A SPATIAL EQUILIBRIUM ANALYSIS
OF THE FED BEEF ECONOMY

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CHAPTER I

INTRODUCTION

Beef is the single most important farm commodity produced in Oklahoma. Cash receipts from the sale of cattle and calves from farms and ranches during 1960 accounted for 92 percent of the cash farm income in the state from all meat animals, 70 percent of the income from all livestock and products and 35 percent of the cash income from the sale of all farm products. Oklahoma ranks among the leading states of the nation in beef cattle inventories. Farm production of cattle and calves has been rising steadily.

Methods of beef production in Oklahoma are characterized by various cow-calf operations and buy-sell calf or steer enterprises in which large acreages of native, improved, or small grain pastures are utilized. The sale of feeder cattle has predominated in Oklahoma's beef industry. More than 800,000 head of stocker-feeder cattle ordinarily are marketed annually by Oklahoma farms and ranches.

Innumerable dynamic economic forces are introducing changes in prevailing patterns of beef production and marketing in Oklahoma as elsewhere. It is clearly evident that Oklahoma's beef industry is heavily dependent upon trade with other areas either in the form of live cattle and feed or meat. Economic forces which operate to shape or change interregional competition, therefore, are of vital importance to Oklahoma agriculture and the state's total economy.

Oklahoma producers are encountering increased competition in the sale of feeder cattle. Demand for the relatively heavy and high quality feeders, the type most suited to the utilization of pasture and other forage, appears to have decreased. Demand for smaller, younger, and lower quality feeder calves has risen considerably and Oklahoma producers are experiencing conditions that may reflect effects of a comparative disadvantage in the production of such calves for sale as feeders. Also, feed grain production in Oklahoma and other Southern Plains states has risen sharply in recent years while the demand for fed beef is increasing in all areas including Oklahoma, Texas and other southern states. These factors pose the important question of Oklahoma's potential in production and marketing of fed beef. With a relatively small population which is trending upward only slightly, potential markets for Oklahoma fed cattle depend primarily on the nature and effects of those factors affecting interregional competition in fed beef.

The substantial rise since World War II in United States' production of fed beef and a marked shift to dry-lot feeding of cattle is, itself, an effect of basic economic forces of change. Immediately after the War, numbers of larger scale feedlots and feedlot production expanded rapidly in California (Table I). Policies and specifications of a few retail food chains and others calling for light-weight Choice grade slaughter cattle was one of the principal motivating forces. General increases in population and consumer incomes in all areas, however, also began immediately to influence fed cattle production in Colorado and some of the other major feeding areas. A rapidly growing and affluent California

TABLE I

NUMBERS OF CATTLE AND CALVES ON FEED BY SELECTED STATE AND REGIONS, UNITED STATES, 1947-62[1]

		North Central					Intermountain West			Pacific Region				
Jan 1 year indicated	North-east	Central Corn Belt	Lake States	Northern Plains	Kansas and Miss-ouri	South-ern Plains	Colo-rado	Arizona and New Mexico	Other	Calif-ornia	Pacif-ic North-west	Total 26 States	11 Other States	Total 37 States
							- Thousand Head -							
1947	90	1773	440	647	557	171	146	61	197	166	59	4307		
1948	85	1460	400	544	440	165	180	87	203	209	48	3821	-	-
1949	88	1677	463	685	580	214	192	95	222	258	56	4530	-	-
1950	88	1754	471	657	494	216	206	76	180	196	52	4390	-	-
1951	90	1745	477	684	482	239	229	103	187	248	50	4534	-	-
1952	90	1817	495	776	472	241	300	125	211	383	51	4961	-	-
1953	90	2242	527	1030	523	271	296	134	261	327	61	5762	-	-
1954	86	2137	536	891	439	205	245	138	278	350	65	5370	-	-
1955	84	2248	526	933	457	200	275	200	301	482	89	5795	-	-
1956	82	2290	552	883	442	214	284	248	324	503	107	5929	-	-
1957	90	2409	593	908	413	218	298	264	306	509	114	6122	-	-
1958	78	2364	580	907	436	163	298	223	305	405	139	5898	-	-
1959	77	2509	623	1020	480	234	355	262	355	511	175	6601	-	-
1960	83	2596	670	1037	545	317	404	319	356	665	181	7173	362	7535
1961	89	2673	725	1168	634	328	414	346	377	716	175	7645	362	8007
1962	89	2643	699	1310	602	409	397	374	345	776	189	7833	454	8287
Percentage Distribution 26 States														
1947	2.1	41.2	10.2	15.0	12.9	3.9	3.4	1.4	4.6	3.9	1.4	100.0		
1962	1.2	33.7	8.9	16.7	7.7	5.2	5.1	4.8	4.4	9.9	2.4	100.0		
Percentage Change to 1962 from:														
1947	-1.1	49.1	58.9	102.5	8.1	154.0	171.9	513.1	75.1	367.5	120.3	81.9		

[1]Where not explicitly stated states in areas are: Northeast; Pennsylvania,- Central Corn Belt; Iowa, Ill., Ind., and Ohio- Lake; Michigan, Minn., and Wisc.- Northern Plains; No. Dakota, So. Dakota, and Nebraska- So. Plains; Oklahoma, and Texas- Other Intermountain; Wyo., Idaho, Mont., Nev., and Utah- Other 11; Geo., Ala., Va., W. Va., No. Car., So. Car., Fla., Ky., La., Miss., Tenn.

Source: Cattle on Feed Report, Statistical Reporting Service, U. S. Department of Agriculture, Selected Issues.

population resulted in the spread of the commercial feedlot movement soon after the War to Arizona. This soon was followed by expansion throughout the Intermountain West.

Meanwhile, fed cattle production was expanding in the Central Corn Belt, the Lake States and in the Northern Plains (Table I). Most of this production and the production increases in this region were accomplished by individual farmer-feeders. Thousands of farmers throughout the North Central region market some or all of their corn through feeder cattle or lambs which they usually buy in the fall or winter. Throughout the period 1947-62 the Northern Plains region, consisting of Nebraska and the Dakotas, was second only to the Corn Belt in numbers of cattle fed. In the early 1950's, a few commercial feedlots began to appear in this region. Partly as a result, the Northern Plains increased its production relative to other areas of the North Central region. In effect, a shift in cattle feeding from the Corn Belt states to the Northern Plains region has taken place (Table I).

Fed cattle production expanded slowly in the Southern Plains and Kansas until about 1958. Drought conditions during the mid-1950's had a retarding effect on the industry in this area. But with high and increasing levels of sorghum grain production in Kansas, Oklahoma, and Texas during 1958-62, numbers of feedlots and feedlot production began to rise rapidly throughout this territory.

The nation's cattle feeding industry remains in a state of transition. Many locational shifts and changes in the nature of interregional competition are anticipated. Oklahoma's role in fed cattle production and marketing and in these shifts and changes is difficult to evaluate. It is to this question that this dissertation is primarily directed.

Numerous differences exist among geographical regions of the United States. Regional differences in the supply and demand for goods and services, per capita income, consumer tastes, transportation rates and natural resources are of primary importance as determinants of location, trade and interregional competition. Differences in population characteristics and social and political institutions are also important.

Many groups, both private and public, are concerned with the beef sector of Oklahoma's agricultural economy. It has been advanced that the income of livestock producers may be increased by expanding the operation of feeding cattle for market. The feasibility of such a proposal would, in part, be determined by a cost analysis associated with feedlot operations. Aside from the cost considerations involved, but quite closely related, are the complex marketing problems. Producers may justify the expansion or initiation of feeding operations on the basis of nonprohibitive costs, but must also take into consideration the market demand for their product and the effects of increased production on interregional competition.

Factors such as available markets, competing production areas and transportation differentials must be contemplated. Also, the essential variables which comprise consumers' demand for beef in various geographical areas must be evaluated. Consumers' income, tastes and preferences and closely competing products must be analyzed with respect to the demand for the product under investigation.

Objectives of Study

Within a limited framework, this dissertation is an empirical analysis of Oklahoma's competitive position in the marketing of fed beef.

More specifically the objectives are to:

(1) develop measures of fed beef production and slaughter by regions in terms of live and dressed weights as well as numbers;

(2) determine national demand equations for all beef, steer-heifer beef and fed beef and to develop regional demand estimates for fed beef;

(3) determine equilibrium flows and prices of fed beef under alternative assumptions regarding the relative volume of fed beef produced in Oklahoma, and in Oklahoma and Texas;

(4) evaluate competitive interrelationships among regions in the marketing of fed beef with particular reference to Oklahoma's competitive situation at present and in the near future.

CHAPTER II

REVIEW OF LITERATURE

Economic activity, with respect to location, interregional competition, and economic development may be considered interdependent. As an economy develops with regard to its institutional arrangements, level of living, etc., there are profound effects upon existing patterns of location. In some economic endeavors, relocation of economic enterprise is fostered. On the other hand, a change in the existing pattern of locational activity may have a catalytic effect on the further development of an economy. Hence, the proposition that the locational aspects of production and distribution and economic development are, to some extent, mutually interdependent.

Analogously, one might also consider the advancement of location theory and the development of economic science. The pursuit of knowledge within the locational framework of general economics has added to the knowledge of economic theory in general. Conversely, the development of economic theory from Adam Smith to the present has supplied tools of economic analysis to locational theorists in their specialized area of interest.

An attempt will be made in this section to survey some of the major contributors to the theory of location and interregional competition.

Limitations on space necessarily will lead to the omission of many influential individuals in the field.[1] This omission is a function of space limitation rather than one of disrespect. For more than a century, economists have been engaged in the effort to establish a niche for location theory in the general field of economics.

Until the last fifteen or twenty years, most of the work done in the area of location theory and interregional competition was by Europeans, notably the German economists. The "pathfinder" in this field was Von Thunen.

Friedrich asserts that "Von Thunen's theory of agricultural location was a by-product of his effort to determine which kind of production would best be carried on at a given place."[2] This theory of location dealt with an isolated state and was highly abstract in nature. It assumed equal transportation rates, one consuming center, equal labor costs throughout the area, etc. Alternative agricultural enterprises

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[1] No area of economics has been more thoroughly explored than international trade theory. The following discussion neglects comparative cost theory and its long history of development primarily because it is reviewed in great detail in many readily available sources. See Viner, J., Studies in the Theory of International Trade, Harper and Bros., New York, 1937, Taussig, F. W., International Trade, The Macmillan Co., New York, 1927, and others. A general review of international trade theory is found in Caves, Richard E., Trade and Economic Structure, Harvard University Press, Cambridge, 1960. Mathematical models of the Lausanne School and their significant contributions by Pareto, Yntema, Mosak and others also is neglected. The present discussion is designed to provide authoritative sources of theoretical concepts found most useful in empirical studies of interregional competition.

[2] C. J. Friedrich, in his introduction to the translation of Alfred Weber, Theory of the Location of Industries, Chicago, 1929, p. 22.

and their location are determined by the relationship between market price and the distance to that market. It was advanced that transportation costs were basic to a comprehension of locational studies. A basic principle derived from Thunen's work was that "the value of produce at the place of production decreases with the distance of the place of production from the market place."[3]

Thunen's location theory was limiting because of its specific reference to agricultural commodities. It did not investigate those general factors which explain the movement of industries to and from specific locations. However, his analysis was a major contribution in the field as it did provide a theoretical framework which was amenable to modification and expansion by location theoreticians.

Weber sought a general theory of location in which a set of general theoretical rules might be appropriate in the determination of location with respect to economic activity.[4] This thesis was concerned with the locational aspects of manufacturing activity. Weber's analysis is based upon the difference between general and special factors of location and between regional and agglomerative factors.[5] Those variables reflecting natural and social conditions in location are taken as given.

The general regional factors which determine the location of industry, according to Weber, are the costs of transportation and labor between

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[3]Ibid., p. 20.

[4]Alfred Weber, Chapter 1.

[5]Agglomeration is expressive of local concentrations of industry which occur because production of a good may be more economically produced. Deglomeration is synonymous with decentralization as related to more economical production.

various regions. The fundamental orientation of an industry is related to costs of transportation, but this is altered in many cases by differing labor costs between areas. Transportation costs are determined essentially by the weight of the commodity to be transported and the distance. Transportation costs will cause industrial production to locate where the fewest ton miles occur during the process of production and distribution.

Labor costs is the second important locational variable in relation to a region's potential to attract industry. Weber addresses himself to the problem of whether a given industry should locate at the minimum point of transportation or take advantage of a favorable labor location. His theoretical solution involves the utilization of isodopanes which signify areas of equal costs. Relocation will take place as deviations from a minimum transportation point lengthen if they are compensated by as much or more by savings in labor costs. In applying this principle Weber was able to illustrate the possibilities of substituting labor orientation for that of transportation insofar as the location of industry was concerned.

Weber asserts that two primary tendencies are associated with the economic development and pattern of locational activities of a progressive economy. First, as a result of relatively decreasing transportation costs, increasing density of population, and the differentiation of culture, the location of production tends to shift from a point of minimum transportation cost. Thus, there is a shifting from the transportation oriented industry to an industry which is labor oriented. Secondly, through increasing technology and the mechanization of the production process the amount of labor required is reduced and may tend to shift a labor cost oriented industry back toward that of a transportation cost oriented industry.

It is very likely that an integration of these two primary locational factors is relevant. Weber states, "to determine, on the basis of the rules we have discovered, to what extent industry is labor-oriented and to what extent transport-oriented will be seen to be one of the principal tasks of the study of empirical material."[6]

Weber's theory used the partial equilibrium approach in his analysis of those factors affecting the location of production. The underlying assumptions of his theoretical framework included the following variables as given: (1) the demand for a certain commodity, (2) the location of raw materials, and (3) the location of markets. Weber contributed a great deal to location theory in his partial equilibrium approach. The development of a general equilibrium model involving the interrelationships of those variables affecting economic activity with respect to location, was needed to add and supplement Weber's work.

Ohlin investigates the location problem in a highly systematic approach.[7] His initial line of attack is made through use of an overly simplified and abstract model of a single market. The basic assumptions of this model are full mobility and divisibility of factors within a given region and pure competition. It is advanced that the first condition for trade between regions is that commodities containing a large proportion of scarce factors are imported into a region. Those commodities

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[6] Alfred Weber, p. 123.

[7] Bertel G. Ohlin, Interregional and International Trade, Cambridge, 1933.

exported from a region will contain a large proportion of cheap factors which are abundant in that region.

Proceeding with his analysis Ohlin extends this theory to several markets. He modifies the assumptions underlying the one market model. The lack of general mobility and divisibility of factors is indicated. The assumption that commodity prices are equal to costs of production also is relaxed. Ohlin recognizes that in reality price equilibrium will differ from the mechanics of a purely competitive model.

Ohlin proceeds to investigate the space aspects of trade between regions. The obstacles to interregional trade are introduced into the analysis. The most important deterrent to trade is transportation cost. The term "cost of transfer" is used to encompass other barriers to trade such as tariffs, taxes, etc. The manner in which these obstacles to interregional trade change the pattern of production and distribution are explained.

An illuminating discussion is presented regarding interregional price relations and the difficulties encountered in price comparisons between trading regions. Ohlin states the problem of ascertaining the determination of related regional pricing in the following statement:

> Knowledge of interregional price conditions implies knowledge of the costs of production and prices in various producing centres, and of the currents of trade from these centres to the various importing regions. A bird's-eye view of interregional price relations is secured through a system of equations which take the interregional costs of transfer into account.[8]

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[8] Ibid., p. 158.

An enlightening discussion with respect to cross transports is presented.[9] There are instances when local price differences will show irregularities that cannot be explained alone by transportation costs. Such price discrepancies may be caused by irregular trade at certain times because of certain short-time shortages or surpluses of factors or commodities in a given region or regions. Location of economic activity, however, is based on the price situation over a longer time period rather than short-time irregular variations in price.

Losch developed a general equilibrium system in an attempt to describe the interrelationship of all locations of economic activity.[10] A theory of economic regions was developed. The regions were not defined in terms of factor mobility. Losch is concerned with the mutual dependence of individual production and consumption units, the location of markets and producing areas, transportation routes and the geographical distribution of population. His book, "The Economics of Location" utilizes many of his concepts with respect to an empirical analysis of various parts of the American economy.

The different motives for firm location are discussed in the light of cost (transport, production and total), gross receipts and profit. Losch asserts that one-sided cost orientation is not, in general, the correct approach. This assertion is qualified to the extent that he does admit that cost orientation might be a special case with regard to the location of some industrial enterprise.

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[9]This has also been called cross-hauling.

[10]August Losch, The Economics of Location, New Haven, 1954.

"In a free economy, the correct location of the individual enterprise lies where the net profit is greatest."[11] The optimum location of economic activity can be determined from the cost and demand curves for the product. Each locational point under consideration, may be analyzed from the point of view of the greatest net profit attainable.

Losch developed three main types of economic regions, simple market areas, regional networks and regional systems. The simple market region encompasses every center of consumption and/or production. A regional network of the market areas is to be found for all groups of commodities. This is the totality of all market areas for a given product. The regional system is based on the principle of advantages to be derived from local demand and traffic density. These districts are not wholly self-sufficient. They are dependent upon other districts or regional systems for capital, commodities, etc.

The nature of the problems of division of labor and their interrelations in location theory describe the conditions of equilibrium in a given system. Losch, then allows changes in his system through the effects of price variations. This approach enables him to illustrate how the price mechanism adjusts for short-run disturbances in the system.

Hoover's, "The Location of Economic Activity" presents a set of principles related to the spatial aspects of economic activities.[12] Those factors affecting various locational patterns of firms in relation to their supply and market areas are discussed. Transportation and

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[11] Ibid., p. 27.

[12] Edgar M. Hoover, The Location of Economic Activity, New York, 1948.

lines of communication and how they affect the choice of location are described. Economies and diseconomies accruing from concentration of industry and the causes and importance of labor-cost differentials are considered in some detail by Hoover. Hoover examines the long and short-run changes affecting location of economic activity. Some of these changes include cyclical fluctuations in investment, income distribution, factor utilization and depletion, population growth, and the development of new resources and techniques.

The question of what determines the location of a given industry with respect to procurement and distribution costs is posed. There are three types of industry orientation. Industries wherein production processes require large volumes of material relative to the volume or weight of the product itself likely will be located near the material's source. Other industries will be of the market oriented type. In general, where the cost of distribution is larger relatively, than those of processing, the given industry will be market oriented. Industries may be located at intermediate points. This might result when the transfer cost of material used in processing and transfer costs associated with the final product are nearly equal. The industry might be located at some trans-shipment point, for example, where a terminal railway and a network of highways meet. Materials for processing might arrive via rail with the finished product being distributed by truck.

Hoover explains that for economic progress in a region, improved transportation facilities and more intensive forms of production are required. He develops the locational significance of boundaries and illustrates the manner in which political boundaries act as deterrents to inter-area trade. Finally, he describes the manner in which public and private groups may work together in influencing location policy.

Dunn attempts to develop an all inclusive formulation of location equilibrium.[13] He sets down the general equilibrium formula of a space economy for an agricultural society. Although highly simplified, Dunn's system shows that agricultural location is a part of the equilibrium system. In this model the industry is thought of as the maximizing unit. There are four equations in the system with four unknowns (prices, demand, boundary and supply). When solved simultaneously, a unique solution is derived which provides estimates of prices and quantities and the spatial orientation of production.

Dunn proceeds from his general equilibrium formulation and introduces modifications into the analysis. The influence of the equilibrium of the individual firm and its effect on the industry equilibrium is considered.

Dunn poses some of the problems encountered in an analysis of the structure of agriculture outside the realm of static analysis. All locational theory has been formulated in a static or comparative static framework. The transition to a new point of equilibrium is never instantaneous, but there are lags in the adjustment of economic and social factors. He suggests that there are many sources of change connected with a dynamic theory of location. Whether or not all are capable of being isolated and identified is open to conjecture.

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[13] Edgar S. Dunn, The Location of Agricultural Production, New York, 1954.

Isaard's objective in his "Location and Space Economy" is to extend and synthesize those partial locational theories already formulated, into a general theory of location.[14] In reference to his volume Location and Space Economy, Isaard writes as follows:

> It derives a general location principle through reducing to common simple terms the basic elements of the diverse location theories embodied in the works of Von Thunen, Launhardt, Weber, Predohl, Ohlin, Palander, Hoover, Losch, Dunn and others. Thereby it seeks to synthesize the separate location theories into one general doctrine, and, where possible, to fuse the resulting doctrine with existing production, price and trade theory.[15]

Isaard contends that such a general theory must be supplemented by techniques which are operational in regional analyses. Weber's analyses of transport-orientation and production theory for the firm are extended by Isaard's concept of transport inputs. The transport input is the movement of a unit of weight over a unit of distance. These inputs may be utilized with other factors of production within an analytical framework. The utilization of transport inputs and their substitutions supplements the principle of transport-orientation. The inclusion of such inputs in the individual firm's product transformation function adds the spatial dimension to production theory.

Isaard pursues this principle of substitution in terms of transport and labor outlays. With the use of graphs, he illustrates the substitution of transport outlays for labor outlays for a given location. The equilibrium location of the individual firm may be obtained by selecting from many possible locations, that location which allows for

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[14]Walter Isaard, Location and Space Economy, New York, 1956, p. VIII.

[15]Walter Isaard, Methods of Regional Analysis, New York, 1960, p. vii.

maximum net revenue. This position can be stated by the use of transformation lines, outlay-substitution lines, revenue-outlay substitution lines, price-ratio lines, is-outlay lines, iso-revenue lines and least cost lines.

Isaard contends that there is not as much division between agricultural and industrial location as some would believe. In the agricultural enterprise the substitution relation between rent and transport outlays must be investigated, while in industry substitution between labor and transport outlays is important. The comparison of cost differentials and the substitution relation among various outlays is of importance to both types of industry. It is the opinion of Isaard that the significant difference between agricultural and industrial location is that firms in the former industry produce a wide variety of products with a concentration of markets at particular points.

Isaard attempts to show how the substitution principle allied with his concept of transport inputs, allows a combination of several location theories with traditional production theory. He considers this to be a core element of a general theory of location. Isaard is cognizant of the fact that aggregate demand and national income are two important variables that have been omitted from the system.

Lastly, Isaard formulates a general theory which embraces Weber's theory of transport orientation and Losch's market area analysis. A basic condition to this model is as follows: "At the point of minimum transport cost, the marginal rate of substitution between any two transport inputs, the others held constant, must equal the reciprocal of the ratio of their prices, namely the corresponding transport rates."[16]

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[16]Walter Isaard, Location and Space Economy, p. 224.

Isaard's general locational theory also embraces the economic activity of the agricultural sector of the economy through an extension of Von Thunen's location theory of agricultural production.

Through the utilization of the principle of marginal rate of substitution, Isaard inserts his concept of transportation inputs into the firm's transformation function so that production theory may account for the locational factor. This factor enhances the opportunity of relating economies of scale and the number and geographical distribution of plants. Also, the relation between spatial differences and capital intensity may be investigated by application of the substitution principle between transport and capital inputs.

CHAPTER III

ELEMENTS OF THE THEORY OF INTERREGIONAL COMPETITION

The purpose of this chapter is to (1) describe the many complexities involved in an analysis of interregional competition and (2) point out the necessary abstractions required in an empirical analysis because of limitations in data, and available methodological techniques sufficient to consider the innumerable variables relevant to such an analysis.

