supplies and Optimum Flows, Prices and Price Differentials, Demand Relations Model, Pork, 1955.

	Destinations																Excess Supplies		
Origins	1	2	3	4	5	6	7	8	10	13	17	22	23	24	25	26	(10,000 lbs.)	U_i [a]	P_i [a]
9			12455					8622									21077	+ .33	53.54
11									28551								28551	0	53.21
12		732	17126						1437								19295	- .18	53.03
14				5472		19509											24981	- .23	52.98
15	41497	56276		14186	12421		3493			24468	4024						156365	- .65	52.56
16		63448															63448	- .75	52.46
18											23100						23100	- .25	52.96
19											12048		6300	3287	25991		47626	- .45	52.76
20												1402			19654	8801	29857	- .43	52.78
21													524				524	+ .44	53.65
Excess Demands	41497	120456	29581	19658	12421	19509	3493	8622	29988	24468	39172	1402	6824	3287	45645	8801	414824		
V_j [a]	2.15	1.75	1.81	2.27	1.38	1.11	.86	.89	.83	1.28	1.07	.71	2.32	1.61	3.06	2.37			
P_j [a]	55.36	54.96	55.02	55.48	54.59	54.32	54.07	54.10	54.04	54.49	54.28	53.92	55.53	54.82	56.27	55.58			

[a]The U_i, V_j, and P_i and P_j are given in cents per pound.

flows. Total estimated flows under this specification decreased 49.2 million pounds.

3. Comparison of 1955 and 1960 Results.

The basic structure of the flow pattern remained stable over the two time samples. Regions 2 (Delaware, Maryland, New Jersey, New York, Pennsylvania, Washington, D. C.), 4 (Florida) and 25 (California) were estimated to have experienced significant increases from 1955 to 1960 in pork consumption. In terms of supply, Iowa increased approximately 340 million pounds and Illinois decreased approximately 180 million pounds. As in the case of beef supply, the entry and exit of slaughtering plants were the major determinents of these regional supply changes. The changes for each region from 1955 to 1960 for both consumption and supply are given in Table 22.

D. Spatial Analyses for Lamb and Mutton

1. The 1955 Analysis.

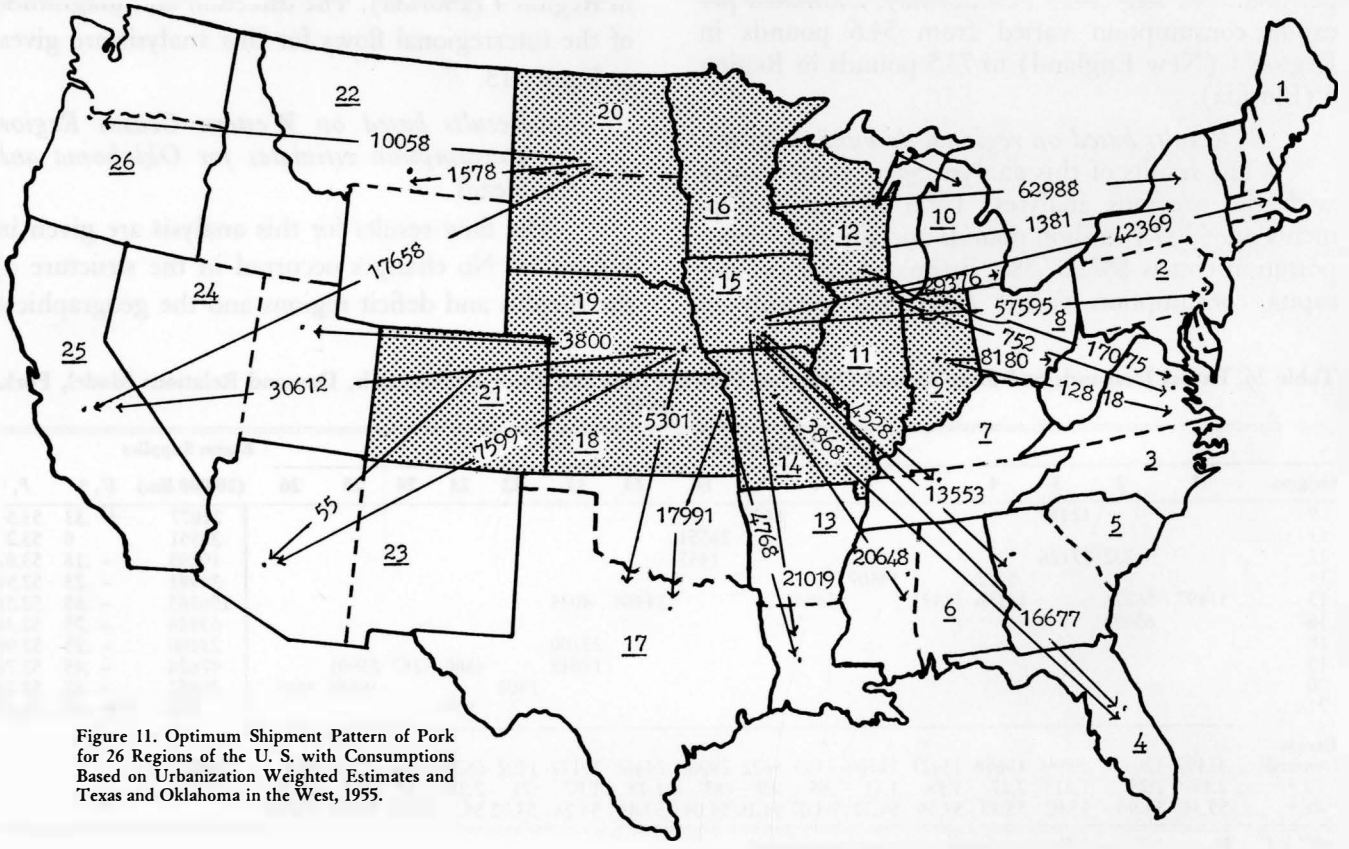
The results of the 1955 analysis for lamb and mutton are given in Table 28 and Figure 15. This analysis resulted in 14 surplus and 12 deficit regions. The slaughter of lamb and mutton was more evenly distributed across the country than for any of the other meat products analyzed. The deficit regions were predominantly in the Northeast and Southeast regions. Regions 20 (North and South Dakota) and 21 (Colorado) were the connecting links between shipments east and west. The total interregional flows of lamb and mutton were estimated to be 333.4 million pounds and the estimated total transportation cost was $8,466,277. The price differentials, relative to Region 12 (Wisconsin), ranged from –1.62 cents per pound in Region 21 (Colorado) to 1.53 cents per pound in Region 1 (New England). Estimated per capita consumption ranged from .3 pounds in Region 6 (Alabama and Mississippi) to 11.3 pounds in Region 25 (California).

2. The 1960 Analysis.

The results for 1960 are given in Table 29 and Figure 16. There were no changes in the structure of the surplus and deficit regions and the flows relative to 1955. The total estimated flows increased to 371.5 million pounds but due to lower transport rates the estimated total transport cost decreased to $7,568,639. The estimated price differentials, relative to Region 12 (Wisconsin), ranged from –1.34 cents per pound in Region 21 (Colorado) to 1.21 cents per pound in Region 1 (New England).

V. SUMMARY AND IMPLICATIONS

In this study the minimum cost flows of beef, veal, pork, and lamb and mutton among 26 component regions of the U. S. were determined by a linear pro-



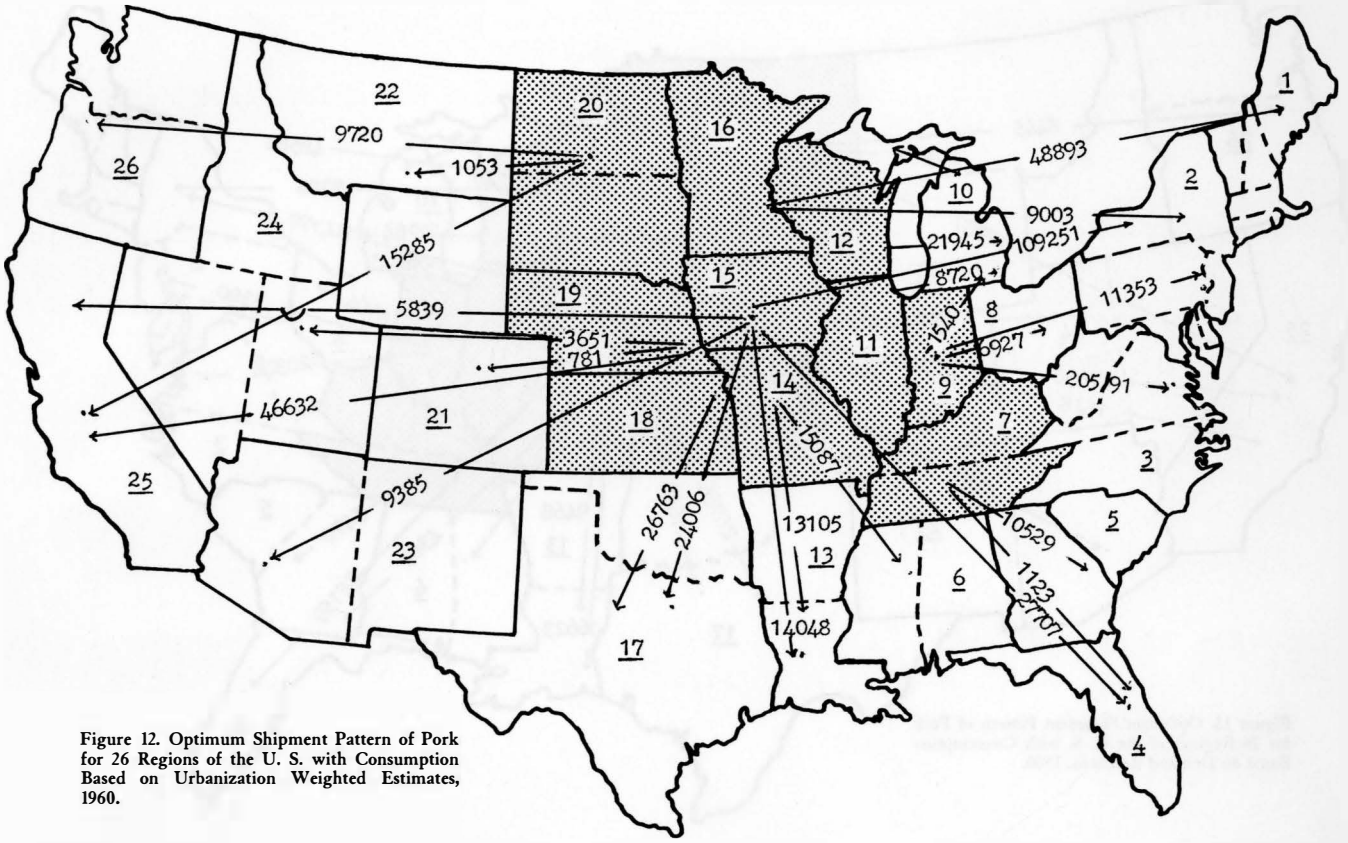


Figure 12. Optimum Shipment Pattern of Pork for 26 Regions of the U. S. with Consumption Based on Urbanization Weighted Estimates, 1960.

gramming transportation model. Regional price differentials consistent with the optimum set of flows for each product were also derived.

Since regional consumption data are not available, it was necessary to generate these estimates by synthetic means. Five alternative sets of regional consumption were developed for beef and three for pork. Regional consumption estimates for beef are as follows: (*a*) urbanization weighted with Oklahoma and Texas considered in the South, (*b*) urbanization weighted with Oklahoma and Texas considered in the West, (*c*) adjusted by regional per capita disposable income with Oklahoma and Texas in the South, (*d*) adjusted by regional per capita disposable income with Oklahoma and Texas in the West, and (*e*) demand relations with adjustments for per capita income, census region and prices. The major difference among the sets of estimates occurs when Oklahoma and Texas are considered to have consumption habits consistent with the Western Census Region.

Table 27. Excess Demands and Supplies, and Optimum Flows and Price Differentials, Urbanized Consumption Model, Pork, 1960.

	Destination																Excess Supplies	
Origin	1	2	3	4	5	6	8	10	13	17	21	22	23	24	25	26	(10,000 lbs.)	U_i [a]
7				1123	10529												11652	+.27
9		11353	20591				6927	1540									40411	+.09
11								8720									8720	0
12								21945									21945	- .14
14						15087			13105								28192	- .24
15		109251		27707					14048	24006			9385		5839		190236	- .51
16	48893	9003															57896	- .58
18										26763							26763	- .22
19											781			3651	46632		51064	- .34
20												1053			15285	9720	26058	- .33
Excess Demand	48893	129607	20591	28830	10529	15087	6927	32205	27153	50769	781	1053	9385	3651	67756	9720	462937	
V_j [a]	1.68	1.46	1.42	1.76	.92	.97	.51	.78	1.15	1.28	1.09	.98	2.09	1.69	2.54	2.14		

[a] The U_i and V_j are in cents per pound.