The theory of interregional trade can be generally characterized as an extension of price theory. A conceptual framework designed to explain interregional competition will include the principles of regional specialization and comparative advantage. Theories associated with the location of production and consumption and the regional supply and demand for commodities and factors of production are essential in the explanation of interregional trade.

The theory of price deals almost exclusively with the price system and its role in the allocation of resources in a given market. In a setting of interregional trade, the spatial features of a pricing system and their affect on resource allocation between many markets must be considered. The spatial element is of importance because, (1) each area is naturally endowed with certain factors of production, and (2) transfer costs and natural and artificial barriers may act as deterrants to the interregional movement of factors of production and of commodities.

Ohlin discussed the need for the extension of price theory to include the spatial element.

> The one market doctrine evidently needs a superstructure for the consideration of the geographical or territorial aspects of pricing, i.e., the location of industry, and of trade between places and districts of various places. A theory of international trade alone would be inadequate, for space is relevant to pricing within countries also. The element of space must be given full consideration in the theory of pricing, through its extension from one to a number of more or less closely related markets.[1]

Like all areas of economic theory, interregional trade theory involves abstractions. It does not purport to explain all of the various factors affecting interregional trade and location. The general nature of the conceptual framework, its underlying assumptions, and the theoretical effects of relaxing particular assumptions are considered in the following section. Since this study is concerned primarily with the flow of trade in a particular commodity under fixed or assumed conditions of industry location, emphasis is placed upon trade rather than location.

The Conceptual Framework

A basic assumption underlying most modern, theoretical discussions of trade is that net returns or profits will determine industry location and the flow of trade. The firm, it is assumed, will select that location which promises the highest long-term net profits. Ideally, this design requires determination of net f.o.b. demand functions as well as the nature and magnitude of per unit cost functions. These considerations, however, raise a multitude of questions regarding length of run, nature and extent of economic knowledge, industry structure and conditions of competition.

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[1] Ohlin, p. 4.

Accordingly, the long-run concept of perfect competition with its conditions of factor and product homogeneity, and perfect knowledge, together with an assumption specifying full employment in each region of available productive factors becomes the basic frame of reference. An initial condition of long-run equilibrium may be assumed. But private firms would have no incentive for relocation under conditions of perfect competition and long-run equilibrium. In addition, all firms would be indifferent regarding shipment patterns. Theories of location and trade concerned with private enterprise therefore are dynamic in nature and involve departures from long-run equilibrium. The departures, however, can be considered within the general framework of long-run considerations in which relocation and trade adjustments constantly are tending to re-establish long-run equilibrium.

From a condition of long-run equilibrium, no profit to the individual importing or exporting firm can arise in the absence of price differences among regions that exceed transfer cost differences. A necessary condition for the initiation of trade between regions therefore is regional prices that differ by more than the cost of transfer. This, however, is not a sufficient condition for interregional trade. This condition is found in Ohlin's statement regarding the nature of interregional trade.

> The nature of interregional trade is determined not only by the supply of productive factors, nor by the relative scarcities that supply in relation to demand has created in each isolated region, but also by the play of demand in each region for goods from the other--the reciprocal demand.[2]

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[2]Ibid., p. 22.

In effect, therefore, interregional trade theory is reduced to a spatial problem in prices. Under the assumptions, regional prices and price differences of factors and commodities are determined by relative demand and supply functions in each region. Any differences among regions either in demand or supply at any particular time will be associated with regional price differences.

Regional demand for a given commodity will be determined by consumer tastes and preferences, prices of competing commodities, the level and distribution of income available for expenditure and other factors. Prices relative to average unit costs, including both variable and fixed costs, will determine differences in net returns associated with various locations. However, it is marginal costs and factors affecting these costs that will primarily determine regional supply functions which together with regional demand functions determine regional prices. Marginal costs and other costs will be influenced by a wide variety of factors and conditions. Some of these include availability and prices of productive resources, technical production possibilities, technological innovation, economies of scale, external economies and diseconomies, and others. Regional differences in endowment of necessary factors of production also will affect costs and regional price differences.

Regional price differences may exist ceteris paribus because of regional differences in consumer tastes and preferences, income, other factors affecting demand, production functions, technology, scale, procurement and distribution costs including costs of transfer, relative regional differences in supplies and prices of necessary factors, and other factors affecting supply. Effects of such factors are illustrated in more detail in following sections.

Underlying effects of location and factors not easily contained within the formal framework of theory cannot be neglected. Among factors leading to regional differences in prices necessary for trade are differences in regional specialization in those activities in which a comparative advantage over other regions exists. A region generally will specialize in that field of endeavor where factors of production are most readily available and the abilities of individuals may be utilized most advantageously. The region possessing a relatively large amount of factors necessary in the production of a commodity, other things equal, will be able to produce that commodity more cheaply. If the other things include processing and marketing costs and demand functions, it follows that it will be to the advantage of a region to export commodities embodying factors in relatively large supply and to import commodities whose necessary factors are relatively scarce in the region under consideration. Although a long-run tendency of this nature might be expected, it must be recognized that "other things," in all probability, will not remain equal. Prevailing price differences, therefore, may prohibit exports of commodities which necessarily contain large amounts of factors that are relatively abundant in the region. In addition, such price differences may prevent inshipments of commodities embodying factors that are scarce in the region.

Quality differences between regions with respect to factors of production and commodities may lead to trade even though regional costs per physical unit of production are the same. Consumer tastes and preferences in a region are essential factors in considering quality differences. The recognition of quality differences increases the complexity of an analysis concerning interregional trade. The quality factor may be taken into consideration in an analysis by treating differing degrees of quality as individual commodities with distinct demand characteristics.

Relative mobility of raw materials and their associated finished products will affect location. Mobility may be defined in terms of relative transfer costs. Prohibitive transfer costs reflect immobility. In a competitive transportation industry relative transfer costs and relative mobility will be affected by transformation characteristics of the manufacturing process. Weight-losing characteristics are particularly important. For instance, livestock lose a considerable percentage of their original weight during slaughtering and processing. A transportation industry which prices its services on a "cost of service" basis likely would establish lower equivalent charges on meat than on livestock. Everything else equal, the slaughtering and processing industry would, under these circumstances, tend to become producer oriented. However, effects of location on distribution costs other than transfer costs and opportunities for competition with other suppliers on a service or quality basis also must be considered.

Location of processing and other marketing facilities also are affected by relationships between procurement and plant costs and changes in these relationships as affected by density of production and other factors. Structure of the marketing system also may be affected. Procurement cost, as for livestock, is determined partially by density of production and plant volume. Such costs are frequently minimized through establishment of a large number of small plants in principal areas of production. Full economies of scale, on the other hand, often are achieved through one or a few large plants at the expense of higher per unit costs of procurement. This would be true particularly of commodities or areas in which production density was low relative to the volume required for significant scale economies. The desirable location, other things equal, would minimize the sum of these costs, i.e., procurement costs, plant costs, and distribution costs.

The economic stability of a region, in addition to that of the total economy, will be an influential factor governing the regional location of industry. Location in a region will be affected by fiscal policies of local government and its attitude toward the particular industry. The degree to which an industry is willing to risk capital in a business venture will be determined, in part, by the economic, social and political conditions of the region.

Institutional arrangements have considerable affect on trade between regions. Regional tariffs and regulations related to interregional shipment of commodities may be beneficial to some regions while detrimental to others. Discriminatory regulation of transportation rates may affect the nature and magnitude of regional price differences as well as transfer costs. Until the last few years, transportation rates on meat were arbitrarily maintained at a level that would reflect not less than an equivalent relationship with established rates on livestock. The meat packing industry, nevertheless, has tended to become producer oriented. These considerations suggest that factors other than transportation rate relationships are principally responsible for the present location of the meat packing industry.

Structural changes in the marketing system and associated changes in the nature of competition affect location and trade.[3] Departures from the assumption of perfect competition introduce decision making under conditions of imperfect knowledge and possibilities for manipulation of important decision-making variables. These variables may be factors affecting market demands, costs and other factors affecting supplies or supply functions and transfer costs.

The ability of an industry to restrict potential newcomers either through natural or artificial barriers will have a major affect on interregional competition. A natural barrier such as size of the commodity market in relation to optimum size of plant is an example. A firm in a region contemplating entrance into an industry with excess profits may be forced to abandon its plans because such a firm may only be capable of initiating production with a smaller than optimum size plant and high costs may eliminate the possibility of profits.

In some instances new firms may be artificially barricaded from entry into an industry because firms already in the industry have control of the sources of raw materials. This is especially true with respect to geographical areas naturally endowed with necessary factors of production.

Nonprice competition is another important factor in the consideration of interregional competition. The opportunity to differentiate

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[3]For a discussion of market structure research and a comprehensive reading list on market structure analysis, see Robert L. Clodius and Willard F. Mueller, "Market Structure Analysis as an Orientation for Research in Agricultural Economics," Journal of Farm Economics, XLIII, August, 1961, pp. 513-53.

products through advertising, trade and brand names, and to impress quality differences on the minds of consumers will alter the purely competitive pricing relationships assumed in the model of interregional trade.

Price discrimination by a regional firm or combination of firms may improve the competitive position of such a firm(s). Favorable conditions for price discrimination may open new markets for the firm(s). However, there is always the possibility of retaliatory measures being invoked, (tariffs, regulations, etc.) because of pressure brought on by producers in the market area in which price discrimination is being practiced.

Consumer Demand in Interregional Competition

The socioeconomic behavior of the consumer in the market place is an essential component of a theoretical framework designed to explain the forces affecting interregional competition. It is assumed that the consumer is a rational individual and attempts to maximize his satisfactions subject to an income restraint and the prices of commodities confronting him. The consumer's tastes and preferences for a given set of commodities are determined by his utility functions at a given period of time. The decision of the consumer is that of determining how much of each commodity should be consumed in order to maximize satisfactions.

The individual's demand function for a commodity may be established by taking into consideration his utility curves for one or more commodities. A market demand curve may be determined for the commodity by summing the individual demand curves.

Consumer demand for a commodity or set of commodities varies between and within regions. Figure 1 illustrates the difference between demand functions of consumers in regions I and II for a commodity x.

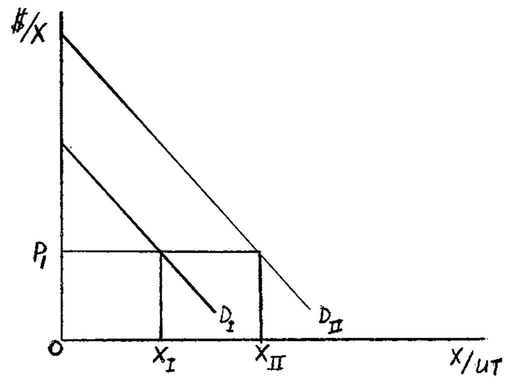

Figure 1. Hypothetical Regional Demand Functions

In this graph it is assumed that the demand functions of consumers in I and II are an aggregation of individual consumer demand functions in each region.

This graph illustrates that, under ceteris paribus conditions, consumer demand in region II for commodity x is at a higher level, given price p as opposed to demand for x by consumers in region I. Alternatively, it may be stated that for a given quantity of x, within a given range, consumers in region II are willing to purchase x at a higher price than consumers in region I. Thus, differences in regional demand functions may arise, based on regional dissimilarities in consumers' tastes and preferences, levels of income, and response to changes in prices.

Differences in regional demand may be of significance to the initiation of trade between regions. Regional price differences, as indicated previously, are determined by those forces underlying supply and demand for factors of production and commodities and their differences in various regions. Assuming that the necessary and sufficient conditions of trade are fulfilled, then interregional trade will emerge.

The Firm in Interregional Competition

The firm within a region is limited in its production possibilities by the amount of natural and other resources available to that region. In addition, the existing technology and the manner in which it is utilized in the production process is extremely important.

A firm's demand for a factor of production is a derived demand, i.e., it is contingent on the demand for the commodity in which the factor is used. When considering the spatial element as in interregional trade, the demand for productive resources is influenced by costs of transport. These transport costs in turn depend upon those factors of production required in providing transport facilities and services.

Regional differences in prices of factors of production result from differences in demand, transport services, social institutions and other factors. Such differences in prices may condition the interregional movement of the factors. Productive resources such as labor and capital which are relatively transferable may lead to a movement of resources between regions. Immobile factors, of which there are few, could lead to trade in commodities rather than factors.

The supply of a commodity may differ between regions because of varying costs of production. Major factors responsible for regional cost differences include regional differences in resource availability and productivity, economies of scale, external economies and diseconomies, technology, factor prices, and managerial ability.

An example illustrating the effect of a limited supply of a factor of production on a firm's output and costs is shown in Figure 2.

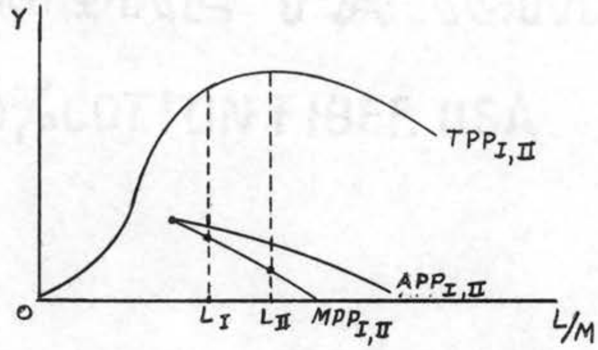

Figure 2. Hypothetical Regional Input-Output Relations

In this figure, $TPP_{I,II}$ is the production function for both regions, Y is the output of a commodity and L represents various input levels of a variable factor associated with a fixed level of factor M. L_I and L_{II} are the amounts of the variable factor available in the respective regions. It is further assumed that the amount and price of M used in both regions are the same. The MPP_L is higher in region I than II, and average physical product is higher in region I. When the factor is free, ceteris paribus, to move between the regions, the MPP_L in both regions would tend toward equalization. An increase in the employment of the factor L in region I will decrease its MPP, while a reduction in its employment in region II will increase L's MPP. Mobility of factor L is not a sufficient condition for trade between regions. The regional price difference of the factor would have to exceed the real cost of transfer between the regions. When mobility does not exist, as in the case of natural resources, a factor price difference between two regions may result in interregional trade in the commodity rather than the factor of production. The commodity would, in this case, move to region I, assuming that the cost difference of factor L between regions, ceteris paribus, was large enough to exceed the cost of transfer between the regions.

Cost differences between regions may be explained by differences in scale of plant. Figure 3 provides an illustration where fixed and variable costs may vary between regions.

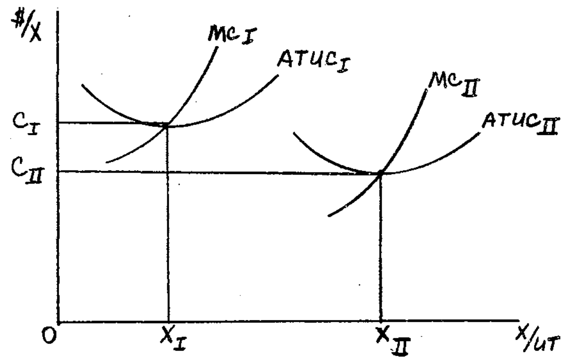

Figure 3. Hypothetical Regional Firm Cost Curves

Assume that $ATUC_I$ and $ATUC_{II}$ are representative of the average total unit cost curves of firms located in region I and II. Both firms are producing at the least-cost level of output. In this case, region II has the larger scale of plant and is producing a greater output at a lower unit cost.

There may be several reasons for differences between regions in output and associated costs illustrated in Figure 3. Region II's firm may have the larger scale of plant because of a larger market potential, a technological advantage, greater possibilities of division and specialization of labor, or a more favorable location with respect to factor supply.

Economies of large scale production can affect interregional competition to a considerable extent. In the long run, internal economies may result in cost reductions to a given firm from a long-run expansion in its output when each output is produced from a plant of optimum scale for that output.[4] Internal economies to the firm may be technological or pecuniary. An individual firm may experience technological economies through average and/or marginal cost reductions in productive resources due to improvements in the organization or technique of production resulting from large scale operations. Pecuniary economies may follow in the form of reduced factor prices to the firm because of larger purchases of factors of production.

External economies of scale may accrue to individual firms in a region as a result of the expansion of the entire industry. Improvements in the organization of resource markets and production techniques are illustrations of external technological or organizational economies accruing to individual firms because of an expanding industry. External pecuniary economies may be present because of reductions in prices of factors of production resulting from increases in the quantities purchased by the industry as a whole. However, external diseconomies of a pecuniary nature are probably more common as an entire industry expands.

Economies of large scale production tend to place the region experiencing such a phenomenon in a favorable competitive position. On the other hand, it is conceivable that internal and external diseconomies through expansion of firm or industry output may offset such economies.

The Market in Interregional Competition

The market place performs an essential role in the framework of interregional trade. In the commodity and factor markets, prices are

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[4] Jacob Viner, "Cost Curves and Supply Curves," American Economic Association Readings in Price Theory, Richard D. Irwin, Inc. (Chicago, 1952), pp. 212-213.

determined by the forces of supply and demand. Prices in the commodity market reflect to producers the amounts and types of goods preferred by consumers. In the factor market, prices assist producers in making decisions regarding the combination of resources in the production process.

The physical size of a market area may be explained by the structure of wants and preferences, per capita income, and the magnitude of the population. Costs of production are an important consideration with respect to the distance that producers may ship their product. Transfer costs which include transportation, handling costs, and institutional barriers will have considerable effect on the size of the market available to producers.

The determination of the size of a market area available to the producer(s) is given by the general law of market areas.

> The boundary line between the territories tributary to two geographically competing markets for like goods is a hyperbolic curve. At each point on this line the difference between freights from two markets is just equal to the difference between the market prices, whereas on either side of the line the freight difference and the price difference are unequal. The relation of prices in the two markets determines the location of the boundary line: the lower the relative price the larger the tributary area.[5]

The law of market areas is based on several restrictive assumptions. It is assumed that pure competition exists; there are two markets in a closed economy; costs of production are the same for all producers, and transport costs are independent of price and vary directly with distance.

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[5]Frank A. Fetter, "The Economic Law of Market Areas," Quarterly Journal of Economics, Volume XXXVIII, May, 1924, p. 520.

One example of conditions flowing from the application of the law of market areas is shown in Figure 4.[6]

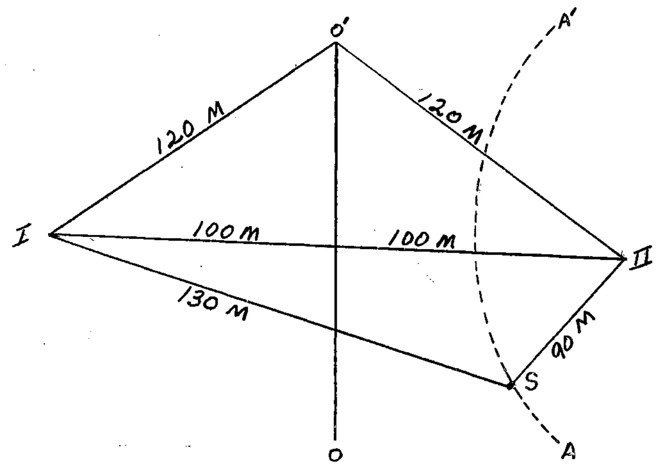

Figure 4. Hypothetical Two Market Trading Territory

Assume that there are two consuming centers I and II with equilibrium market prices. Line O-O' is a line of indifference for location of producers in regard to which market they will ship their commodity. Any location on this line will enable a producer to receive the same price, minus the transportation cost, from either market I or II. A producer located anywhere to the right of O-O' would find it advantageous to ship to market II.

When market prices differ, the area commanding the higher price will expand its trading territory. The line of indifference will move toward the lower priced market and will assume the form of a hyperbola. The difference in transport costs to alternative markets is a constant equal to the difference in market prices.

The new indifference line will be A-A' assuming that prices in market I and II are $1.90 and $1.50, respectively, and the transportation

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[6]Warren C. Waite and Harry C. Trelogan, Agricultural Market Prices, John Wiley & Sons, Inc., New York, 1948, p. 163.

cost is one cent per unit per mile. In this case, producers between O-O' and A-A' who shipped to market II would find it advantageous, in terms of net price, to ship to market I.[7] Alternative assumptions may be made with respect to changes in market price or transportation cost. The indifference line will shift toward the market when a disturbance places that market at a disadvantage relative to the other market.

Transfer Costs

The term "transfer costs" includes transportation, loading and unloading costs and other services related to the transfer of commodities and factors of production. In addition, impediments to trade such as tariffs and regulations are included in transfer costs.

The simplified model of interregional trade implies that prices of commodities and/or factors of production will tend toward equalization between regions under the influence of free trade. Prices in the two regions will differ only by the transfer cost of the commodity.

Transfer costs are of importance in determining the location of manufacturing and processing and the production of raw material in relation to consumer markets. Costs of transportation are determined by the supply and demand conditions for transport facilities, distance, transport resources, topographical factors and the characteristics of the commodity.

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[7]At point(s) producers would be indifferent regarding shipment to markets I and II.

Market II price	$1.90	Market I price	$1.50
Transport cost	1.30	Transport cost	.90
	$ .60		$ .60

Weber[8] used the ton-mile rate as the basic determination of transportation costs. It is assumed that transport costs vary directly with distance and weight. A simple linear equation which may reflect transportation cost between a supply and consuming center is postulated as follows:

$$TC_{ij} = b_1 M_{ij} + b_2 W_{ij}$$

where TC_{ij} = transport cost of commodity shipped from area i to area j,

M_{ij} = mileage from area i to area j,

W_{ij} = weight of commodity shipped from area i to area j.

In reality such considerations as different systems of transportation and deviations from theoretical calculations of cost with respect to weight and distance should be taken into account. Deviations from theoretical cost structures may arise because of special reduced rates on various commodity weights, length of haul and the inclusion of other variables such as labor costs and other services associated with the transfer of a commodity.[9]

The combination of transport and firm operating costs may be used in determining the least cost organization of a firm for a given location.[10]

In Figure 5, OB is the firm's total cost curve in relation to the volume of a commodity processed at a given location. Curve OC shows the

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[8]Weber, pp. 41-48.

[9]Empirical analyses of interregional competition to date have not utilized some of these variables because of the lack of regional data.

[10]Raymond G. Bressler, Jr., Efficiency in the Production of Marketing Services, Economic Efficiency Series, Paper number 6, Social Science Research Council, (Chicago, 1950) pp. 47-50.

transport cost associated with various volumes of a commodity to be shipped from a given location. The transport function may vary for other locations.

The function may be increasing at a constant, increasing or decreasing rate. The curve OA is an aggregation of the processing and transportation costs. Minimum cost is at a volume of OG in relation

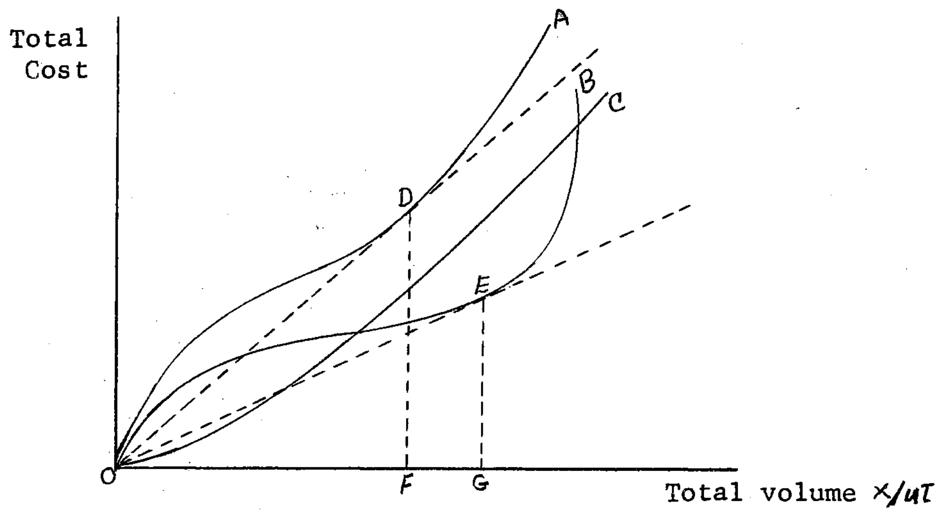

Figure 5. Hypothetical Firm Transportation and Processing Costs

to plant costs alone. The combined minimum cost output for processing and transportation, however, is at OF. This lower output reflects the effects of a transport function which is initially increasing at an increasing rate.[11]

Differences in firm costs between regions and in relation to a consumption center may be obtained in order to account for a region's cost and location advantage. This type of an analysis lends itself well to an explanation of regional price differentials.

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[11]In empirical analyses most transportation functions are postulated as increasing at a decreasing rate.

Graphic Analyses of Two Regions

A simplified theoretical framework basic to many empirical analyses of interregional competition, was represented graphically by Samuelson.[12] This framework is basic to the spatial equilibrium model analyses in this study and is generalized to twenty regions.

Initially, the model illustrates the determination of regional prices and the quantities of a commodity demanded under a nontrade restriction. Assuming that trade does exist between two regions, an equilibrium price and the amount of surplus and deficit quantities accruing to either region may be determined.

The model assumes pure competition. Producers and consumers are assumed to be maximizers of profit and satisfactions. In the analyses to follow, there are two markets and sources of supply in a closed economy.

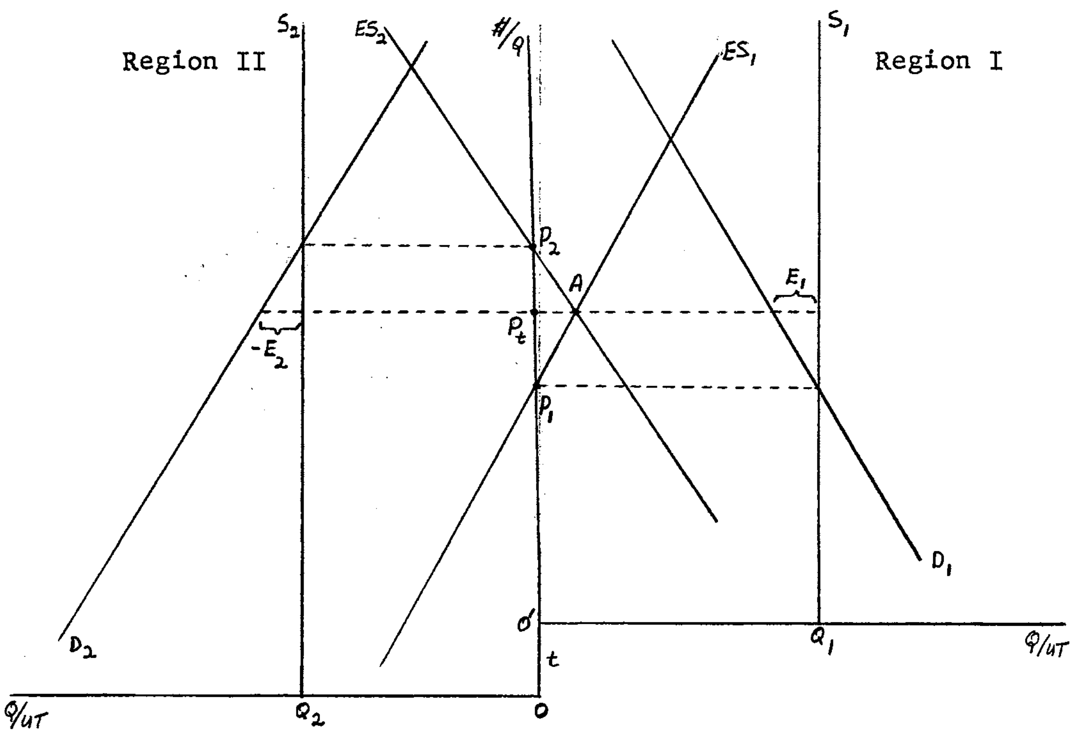

Figure 6. Two Region Spatial Equilibrium Model

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[12] Samuelson, pp. 283-303.

It is also assumed that the commodity under investigation is homogeneous and consumers do not differentiate between regional supplies of the commodity. Further, the transportation cost per unit of commodity from one region to another is constant and independent of price.

In Figure 6, S_1 and S_2 represent the supply schedules and D_1 and D_2, the demand schedules in the two regions under consideration. Elasticity of demand in both regions is assumed to be the same.[13] Supply in both regions is assumed to be predetermined, hence the perfectly inelastic supply functions. The excess supply schedules are determined by the horizontal subtraction of demand from supply in each region. Assuming that trade does not exist between the regions, P_1Q_1 and P_2Q_2 are the equilibrium prices and quantities. At these prices the excess supply schedules of both regions are zero.

Given regional prices P_1 and P_2, movement of a commodity will occur between the regions provided that no obstacles to trade such as tariffs or natural barriers exist. Prices in the two regions will differ only by a constant transport cost. The commodity will be shipped to region II since price is higher in that market and the price differential exceeds the transport cost. The new equilibrium price will be where $OP_t = O' P_t + t$. At the price P_t the excess supply schedules will intersect as shown by point A. Given a price of P_t the amount of the surplus commodity in region I is denoted by E_1. In region II, $-E_2$

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[13]Under the assumption that demand is more elastic in region II, ceteris paribus the equilibrium price under conditions of trade will be higher than shown in Figure 6. A larger surplus and deficit will occur in region I and II, respectively.

indicates the amount of commodity required to satisfy demand in that market. Price in region II is determined by the price in region I plus the cost of transport, or $P_2 = P_1 + t$.

Increased Utilization of an Existing Technique

The two region model may be employed to investigate the effects of a change on the equilibrium position attained in Figure 6. Assume that region I is benefited by a short period advantage in the increased utilization of an already existing technique as shown in Figure 7.

The supply schedule in region I will shift to S_{1a}. Region I's excess supply curve will shift to ES_{1a}. In the absence of trade, price in region I will fall to P_{1a} and the differential between P_{1a} and P_2 will exceed the transportation cost $\underline{t}$. Assuming that trade does exist, the equilibrium price will fall to P_{t2} with E_{1a} and $-E_{2a}$ denoting the increased surplus and deficit amounts of the commodity in the respective regions relative to the initial position in Figure 7.

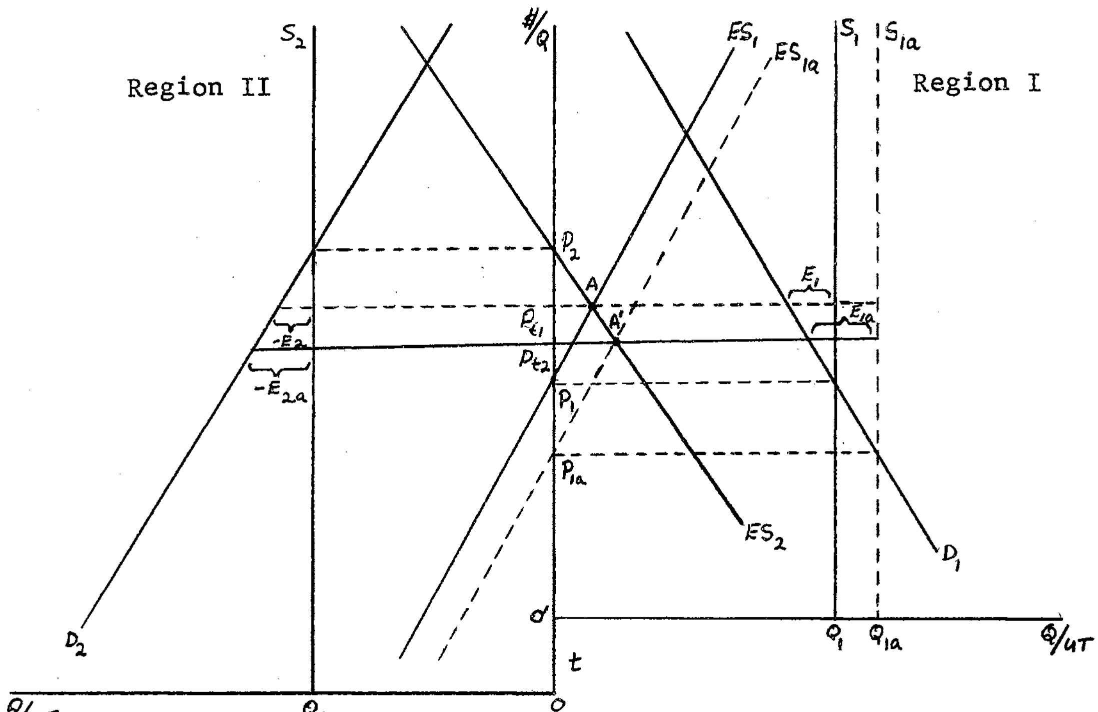

Figure 7. Two Region Spatial Equilibrium Model with Shift in Supply

Increased Demand in Region II

An increase in demand for a given commodity by consumers in region II will shift the demand schedule from D_2 to D_{2a} as illustrated in Figure 8. Assuming that, in the short period, region I supplies the entire increase in demand by region II, then price P_{t1} will be the equilibrium price. The increase in region II's demand causes price in that region to increase to P_{2a}. The excess supply schedule, ES_2 will shift to ES_{2a}.

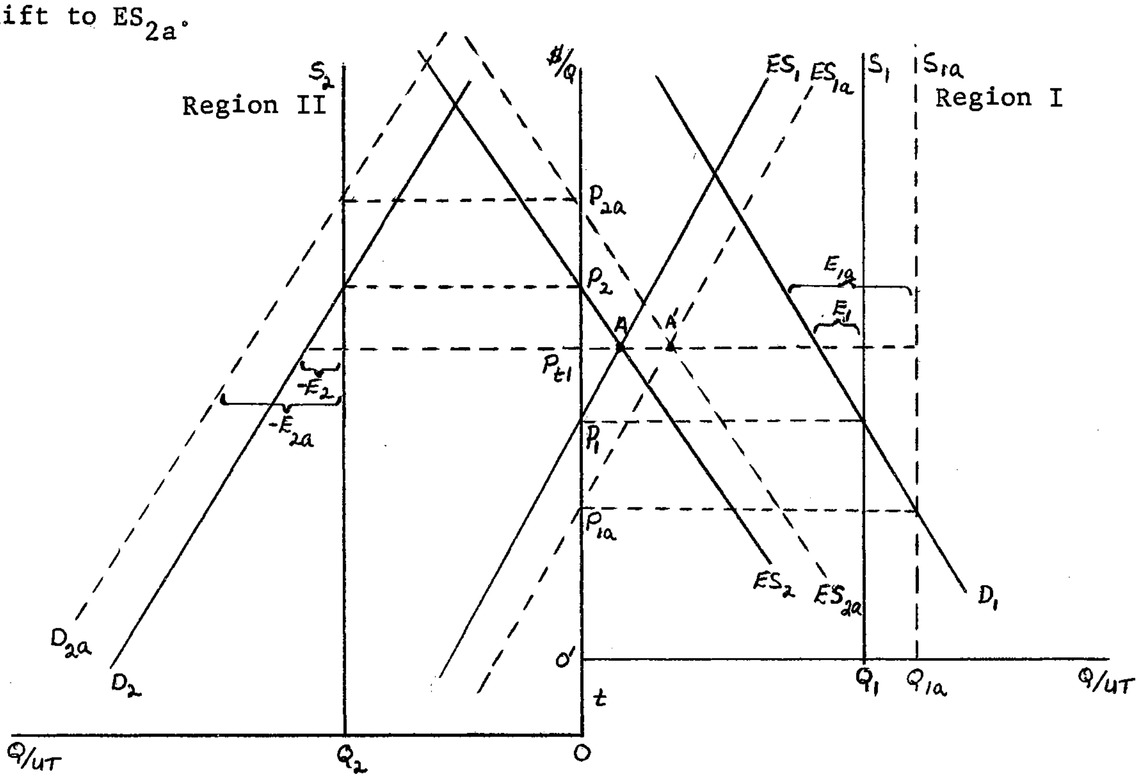

Figure 8. Two Region Spatial Equilibrium Model with Shift in Demand

Under conditions of trade, region I will increase its output and S_1 and ES_1 will shift to S_{1a} and ES_{1a}, respectively. The intersection of ES_{1a} and ES_{2a} at point A' will determine the equilibrium price P_{t1} which is the same price prior to the increase in region II's demand. However, the surplus and deficit amounts of the commodity have increased considerably as shown by E_{1a} and $-E_{2a}$.

The two region graphic model may be employed to analyze changes in the direction and magnitude of economic variables given some disturbance in the economy. The model may be used to gain insight with respect to various government programs, discriminatory pricing practices, changes in transportation rates and innumerable other changes in economic conditions.

Assumptions Relevant to the Problem

Hypotheses tested empirically in this study were drawn directly from the conceptual framework described in preceding sections. Limitations imposed by the problem, data, methodology and other factors, however, required restrictive assumptions that are more limiting than those provided by a general equilibrium theory of trade. Characteristics of the economic model adapted for use in this study follow. They include:

1. Pure competition exists at all levels of the fed beef industry.
2. A relatively short-run situation in which the location of consumers, the structure of wants and preferences, the location of production and the location of the meat packing industry are fixed and unchanging.
3. Per unit costs of production, packing, processing and other marketing activities are the same for all firms in all regions.
4. Regional price differences are equivalent to transfer cost differences.
5. Regional differences in demand functions, fixed supplies available in each region, and transfer costs largely determine interregional flows of the product.

6. All units of the product, fed beef, are assumed to be homogeneous. A region, therefore, will first supply its own needs and will export the remainder to the region or regions which offer(s) the highest net f.o.b. returns.
7. All shipments are made from a single location in one region to a single point in an importing region and intraregional transfer costs either are the same among all regions or nonexistent.

Within this general economic framework, optimum interregional distribution patterns for fed beef and associated equilibrium prices in each region were determined. Alternative economic models were developed in which artificially high levels of production were assumed for Oklahoma, Texas or Oklahoma and Texas. Demand characteristics among regions were assumed to be unaffected by these adjustments. Supplies in all other regions were held constant at initial pre-determined levels.

Departures from the basic economic model were introduced to examine affects on transfer costs and trade flows of (1) a relocation of the meat packing industry to reflect an industry more completely oriented toward the producer, and (2) a relocation of production in accordance with findings of an earlier study.

CHAPTER IV

RESEARCH METHODOLOGY AND GENERATION OF DATA

The objectives of this chapter are to (1) briefly survey some of the methods of spatial analysis used in the area of interregional competition with particular emphasis on empirical work related to the livestock-meat economy, (2) indicate the general problem area related to spatial equilibrium model analysis and the specific problem to which this study is directed, (3) discuss the development of data required for the spatial analysis of the fed beef sector of the economy, and (4) present the spatial equilibrium models used in this study.

Methods of Analysis Used in Spatial Studies

Samuelson was one of the first pioneers in the area of spatial analysis and linear programming.[1] The objectives of his research were to (1) show how a descriptive problem in non-normative economics could be cast mathematically into a maximizing problem, and (2) relate the problem of interspatial markets, via linear programming into a minimum transportation cost problem.

In the last several years agricultural economists have become interested in empirical studies of location and interregional competition.

[1] P. A. Samuelson, "Spatial Price Equilibrium and Linear Programming," The American Economic Review, Volume XXLII, June, 1952, pp. 283-303.

The basic approach as illustrated by Samuelson and others has been utilized by agricultural economists with varying degrees of modification depending upon the specific problem under consideration, the availability of data, and the programming procedures used.

Fox attempted to formulate the complex relationships of the livestock-feed economy by subdividing the United States into ten regions.[2] This essentially was the first application of programming procedures to the feed-livestock sector. The model involved a demand function for feed in each region and a structure of transportation costs between all pairs of regions. Regional demands were based on a national demand function, and supply was treated as predetermined. The model developed by Fox was used in an attempt to evaluate effects of changes in transport costs and supply changes. The model was highly aggregative in nature which is a limitation of most studies in the spatial field. Fox suggested some extensions that might be applied to spatial equilibrium models. Some of the more important of those mentioned were the use of time lagged variables, supply response in a more dynamic setting, and further disaggregation of the data employed.

Judge and Wallace employed spatial equilibrium analyses of the beef and pork marketing sectors.[3] Quarterly as well as annual models were

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[2]K. A. Fox, "A Spatial Equilibrium Model of the Livestock-Feed Economy of the United States," Econometrics, Volume XXI, Number 4, October, 1953, pp. 547-566.

[3]G. G. Judge and T. D. Wallace, Spatial Price Equilibrium Analyses of the Livestock Economy. 1. Methodological Development and Annual Spatial Analysis of the Beef Marketing Sector, Oklahoma Agricultural Experiment Station Technical Bulletin TB-78 (Stillwater, 1959); 2. Application of Spatial Analysis to Quarterly Models and Particular Problems Within the Beef Marketing System, Technical Bulletin T-79, 1959; 3. Spatial Price Equilibrium Models of the Pork Marketing System, Technical Bulletin T-81, 1960.

developed for beef. In all of the models, supply was assumed to be predetermined, and regional demands were based on a national demand function. No adjustments were made in the national demand function to account for regional differences in demand. In the beef analysis, Judge and Wallace reported that transport costs were reduced substantially when slaughter is producer rather than market oriented. Although differences between the annual and quarterly models were found, these differences were not deemed significant.

Two notable shortcomings exist in the beef analysis mentioned above. First, the application of a national demand function fails to take into account regional differences in demand. Secondly, no consideration is given to the component forms of beef. Distribution patterns for higher and lower qualities of beef, for instance, differ sharply and in a total beef analysis some of these patterns tend to offset each other. These limitations were recognized by Judge and Wallace and were suggested as areas for further research.

Hertsgaard and Phillippi analyzed distribution patterns for beef, live and dressed, in the United States.[4] In this study a transportation model was employed in which both supply and demand were predetermined. Models were developed for several different years and incorporated data on production, slaughter and consumption of beef for eighteen regions in the United States. Demand functions for beef were not used in this analysis and estimates of regional consumption were developed from the

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[4]T. A. Hertsgaard and S. D. Phillippi, Distribution Patterns For Beef, An Economic Analysis, Bulletin Number 38, Agricultural Experiment Station, North Dakota State University, Fargo, June, 1961.

1955 Household Food Consumption Survey. This study suggests that locational advantage in terms of transport cost may not be the primary factor in determining interregional production patterns. Such considerations as regional production costs and relative profitability of alternative enterprises may be of some importance.

A spatial equilibrium analysis for the marketing of live hogs and dressed pork was recently published.[5] A nineteen region model was developed in the attempt to ascertain the competitive position of Kansas in the marketing of hogs in live and dressed form. A national demand equation for dressed pork consumption was applied to each of the regions in an effort to obtain estimates of regional consumption. As indicated by the authors, a shortcoming of this study and others has been the inability to take into account regional differences in consumer demand.

Henry and Bishop utilized a transportation model to evaluate North Carolina's competitive position in the nation's broiler industry.[6] In this study, both supply and demand were predetermined. The objective of the study was to obtain optimum interregional flows of broiler meat at minimum transport costs and to obtain uniform price differentials at points of origin and destination of shipments. Relative disadvantages expressed in terms of per pound costs of shipping to various markets as compared with costs of shipping to best markets were estimated with

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[5] P. L. Kelly, J. H. McCoy, and M. L. Manual, The Competitive Position of Kansas in Marketing Hogs, Technical Bulletin 118, Agricultural Experiment Station, Kansas State University, Manhattan, October, 1961.

[6] W. R. Henry, and C. E. Bishop, North Carolina Broilers in Interregional Competition, A. E. Series Number 56, North Carolina State College, Department of Agricultural Economics, (Raleigh, 1957).

respect to the North Carolina broiler industry. A shortcoming of this study was inability to assess differences in regional demand and to evaluate effects on interregional flows.

Tramel and Seale employed a process called reactive programming as a means of obtaining equilibrium flows of watermelons between areas.[7] In this study 12 marketing periods during the year 1956, fixed supplies in 34 producing areas and 22 consuming centers were considered. In each consuming center a regression of quantity on price was obtained to represent demand for watermelons.[8] Reactive programming simultaneously determines equilibrium prices, consumption, and optimum interregional flows of a commodity. In assessing the effect of increased production in an area, the supply of other competitive regions was reduced by the amount of the postulated increase. Availability of regional data for use in generating regional demand functions will largely determine use made of the reactive programming process.

The General Problem

Spatial equilibrium prices and optimum flows of various products between regions have been determined by the use of linear programming techniques. Spatial analyses usually have involved (1) demarcation of space into regions, (2) an economy characterized by pure, or near-perfect, competition throughout, in which regional prices differ by transportation costs, (3) predetermined regional and national supplies, and

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[7]T. E. Tramel and A. D. Seale Jr., "Reactive Programming of Supply and Demand Relations-Applications to Fresh Vegetables," <u>Journal of Farm Economics</u>, Volume XLI, December, 1959, pp. 1012-1022.

[8]Reactive Programming may also include supply functions for each region.

(4) shipping activities assumed to originate at single points within surplus regions, to move by the shortest and least costly routes and culminate at single points within deficit regions.

The task of the spatial equilibrium model is the generation of (1) equilibrium product prices and consumption in each region, and (2) interregional movement patterns consistent with equilibrium prices that have been optimized in the sense that total transportation costs have been minimized.

The spatial model in the context of a linear programming problem may be described briefly as follows:

Once supply and demand requirements of the various regions in the model are determined, the objective is to satisfy all consumption required out of existing supplies in such a manner as to minimize total transport costs. Stated in the framework of the simplex method, the objective is to minimize a linear function subject to certain linear restraints. The minimization problem can be stated algebraically as follows:

$$\text{Minimize } V_o = \sum_{i=1}^{M} \sum_{j=1}^{N} C_{ij} X_{ij} \quad (4.1)$$

where V_o = total transportation cost of interregional movements of a given commodity,

C_{ij} = cost of transporting one unit of product from region i to j,

X_{ij} = the amount of commodity shipped from region i to j.

The linear function above is subject to the following linear restraints:

$$\sum_{i=1}^{M} X_{ij} = y_j \quad (4.2)$$

where y = consumption of the j^{th} region,

$$\sum_{j=1}^{N} X_{ij} = b_i \qquad (4.3)$$

where b_i = supply of the i^{th} region,

$$\sum_{j=1}^{N} y_j = \sum_{i=1}^{M} b_i \qquad (4.4)$$

where y_j = the total quantity demand is equal to b_i, the total quantity available,

$$X_{ij} \geq 0 \qquad (4.5)$$

which states that no interregional flows of a commodity may occur at negative levels.

Many relevant factors are neglected by the general spatial equilibrium model. For example, regional differences in production costs, intra-area transfer costs and other factors responsible for regional differences in supply functions are ignored. In addition, dynamic effects of technological or organizational innovations, market structure, and shifts or changes in demand or supply can be approximated only through the use of comparative statics.