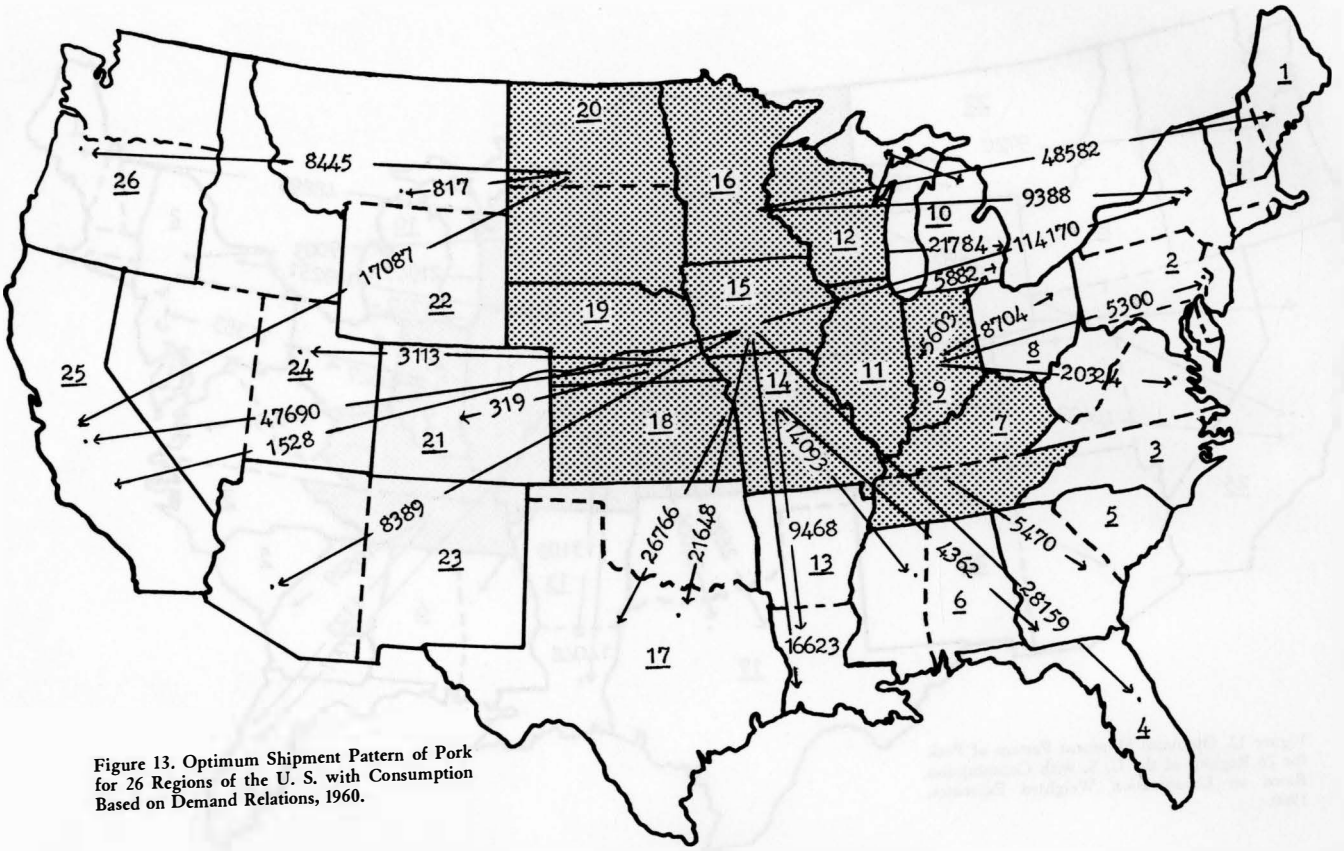


Figure 13. Optimum Shipment Pattern of Pork for 26 Regions of the U. S. with Consumption Based on Demand Relations, 1960.

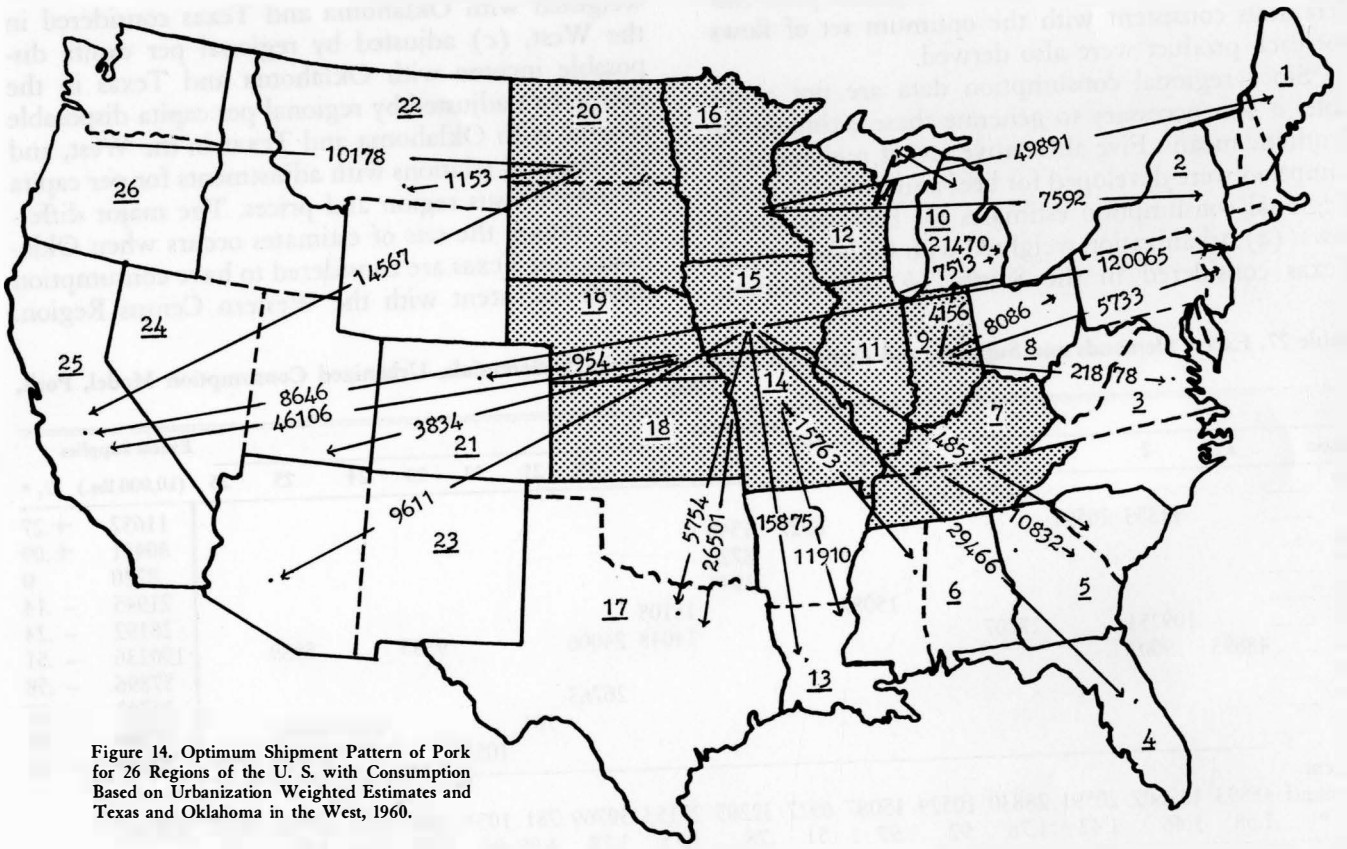


Figure 14. Optimum Shipment Pattern of Pork for 26 Regions of the U. S. with Consumption Based on Urbanization Weighted Estimates and Texas and Oklahoma in the West, 1960.

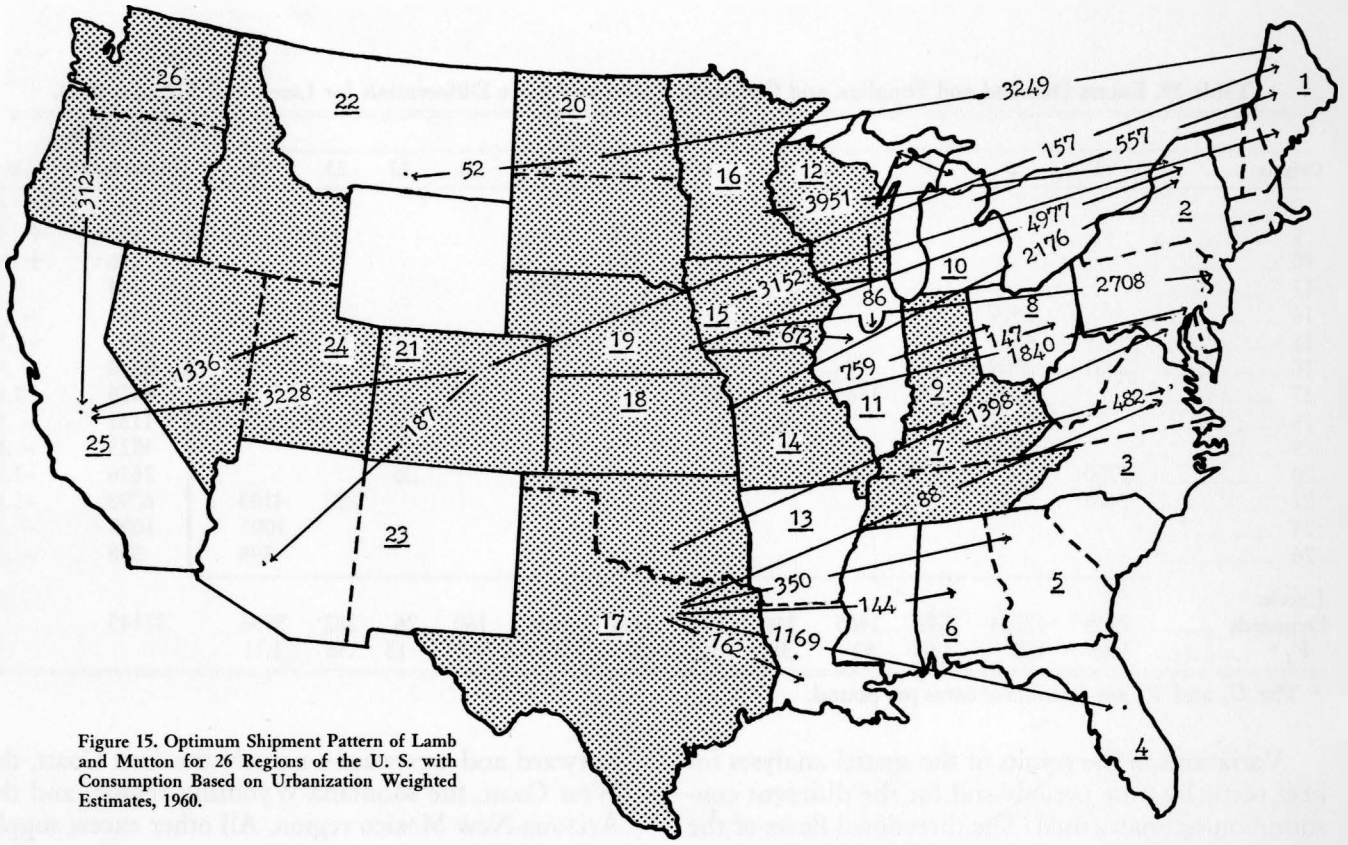


Figure 15. Optimum Shipment Pattern of Lamb and Mutton for 26 Regions of the U. S. with Consumption Based on Urbanization Weighted Estimates, 1960.

Relative to specification (*a*) total beef consumption for specification (*b*) in Oklahoma and Texas increased by about 70 percent. As a basis for the adjustment coefficients for specifications (*c*) and (*d*), income consumption relations were derived for each census region from data from the Household Food Consumption Survey.