Data limitations usually affect the validity and usefulness of findings still further. Ordinarily, constructed transportation costs, rather than measured transfer costs, normally are used in spatial analyses. Effects of factors other than distance on transfer costs usually are neglected. Adequate data on regional average retail prices of the commodity under consideration frequently are not available. While regional data on per capita income are readily accessible, regional differences in income elasticities of demand are difficult to ascertain with precision and sophistication. The logical conclusion is that spatial models can provide little more than general insights regarding interregional competitive relationships until additional refinements can be made. A superior methodological alternative, however, is not available.

The Specific Problem

Major attention in this study is placed upon the spatial price equilibrium analysis of the fed beef sector of the economy. The specific aim of this spatial analysis is to examine the interregional competitive position of Oklahoma and the Southern Plains.

Earlier studies have suggested that (1) potentials for fed beef production in Oklahoma are closely related to interregional considerations and particularly to developments in Texas, (2) Oklahoma and Texas are rapidly becoming surplus fed beef producing regions, and (3) potentials for increasing fed beef consumption in Oklahoma and Texas are limited. The aim of this study is to determine the changing competitive position of Oklahoma and the Southern Plains as these regions increase production of fed beef relative to consumption.

National and regional demand functions for fed beef, regional supplies of such beef and inter-area transportation costs were developed. Two principal areas with respect to data and methodology were encountered. These were problems associated with (1) estimation of regional income coefficients and demand functions, and (2) estimation from published estimates of fed cattle production of the regional distribution of fed beef slaughter.

Initially, fourteen spatial models were developed in this study. However, eight models ultimately were utilized in the analysis. Based upon projections, alternative higher-than-actual levels of fed beef production were postulated for Oklahoma and Texas. With the exception of these postulated increases, supplies of fed beef for use in each model were based primarily on economic conditions as they existed in the fed beef industry during 1960.

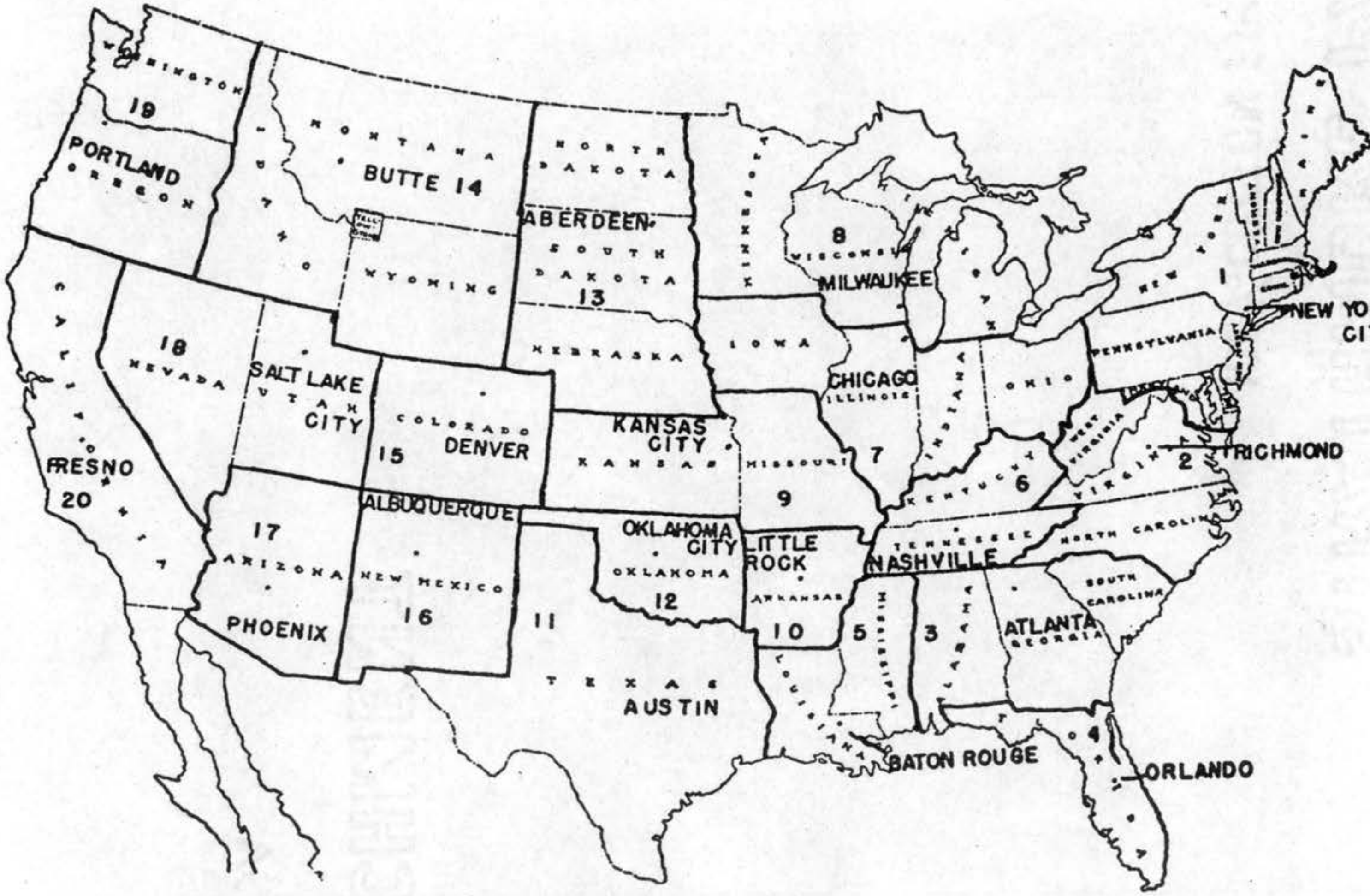
Generation of Basic Data

A spatial equilibrium analysis of the fed beef economy requires utilization of national and regional data concerning production, marketing, slaughter, consumption, prices and income. All data in this study were obtained from secondary sources either directly or in the form of estimates based on published data.

Regional Demarcation

The fed beef sector of the economy was divided into regions as shown in Figure 1. Region 13 was selected as the base or origin for the spatial models. Nebraska, North Dakota and South Dakota is the largest surplus region of fed beef production and in addition is centrally located relative to other surplus regions.

Oklahoma and Texas were the regions of principal concern in this analysis. Therefore, most states surrounding these two regions were treated as single state regions. It was believed that an aggregation of states into regions in the immediate area of Oklahoma and Texas might make such an evaluation more difficult. Location of points of origin or destination within each region were selected on the basis of several considerations. Most were selected to approximate the center of any region as close as possible. In some cases centrally located cities were not



Spatial Fed Beef Model: Regional Demarcation, Regional Receiving and Shipping Points.

selected because of difficulties in obtaining rail mileage to other regional centers. Location of actual shipping and receiving facilities was considered and employed as a criterion whenever it did not conflict directly with others.

National Data

National demand functions for all beef and fed beef were essential to the spatial model analysis. The demand equation for steer-heifer beef was developed as a guide to the reliability of the models for fed beef.

The period 1947-60 was selected for estimation of the demand relationships. Construction of demand equations required estimation of much essential data for each year of this period. Figures on disposable personal income, average retail prices of all grades of beef, and total national consumption of both beef and pork were readily available. Estimates were required, however, of retail prices of steer-heifer fed beef and steer-heifer nonfed beef. This analysis was concerned with purchased consumption. No attempt was made to estimate consumption of home produced meat. Since purchased consumption is a function primarily of commercial slaughter and net imports, estimates of these determinants were needed. No data on commercial slaughter of beef by grades or classes are found in published form.

Derivation of Retail Prices

Two retail price series, one for fed beef and one for nonfed steer-heifer beef, were required in the estimation of the U. S. demand for fed beef. These were employed as two independent variables in the form of (1) the retail price of fed beef and (2) a ratio of retail prices for fed and nonfed steer-heifer beef.

Retail as well as wholesale prices of fed beef were readily available. These prices, together with wholesale prices of lower quality beef, were used to estimate retail prices of nonfed steer-heifer beef.

Wholesale price series for U.S. Choice grade steer beef at Chicago, New York, and San Francisco were available for the period of 1949-60. Since quantities of beef were not available at these three markets, a simple average of wholesale prices was used in place of weighted prices. Average wholesale price was then adjusted to a retail weight basis so as to establish a wholesale-retail margin for Choice grade beef. In detail the procedure was as follows:

$$P_w^c \cdot 1.25 = P_w^{c1} \qquad (4.6)$$

$$\frac{P_c^r}{P_w^{c1}} = R^c \qquad (4.7)$$

$$P_w^g \cdot 1.18 = P_w^{g1} \qquad (4.8)$$

$$P_w^{g1} \cdot R^c = P_n^r \qquad (4.9)$$

where P_w^c = a simple average of annual average wholesale prices of U.S. Choice grade steer beef at Chicago, New York and San Francisco,

1.25 = adjustment factor assuming a 20 percent trimming and shrinkage loss at retail level, used to adjust wholesale prices of U.S. Choice grade beef in terms of wholesale weight to a wholesale price in terms of retail weight,

P_w^{c1} = average U.S. wholesale price of U.S. Choice grade beef in terms of retail weight,

P_c^r = average (published) retail prices of U.S. Choice grade beef,

R^c = ratio of retail to wholesale prices of U.S. Choice grade beef,

P_w^g = a simple average of annual average wholesale prices of U.S. Good grade beef,

1.18 = adjustment factor assuming a 15 percent trimming and shrinkage loss at the retail level used to adjust wholesale price of U.S. Good grade in terms of wholesale weight to a wholesale price in terms of retail weight,

P_n^{gl} = average U.S. wholesale price of U.S. Good grade beef in terms of retail weight, and

P_n^r = average U.S. retail price of nonfed beef.

Missing observations of retail prices of nonfed steer-heifer beef (U.S. Good) for 1947 and 1948 were estimated by simple regression analysis. The correlation (r) between fed and nonfed beef prices was high (.96), therefore a regression of retail fed beef price on nonfed beef retail price was run for the period 1949-1960 in order to estimate the two missing observations for nonfed beef.[9]

Commercial Slaughter (Liveweight)

The national demand functions required variables reflecting quantities of various types of beef consumed in the United States. With

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[9]The regression equation was, $Y = 66.85 + 1.3257X_1$ where Y = nonfed beef retail price and X_1 = retail price of fed beef.

respect to quantities entering into foreign trade, it was assumed that all imports and exports of beef, both small relative to production and consumption of beef, consisted of lower qualities and did not affect supplies or consumption of fed beef or other steer-heifer beef.

Commercial slaughter data were utilized in obtaining estimates of the various types of beef consumed. Numbers of cattle slaughtered commercially and the total live and dressed weights of this slaughter were available for each state as well as for the nation. In addition, average per head live and dressed weights of cattle slaughtered under federal inspection and similar data for commercial slaughter were accessible. Also, data on steer, heifer, and cow-bull numbers slaughtered under federal inspection were published for the period 1947-60. Similar data on commercial slaughter as well as dressed weights by classes had to be derived. Percentage distributions derived from data on federally inspected production were applied to total commercial slaughter data to obtain estimates on numbers of steers, heifers, and cow-bulls slaughtered commercially.

As indicated, data were available on average per head liveweight of steers and of heifers slaughtered under federal inspection. In arriving at similar estimates applicable to commercial slaughter, the following relationship was used and is illustrated for the steer class as follows:

$$\frac{X}{Y} \cdot Z = Z^* \qquad (4.10)$$

where X = average liveweight of all cattle under commercial slaughter, Y = average liveweight of all cattle under federally inspected slaughter,

Z = average liveweight of steers under federally inspected slaughter, and

Z* = average liveweight of steers under commercial slaughter.

With the determination of aggregate liveweight of steers and of heifers, total and weighted average liveweight of the class was derived. The residual or difference between total or aggregate steer and heifer liveweight and total liveweight of commercial slaughter was allocated to the cow-bull class.

Commercial Slaughter (Dressed Weight)

Total liveweights derived as described in the preceding section were converted to dressed weights, for use as estimates of domestic supply and consumption. The derivation required consideration of differences among classes in dressing percentage.

Weight data on commercial slaughter of all cattle indicated that dressing percentages on cattle have risen since 1947. The major problem of this section was to determine how much of this increase in dressing percentage could be attributed to the steer-heifer class. It was assumed that dressing percentages on the cow-bull were highly correlated with variations in average weights of cows and bulls slaughtered. Dressed weights for steers-heifers were obtained as differences between total dressed weights of total commercial slaughter and total cow-bull dressed weights.

Data on total dressed weights of fed beef marketed for slaughter and used in the equation depicting demand for fed beef were published for the period 1947-55. In an attempt to derive total dressed weight of fed beef for 1956-60, data on numbers of cattle on feed and feedlot marketings were utilized. Feedlot marketings were considered equivalent to numbers slaughtered. Equation (4.11) illustrates the procedure for arriving at total feedlot marketings in the United States for the years 1956-57. Total feedlot marketings for 1958, 1959 and 1960 were obtained in the same manner but included more regional data on cattle on feed and feedlot marketings.

$$\frac{Y}{\sum_{i=1}^{8} X_i} \cdot \sum_{i=1}^{8} Z_i = Z^* \qquad (4.11)$$

where Y = total numbers of cattle on feed in the U. S.,

X_i = number of cattle on feed in region i,

Z_i = feedlot marketings in region i, and

Z^* = total feedlot marketings in the U. S.

Given the number of feedlot marketings, estimates of liveweights for steers and for heifers were obtained in accordance with the percentage distribution of each class on feed. A constant dressing percentage of 60.1 percent was applied to estimates of total liveweight of feedlot marketings for the period 1956-60.

National Demand Equations

The spatial equilibrium model makes use of regional demand functions in obtaining estimates of regional consumption. Most previous studies, as suggested earlier, have employed a United States demand function and assumed that it applied to the individual regions. In this study national demand functions for all beef, fed beef, and steer-heifer beef were developed based on time series data for the period 1947-1960. Adjustments were made on the national demand equation for fed beef in an attempt to estimate regional demands for fed beef. The national all beef equation also was utilized in estimating regional demand functions and its role will be discussed at a later point. Derived regional demand equations for fed beef differed primarily with respect to levels of income elasticity.[10] The steer-heifer equation was estimated with the expectation of its use in the development of other spatial models and as a check on the reasonableness of the model for fed beef.

All three demand equations were developed by the single equation approach. It was assumed that the supply of beef available for consumption was predetermined for any given year. All independent variables in the equations were assumed to be exogenous in nature. There is much discussion in the literature regarding the use of single least squares regression and the multi-equation techniques.[11] It was decided that the former estimating procedure was adequate for this analysis since primary emphasis was placed on the equations for estimating purposes.

Demand for all Beef

The equations to follow are based on time series data for the period 1947-60, and all variables are in the form of natural units.[12]

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[10]This will be discussed more fully in the Regional Demand Section.

[11]For such discussions see: 1. R. J. Foote, Analytical Tools For Studying Demand and Price Structures, U. S. Department of Agriculture, Agricultural Handbook 146, 1958. 2. K. A. Fox, The Analysis of Demand For Farm Products, U. S. Department of Agriculture, Technical Bulletin 1081. 3. E. J. Working, "What Do Statistical Demand Curves Show?" Quarterly Journal of Economics, Volume 41, pp. 212-235, 1927.

[12]Variables other than those appearing in the final estimating equation used in the attempt to derive the demand function for fed beef are presented in Appendix A.

The following format for the estimating equations is used. The t-value of the estimated parameter will appear directly below each coefficient.[13] The coefficient of determination (R^2), the estimated residual variance (S^2) and the Durbin-Watson statistic (d') appear below each equation.[14] The demand equation for all beef is as follows:

$$\hat{Y}_1 = 17.2068 - \underset{(2.50)*}{.6526 Z_1} - \underset{(.20)}{.2473 Z_3} + \underset{(5.83)**}{.0817 Z_{2t-1}} \qquad (4.12)$$

$R^2 = .88 \quad S^2 = 15.33 \quad d' = d' = 1.9171 \quad 4-d' = 2.0829$

where $\hat{Y}_1$ = per capita consumption of all beef in pounds (equivalent carcass weight),

Z_1 = average retail price of all grades of beef deflated by an all meat index 1947-49 = 100,

Z_3 = per capita consumption of pork,

Z_{2t-1} = per capita disposable income lagged one year, deflated by the consumer price index 1947-49 = 100.

The signs of the coefficients are consistent with a priori expectations. The price and income parameters are significant at the five and one percent levels, respectively, while Z_3 is not statistically significant. The test for serial correlation of the unexplained residuals indicated that their successive values over the time series were not correlated. The symbols d' and 4-d' indicate the lower and upper bounds of the test.

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[13] *, **, statistically significant at the five and one percent level, respectively.

[14] A discussion of the Durbin-Watson statistic appears in J. Durbin, and G. S. Watson, "Testing for Serial Correlation in Least Squares Regression," Biometrika, Vol. 38, pp. 159-177, 1951.

The following statements may be made ceteris paribus from the estimating equation:

1. A one cent increase in the retail price of beef would result in a .65 pound decrease in per capita consumption of all beef.
2. A one pound increase in per capita consumption of pork would lead to a .24 pound decrease in the consumption of all beef.
3. A one dollar increase in per capita real disposable income would result in a .08 pound increase in the consumption of all beef.

Demand for Steer-Heifer Beef[15]

The steer-heifer demand equation is as follows:

$$\hat{Y}_2 = -8.3329 - \underset{(2.00)}{.5557Z_5} + \underset{(6.23)^{**}}{.0809Z_{2t-1}} - \underset{(.53)}{.1535Z_4} \qquad (4.13)$$

$$R^2 = .85 \quad S^2 = 17.26 \quad d' = 1.7022 \quad 4-d' = 2.2978$$

where $\hat{Y}_2$ = per capita consumption of steer-heifer beef in equivalent carcass weight,

Z_5 = retail price of beef (Choice) deflated by an all meat index 1947-49 = 100,

Z_4 = per capita consumption of all other meat, other than steer and heifer beef, and Z_{2t-1} has been previously defined.

The signs of the coefficients agree with theoretical expectations. The income parameter is highly significant and the price coefficient is

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[15]The steer and heifer beef equation was not actually used in this study as initially planned, but was included as a point of interest.

significant approximately at the 10 percent level. Once again the variable employed to reflect the consumption of a competing group of products with beef was not statistically significant. The residuals in this equation were not serially correlated.

Demand for Fed Beef

The estimating equation for fed beef is shown below:

$$\hat{Y}_3 = 3.3000 - \underset{(.53)}{.1313Z_5} - \underset{(2.63)*}{56.1971Z_6} + \underset{(7.14)**}{.0749Z_{2t-1}} \qquad (4.14)$$

$R^2 = .85 \quad S^2 = 9.9326 \quad d' = 2.0763 \quad 4-d' = 1.9237$

where $\hat{Y}_3$ = per capita consumption of fed beef (equivalent carcass weight)

Z_5 = retail price of fed beef (Choice) deflated by an all meat index 1947-49 = 100,

Z_6 = the ratio of retail price of fed to nonfed steer-heifer beef and Z_{2t-1} has been defined.

The signs of the coefficients were as expected. The income and price ratio coefficients were significant at the one and five percent level while the parameter associated with the price of fed beef was insignificant, indicating that it did not contribute much to the explanation of variation in the consumption of fed beef.

It will be noted on page 86 that the price ratio variable (Z_6) is not directly used in approximating the base region price for the spatial analysis. It was assumed that the ratio of fed to nonfed beef retail price was constant in all regions, therefore the price ratio variable was included in the <u>a</u> term.

The elasticity of demand, implied by Z_5 above was -.27. However, it is difficult to make meaningful statements regarding the elasticity of demand derived from a variable which is not statistically significant. In addition, this elasticity estimate assumes the price ratio variable (Z_6) is constant.

An estimate of the elasticity of demand, which appears quite reasonable (-2.1) was obtained by using the price ratio variable (Z_6).

$$\eta_D = \frac{\partial Y_3}{\partial Z_5} \cdot \frac{Z_5}{Y_3} \qquad (4.15)$$

Z_6 includes the retail price of nonfed beef. The mean price of nonfed beef used in calculating η_D (4.15) was 60.5 cents.

The estimated income elasticity of demand for fed beef was 3.03. This estimate indicates a high consumer response to changes in real disposable income.

Regional Data

In this section an attempt is made to estimate regional (1) produced supply of fed beef, (2) slaughter supply of fed beef, and (3) disposable income.

Two sets of regional data for 1960 were utilized in this study with respect to fed beef supplies. They are as follows:

A. The produced supply of fed beef in equivalent carcass weight, i.e., the supply at the feedlot level,

B. The slaughter supply of fed beef in equivalent carcass weight, i.e., the supply at the meat packer level.

Estimates of supply at the feedlot level required the conversion of published data on fed cattle marketings by state or region to carcass weight equivalents. These data were used in the spatial model analyses as explained in the models section to follow, with the assumption that regional supplies of fed cattle are slaughtered where produced. This assumption is fairly reasonable in many regions, however, a priori knowledge suggests significant departures from it. For example, it has been observed that large volume shipments of fed cattle have been made to the Northeast for slaughter. Also, a high percentage of the fed cattle produced in Arizona are shipped into California for slaughter. An Oklahoma survey indicates that nearly half of the fed cattle produced in this state are shipped to meat packers in other states. Some fed cattle are shipped into the South for slaughter, while shipments from Montana and Idaho to Washington and Oregon are common. While no published data are available on these shipment patterns it is probable that they are sufficiently large to alter the regional distribution of fed beef supplies. Accordingly, methodology for estimating the extent of this redistribution was developed. The methodology was complex and involved and required the use of much judgment. The essential elements of the procedure are described here.

The Produced Supply of Fed Beef

Quarterly data are published regularly by the U. S. Department of Agriculture on numbers of cattle marketed from feedlots. In 1960, these data were available for the 26 principal feeding states. However, no national series of data on total fed cattle marketings were available.

A further complication is that a small percentage of fed cattle marketed consists of cows, stags, or bulls, and data were desired which would exclude these classes. In addition, since the average marketing weights of fed steers and heifers differ significantly and the extent of this difference varies among regions, separate regional estimates of fed steer and heifer marketings were required. These required estimates were developed through the use of the more adequate cattle on feed data.

Numbers of Steer-Heifer Marketings from Feedlots

Estimates for the 26 principal feeding states (14 of the 20 regions defined for use in this study) were derived in the following manner.

$$SH_i = TM_i \cdot R_i \qquad (4.16)$$

where SH_i = numbers of steers and heifers marketed in region i in 1960,

TM_i = total fed cattle marketings in region i, 1960,

$$R_i = \frac{SH_i'}{TM_i'} \qquad (4.17)$$

where SH_i' = the sum of quarterly totals of steers and heifers on feed, 1960,

TM_i' = the sum of quarterly totals of all cattle on feed, 1960.

R_i in all instances was not less than .97, indicating that not more than three percent of the cattle on feed in any given region consisted of cows, bulls or stags. It was assumed that R also represented the ratio of steers and heifers to all cattle marketed from feedlots. It is possible that the ratios are somewhat high as the rate of turnover of cows on feedlots is probably relatively high (Appendix Table B-1).

Only January 1, 1960 inventories of cattle on feed were available for the remaining six regions, all of which are located in the South. These data showed that cattle on feed in these six regions represent only about five percent of the United States total. Based on a priori knowledge and rates of turnover in other regions, a ratio of January 1 inventories to annual marketing of 1.1 was used for the six regions. These yielded estimates of marketings as indicated in Appendix Table B-1. No adjustments for cows and bulls marketed from feedlots in the South were attempted.