The sets of estimates for pork include specifications (*a*), (*b*), and (*e*). The major difference occurred between (*a*) and (*b*). Relative to specification (*a*) considering Oklahoma and Texas in the West, the estimated consumption in this region decreased by approximately 21 percent. One set of consumption estimates, weighted by urbanization groups, was generated for veal and one set of estimates based on USDA data was developed for lamb and mutton.

Table 28. Excess Demands and Supplies and Optimum Flows and Price Differentials for Lamb and Mutton, 1955.

	Destinations												Excess Supplies	
Origins	1	2	3	4	5	6	8	11	13	22	23	25	(10,000 lbs.)	U_i [a]
7			482										482	+ .01
9							147						147	+ .38
10	557												557	+ .58
12								86					86	0
14		1840					759						2599	- .38
15	3152	2708						673					6533	- .57
16		3951											3951	- .67
17		1398	88	1169	350	144			162				3311	-1.38
18		2176											2176	- .62
19		4977											4977	- .83
20	3249									52			3301	-1.39
21	157										187	3228	3572	-1.62
24												1336	1336	- .80
26												312	312	- .66
Excess Demands	7115	17050	570	1169	350	144	906	759	162	52	187	4876	33340	
V_j [a]	2.23	1.83	1.52	1.07	.59	.04	.94	.35	-.44	-.25	.26	1.13		

[a] The U_i and V_j are in units of cents per pound.

Table 29. Excess Demand and Supplies, and Optimum Flows and Price Differentials for Lamb and Mutton, 1960.

Origins	Destinations 1	2	3	4	5	6	8	11	13	22	23	25	Excess Supplies (10,000 lbs.)	U_i [a]
7			455		340								795	+ .27
9							370						370	+ .20
10							210						210	+ .16
12								364					364	0
14		1807					607						2414	- .58
15		4824						2067					6891	- .70
16	2061	2559											4620	- .77
17		2590	77	1465		133			160				4425	-1.18
18		1131											1131	- .73
19		4823											4823	- .87
20	2790									26			2816	-1.18
21	2408										282	4103	6793	-1.34
24												1095	1095	- .17
26												398	398	- .73
Excess Demands	7259	17734	532	1465	340	133	1187	2431	160	26	282	5596	37145	
V_j [a]	1.49	1.27	1.08	.82	.38	.10	.62	.14	-.33	.13	.56	1.11		

[a] The U_i and V_j are in units of cents per pound.

Variations in the results of the spatial analyses for beef occur by time periods and for the different consumption estimates used. The directional flows of the optimum flow pattern for 1955 and 1960 are very similar; however, some substantial differences occur in the quantities of beef involved. In both 1955 and 1960 optimum solutions, Region 20 (North and South Dakota) and Region 21 (Colorado) shipped beef eastward and westward—namely the East Coast, the West Coast, the Montana-Wyoming region, and the Arizona-New Mexico region. All other excess supply regions shipped in one direction, either eastward or westward. For both 1955 and 1960, optimum shipments from the Cornbelt states were eastward. The optimum shipment patterns are very similar for regional consumption estimates based on urbaniza-