Separate estimates of steer and heifer marketings from feedlots were derived as follows:

$$S_i = SH_i \cdot R_i' \qquad (4.18)$$

where S_i = numbers of steers marketed from feedlots in region i, 1960, and SH_i was previously defined,

$$R_i' = \frac{S_i'}{SH_i} \qquad (4.19)$$

where S_i' = the sum of quarterly totals of steers on feed, 1960, and SH_i was defined earlier.

Estimates of R_i' were developed for regions 2 through 6 and region 10 from published data on Alabama and Georgia and the use of the ratio for the Northeast, the central corn belt and Oklahoma and Texas.

Distribution of Slaughter Supply of Beef

Regional estimates of slaughter supply of fed beef for 1960 involved a disproportionate amount of work and yielded results which are considered as approximations and only nominally satisfactory. Original plans had called for the calculation of an optimum distribution of fed beef slaughter via programming procedures. Time considerations and lack of reliable data on transportation rates for live cattle, however, resulted in the substitution of the procedures outlined below.

Separate estimates were developed for fed steers and heifers. These required regional estimates, in addition to those on fed cattle marketings described earlier, and net in or outshipments of fed cattle for slaughter. These, in turn, required a multitude of regional estimates on all (fed and nonfed) steers and heifers including (1) commercial slaughter, (2) marketings for slaughter, and (3) net in or outshipments for commercial slaughter.

Commercial Slaughter of all Steers and Heifers

Separate estimates for 1960 were published by the U. S. Department of Agriculture on federally inspected slaughter of steers and heifers and all cattle by census regions.[16] State and regional estimates of total commercial slaughter are published regularly.

Nationally, federally inspected slaughter represented about 77 percent of total commercial slaughter of cattle. This slaughter varies regionally, however, from 58 percent in the South and 68 percent in the Northeast to 83 percent in the North Central region, excluding Kansas and Missouri. Even wider regional differences in federally inspected slaughter as percentages of total are suggested for individual classes of cattle.

[16]These data were published for three subregions of the North Central region. One of these was Kansas and Missouri, coinciding with region 9 as defined in this study.

Nevertheless, it was assumed that the ratio of commercial steer or heifer slaughter to total commercial slaughter was reflected by the ratio of federally inspected steer or heifer slaughter to total federally inspected slaughter.

Marketings of Steers and Heifers for Slaughter

Estimates of steer and heifer marketings for immediate slaughter were developed from a variety of published data. These included U.S.D.A. inventory and production and dispositions data in addition to feedlot marketings.

It was assumed that marketings for immediate slaughter were proportionate to net inventories of the specific classes of cattle considered. Net inventories for cattle and calves used in deriving marketings for immediate slaughter were defined to include marketings, deaths, farm slaughter, calf births and inshipments.

Provided with estimates of regional net inventories of a specific class, regional marketings for slaughter of that class were derived. Regional marketings of steers and heifers for slaughter for 1960 are shown in Appendix Table B-2. These data reflect the effects of appropriate adjustments, (1) among classes of cattle in each region to published data on total cattle for each region, and (2) among regions in conformance with national data. A detailed explanation of the methodology employed in estimating regional marketings of steers and heifers for slaughter appears in Appendix B.

Regional Distribution of Fed Steers and Heifer Slaughter

With separate regional estimates for steers and heifers of (1) commercial slaughter and (2) marketings for slaughter, net in or out-shipments for slaughter were represented by the difference between the two estimates.

Thus:

$$OS_i = MS_i - CS_i \tag{4.20}$$

where OS_i = outshipments of steers for slaughter in region i,

MS_i = marketings of steers for slaughter in region i, and

CS_i = commercial slaughter of steers in region i.

Estimates of $\pm$ OS_i are shown in Appendix Table B-4, where surplus and deficit regions are delineated by sign. The surplus or deficit conditions of a region were not always the same for steers and heifers. In general, however, the findings conformed closely to a priori knowledge.

The task remaining was (1) to estimate that portion of shipments which consisted of fed beef, and (2) to use these in connecting estimates of the regional distribution of fed beef production to a regional distribution of slaughter. In this procedure, inshipments and outshipments were estimated independently. The methodology used in estimating regional in or outshipments of fed beef and fed beef slaughter is illustrated in Appendix B.

Estimation of Regional Live and Dressed Weights of Fed Beef Production and Slaughter

Once regional estimates of fed beef slaughter numbers were derived, the final task was that of estimating regional dressed weights for fed steers and heifers.

Average liveweights of steers and heifers, fed and nonfed were estimated for the regions in this study by utilizing published liveweight data at twelve terminal markets throughout the nation. A regional average liveweight was determined by the terminal market most closely located to that region.

Average liveweights of steers for a region based on a terminal market was estimated as follows: The numbers of steers and their average liveweights in the Prime, Choice and Good grades were used. A weighted average liveweight was determined for fed steers (and heifers) in each terminal market which was used to reflect the average liveweight in the region corresponding to that terminal market.[17] These markets also reported "other grades" and these average liveweights were used to reflect the average liveweight of nonfed steers (and heifers).

A dressing percentage of 60.1 percent was used for fed steers and heifers as was the case in determining dressed weight for fed beef for the national data. Appendix Table B-5 shows the regional dressed weight estimates for fed production and slaughter.

Regional Disposable Income

In the estimation of regional demand for fed beef, disposable personal income data in each region was required. Personal income by states was readily accessible for 1959 and 1960. Regional disposable personal income was published for 1959, but it was necessary to estimate

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[17] A further adjustment was made in average liveweights of fed steers and heifers in regions 16-20. This adjustment appears in Appendix Table B-5.

disposable income for 1960. Personal and disposable personal income tend to move together over short periods of time, and knowledge of this relationship was the rationale behind the estimating procedure used below.

$$\frac{\sum_{i=1}^{20} Z_i \ 1960}{\sum_{i=1}^{20} Z_i \ 1959} \cdot \sum_{i=1}^{20} Y_i \ 1959 = \sum_{i=1}^{20} Y_i^* \qquad (4.21)$$

where Y_i^* = disposable personal income in the i^{th} region, 1960, and

Z_i = personal income in the i^{th} region.

Regional Demand

The most direct method of obtaining estimates of regional demand is that of generalizing the national demand function for fed beef to all regions. In utilizing the national demand function the ratio of the retail price of fed to nonfed steer-heifer beef (Z_6) was included in the constant term.[18] Regional real income was inserted in the national demand function. Per capita consumption estimates obtained, according to this procedure, were extremely low in the South (Table II). The demand equation estimated zero consumption of fed beef at approximately the 920 dollar annual per capita real income level. Money income and prices were used in the effort to obtain more reasonable estimates of per capita consumption. In this situation, consumption estimates increased in the South and were increased beyond a priori expectations in higher income areas.

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[18]It was assumed that this price ratio for the U. S. was the same in all regions.

TABLE II

REGIONAL PER CAPITA CONSUMPTION DERIVED BY NATIONAL AND REGIONAL FED BEEF DEMAND FUNCTIONS

Regions	Per Capita Consumption U. S. Fed Beef Demand Equation	Per Capita Consumption Regional Fed Beef Demand Equation
	lbs.	lbs.
1	62.6	52.3
2	20.1	24.4
3	10.2	20.1
4	35.2	35.6
5	6.9	19.3
6	11.9	20.5
7	54.9	53.2
8	46.6	49.2
9	43.4	47.5
10	2.6	18.2
11	31.3	33.0
12	27.1	29.9
13	32.2	40.5
14	34.4	51.0
15	49.7	61.3
16	24.9	42.6
17	34.2	50.1
18	40.0	55.2
19	47.5	60.0
20	72.7	72.6

Use of the national demand function would have permitted some variation in regional income elasticities for fed beef, but this variation apparently was not sufficient to achieve reasonable estimates for some regions of per capita consumption.

In an effort to obtain more reasonable regional demand estimates than those provided by the national demand function alone, alternative methods of adjusting regional income elasticities were investigated. One such method involved adjustments in regional income coefficients for (1) the West, (2) four regions in the deep South, and (3) Arkansas. These adjustments required compensating adjustments in the remaining areas of the nation, namely, the Northeast and North Central regions. The basic assumption underlying this method was that for any particular year, consumption of fed beef in the West, excluding Colorado and the Montana-Wyoming-Idaho area, was at least as high as the production of fed beef in those states. This provided a rough indication of income elasticity for the West. It was further assumed that per capita consumption of fed beef in California was that estimated by the fed beef equation adjusted for California's real income. Income parameters for regions 3, 5, and 6 arbitrarily were based on the estimated average income elasticity of demand for the areas comprising regions 2, 3, 5, and 6. Appropriate adjustments were made for other regions.

This initial alternative relied heavily upon a priori judgment of the researcher. Assumptions underlying the adjustments, however, were not altogether unrealistic. Consumption estimates were derived for the South and for Intermountain areas that were considered low. Accordingly, a procedure was adopted which yielded estimates for these regions which were considered more satisfactory. Although reliability of the estimating procedure adopted can be questioned, it appears to be more objective and defensible. Details of the procedure are presented below.

Regional Demand Functions for Fed Beef

In estimating regional demand functions for fed beef, simple regression equations of per capita income on per capita purchased consumption of all beef for 1955 were estimated for the Northeast, South, North Central and Western regions.[19] Utilizing 1955 Household Food Consumption Survey data, these equations were used in conjunction with the all beef equation (4.12) and the fed beef equation (4.14) in deriving regional per capita consumption estimates of fed beef for 1960.

The following procedure was used in deriving regional per capita consumption estimates of fed beef for 1960 through use of equations for purchased beef, in 1955, all beef in 1960, and fed beef in 1960.

$$\frac{\sum_{i=1}^{20} Y_{1i}}{\sum_{i=1}^{20} Y_{2i}} \cdot \sum_{i=1}^{20} Y_{3i} = \sum_{i=1}^{20} Y_i^* \qquad (4.22)$$

where Y_{1i} = total consumption of fed beef in region i, derived from the national demand function for 1960,

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[19] Northeast $\hat{Y} = 46.7574 + .0072Z_2$

South $\hat{Y} = 24.7366 + .0163Z_2$

North Central $\hat{Y} = 48.9644 + .0085Z_2$

West $\hat{Y} = 61.3783 + .0085Z_2$

Where $\hat{Y}$ = per capita purchased consumption of all beef, Z_2 = real per capita disposable income.

Y_{2i} = total consumption of all beef derived from the national demand function for 1960,

Y_{3i} = total consumption of all beef in region i for 1960, derived from 1955 Household Consumption data,

Y_i^* = estimated total consumption of fed beef in region i, 1960.

The variable, Y_3, requires further explanation. The 1960 purchased consumption of all beef was obtained from the regressions based on 1955 Household data using 1960 regional real income. Since Household data was based on purchases for one week during a three-month period, a seasonal adjustment factor was applied to the consumption estimates obtained. These consumption estimates were measured at the retail level. Since the national demand functions were in terms of equivalent carcass weights, an adjustment factor for conversion from retail to equivalent carcass weights was applied. Thus, 1960 estimates of the consumption of all beef for 1960 were obtained. The sum of these estimates diverged approximately one percent from consumption estimates of all beef used in the 1960 national demand function for all beef.

Regional estimates for fed beef obtained by this procedure (equation 4.22) yielded estimates that were considered reasonable. Those for western states may be higher than would be indicated by more reliable data. But estimates for the South still were considered low for some subregions. Income parameters for regions 3, 5, 6, and 10 were adjusted upward based on an average income elasticity of demand for fed beef applicable to the entire South.

The average income elasticity of demand for the four regions in the South was estimated utilizing the national demand function for fed beef.

$$\hat{Y} = -a^* + .0749Z_{2t-1} \quad (4.23)$$

where a^* = the constant term estimated in the national fed beef demand equation, including the retail price (Z_5) and price ratio variable (Z_6) evaluated at the mean; Z_{2t-1} was defined earlier.

By transposing this equation and using average per capita consumption and real income in the South, an estimated income parameter, (b^*) was obtained for the southern region. An income elasticity of demand then was derived as indicated below.

$$\eta_{D/I_{South}} = b^* \cdot \frac{I}{C} \quad (4.24)$$

where b^* = the estimated income parameter for the South,

I = average per capita real disposable income,

C = average per capita consumption of fed beef in the South.

Adjusted per capita consumption for region 3, for example, was then obtained as follows:

$$\eta_{D/I_{South}} \cdot C = b^* \cdot I$$

$$C = \frac{b^*}{\eta_{D/I}} \cdot \frac{I}{\eta_{D/I}} \quad (4.25)$$

where C = per capita consumption in region 3. All other variables were defined above.

The procedure adapted provided estimates that appear much superior to those derived through use of the national demand equation above or other means of adjusting income elasticities. The method, however, also has limitations. The Household Consumption Survey was conducted in 1955. The relative importance or influence of the factors affecting beef consumption may have changed somewhat. Despite this, regional differences probably have not been greatly affected. In addition, procedures involved in deriving regional estimates of fed beef consumption from data on purchased consumption of all beef may leave something to be desired. Results, nevertheless, appear logical and fairly reasonable.

Characteristics of the Spatial Models

Eight spatial models, as indicated in Table III, were employed. These spatial models differed primarily with regard to assumptions underlying regional distribution of supply. The same set of regional demand functions was used throughout the spatial analysis. Three basic supply models were considered. Two of these models were modified such that three variations of one (Model I) and four variations of the other (Model II) were used.

Supply Models

In all spatial models supply was treated as predetermined. Alternative assumptions underlying the predetermination, however, present themselves. In general, fed beef slaughter is producer oriented, but many exceptions exist. Shipments of fed cattle, for instance, are made regularly to slaughtering facilities in the Northeast, California, and portions of the South. Oklahoma is a surplus producer of live fed cattle, exporting a high percentage for slaughter in other regions.

Supply Model I: One supply model was developed with the intent of reflecting the actual regional pattern of fed beef slaughter. Since data on net interregional shipments of fed cattle for slaughter were not readily available, an estimating procedure had to be developed.

TABLE III

SLAUGHTER SUPPLY AND PRODUCTION OF FED BEEF FOR OKLAHOMA AND TEXAS--1960, 1965, 1970 AND OPTIMUM FEEDING REGIONS 1958, USED IN SPATIAL MODELS

Spatial Model Number	Slaughter Supply of Fed Beef (Million lbs.)		Spatial Model Number	Production of Fed Beef (Million lbs.)	
	Oklahoma	Texas		Oklahoma	Texas
IA	40[a]	292[a]	IIA	82[a]	252[a]
IB	93[b]	292	IIB	127[b]	252
IC	93	333[b]	IIC	127	380[b]
			IID	175[c]	510[c]
			III	263[d]	875[d]

[a]Slaughter supply and fed beef production for Oklahoma and Texas, 1960.

[b]Slaughter supply and fed beef production for Oklahoma and Texas, based on 1965 projection.

[c]Fed beef production for Oklahoma and Texas, based on 1970 projection.

[d]Fed beef production for Oklahoma and Texas, based on 1958 optimum feeding regions.

Statistical reliability of the resulting estimates is unknown, but they do meet various tests of consistency and reasonableness.

Supply Model II: This supply model assumes a relocation of the slaughter industry such that it is oriented strictly to production. Data on marketings of fed cattle by regions are readily available and are considered fairly reliable. Estimates of fed cattle marketings in each region when converted to dressed weight were considered equal to slaughter supply.

Supply Model III: When such factors as location of feeder cattle supplies, regional differences in feed production and others are considered, the present regional distribution of fed cattle production appears to depart significantly from what might be considered an optimum distribution. A priori considerations suggest that an optimum plan would require increased production and slaughter of fed cattle in Oklahoma and Texas. Since Schrader and King provide estimates, derived from a spatial model, depicting an optimum regional distribution of fed cattle production, these were employed.[20] In spatial Model III location of the slaughter industry is further oriented to reflect the optimum distribution of fed cattle production suggested by Schrader and King. Regional demand functions remain unchanged in this model.

Modification A:[21] Supply Models I and II were modified to accomodate projected increases in slaughter and supply of fed beef production

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[20]Lee F. Schrader and Gordon A. King, "Regional Location of Beef Cattle Feeding," Journal of Farm Economics, Vol. XLIV, February, 1962, pp. 64-81.

[21]See Table III for description and data used in the various models.

in Oklahoma while holding supply for all other regions constant. Spatial Model IA employs supply Model I in which no modification is made in Oklahoma slaughter supply. Spatial Model IB relies upon supply Model IA in which the modification for Oklahoma is made.

Modification B: Supply Models I and II were further modified to accomodate assumed simultaneous relative increases for Oklahoma and Texas in slaughter, and therefore, production of fed beef. Again supply for other regions was held constant. Spatial Models IC and IIC assume relatively small increases for Oklahoma and Texas. These increases are consistent with projections to 1965. Spatial Model IID is based upon projections for both states to 1970, and assumes a considerably larger rise in production and slaughter of fed beef.

The Linear Program

The specific program and its computational capacity is discussed here because of its direct bearing on the procedure used in this analysis.[22] This program did not have the capacity to accomodate the matrix size used in this study. Therefore, it was necessary in each model to eliminate some shipping activities prior to the analysis. It was quite reasonable to assume that certain regions would not ship to others because of distance, or small supplies of fed beef available for shipping. As more models were analyzed, it was observed that some supply areas, because of prohibitive costs, did not ship to certain regions. When it was necessary to eliminate any activities in a larger model, these regions were chosen.

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[22] O. R. Perry and J. S. Bonner, Linear Programming Code for the Augmented 650, Number 10.1.006, Los Angeles and Houston (1958).

Inequality of Supply and Demand

The introduction of a dummy destination into the spatial model analysis is one alternative which allows the researcher to evaluate the effect of an excess supply condition on interregional flow patterns and regional equilibrium prices. The dummy destination allows for the restriction regarding equality of supply and demand. In the programming process all supplying regions are given access to ship to the dummy at zero costs. The program is structured such that only after the requirements of the deficit areas are satisfied in an optimum manner are shipments made to the dummy destination.

In the spatial model analysis a region may ship all or part of its supply to the dummy region. The dummy destination used in the analysis is artificial in the sense that a demand does not exist in the area and the quantities shipped there, in reality, would result in a storage or disposal problem for any region involved. In spatial analysis it does enable one to postulate an increased supply in a given area and to evaluate the effect of such a disturbance with regard to prices and flows among regions without changing supplies for other areas.

Two alternatives other than use of a dummy destination existed. First, the postulated increase in supply of a given region may be compensated by proportioned decreases in all other supply areas. Second, the increase in a given area may be compensated by a decrease in closely competing supply regions. Both alternatives have the disadvantage, in some cases, in that regions experiencing decreases in supply are in a strong unfavorable position at the initiation of the analysis. The use of a dummy destination allows these supply areas to maintain a constant supply.

A major disadvantage in utilizing the dummy destination is its affect on the equilibrium prices of those regions shipping to the dummy. This procedure tends to under or overestimate equilibrium prices of some regions shipping to a dummy area. This affect will be more clearly shown in the empirical chapter.

Approximation of Regional Equilibrium Consumption, Prices and Price Differentials

Initially, estimates of regional per capita consumption in this study were obtained through use of the regional demand functions previously described. However, regional equilibrium prices and consumption are determined relative to the demand function for a predetermined base region. In this study, as was pointed out, region 13 (Nebraska, North Dakota and South Dakota) was the base region.

Prior to estimating regional equilibrium prices and consumption, regional price differentials must be ascertained. The price differentials are based on transport costs of shipping fresh beef between the various regions. These transport costs were generated by utilizing rail and truck transportation functions developed by Judge.[23] Transport costs used in this study were the lowest of the two estimates between all regions for rail and truck transportation. These rates are shown in Appendix Table B-6.

In developing price differentials for surplus and deficit regions, the following formulation was used. A base region is denoted as was region 13 in this study. All regional prices are tied to the base

[23]G. G. Judge, p. 21.

region. The principle involved is that all regional price differences shall be equal to transport cost differences. An initial approximation of a surplus region's price is determined as follows: When two surplus regions are shipping to a deficit region, the difference between their equilibrium prices will be equal to the differences between their transportation costs to the deficit region. An approximation of the equilibrium price in a deficit region is derived by the transport cost of the surplus area shipping to the deficit region, plus or minus the surplus region's differential relative to the base region. In essence, an initial approximation of regional price differentials may be ascertained as shown below.

$$V_j - U_i = C_{ij} \qquad (4.26)$$

where[24] V_j = an approximation of a deficit region, j's price differential relative to the base region,

U_i = an approximation of a surplus region, i's price differential, and

C_{ij} = transportation cost between regions i and j.

Once the approximations of regional price differentials are obtained, the derived national demand function is used to generate an equilibrium price for the base region, based on data observed for 1960. The remaining regional prices are determined by their individual price differential relative to the base region's equilibrium price. In this

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[24] In order to determine a set of approximate regional price differentials, the U_i for the base region is assigned a zero value.

study, the demand function and equilibrium price of the base region was determined as shown below.

$$\hat{Y}_3 = -59.8655 \sum_{i=1}^{20} P_i - .1313Z_{o5} \sum_{i=1}^{20} P_i - .1313Z_5 \sum_{i=1}^{20} P_i d_i + .0749Z_{2t-1} \sum_{i=1}^{20} P_i \tag{4.27}$$

where all variables have been previously defined, $\sum_{i=1}^{20}$ is total United States population, d_i are regional price differentials, and Z_{o5} is the price variable associated with the base region.

It is noted that the a value has changed significantly relative to its magnitude in equation (4.14). The reason is that the price ratio variable (Z_6) in equation (4.14) was included in the constant term. Inserting the population and price differential values into the above equation, the equilibrium price Z_{o5} for the base region is determined. Once the base region's equilibrium price is known, per capita consumption estimates for all regions are determined as follows:

$$\hat{Y}_{1i} = - 59.8655 - .1313 (Z_{o5} \pm d_i) + b^*Z_{i2t-1} \tag{4.28}$$

where $\hat{Y}_{1i}$ is per capita consumption of fed beef in the i^{th} region, d_i is the estimated price differential for region i relative to the base, Z_{i2t-1} is real per capita disposable income in the i^{th} region, and b^* is the estimated income parameter for the i^{th} region.

These approximations of regional equilibrium consumption along with predetermined supplies and transport costs between regions are entered into the linear program in order to arrive at an optimum solution regarding interregional flows of fed beef. The optimum solution is achieved when there are no changes in the volume and direction of flows of fed beef between regions. Any change in volume and direction of movement would result in a higher total transportation cost.

CHAPTER V

EMPIRICAL FINDINGS OF THE SPATIAL MODEL ANALYSIS

The purpose of this chapter is to (1) describe the general and specific nature of empirical findings, (2) analyze economic relationships generated by spatial models, and (3) evaluate findings with respect to Oklahoma's competitive position in the fed beef economy.

Findings of the study and their implications provide significant and useful insights regarding Oklahoma's competitive potential in fed beef production and marketing. The results also suggest the manner and relative extent to which other surplus regions might be affected by the emergence of Oklahoma and Texas as important surplus producing regions. Restrictive assumptions and programming limitations must be considered at each point in the analysis. Such factors to be considered during the analysis are (1) the manner of regional demarcation in which areas were structured to maximize the analytical capacities of spatial models with respect to Oklahoma's competitive situation, (2) the necessary deletion of shipping activities from each program which were assumed unlikely to enter the optimum flow solution,[1] and (3) the employment of a dummy destination in some of the models and its effect on the findings.

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[1]An alternative linear programming procedure, possessing other limitations, was used for two spatial models in which all possible shipping activities were included. Results indicated that the deletion of some shipping activities in the programming procedure used in this study had no affect either on direction or magnitude of interregional flows.

General Nature of Findings

The major surplus regions for fed beef in 1960 were 13 (Northern Plains), 7 (Central Corn Belt), 15 (Colorado), and 9 (Kansas-Missouri). Exports from other regions, were in general, relatively small. Principal deficit areas were the Northeast and the South. In general, findings suggest that:

1. Arkansas and other deficit areas of the South were potential markets for Oklahoma Fed beef.
2. Oklahoma's principal competitors in shipping fed beef to markets in the South were Colorado, Kansas-Missouri, and Texas.
3. Oklahoma enjoyed a relatively favorable locational advantage over Colorado, the Northern Plains and the Central Corn Belt in shipping to southern markets. Oklahoma's locational advantage relative to Kansas-Missouri and Texas was not so clear. In some of the models such an advantage was apparent for Oklahoma, while in others it was not.
4. As a shipper of fed beef, Oklahoma could not compete successfully with other supply areas on shipments of fed beef to the Far West or the Northeast, without accepting substantial reductions in net returns.
5. Results of models involving hypotheses regarding substantial increases in fed beef production in Oklahoma and Texas, and additional outshipments of dressed fed beef from these regions indicate that:

(a) Flows of fed beef from Kansas-Missouri and Colorado would be shifted from the South, including the Southern Plains and southern portions of the Southeast, to markets further north.

(b) Relatively larger quantities would be shipped from Kansas-Missouri to Kentucky-Tennessee, and northern portions of the Southeast (region 2), and from Colorado to the Northeast.

(c) The dummy region would receive shipments from Colorado and other surplus regions in the Mountain region, indicating that these regions were most severely affected by increased production and slaughter of fed beef in the Southern Plains.

6. Surplus areas of the Northern Mountain region apparently experienced a locational disadvantage relative to other surplus or potential surplus regions in the complex of inter-regional competition for fed beef markets.

Description of Empirical Results of Spatial Model Analysis

The purpose of this section is to report similarities and differences in the spatial models with respect to (1) surplus and deficit regions, (2) regional flow patterns of fed beef, (3) regional equilibrium prices and price differentials, and (4) transport costs for fed beef.

Surplus-Deficit Regions

Regions were classified as surplus or deficit, according to differences between consumption and production of fed beef. In this study,

TABLE IV

OPTIMUM REGIONAL FLOWS OF FED BEEF
(000 lbs.)

Regions	- Model - IA	IB	IC	IIA	IIB	IIC	IID	III
1	-1,714,548 (7,8,13,15)	-1,714,659 (7,8,13,15)	-1,714,591 (7,8,13,15)	-2,460,492 (7,13,14,18)	-2,460,440 (7,13,14,18)	-2,460,561 (7,13,15)	-2,460,445 (7,13,15)	-2,493,231 (8,13)
2	-213,854 (9,15)	-213,887 (9,15)	-213,858 (9,15)	-215,995 (7,9,15)	-215,982 (7,9,15)	-216,063 (9,15)	-216,038 (9,15)	-252,449 (8)
3	-100,599 (9)	-100,630 (9)	-100,602 (9)	-121,728 (9)	-121,717 (9)	-121,792 (9,12)	-121,768 (9,12)	-193,135 (11)
4	-134,483 (15)	-134,497 (15)	-134,486 (15)	-146,522 (15)	-146,545 (15)	-146,585 (15,16)	-146,573 (11,15,16)	-177,922 (11)
5	-55,531 (15)	-55,548 (12,15)	-55,533 (11,12,15)	-75,603 (15)	-75,597 (12,15)	-75,797 (11,12)	-75,940 (11)	-105,319 (11)
6	-71,433 (9)	-71,455 (9)	-71,435 (9)	-69,523 (9)	-69,515 (9)	-69,565 (9)	-69,549 (9)	-135,525 (12)
7	680,961 (1)	680,898 (1)	680,934 (1)	1,416,435 (1,2)	1,416,463 (1,2)	1,416,396 (1)	1,416,460 (1)	-18,971 (8)
8	164,848 (1)	164,811 (1)	164,834 (1)	-140,506 (13)	-140,490 (13)	-140,527 (13)	-140,492 (13)	289,680 (1,2,7)
9	366,039 (2,3,6,10)	366,024 (2,3,6)	366,033 (2,3,6)	274,948 (2,3,6,10)	274,768 (2,3,6)	274,905 (2,3,6)	274,920 (2,3,6)	-182,351 (13)
10	-16,532 (9)	-16,540 (12)	-16,535 (12)	-17,556 (9,12)	-17,556 (12)	-17,622 (12)	-17,618 (12)	-32,650 (12)

TABLE IV (Continued)

Regions	IA	IB	IC	IIA	IIB	IIC	IID	III
				- Model -				
11	-26,344 (15)	-26,672 (15)	13,653 (5)	-66,777 (15,16)	-66,766 (15,16)	60,185 (5)	189,931 (4,5)	553,907 (3,4,5,20)
12	-30,371 (15)	22,525 (5,10)	22,530 (5,10)	11,502 (10)	56,502 (5,10)	56,416 (3,5,10)	104,442 (3,10)	192,269 (6,10,20)
13	792,361 (1)	792,353 (1)	792,359 (1)	1,119,309 (1,8)	1,119,312 (1,8)	1,119,305 (1,8)	1,119,311 (1,8)	3,341,311 (1,9,14,19,20)
14	18,533 (19)	18,611 (19)	18,613 (19)	176,367 (1,19)	176,370 (1,19,21)	176,503 (19,21)	176,507 (19,21)	-4,228 (13)
15	376,927 (1,2,4,5, 11,12,16)	376,928 (1,2,4,5, 11,16,21)	376,929 (1,2,4,5, 16,21)	349,907 (2,4,5,11)	349,908 (2,4,5,11)	349,895 (1,2,4,21)	349,899 (1,2,4,21)	108,550 (20)
16	-17,938 (15)	-17,940 (15)	-17,939 (15)	16,958 (11)	16,960 (11)	16,946 (4)	16,947 (4)	165,522 (20)
17	-37,622 (18,20)	-37,968 (18,20)	-37,559 (18,20)	178,123 (20)	178,124 (20)	178,206 (20)	178,220 (20)	56,934 (20)
18	23,050 (16,17,19)	22,849 (17,19,21)	22,849 (17,19,21)	30,742 (1,20)	30,743 (1,20)	30,826 (20,21)	30,829 (20,21)	1,912 (20)
19	-34,745 (14,18)	-34,528 (14,18)	-34,524 (14,18)	-77,196 (14)	-77,196 (14)	-76,829 (14)	-76,818 (14)	-278,838 (13)
20	31,581 (17)	32,325 (17)	32,228 (17)	-182,363 (17,18)	-182,346 (17,18)	-181,242 (17,18)	-181,205 (17,18)	-835,466 (11,12,13,15 16,17,18)
21	0	-53,000 (15,18)	-94,000 (15,18)	0	-45,000 (14)	-173,000 (14,15,18)	-351,000 (14,15,18)	0

\+ = Outgoing Shipments.
\- = Incoming Shipments.
() = Regions Shipping or Receiving.

only net surpluses and deficits were considered. Table IV indicates surplus and deficit fed beef regions in the various models. Net inshipments or outshipments for each region are shown together with sources or destinations.

Negative or positive signs associated with flows of fed beef indicate deficit or surplus regions, respectively. In general, regional classifications with respect to surplus-deficit conditions remained constant throughout the model analysis. Classifications were subject to change only by introduction of a modification in any given model.

The estimated actual regional distribution of fed beef slaughter was considered in Models IA-IC. In Model IA, regions 1, 2, 3, 4, 5, 6, 10, 11, 12, 16, 17, and 19 were deficit regions. Regions 7, 8, 9, 13, 14, 15, 18, and 20 were surplus producers of fed beef.

Oklahoma was designated a surplus producer of fed beef in Models IB and IC, based on a recent 1965 projection of fed beef slaughter.[2] In Model IC, slaughter supply for Texas was increased to the point that status of this region shifted from deficit to surplus. The dummy region as shown in Table IV is employed only in those models where supplies were increased. Rationale for use of this artificial region was given in the preceding chapter.

Models IIA, IIB, IIC, and IID reflect the assumption that fed beef is slaughtered where produced. Regions 8 and 20 were deficit areas in these models while regions 12, 16, and 17 shifted to a surplus status. Texas again was introduced as a surplus region in Model IIC.

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[2]Projections of slaughter and production for slaughter for Oklahoma and Texas in 1965 and 1970 were developed by A. Wallace, Jr., Livestock and Meat Marketing in Oklahoma," unpublished Master's Thesis, Stillwater, 1962.

Classification of regions in Model III differed considerably from those in other models. This model was based on the optimum location of fed cattle production.[3] Deficit regions in this model were 1, 2, 3, 4, 5, 6, 7, 9, 10, 14, 19, and 20. The surplus regions were 8, 11, 12, 13, 15, 16, 17, and 18. Compared with the actual situation and models presented earlier, marked differences in classification are evident. In this model, regions 2, 3, 4, 5, 6, and 19 no longer feed cattle. The Corn Belt states and Kansas-Missouri and California are no longer surplus states. Another striking shift is noted in region 14, where Montana-Idaho-Wyoming have become deficit in fed beef. Region 13, Nebraska, North and South Dakota remained as the base region and is by far the largest surplus producing region. Exceptionally large increases in production are indicated for Oklahoma and Texas.

Regional Flow Patterns of Fed Beef

Optimum regional flows of fed beef vary somewhat in direction and magnitude between spatial models (Table IV). Flow patterns and magnitudes of fed beef shipments also are illustrated on flow maps in Appendix C.

In Models IA-IC, the Northern Plains region, the Lake States, and the Corn Belt region shipped fed beef exclusively into the heavily

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[3]Regional demarcation in the Schrader-King model varied from regional classifications in this study. In the original Schrader-King model, for example, Oklahoma and Texas were combined. In breaking out optimum fed cattle production for Oklahoma and Texas, relative volumes of feedlot marketings in Oklahoma and Texas for 1960 were applied to the Schrader-King model. This procedure was used for other regions in this study not conforming to those of the Schrader-King model.

deficit Northeast. The Kansas-Missouri area moved fed beef to Arkansas, (Model IA only) Kentucky-Tennessee, and the Southeast. These North Central surplus regions did not compete in western and southwestern markets. Although movements of fed beef from midwestern to western markets have been observed they are not consistent with the least-cost pattern of flow dictated by purely competitive spatial models.

Colorado is the third largest exporter of fed beef in Models IA-IC. Shipments from this state were widely dispersed to seven deficit regions including the dummy. Oklahoma receives fed beef from Colorado in IA, as does Texas in IA and IB.

Model IB: With the exception of shipments to and from Oklahoma, flow patterns are about the same in Model IB as in IA. Oklahoma shipped its small surplus to Arkansas, replacing Kansas-Missouri, and to Mississipi-Louisiana. Loss of Oklahoma as a market and its emergence as a competitor forced Colorado to ship to the dummy. In addition, Utah-Nevada shipped to the dummy rather than to New Mexico where it could no longer compete with Colorado.

Model IC: The reclassification of Texas as a surplus region in Model IC did not substantially change shipping patterns of fed beef relative to Model IB. Texas entered the Mississippi-Louisiana market with Colorado and Oklahoma as the other supplying regions. Colorado lost a considerable portion of this market and with the additional loss of Texas as a market was forced to ship excess supplies to the dummy area.

Model IIA: Differences in shipping patterns are readily apparent when IIA is compared with IA. The Intermountain regions 14 and 18 shipped to the Northeast which was heavily deficit in terms of fed beef production. The Corn Belt region moved fed beef to the Northeast and North Carolina-Virginia-West Virginia where consumption was heavily increased. The Northern Plains area shipped fed beef to Michigan-Minnesota-Wisconsin since this region was deficit in terms of fed beef production. With increased shipments from the Corn Belt to the Northeast, Colorado no longer shipped Northeast, but increased movements of fed beef to the South, (regions 2, 4, and 5) and the Southern Plains (region 11).

Oklahoma was a surplus producer of fed beef in IIA and shipped fed beef to Arkansas. Texas, remained a deficit area and received shipments from Colorado and New Mexico, the latter becoming a surplus region for the first time in any of the models.

Arizona, now designated as a surplus supply region, shipped its exportable supply to California, now a heavily deficit area in fed beef production. Utah-Nevada shipped to California and the Northeast. Montana-Idaho-Wyoming moved fed beef both East and West to Oregon-Washington and the Northeast.

Model IIB: In Model IIB, as in IB, Oklahoma shipped fed beef to the Arkansas and Mississippi-Louisiana regions. The latter market was shared with Colorado. Although Montana-Idaho-Wyoming maintained its position in the Oregon-Washington market, shipments from this region to the Northeast were reduced by increased shipments from the Corn Belt area which held a locational advantage. The Montana-Idaho-Wyoming region, therefore, was forced to ship excess supplies to the dummy area.

Model IIC: Effects of increased supplies in Oklahoma and Texas on Mountain region supply areas were most striking in this model.

Colorado lost Mississippi-Louisiana as a market and suffered reductions in markets 2 and 4. As a result, Colorado entered the Northeast market for the first time in this set of models. Montana-Idaho-Wyoming and Utah-Nevada were forced out of the Northeast market entirely, and together with Colorado, shipped excess supplies to the dummy destination.

Oklahoma gained part of a new market in this model. The Alabama-Georgia-South Carolina area, as well as regions 5 and 10, became destinations for Oklahoma fed beef. Increased shipments by Oklahoma to region 3, replaced those of the Kansas-Missouri area. Compensating increases by Kansas-Missouri to region 2 were indicated. Texas shipped its surplus of fed beef to Mississippi-Louisiana. This movement reduced Oklahoma's shipments to region 5 by more than fifty percent.

Model IID: In general, flow patterns for fed beef in this model were similar to those in Model IIC. Regions 14, 15, and 18 shipped relatively larger quantities to the dummy area. With supplies heavily increased in Oklahoma and Texas, Colorado was almost completely eliminated from competition in Southeastern markets. Colorado's remaining markets, with the exception of a small portion of the Florida market, were in the heavily deficit North Carolina-Virginia-West Virginia and Northeastern regions. However, Colorado's shipments were reduced considerably in the Middle Atlantic states as Kansas-Missouri became more active in that market. This shift was the result of inroads made by Oklahoma into Alabama-Georgia-South Carolina which formerly was supplied primarily by Kansas-Missouri.

Modell III: National shipping patterns of fed beef changed significantly in Model III. Region 13, with large supplies of fed beef, shipped East and West. It also shipped southward as far as the Kansas-Missouri region. The Mountain States and Arizona and New Mexico marketed fed beef to the heavily deficit California market. The Lake States shipped Fed beef into the Corn Belt, Northeast and North Carolina, Virginia, West Virginia regions. Oklahoma and Texas, with large increases in available supplies, served all Southeastern markets and the Kentucky-Tennessee area. In addition, Oklahoma and Texas shipped fed beef to California for the first time in any of the models.

Regional Equilibrium Prices and Price Differentials

Regional prices and price differentials derived from the spatial models, and shown in Table V, represent equilibrium prices and differentials that might be generated in a purely competitive model of the national economy. The base region in all models is region 13 (Nebraska, North Dakota and South Dakota). All regional prices are tied to the base region by transport cost differentials between regions.[4]

Economic forces are the underlying cause of change in base and regional prices. An assumption underlying all of the models is that the U. S. average price remains constant. The mechanics of the models used result in small variations in this respect. In effect, however, the U. S. average price remains constant. The base region price varies

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[4]Regional price differentials in Table V are not transport cost differentials, per se, but are values per unit of fed beef at origins or destinations relative to the base region.

TABLE V

REGIONAL EQUILIBRIUM PRICES AND PRICE DIFFERENTIALS

	- Models -							
Regions	IA	IB	IC	IIA	IIB	IIC	IID	III
	75.06	75.03	75.06	74.92	74.93	74.91	74.93	74.58
N.E.	3.14	3.14	3.14	3.14	3.14	3.14	3.14	3.14
N.C.,Va.,	74.92	74.89	74.92	74.82	74.83	74.77	74.49	74.49
W.Va.	3.00	3.00	3.00	3.04	3.04	3.00	3.00	3.05
Ala., Ga.	74.38	74.35	74.38	74.28	74.29	74.23	74.25	73.96
S.C.	2.46	2.46	2.46	2.50	2.50	2.46	2.46	2.52
	75.06	75.03	75.06	74.96	74.97	74.91	74.93	74.40
Fla.	3.14	3.14	3.14	3.18	3.18	3.14	3.14	2.96
	74.10	74.07	74.10	74.00	74.01	73.73	73.53	73.00
Miss.,La.	2.18	2.18	2.18	2.22	2.22	1.96	1.74	1.56
	73.89	73.86	73.89	73.79	73.80	73.74	73.76	73.79
Ky.,Tenn.	1.97	1.97	1.97	2.01	2.01	1.97	1.97	2.35
Ohio,Ill.	73.14	73.11	73.14	73.00	73.01	72.99	73.01	72.85
Ind.,Ia.	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.41
Mich.,Minn.	72.98	72.95	72.98	73.31	73.32	73.30	73.32	72.50
Wisc.	1.06	1.06	1.06	1.53	1.53	1.53	1.53	1.06
	72.53	72.50	72.53	72.43	72.22	72.38	72.40	72.89
Kan.,Mo.	.61	.61	.61	.65	.43	.61	.61	1.45
	73.59	73.55	73.58	37.49	73.49	73.21	73.23	73.09
Ark.	1.67	1.66	1.66	1.71	1.70	1.44	1.44	1.65

TABLE V (Continued)

Regions	IA	IB	IC	IIA	IIB	IIC	IID	III
				- Models -				
	73.51	73.48	72.96	73.41	73.42	72.59	72.39	71.86
Tex.	1.59	1.59	1.04	1.63	1.63	.82	.60	.42
	72.95	72.60	72.63	72.54	72.54	72.26	72.28	72.14
Okla.	1.03	.71	.71	.76	.75	.49	.49	.70
Neb.,N.D.	71.92	71.89	71.92	71.78	71.79	71.77	71.79	71.44
S.D.	0	0	0	0	0	0	0	0
Mont.,Id.	71.45	71.79	71.82	70.71	70.72	71.32	71.34	73.25
Wyo.	-.47	-.10	-.10	-1.07	-1.07	-.45	-.45	1.81
	71.47	71.44	71.47	71.37	71.38	71.32	71.34	72.33
Colo.	-.45	-.45	-.45	-.41	-.41	-.45	-.45	.89
	72.57	72.54	72.57	71.75	71.76	71.65	71.67	73.07
N.M.	.65	.65	.65	-.03	-.03	-.12	-.12	1.63
	72.72	70.72	73.09	71.26	71.27	71.80	71.82	73.70
Ariz.	.80	1.17	1.17	-.52	-.52	.03	.03	2.26
	72.74	71.44	71.47	70.78	70.79	71.32	71.34	73.22
Utah,Nev.	-.82	-.45	-.45	-1.00	-1.00	-.45	-.45	1.78
	72.95	73.29	73.32	72.21	72.22	72.82	72.84	74.45
Ore.,Wash.	1.03	1.40	1.40	.43	.43	1.05	1.05	3.01
	71.25	71.59	71.62	72.73	72.74	73.27	73.29	75.17
Calif.	-.67	-.30	-.30	.95	.95	1.50	1.50	3.73
Dummy		-.45	-.45		-1.07	-.45	-.45	

in relation to the average, and prices for other regions vary in relation to both the base and U. S. average price.

With a constant national average price, upward shifts in supply associated with assumptions regarding production in Oklahoma and Texas are offset by an equal shift in national demand through the influence of a dummy region. Alternatively, a constant national level of demand and reductions in U. S. average prices with supply increases assumed for Oklahoma and Texas could have been assumed. This, however, would have introduced another variable. Competitive effects of supply changes alone would have been more difficult to determine.

The mechanics of a change in base price between models is a function of the relative magnitude of the $\Sigma P_i d_i$ which are inserted in the national demand function for each model. As the $\Sigma P_i d_i$ increase, the base price decreases, and vice versa. Population values for each region remain constant from model to model, but some regional price differentials change because of designated changes in surplus and/or deficit regions resulting from changes in regional supply conditions.

The range of regional equilibrium prices within models vary from a high of 4.25 in Model IIB to a low of 3.59 cents per pound in Models IB, IC, and IIC. The small price range, with a low elasticity of demand, indicates that income is probably the most influential factor affecting regional differences in demand for fed beef.

Although regional price differentials vary considerably between models, they remain relatively constant for some regions. Price differentials were fairly constant for deficit regions receiving inshipments primarily from one particular source throughout the models. Price differentials of deficit regions change when the differentials of the supplying area changes or a new major supplier enters the deficit market in question.

Regions experiencing an increase in supply will ordinarily show a decrease in their price or differential. In Models IA-IID, for example, price differentials decreased for Oklahoma and Texas with postulated increases in supply. An exception to this was in Model IID, where Oklahoma's differential remained constant. New Mexico and Arizona experienced reductions in their respective differentials when shifting to surplus areas between Models IA-IC and IIA-IID. Michigan-Minnesota-Wisconsin, and California had increases in their respective differentials between Models IA-IC and IIA-IID in changing from surplus to deficit regions.

Regional price differentials are shown in Table V and are denoted by u_i and V_j in Appendix Tables C.1-C.8. The u_i measure comparative locational advantages of surplus regions relative to the base region and the V_j are delivered price differentials for deficit regions relative to the base region. For example, in Model IA, Table V, price of fed beef is valued at 3.14 cents per unit in the northeastern market relative to base region 13. On the other hand, the value of fed beef in Oklahoma is worth 1.03 cents more per unit than in the base region.

"Price differentials" are shown for the dummy destination in models IB, IC, IIB, IIC, and IID. In Model IB, regions 15 and 18 "shipped" surplus supplies to the dummy destination. It is observed that these surplus areas have the same price whether shipping all or part of their supplies to the dummy. The mechanics of the model dictate this situation.

The relative disadvantage[5] of the base region in shipping fed beef to the dummy is 45 cents per cwt. Since all regional prices are tied to the base region via price differentials, and transport costs to the dummy region are zero, regions shipping to the dummy necessarily have the same regional price. The price or differential of any region shipping to the dummy is the relative disadvantage of the base region in shipping to the dummy destination.

Equilibrium price of regions shipping to the dummy area is lowest of all regions. In an economic sense this phenomenon is reasonable. After optimum flows are obtained, any region shipping to the dummy must suffer a reduction in price in an effort to dispose of its excess supply. It seems logical that these supplying regions would receive the same price.

In Model III, it is noted that price differentials of all surplus producers of fed beef are positive in sign. This may be interpreted to mean that all surplus producing areas enjoy a locational advantage in deficit markets relative to the base region (13).

Transportation Costs of Fed Beef in Spatial Models

Total transportation costs of fed beef differ between groups and within groups of models and is a function of the distance and magnitude of fed beef movements. Per unit transportation costs differ slightly within model group IA-IC, but larger differences are found within model group IIA-IID. The smaller differences within model group IA-IC are explained

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[5]This term is defined as the additional cost to a surplus region in shipping to a market other than the "choice market(s)" indicated by the optimum flow solution.

largely by less extreme shifts in distance and volume of fed beef movements.