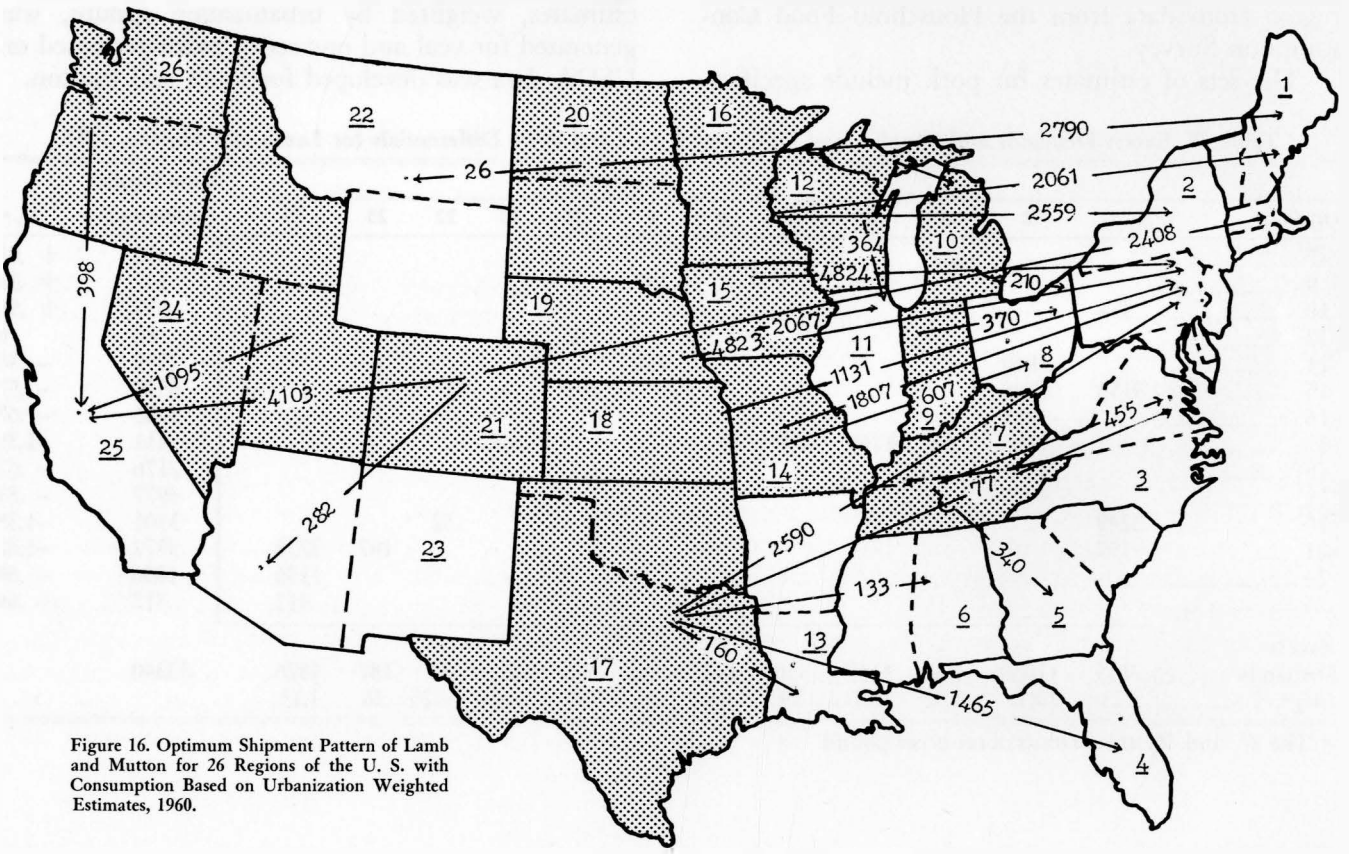


Figure 16. Optimum Shipment Pattern of Lamb and Mutton for 26 Regions of the U. S. with Consumption Based on Urbanization Weighted Estimates, 1960.

tion weighting with the Oklahoma and Texas region assumed in the South and estimates based on regional demand relations. When the Oklahoma and Texas region is considered in the West and the higher consumption levels of the Western Census Region are assumed to apply, substantial differences occur in the optimum shipment pattern. In both 1955 and 1960 the Oklahoma and Texas region changed from an excess supply region to an excess demand region. The deficit in this region was fulfilled by shipments from Colorado. Also, the destinations and volumes of shipments from the regions along the western border of the Cornbelt changed substantially. Results such as these are indicative of the types of changes which may occur in the future if population shifts geographically, regional incomes increase at different rates, and changes occur in consumer preferences.

The total beef shipments in the optimum solution for 1960 when consumption was based on the urbanization weighted estimates were 4,747.4 million pounds and the total transportation cost was 89 million dollars. Using consumption estimates based on regional demand relations resulted in total shipments increasing to 4,879.2 million pounds and total transportation cost increasing to 91.0 million dollars. Considering the Oklahoma and Texas region in the West yielded approximately 100 million pounds less of beef shipments and total transportation cost was reduced over 3 million dollars. The optimum beef flows for 1955 exhibited a similar pattern among the three sets of consumption estimates. The total U. S. beef production was approximately 1.2 billion pounds greater in 1960 than in 1955 and the total optimum beef flows increased approximately 800 million pounds from 1955 to 1960. Due to lower transportation costs, geographical shifts in production, and geographical shifts in consumption, the total transportation costs associated with the optimum beef flows in 1960 was approximately 1.5 million dollars less than in 1955.

Region 11 (Illinois) was chosen as the base region for the 1955 beef analysis. Illinois had the greatest comparative price advantage of all the surplus regions when consumption was based on regional demand relations or estimates weighted by urbanization. This is largely because of its proximity to the deficit regions of the East. Colorado and the North Dakota-South Dakota regions had the least comparative advantage in 1955. Some of the highest delivered price differentials relative to Illinois occurred along the Atlantic Coast from New England to Florida. When consumption is based on estimates weighted by urbanization and the Oklahoma and Texas region is considered in the West, the Kentucky-Tennessee region, with a relatively small beef surplus, had the greatest comparative price advantage and was followed by the Illinois, Wisconsin, and Missouri regions. Colorado and the North Dakota-South Dakota regions still continued to have the least comparative advantage relative to other beef surplus regions. The regions with the highest beef price per one hundred pounds continued to be located along the Atlantic Coast.

In the analysis for 1960, Illinois was a deficit region. The Idaho-Nevada-Utah region had the greatest comparative price advantage when consumption was based on estimates weighted by urbanization or regional demand relations. This region was followed by Wisconsin, Missouri, and the Oklahoma-Texas regions. Colorado and the North Dakota-South Dakota regions had the least comparative price advantage; however, their relative positions were greatly improved over what they were in 1955. The regions along the Atlantic Coast continued to have the highest beef price per one hundred pounds followed by regions along the Pacific Coast. When consumption was based on estimates weighted by urbanization and the Oklahoma and Texas region in the West, Wisconsin had the greatest comparative price advantage and was followed by Missouri and the Idaho-Nevada-Utah region. The relative position of Colorado was greatly improved. The regions with the highest price of beef remained as before. In general, the spread of price differentials among surplus regions was less in 1960 than in 1955.