Differences with respect to per unit transportation costs between, as well as within, groups of models are indicated in Table VI. In the group II models, larger volumes of product were shipped, but average per unit transportation costs were slightly lower than in group I models. With slaughter oriented more strictly to production, effects of a larger volume of shipments on per unit transportation costs apparently were more than offset by the reduction in average shipping distance. Smaller volumes of long distance shipments were required in the group II models.

TABLE VI

FED BEEF: TOTAL QUANTITIES SHIPPED,[a] TOTAL TRANSPORTATION COSTS, PER UNIT TRANSPORTATION COSTS

Spatial Model Number	Total Quantity Shipped (Mil. lbs.)	Total Cost (000 dollars)	Cost Per Pound (cents)
IA	2,454	61,252	2.496
IB	2,424	60,547	2.498
IC	2,397	59,786	2.494
IIA	3,574	85,613	2.395
IIB	3,574	84,791	2.372
IIC	3,507	82,097	2.341
IID	3,506	80,242	2.289
III	4,710	132,303	2.810

[a]Figures do not include shipments to dummy destination at zero cost.

With slaughter oriented closely to production, an optimal locational pattern of fed beef production apparently would tend to increase per unit transportation costs on dressed fed beef. This increase, however, presumably would be offset by even larger reductions in costs of shipping feeder cattle and feed to locations of fed cattle production.

Competitive Position of Oklahoma in the Fed Beef Economy

The competitive position of Oklahoma as a producer of fed beef may be evaluated by comparing its relative advantage or disadvantage in various markets with other competing regions. The relative disadvantage of a region is the additional cost to that region in shipping to a market other than the "choice" or "best" market as indicated by the optimum flow solution. Comparative locational advantages of surplus regions relative to the base region were shown in Table V.

In estimating a surplus region's relative disadvantage in shipping to any given deficit region, the following formulation is used:

$$(C_{a_{ij}} - C_{b_{ij}}) - (P_{a_j} - P_{b_j}) = R.D._{b_j} \qquad (5.1)$$

where

$R.D._{b_j}$ = relative disadvantage (cents per lb) in shipping from the i^{th} region to the b_j^{th} region,

$C_{a_{ij}}$ = cost of shipping one pound of fed beef from the i^{th} to the a_j^{th} region,

$C_{b_{ij}}$ = cost of shipping one pound of fed beef from the i^{th} to the b_j^{th} region,

P_{a_j} = equilibrium price per pound of fed beef in the a_j^{th} region,

P_{b_j} = equilibrium price per pound of beef in the b_j^{th} region.

Actual and Potential Markets of Oklahoma and Competitors

The discussion of empirical results in this section will be concerned primarily with actual and "near" potential competitors of Oklahoma and Texas in various markets for fed beef.[6]

Model IB: This model introduces Oklahoma as a surplus region in terms of fed beef slaughter supply. Oklahoma's best markets are regions 5 and 10, with Colorado sharing the market in region 5.

TABLE VII

RELATIVE DISADVANTAGES OF OKLAHOMA AND COMPETING REGIONS IN VARIOUS MARKETS (ACCORDING TO MODEL IB)

Regional Markets		Relative Disadvantage for Oklahoma[a]	Relative Disadvantage of Oklahoma's Competitors		
		(Cents per Cwt)			
Mississippi-Louisiana	(5)	0	Kansas-Missouri	(9)	.24
			Colorado	(15)	0
			Corn Belt	(7)	1.16
			Base Region[b]	(13)	.88
Arkansas	(10)	0	Kansas-Missouri		.01
			Colorado		.04
			Corn Belt		1.10
			Base Region		.56
Texas	(11)	.19	Kansas-Missouri		.78
			Colorado		0
			Corn Belt		1.01
			Base Region		1.07

[a]A zero indicates that the surplus region in question shipped to the deficit area in the optimum flow solution.

[b]The Base Region is comprised of Nebraska, North Dakota and South Dakota.

[6]All surplus production regions are potential competitors; but for purposes of analysis, only those which closely compete with Oklahoma and Texas are included in the analysis.

Oklahoma supplies all shipments of fed beef into region 10, and 11 percent of region 5's inshipments. Kansas-Missouri and Colorado are close potential competitors of Oklahoma for the Arkansas market with relative disadvantages of only .01 and .04 cents per hundred pounds, respectively.

With a larger exportable supply, and assuming a deficit situation in Texas, it seems likely that Oklahoma could obtain a larger share of the Mississippi-Louisiana market. Under conditions specified in Model IB, Oklahoma enjoys a locational advantage over Colorado and other potential entrants. Given larger supplies, the same reasoning applies to Oklahoma's market potential in Texas.

In the present day fed beef economy, the Corn Belt and Base Region must be considered potential competitors of any actual or potential surplus producing area. It is informative and useful to evaluate competitive positions of these two regions relative to Oklahoma's actual and potential situation. In this model, as in those to follow, magnitudes of relative disadvantages for these two areas in markets available to Oklahoma were large.

Model IC: Interarea competitive relationships associated with an increased fed beef slaughter in Texas and Oklahoma are shown in Table VIII. As in Model IB, Oklahoma's choice markets are regions 5 and 10. Kansas-Missouri and Colorado, again are close competitors in region 10 with only a small price or cost change required to enable either of these competing supply areas to enter that market.

Oklahoma maintained a foothold in the Mississippi-Louisiana market, but a distinct locational advantage permits Texas to dominate this market.

TABLE VIII

RELATIVE DISADVANTAGES OF OKLAHOMA AND COMPETING REGIONS IN VARIOUS MARKETS (ACCORDING TO MODEL IC)

Regional Markets		Relative Disadvantage for Oklahoma	Relative Disadvantage of Oklahoma's Competitors		
		(Cents per Cwt)			
Alabama-Georgia-So. Carolina	(3)	.22	Kansas-Missouri	(9)	0
			Texas	(11)	.68
			Colorado	(15)	.06
			Corn Belt	(7)	.41
			Base Region	(13)	.43
Florida	(4)	.29	Kansas-Missouri		.16
			Texas		.44
			Colorado		0
			Corn Belt		.66
			Base Region		.40
Mississippi-Louisiana	(5)	0	Kansas-Missouri		.12
			Texas		0
			Colorado		0
			Corn Belt		.76
			Base Region		.88
Arkansas	(10)	0	Kansas-Missouri		.01
			Texas		.62
			Colorado		.04
			Corn Belt		1.11
			Base Region		.56

Two new potential regional markets for Oklahoma appear in this model. Although Oklahoma producers find it most profitable to ship fed beef to regions 5 and 10, relatively small changes in price differentials would permit Oklahoma to ship into regions 3 and 4.

TABLE IX

RELATIVE DISADVANTAGES OF OKLAHOMA AND COMPETING REGIONS IN VARIOUS MARKETS (ACCORDING TO MODEL IIA)

Regional Markets		Relative Disadvantages for Oklahoma	Relative Disadvantage of Oklahoma's Competitors		
		(Cents per Cwt)			
Mississippi-Louisiana	(5)	.01	Kansas-Missouri	(9)	.24
			Colorado	(15)	0
			New Mexico	(16)	.08
			Corn Belt	(7)	1.12
			Base Region	(13)	.84
Arkansas	(10)	0	Kansas-Missouri		0
			Colorado		.03
			New Mexico		.28
			Corn Belt		1.06
			Base Region		.51

Model IIA: Oklahoma's best market in Model IIA is Arkansas (Table IX). This market is shared with Kansas-Missouri, with Oklahoma providing 65 percent of the Arkansas inshipments. In addition, Colorado's relative disadvantage in the Arkansas market is only .03 cents per hundred weight. This means that an increase in price or decrease in transport cost of .03 cents per hundredweight would be sufficient to induce entrance of Colorado into region 10. New Mexico, the Corn Belt and Base Region have distinct relative disadvantages in region 10's market.

Colorado dominates the Mississippi-Louisiana market, but Oklahoma and New Mexico are serious contenders for portions of this market as indicated by their respective relative disadvantages of .01 and 08 cents per hundredweight. It seems probable that with larger exportable supplies of fed beef, Oklahoma and New Mexico would reduce Colorado's participation in the Mississippi-Louisiana market. Colorado has a locational disadvantage in region 5, relative to Oklahoma and New Mexico. The remaining surplus regions are not potential contenders for the Mississippi-Louisiana market under conditions specified in the model.

Model IIB: In this model, Oklahoma shipped 69 percent and 31 percent of its exportable supply to regions 5 and 10, respectively. With a postulated increase of 45 million pounds of fed beef in this model, Oklahoma had a supply sufficient to enter region 5's market. Another striking feature of this model is that Oklahoma forced Kansas-Missouri out of the Arkansas market completely, although the Kansas-Missouri area still is a highly potential entrant as signified by the relative dollar disadvantage of .01. As shown by the magnitude of Colorado's relative dollar disadvantage, this region also must be regarded as a potential competitor for the Arkansas market.

With fed beef production in Texas held constant at a deficit level, Oklahoma replaced much of Colorado's fed beef in region 5. Oklahoma supplied approximately 52 percent of the shipments to that market. As a result, Colorado was required to divert shipments from region 5 to North Carolina-Virginia-West Virginia.

New Mexico's best market is in Texas, and as in model IIA, New Mexico has a relative disadvantage in the Arkansas market. Arizona has

TABLE X

RELATIVE DISADVANTAGES OF OKLAHOMA AND COMPETING REGIONS IN VARIOUS MARKETS (ACCORDING TO MODEL IIB)

Regional Markets		Relative Disadvantages for Oklahoma	Relative Disadvantages of Oklahoma's Competitors		
		(Cents per Cwt)			
Mississippi-Louisiana	(5)	0	Kansas-Missouri	(9)	.24
			Colorado	(15)	0
			New Mexico	(16)	.08
			Arizona	(17)	.25
			Corn Belt	(7)	.72
			Base Region	(13)	.84
Arkansas	(10)	0	Kansas-Missouri		.01
			Colorado		.04
			New Mexico		.29
			Arizona		.61
			Corn Belt		1.07
			Base Region		.52
Texas	(11)	.19	Kansas-Missouri		.68
			Colorado		0
			New Mexico		0
			Arizona		.07
			Corn Belt		.97
			Base Region		1.03

no best market in an easterly direction. Its most favorable potential market is Texas. Arizona's best market, as in the previous model, was California. Once again, the Corn Belt and Base Region are not serious potential entrants in markets 5, 10, and 11.

Model IIC: Choice markets for Oklahoma are in regions 3, 5, and 10 (Table XI). Distribution of Oklahoma shipments to the markets are 41 percent, 28 percent, and 31 percent, respectively. The model suggests that with a larger excess supply, price differences would adjust sufficiently to introduce region 4 as a market for Oklahoma. Texas accounted for 79 percent of beef shipments to region 5. With the introduction of Texas as a surplus producer of fed beef, region 5 no longer is a major market for Oklahoma.

Oklahoma's relative advantage over Kansas-Missouri in the Arkansas market increased as shown by the difference in the magnitude of their respective relative dollar disadvantages. In this model, however, these two supply areas became competitors for markets in region 3, Alabama-Georgia-South Carolina.

Oklahoma supplied 19 percent of region 3's requirements for fed beef. To compensate for losses sustained in region 2, Kansas-Missouri increased its shipments to region 3.

With the exception of Florida, Colorado lost all of her markets in the South, and as a result, was forced to ship larger quantities in a northeasterly direction. Texas undoubtedly would have entered the Florida market, assuming a larger exportable supply, since it possessed a locational advantage over Colorado in this market.

Arizona is not deemed a potential competitor in this model for markets 3, 4, 5, and 10. As shown in Table V, Model IIC, market price decreased in the majority of regions relative to Model IIB. However, price increased in the Arizona market. With a decreased consumption in Arizona, larger supplies were available for shipment. These shipments went to California where Arizona had a locational disadvantage. As a

TABLE XI

RELATIVE DISADVANTAGES OF OKLAHOMA AND COMPETING REGIONS IN VARIOUS MARKETS (ACCORDING TO MODEL IIC)

Regional Markets		Relative Disadvantages for Oklahoma	Relative Disadvantages of Oklahoma's Competitors		
		(Cents per Cwt)			
Alabama-Georgia-So. Carolina	(3)	0	Kansas-Missouri	(9)	0
			Texas	(11)	.46
			Colorado	(15)	.06
			New Mexico	(16)	.40
			Corn Belt	(7)	.41
			Base Region	(13)	.43
Florida	(4)	.07	Kansas-Missouri		.16
			Texas		.22
			Colorado		0
			New Mexico		0
			Corn Belt		.66
			Base Region		.40
Mississippi-Louisiana	(5)	0	Kansas-Missouri		.46
			Texas		0
			Colorado		.22
			New Mexico		.25
			Corn Belt		.98
			Base Region		1.10
Arkansas	(10)	0	Kansas-Missouri		.23
			Texas		.62
			Colorado		.26
			New Mexico		.46
			Corn Belt		1.33
			Base Region		.78

result of Arizona's increased price, all market potentials in an easterly direction were erased.

In Model IIC, New Mexico, with loss of a market in Texas, was unable to compete effectively in markets 3, 5, and 10. New Mexico was able to enter the Florida market through a price reduction, however.

Again, the Corn Belt and the Base Region were not close potential competitors in the South. Regions 3 and 4 in the South were least disadvantageous for these two supplying regions, the former market because of its closer location and the latter as a result of its larger consumption requirements.

Model IID: Oklahoma's best markets are located in regions 3 and 10 with 83 percent of Oklahoma's shipments entering region 3. Texas supplied the entire inshipments of fed beef required by region 5. Oklahoma lost this market as a result of the locational and price advantage enjoyed by Texas. Texas supplied all shipments of fed beef to region 5 and provided 78 percent of Florida's requirements. The Kentucky-Tennessee area is a new potential market for Oklahoma. Price or cost, with reference to this market, would have to change by .17 cents per hundredwieght of fed beef for this region to be considered an actual outlet for Oklahoma fed beef.

Colorado, with the exception of a relatively small volume of shipment to Florida, was eliminated from markets in southern portions of the Southeast and the Southern Plains. Colorado, in most previous models had been shipping large quantities into these areas even though it had a distinct locational disadvantage relative to most other supply areas.

TABLE XII

RELATIVE DISADVANTAGES OF OKLAHOMA AND COMPETING REGIONS IN VARIOUS MARKETS (ACCORDING TO MODEL IID)

Regional Markets		Relative Disadvantages for Oklahoma	Relative Disadvantages of Oklahoma's Competitors		
		(Cents per Cwt)			
Alabama-Georgia-So. Carolina	(3)	0	Kansas-Missouri	(9)	0
			Texas	(11)	.24
			Colorado	(15)	.06
			New Mexico	(16)	.40
			Corn Belt	(7)	.41
			Base Region	(13)	.43
Florida	(4)	.07	Kansas-Missouri		.16
			Texas		0
			Colorado		0
			New Mexico		0
			Corn Belt		.66
			Base Region		.40
Mississippi-Louisiana	(5)	.22	Kansas-Missouri		.68
			Texas		0
			Colorado		.44
			New Mexico		.47
			Corn Belt		1.20
			Base Region		1.32
Kentucky-Tennessee	(6)	.17	Kansas-Missouri		0
			Texas		.57
			Colorado		.09
			New Mexico		.34
			Corn Belt		.40
			Base Region		.46
Arkansas	(10)	0	Kansas-Missouri		.23
			Texas		.40
			Colorado		.26
			New Mexico		.46
			Corn Belt		1.33
			Base Region		.78

Once supplies were increased in Oklahoma and Texas, these Colorado markets progressively declined.

Model III: Table XIII shows those markets in which Oklahoma and Texas would compete under specified conditions which include an optimum locational pattern of cattle feeding.

TABLE XIII

RELATIVE DISADVANTAGES FOR OKLAHOMA AND TEXAS IN VARIOUS MARKETS (ACCORDING TO MODEL III)

Regional Markets		Relative Disadvantage for Oklahoma	Relative Disadvantages for Texas		
		(Cents per Cwt)			
Alabama-Georgia-So. Carolina	(3)	.15	Texas	(11)	0
Florida	(4)	.46			0
Mississippi-Louisiana	(5)	.61			0
Kentucky-Tennessee	(6)	0	Texas		.01
Arkansas	(10)	0	Texas		.01
California	(20)	0	Texas		0

Oklahoma's choice markets are 6, 10, and 20, with domination in markets 6 and 10. However, Oklahoma's position in these two markets is not clear. In both markets, Texas has a relative disadvantage of only .01 cents per hundredweight. Oklahoma ships 70 percent, 17 percent, and 13 percent of its available supply to markets 6, 20, and 10, respectively. Regional markets 3, 4, and 5 are no longer as favorable for Oklahoma as was the case in previous models. Texas has a strong locational advantage relative to Oklahoma in markets 4 and 5. This advantage is not as strong in market 3 as witnessed by Oklahoma's small relative disadvantage compared to markets 4 and 5.

Both Oklahoma and Texas ship fed beef West for the first time in any of the models. Oklahoma and Texas supply two percent and nine percent, respectively, of fed beef requirements of California, a heavily deficit area in fed beef production.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Beef production is of major importance in the agricultural sector of Oklahoma's economy. Dynamic economic forces are affecting existing patterns of beef production and marketing in the national economy. An understanding of the factors affecting Oklahoma's competitive position in relation to other beef producing regions is essential if insight is to be gained with respect to Oklahoma's role in the nation's fed beef industry.

The overall objective of this study was to examine potential markets that may exist for Oklahoma fed beef. In particular, the first objective was to measure fed beef production and slaughter by regions in terms of live and dressed weight. Second, an attempt was made to determine national demand equations for all beef, steer-heifer beef and fed beef. Regional demand estimates of fed beef were developed. Third, spatial equilibrium models were developed to ascertain regional equilibrium prices, consumption and regional flows of fed beef under alternative assumptions regarding relative volumes of fed beef produced and slaughtered in Oklahoma and Texas. Finally, an attempt was made to assess Oklahoma's position in the marketing of fed beef in interregional competition.

Analytical Procedures

In this study problems related to data and methodology relative to regional supply and demand for fed beef were of major importance. This analysis required utilization of national and regional data concerning production, marketing, slaughter, consumption, prices and income. All data were derived from secondary sources or were estimates based on published data.

The fed beef sector of the national economy was divided into 20 regions with Nebraska, North and South Dakota selected as the base region. Selected shipping and receiving points were regional cities located as close as possible to the center of each region.

National demand functions using the single equation technique were developed for all beef, steer-heifer beef and fed beef for use in the spatial equilibrium models. These demand functions represented the time period 1947-60. Development of some price and quantity measurements was necessary in the construction of variables entering the equations.

Estimates of regional data for 1960 were concerned with fed beef production, slaughter supply and personal disposable income. In developing estimates of regional supplies of fed beef, data on feedlot marketings, cattle on feed, commercial slaughter and production and disposition of cattle and calves were considered. Adjustments were made among classes of cattle in each region to published data on total cattle from each region and among regions in conformance with national data.

A regional demand model was used in an effort to reflect regional differences in demand for fed beef. Regression equations of per capita income on per capita purchased consumption of all beef for 1955 were estimated utilizing 1955 Household Food Consumption Survey data. These equations were used in conjunction with the estimated national demand functions for all beef and fed beef.

Three supply models with modifications were used in the spatial model analysis. The first supply model was designed to reflect the actual regional pattern of fed beef slaughter. Supply Model II utilized estimates of regional fed beef production which assumed that fed beef was slaughtered where produced. This model represented a producer oriented slaughtering industry. Supply Model III employed estimates derived in a recent study from a spatial model depicting an optimum regional distribution of fed cattle production. Modifications were applied to Models I and II and consisted of postulated increases in supplies of fed beef for Oklahoma and Texas based on 1965 and 1970 projections.

Eight spatial models were employed using variations of the supply models mentioned. The same regional demand functions were used throughout the analysis. Regional equilibrium prices, consumption and optimum interregional flows of fed beef were obtained. Optimum markets and relative disadvantages in various markets for Oklahoma and its competitors in the fed beef economy were evaluated for each model.

Major Findings

An evaluation of the spatial equilibrium models suggests the following:

1. Major surplus regions for fed beef in 1960 were 13 (Northern Plains) 7, (Corn Belt), 15 (Colorado), and 9 (Kansas-Missouri). Principal deficit areas were the Northeast and South.

2. Arkansas and other deficit areas of the Southeast are potential markets for Oklahoma fed beef.
3. Principal competitors of Oklahoma in shipping fed beef to markets in the South are Colorado, Kansas-Missouri and Texas.
4. Oklahoma has a relative locational advantage over Colorado, the Northern Plains and Corn Belt in shipping to southern markets. Findings of the spatial model analysis did not indicate clearly Oklahoma's competitive advantage over Kansas-Missouri and Texas in relation to Southern markets.
5. Oklahoma producers of fed beef cannot compete successfully with other supply areas in shipping to the Far West or Northeast without accepting substantial reductions in net returns.
6. Results of models using hypotheses regarding increases in fed beef supplies in Oklahoma and Texas, and additional out-shipments of dressed fed beef indicate that:
   a. Shipment patterns for Kansas-Missouri and Colorado, would be shifted from the South, including the Southern Plains and southern portions of the Southeast to markets further north.
   b. Relatively larger quantities of fed beef would be shipped from Kansas-Missouri to Kentucky-Tennessee and northern portions of the Southeast (region 2), and from Colorado to the Northeast.

c. The dummy region would receive shipments from Colorado and other surplus areas in the Mountain region indicating that these regions were most severely affected by increased production and slaughter of fed beef in the Southern Plains.

Conclusions

Considering recent trends in population and per capita real income in Oklahoma, it appears unlikely that the Oklahoma market can absorb the rapidly increasing production of fed beef in Oklahoma. In addition, Texas probably will not become a major market for fed beef slaughtered in Oklahoma. While Texas is experiencing a rapidly increasing population and income, fed beef production is rising even more rapidly than in Oklahoma. Furthermore, in many areas of Texas demand for fed beef, mature fed beef particularly, is relatively low. But, Oklahoma has other potential markets for fed beef in the South. With the probable emergence of both Oklahoma and Texas as surplus supply areas, Oklahoma producers likely will be competing in southern markets with Kansas-Missouri, Colorado and Texas.

Markets in the Southern region would be attractive for Oklahoma producers because of location and the present deficit position of these areas with respect to fed beef supplies. It is likely, however, that fed beef production will increase in the South to some extent as elsewhere. In addition, fed beef will encounter sharp competition in the South with highly substitutable meat products such as pork, poultry, relatively less finished beef, and cow beef.

Economic development of southern regions in the near future in an important factor in determining whether these regions will be markets for Oklahoma fed beef. Increasing trends in population and per capita real income are major economic forces leading to increases in fed beef consumption in an area.

Potential markets for Oklahoma fed beef will heavily depend upon regional cost differences in fed beef production. Also, adequate feed supplies, weather, and existing or changing institutional arrangements in relation to other regions active in the fed beef industry are of importance. Oklahoma producers of fed beef and related processing and marketing firms in the livestock-meat industry must consider these factors and others in relation to Oklahoma's competitive position in the fed beef industry.

Suggestions for Further Study

Limitations in this study are fairly obvious. Many of these are not peculiar to this study in particular, but to the majority of studies concerning interregional competition.

This analysis was conducted within a static framework. A study of the fed beef sector in a framework of comparative statics, and further into a dynamic setting should be undertaken in an attempt to more clearly understand economic forces affecting the fed beef economy.