The urbanization weighted estimates of consumption provided the basis for the spatial analyses of veal. Major changes occurred between 1955 and 1960 in the estimated flow patterns of veal. Much of the difference between 1955 and 1960 can be attributed to the large reduction in veal supplies. In 1955 the excess supply regions were located in the Midwest and Southeast while the deficit areas were in the Northeast and West. The estimated total interregional flow of veal in the optimum allocation was 592.6 million pounds and the total transportation cost was approximately 16.1 million dollars. In 1960 the total estimated flows were 573.1 million pounds and the total cost was approximately 9.5 million dollars. The large reduction in total transportation costs is due to the interaction of several factors including lower transportation rates, reduced supplies, and shifts in the geographical location of supply and consumption. Regions in the Cornbelt such as the Dakotas, Nebraska, Missouri, and Illinois which were excess supply regions in 1955 became deficit areas in 1960; however, regions in the Northeast and the West continued to be the major deficit areas. In 1955 the North Dakota-South Dakota region had the greatest comparative price advantage followed by Illinois, Georgia-South Carolina, Kentucky-Tennessee, and Wisconsin regions. The Oklahoma-Texas region had the least comparative price advantage of all excess supply regions. The deficit regions with the highest veal price were loca-

ted in the Northeast and Northwest. In 1960 the greatest comparative price advantage had shifted to the North Carolina-Virginia-West Virginia region followed by the Kentucky-Tennessee, Wisconsin, and Georgia-South Carolina regions. The Oklahoma-Texas region continued to have the least advantage of all excess supply regions. Regions in the Northeast and West continued to have the highest delivered price differentials.

The optimum spatial flows of pork in 1955 and 1960 were estimated for three sets of regional consumption estimates. Regions located in the Cornbelt were surplus for both years and supplied the excess demand requirements of regions in the East, South and West. The optimum flow patterns were very similar for the three sets of regional consumption estimates for each of the two time periods considered and there were only minor differences between the optimum flow patterns for 1955 and 1960. In 1955 the total interregional flows of pork were approximately 4.2 billion pounds and total shipment cost was approximately 92 million dollars. In 1960 the total optimum flows were approximately 4.6 billion pounds and total transportation cost was approximately 88 million dollars. From 1955 to 1960 Colorado shifted from a surplus region to a deficit region and the Kentucky-Tennessee region changed from a deficit to a surplus region while all other regions were the same in 1960 as in 1955. In 1955 Colorado had the greatest comparative price advantage of all excess supply regions for pork and was followed by Indiana and Illinois. In 1960 the Kentucky-Tennessee region had the greatest comparative price advantage and close to it were Indiana and Illinois. For both 1955 and 1960 Minnesota and Iowa had the least comparative price advantage and the regions with the highest delivered price differentials were located along the Atlantic Coast, the Northeast in particular, and in the West. The stability of the results from the pork analyses suggest that the comparative advantage of regions and the spatial pattern of interregional flows is not likely to change much even with substantial changes in the location of consumption.

The slaughter of lamb and mutton was more evenly distributed among the regions than any of the other three meat products analyzed. Only the urbanization weighted estimates of consumption were considered. Major deficit regions in both 1955 and 1960 were located in the Northeast and Southeast although California and the Arizona-New Mexico regions were also deficit areas. The optimum shipment patterns were similar for 1955 and 1960. In both years Colorado and the North Dakota-South Dakota region shipped both eastward and westward and acted as the connecting link between shipment east and west. The total interregional flows of lamb and mutton in 1955 were estimated to be 333.4 million pounds and the total transportaton cost was approximately 8.5 million dollars. In 1960 the total flows in the optimum shipment pattern were 371.5 million pounds and the total transportation cost approximately 7.6 million dollars. In both 1955 and 1960 Michigan had the greatest comparative price advantage of the surplus regions followed by the Indiana, Kentucky-Tennessee, and Wisconsin regions. Of the excess supply regions Colorado, North Dakota-South Dakota, and Oklahoma-Texas regions had the least comparative price advantage. The regions with the highest delivered price differentials were located in the Northeast.

These spatial analyses provide information for decision making at all structural levels. In particular the results from these analyses suggest how changes in transportation costs and the geographical distribution and level of population, income, and supply might alter regional meat prices and flows. The price effects of these outcomes may then be used as a basis for resource adjustments in producing and processing firms. In addition, information is provided about the present and potential competitive price position of one region relative to another. From the standpoint of processing and distribution firms, the information provided by the analyses should be helpful in deciding among alternative geographical destinations of product shipments and in assessing the consequences of alternative geographical locations of processing facilities. The results of these analyses provide one standard for judging the efficiency of the pricing and distribution system for meat. Until more complete data become available on regional consumption and the interregional flows of meat, analyses of this type provide one operational way of describing the spatial characteristics of the meat sector and ascertaining the probable consequences of alternative courses of actions or disturbances.