Results of this study are based on the use of normative models. Such findings should be used in conjunction with predictive models in an attempt to gain a more thorough understanding of interregional competition in fed beef.

Lack of comprehensive data for use in analyzing regional differences in supply and demand continues to be a major limitation. Regional consumption and price data are required for further analyses of interregional competition for fed beef. Although an attempt has been made in this study to account for regional differences in demand, important variables reflecting demand differences such as age, sex, race, institutional arrangements, etc. have not been accounted for.

More adequate interregional transportation rates for live and dressed weights for various classes of cattle are required. In many instances, variation in transportation rates are dependent on the direction of movement of a commodity. Some work has been done in the area, but there is need for improvement of transportation functions. Single regional basing points are selected rather arbitrarily because of lack of data. These single basing points do not always reflect representative economic conditions of a region.

Measurement of regional differences in marketing and processing costs of various forms of beef is difficult to obtain. Such knowledge would be invaluable in an interregional analysis of the beef economy.

Costs of fed beef production in Oklahoma and other regions have not been considered in this study. Such regional analysis is necessary in an effort to more fully comprehend interregional competition in fed beef.

More research is indicated in determining supply and demand relationships for fed beef on the national and regional level. Various estimating techniques available for supply and demand analysis should be utilized. A simultaneous equation approach would enable the researcher to investigate structural relationships in the fed beef industry.

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A P P E N D I X   A

TIME SERIES DATA AND ADDITIONAL REGRESSION AND CORRELATION ANALYSIS

APPENDIX TABLE A-1

TIME SERIES DATA FOR FED BEEF DEMAND EQUATIONS

Year	Per Capita Cons. Fed Beef Carcass Weight Equivalent	Retail Price of Beef (Choice) Deflated By All Meat Index 1947-49 = 100	Ratio of Retail Price of Fed Beef Deflated By All Meat Index 1947-49 = 100	Per Capita Dispos. Income Deflated By C.P.I. 1947-49 = 100
	Y_3	Z_5	Z_6	$Z_{2_{T-1}}$
1947	24.8	65.7	1.266	1381
1948	23.2	71.0	1.061	1242
1949	31.0	68.4	1.057	1261
1950	29.4	71.8	1.065	1263
1951	28.2	75.4	1.101	1336
1952	31.3	74.7	1.144	1336
1953	33.2	62.8	1.167	1351
1954	33.0	63.4	1.161	1393
1955	36.9	66.2	1.145	1389
1956	39.1	68.0	1.187	1459
1957	38.5	67.2	1.157	1507
1958	40.5	70.4	1.130	1508
1959	45.3	74.5	1.124	1486
1960	46.2	74.3	1.124	1536

APPENDIX TABLE A-2

TIME SERIES DATA FOR ALL BEEF AND STEER AND HEIFER BEEF EQUATIONS

Year	Per Capita Cons. All Beef Carcass Weight Equiv.	Retail Price All Grades of Beef Deflated By All Meat Index 1947-49 = 100	Per Capita Cons. of Pork Carcass Weight Equiv.	Per Capita Dispos. Income Deflated By C.P.I. 1947-49 = 100	Per Capita Cons. of Steer-Heifer Beef Carcass Weight Equiv.	Retail Price of Beef (Choice) Deflated by All Meat Index 1947-49 = 100	Per Capita Cons. of All Other Meat Other Than Steer-Heifer Beef	Per Capita Dispos. Income Deflated By C.P.I. 1947-49 = 100
	Y_1	Z_1	Z_3	$Z_{2_{T-1}}$	Y_2	Z_5	Z_4	$Z_{2_{T-1}}$
1947	69.1	58.3	69.6	1381	43.0	65.7	111.3	1381
1948	61.9	63.9	67.8	1242	36.1	71.0	108.5	1242
1949	62.9	62.0	67.7	1261	41.7	68.4	101.9	1261
1950	62.4	66.0	69.2	1253	40.2	71.8	103.5	1253
1951	58.8	69.9	71.9	1336	36.6	75.4	99.3	1336
1952	62.5	65.9	72.4	1336	41.7	74.7	102.1	1336
1953	77.5	55.0	63.5	1351	53.3	62.8	99.7	1351
1954	79.2	54.2	60.0	1393	53.4	63.4	99.3	1393
1955	81.4	57.7	66.8	1389	54.3	66.2	106.6	1389
1956	84.8	59.6	67.3	1459	59.0	68.0	105.9	1459
1957	82.8	60.5	61.1	1507	57.8	67.2	99.6	1507
1958	79.9	65.3	60.2	1508	56.6	70.4	93.8	1508
1959	80.8	69.2	67.6	1486	59.1	74.5	99.3	1486
1960	84.2	68.1	65.3	1534	62.7	74.3	99.6	1536

Regression and Correlation Analyses for Fed Beef

In attempting to derive a national demand function for fed beef, several variables were used other than those appearing in the final equation (4.14) in Chapter IV. Variables other than those used in the final equations for all beef and steer and heifer beef were also employed. However, only those additional analyses related to the fed beef equation will be shown.

$$\hat{Y}_3 = \underset{}{53.9590} - \underset{(.65)}{.4222Z_5} - \underset{(.81)}{31.459Z_6} - \underset{(1.09)}{.6106Z_7} - \underset{(.19)}{.1296Z_8} + \underset{(1.13)}{.0450Z_{2t-1}}$$

$$+ \underset{(.42)}{.1107Z_9} + \underset{(.23)}{1.1422Z_{10}} \qquad \text{(A.1)}$$

$R^2 = .93$

where Y_3 = per capita consumption of fed beef

Z_5 = retail price of fed beef

Z_6 = ratio of retail price of fed to nonfed beef

Z_7 = retail price of pork

Z_8 = retail price of broilers

Z_{2t-1} = per capita disposable income, lagged one year

Z_9 = per capita consumption all meat other than fed beef

Z_{10} = ratio of nonfarm to farm population

The simple correlation matrix for the variables used is shown in Appendix Table A-3.

In examining equation (4.1) and the simple correlation analysis Z_8 and Z_{10} were eliminated from further consideration. The equation with these two variables omitted is as follows:

APPENDIX TABLE A-3

MATRIX OF SIMPLE CORRELATIONS OF VARIABLES IN DEMAND EQUATION (4.1)

	Y_3	Z_5	Z_6	Z_7	Z_8	Z_{2t-1}	Z_9	Z_{10}
Y_3	1.0	.17	.07	-.41	-.89	. .84	-.21	.95
Z_5	--	1.0	-.48	-.75	-.35	.03	-.60	.12
Z_6	--	--	1.0	.49	-.02	.45	.61	.09
Z_7	--	--	--	1.0	.41	-.07	.58	-.34
Z_8	--	--	--	--	1.0	-.84	.42	-.93
Z_{2t-1}	--	--	--	--	--	1.0	.68	.87
Z_9	--	--	--	--	--	--	1.0	-.21
Z_{10}	--	--	--	--	--	--	--	1.0

$$\hat{Y}_3 = 60.5500 - \underset{(2.18)}{.5593Z_5} - \underset{(2.25)}{45.1274Z_6} + \underset{(8.08)}{.0703Z_{2t-1}} + \underset{(.50)}{.0773Z_9} - \underset{(2.94)}{.7742Z_7} \quad (4.2)$$

$R^2 = .93$

All variables in the equation were defined previously. The matrix illustrating simple correlations of the variables in the above equation appears in Appendix Table A-4.

Inspection of equation (4.2) and the matrix of simple correlations led to the deletion of the variables Z_7 and Z_9 and resulted in the final estimating equation for fed beef as shown by equation (4.9)

APPENDIX TABLE A-4

MATRIX OF SIMPLE CORRELATIONS OF VARIABLES IN DEMAND EQUATION (A.2)

	Y_3	Z_5	Z_6	Z_{2t-1}	Z_9	Z_7
Y_3	1.0	.17	.07	.84	-.21	-.41
Z_5	--	1.0	-.48	.03	-.60	-.75
Z_6	--	--	1.0	.45	.61	.49
Z_{2t-1}	--	--	--	1.0	.68	-.07
Z_9	--	--	--	--	1.0	.58
Z_7	--	--	--	--	--	1.0

A P P E N D I X B

NATIONAL AND REGIONAL DATA USED IN SPATIAL MODELS

APPENDIX TABLE B-1

NUMBERS OF FED CATTLE MARKETED BY REGION IN 1960: CALCULATION OF TOTAL NUMBERS AND OF SEPARATE ESTIMATES FOR STEERS AND HEIFERS

Region	Fed Cattle Marktd. from Feed-lots 26 States	R Ratio of Steers, Heifers Numbers on feed to Total	Steers and Heifers Marktd. from Feed-lots 26 States	Number of Cattle on Feed Jan. 1 1960 South	Number Marktd. (No. on Feed x 1.1)[1] South	Fed Steers and Heifers Marktd. United States	R' Ratio of Steers on Feed to Total, 1960[2]	Fed Steers Marktd. United States	Fed Heifers Marktd. United States
	1,000	Percent	1,000	1,000	1,000	1,000		1,000	1,000
1	146	.9730	142			142	.9206	131	11
2				49	54	54	.8519	46	8
3				107	118	118	.8559	101	17
4				46	51	51	.8627	44	7
5				45	49	49	.6939	34	15
6				92	101	101	.7525	76	25
7	4,400	.9974	4,389			4,389	.7463	3,276	1,113
8	944	.9969	941			941	.6939	653	288
9	951	.9916	943			943	.7126	672	271
10				23	25	25	.6000	15	10
11	477	.9898	472			472	.5936	280	192
12	143	.9899	142			142	.6091	86	56
13	1,974	.9893	1,953			1,953	.6591	1,287	666
14	428	.9709	416			416	.5521	230	186
15	738	.9958	735			735	.4906	361	374
16	113	.9681	109			109	.4670	51	58
17	466	.9853	459			459	.7747	356	103
18	162	.9718	157			157	.5311	83	74
19	337	.9834	331			331	.7800	258	73
20	1,595	.9824	1,567			1,567	.8176	1,281	286
Total	12,874		12,756	362	398				
U. S.						13,154	.7086	9,321	3,833

[1]It was assumed, based upon a prior knowledge and data rate of turnover in feedlots in other similar areas and other considerations, that a turnover rate of 1.1 was representative for feedlot feeding in the South during the winter with one lot of cattle per operator. No adjustment was made for cow-bull marketings from these lots as these were considered insignificant.

[2]Derived from numbers of steers on feed relative to total numbers. Average of four quarterly reporting periods.

Calculation of Regional Commercial Slaughter of Steers, Heifers and Steers and Heifers

It was pointed out in the methodology chapter that a problem existed in obtaining regional estimates of commercial slaughter for steers and heifers.

The key in the methodology to the solution lies in the use of data on marketings, steer slaughter estimates for regions j = 1-6, and calculation of a factor r_j. The factor r_j is the percentage which when multiplied by nonfed marketings provides, together with fed marketings, a ratio of steer (or heifer) marketings to total marketings which when applied to total slaughter yields CS_j or commercial slaughter of steers (or heifers) in region j.

$$\left(\frac{r_j \, (TM_j - FMS_j) + FMS_j}{TM_j} \right) TCS_j = CS_j \qquad \text{(B.1)}$$

or

$$r_j = \frac{(CS_j)(TM_j) - (FMS_j)(TCS_j)}{(TM_j - FMS_j) \quad (TCS_j)}$$

where

TM_j = total marketings of cattle in region j (published)

FMS_j = feedlot marketings of steers in region j and CS_j and TCS_j were previously defined. Given r_j, the commercial slaughter of steers in region i, CS_i was derived as follows:

$$CS_i = \frac{(CS_j)(S_i)}{\sum_{i=1}^{r} S_i} \qquad \text{(B.2)}$$

where r = number of delineated subregions in each j (r = 8 for the South)

$$\text{and } S_i = \left((TCS_i) \frac{TM_i}{FMS_i + r_j \, (TM_i - FMS_i)} \right) \tag{B.3}$$

S_i = an unadjusted estimate of commercial slaughter of steers in region i.

TCS_i = total commercial slaughter of cattle in region i.

TM_i = total marketings of cattle in region i.

FMS_i = total marketings of fed steers in region i and r_j was defined above.

These procedures yielded data as shown in Appendix Table B-2. The marketing estimates are not those described later and were not used elsewhere in the study.

APPENDIX TABLE B-2

COMMERCIAL SLAUGHTER OF STEERS, HEIFERS, AND STEERS AND HEIFERS AND RELATED DATA USED IN DERIVATION BY REGION, 1960

Regions	TCS Total Comm. Sltr. Cattle	TM Total Mktg. of Cattle	Steers: FMS Feedlot Mktgs.	Steers: r_j[1]	Steers: Other Mktgs.[1]	Steers: TMS Total Mktgs.	Steers: CS Comm. Sltr.	Heifers: Feed-lot Mktgs.	Heifers: r_j[1]	Heifers: Other Mktg. for Sltr.	Heifers: Total Mktgs.	Heifers: Comm. Sltr.	Steers and Heifers Comm. Sltr.
	1,000	1,000	1,000		1,000	1,000	1,000	1,000		1,000	1,000	1,000	1,000
1	2,072	1,040	131	.6974	634	765	1,524	11		7	18	35	1,559
2	380	574	46		187	233	154	8		117	125	87	241
3	644	837	101		260	361	274	17		169	186	147	421
4	327	354	44		110	154	161	7		72	79	53	214
5	497	773	34		261	295	191	15		157	172	118	309
6	579	937	76		304	380	233	25		189	214	137	370
10	131	328	15		111	126	50	10		66	76	32	82
11	1,492	3,207	280		1,034	1,314	590	192		634	826	388	978
12	334	1,237	86		407	493	131	56		244	300	84	215
South	4,384	8,247	682	.3535	2,674	3,356	1,784	330	.2069	1,638	1,968	1,046	2,830
7	5,780	7,427	3,276		1,203	4,479	3,383	1,113		500	1,613	1,303	4,686
8	3,120	2,811	653		625	1,278	1,626	288		200	488	515	2,141
13	2,572	3,791	1,287		725	2,012	1,344	666		247	913	647	1,991
N. C.	11,472	14,029	5,216		2,553	7,769	6,353	2,067		947	3,014	2,465	8,808
9	2,270	3,530	672	.2869	1,451	2,123	1,365	271	.0792	366	637	410	1,775
14	325	1,676	230		185	415	88	186		579	765	158	246
15	1,046	1,382	361		131	492	348	374		391	765	532	880
16	76	584	51		68	119	17	58		204	262	40	57
17	161	669	356		40	396	79	103		220	323	63	142
18	240	364	83		36	119	77	74		113	187	117	194
Mountain	1,848	4,675	1,081	.1280	460	1,541	609	795	.3884	1,507	2,302	910	1,519

APPENDIX TABLE B-2 (Continued)

Regions	TCS Total Comm. Sltr. Cattle	TM Total Mktg. of Cattle	Steers: FMS Feedlot Mktgs.	Steers: r_j[1]	Steers: Other Mktgs.[1]	Steers: TMS Total Mktgs.	Steers: CS Comm. Sltr.	Heifers: Feedlot Mktgs.	Heifers: r_j[1]	Heifers: Other Mktg. for Sltr.	Heifers: Total Mktgs.	Heifers: Comm. Sltr.	Steers and Heifers Comm. Sltr.
	1,000	1,000	1,000		1,000	1,000	1,000	1,000		1,000	1,000	1,000	1,000
19	702	675	258		115	373	406	73		23	96	105	517
20	2,476	2,233	1,281		262	1,543	1,688	286		73	359	392	2,080
Pacific	3,178	2,908	1,539	.2751	377	1,916	2,094	359	.0376	96	455	497	2,591
U. S.	25,224	34,429	9,321		8,149	17,470	13,729	3,833		4,561	8,394	5,363	19,092

[1] See text for derivation.

Regional Marketings of Steers and Heifers for Slaughter

A variety of approaches for the estimation of steer, heifer, and steer-heifer marketings for slaughter were investigated. Most of these involved the evaluation and use of published "balance-sheet" data on total cattle and calves.[1] Attempts were made with some degree of success to develop similar estimates for the various classes of cattle to arrive at reasonable estimates of total marketings by classes. The objective was then to divide these into slaughter and nonslaughter types on the basis of slaughter, interstate movements of slaughter and nonslaughter cattle and other estimates. Failure of data on interstate movements of cattle to materialize as anticipated for this study, led to the adaptation of a slightly more indirect approach.[2] Inventory data and estimates, however, were utilized.

The Statistical Reporting Service accounts for the inventory, production and disposition of total cattle and calves in the following manner:

$$B_i + R_i + I_i = TM_i + FS_i + D_i + E_i \qquad (B.4)$$

or

$$B_i + R_i - FS_i - D_i - TM_i + I_i = E_i \qquad i = 1960$$

Where

B_i = beginning inventory,

R_i = replacements (for total cattle and calves, it is the calf crop for the year),

FS_i = farm slaughter,

---

[1]These are data on cattle and calf inventories, marketings, deaths, farm slaughter, calf births, and inshipments, U.S.D.A. publication.

[2]These are data currently being generated through the Interregional Livestock Marketing Research Committee by the Statistical Reporting Service.

TM_i = total marketings,

D_i = deaths,

I_i = inshipments,

E_i = ending inventory.

The equation above is applicable to individual classes of cattle. For particular classes, however, R_i may be increased or decreased by the shift of cattle among classes as from calves to heifers or from heifers to cows. Accordingly R was defined as the addition of cattle to a particular class and R' as a subtraction. Thus for steers in 1960:

$$B_s + R_s - R'_s - FS_s - D_s - M_s + I_s = E_s \quad \text{(B.5)}$$

With 1960 inventory data available, the regional marketings of steers (heifers) for slaughter were obtained in the following manner: The use of net inventories are used in this formulation /where NS_i = net inventory of steers = $(BS + RS - R'S - FS_s - DS)$/. Certain regions such as the Corn Belt accumulate cattle during the fall from other regions which appear in the January 1 inventories. Other regions such as Oklahoma market most of their cattle in the fall so beginning inventories are not the most reliable basis for estimating marketings. By adjusting for RS and R'S, (R'S = 0) this difficulty is largely corrected. The steer category, for instance, receives a large influx from the calf class during the year.

Inventory data on dairy cattle and "other cattle" were evaluated separately. These data, the literature and other sources were checked for information on replacement rates and procedure for making estimates of such rates. A national balance sheet for 1960 was developed which incorporated the elements of NS_i for the dairy classes of cows, heifers and heifer calves and for the "other cattle" classes of cows, heifers, calves and steers. For steers, R_i, essentially was calculated from the ratio derived from the national data. In the case of heifers, R_i was made to vary with the ratio of dairy heifers to other heifers. The formulation of replacements for steers and heifers is presented in the section to follow. A similar procedure for determining the R_i for cows provided the R'_i for heifers. D_i and F_i, deaths and farm slaughter, were distributed among classes within each region according to ending, E_i. No farm slaughter was allocated to cows or bulls.

Provided with estimates of NS_i, the net inventory of steers in region i, the procedure used in obtaining marketings for slaughter is as outlined below.

$$MS_i = (NS_i - FMS_i)\frac{(CS - \sum_{i=1}^{n} FMS)}{TMS - \sum_{i=1}^{n} FMS} + FMS_i \qquad (B.6)$$

where MS_i = marketings of steers for slaughter in region i,

FMS_i = feedlot marketings of steers in region i,

TMS = total marketings of steers.

In essence, feedlot marketings of steers (and heifers) were taken as given. Marketings of other steers or heifers for slaughter were determined by multiplying nonfeedlot net inventories by the national ratio of nonfed steer slaughter to nonfed steer marketings. This procedure was used to provide assurance that MS_i would be sufficiently large to accomodate FMS_i.

These procedures yielded estimates of MS_i for 1960 as indicated in Appendix Table B-3. These data reflect the effects of appropriate adjustments, (1) among classes of cattle in each region to published data or total cattle for each region and (2) among regions in conformance with national data.

Formulation of Replacement Rates for Steers and Heifers

In estimating marketings of steers and heifers for slaughter, it was necessary to utilize replacement figures for these losses in the balance sheet approach. The formulation of these replacement rates are as follows:

Steers: $R_i = E_i \; (R/\sum_{i=1}^{n} E_i) \qquad n = 20$ (B.7)

Where R_i = replacements of steers in the i^{th} region,

E_i = ending inventory of steers in the i^{th} region,

R = replacements of steers nationally.

In the case of heifers, R_i was made to vary with the ratio of dairy heifers to other heifers.

Heifers: $R_i = ED_i \; (RD/\sum_{i=1}^{n} ED_i) + EO_i \; (RO/\sum_{i=1}^{n} ED_i)$ (B.8)

Where ED_i = ending inventory of dairy heifers,

EO_i = ending inventory of other heifers,

RD = replacements of dairy heifers from dairy calves,

RO = replacements of other heifers with other calves.

APPENDIX TABLE B-3

MARKETINGS OF STEERS AND HEIFERS FOR SLAUGHTER AND RELATED DATA AND ESTIMATES BY REGION

	Steers							Heifers						
	B_{si}	R_{si}	R'_{si}	D_{si}	FS_{si}	N_{si}	M_{si}	B_{Hi}	R_{Hi}	R'_{Hi}	D_{Hi}	FS_{Hi}	NH_{si}	
Region	Beginning Inventory	Repl. +	Repl. -	Deaths	Farm Sltr.	Net Inventory	Mktg. for Sltr.	Beginning Inventory	Repl. +	Repl. -	Deaths	Farm Sltr.	Net Inventory	Mktg. for Sltr.
	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
1	280	388	0	4	9	655	283	861	908	543	14	27	1185	144
2	194	254	0	4	4	440	160	387	407	233	7	5	549	69
3	218	307	0	4	2	519	222	444	464	292	9	5	602	83
4	184	243	0	3	1	423	154	165	172	135	3	1	198	29
5	152	199	0	3	1	347	125	487	519	345	10	3	648	87
6	290	391	0	6	3	672	249	528	570	320	10	5	763	108
7	3129	4163	0	50	67	7174	4405	1910	1862	756	32	39	2945	1320
8	796	1106	0	11	24	1867	1005	1625	1688	760	23	47	2483	536
9	1146	1558	0	20	16	2668	1250	968	980	519	16	13	1400	399
10	59	80	0	1	-	138	51	157	165	119	3	1	199	31
11	537	723	0	8	1	1251	561	923	984	740	14	4	1149	300
12	320	392	0	4	3	705	265	344	361	262	5	4	434	99
13	1267	1796	0	21	18	3024	1790	1108	1164	653	18	15	1586	770
14	349	416	0	5	5	756	382	513	523	355	7	6	668	241
15	310	365	0	5	3	667	450	368	399	136	5	4	622	402
16	58	73	0	1	1	129	73	119	128	100	2	1	144	68
17	231	332	0	5	2	556	414	100	120	56	2	1	161	110
18	98	124	0	2	1	219	122	167	170	97	3	2	235	92
19	191	278	0	3	7	459	316	333	355	190	5	11	482	119
20	765	1123	0	12	5	1871	1452	608	575	260	10	4	909	356
U.S.	10574	14311	0	172	173	24540	13729	12115	12514	6871	198	198	17362	5363

Surplus Areas

An initial estimate of fed beef shipments from surplus regions was estimated as follows for steers:

$$OF'S_i = OS_i\ (FMS_i/MS_i)\quad i = 1\text{-}r,\ r = \text{number of surplus regions} \qquad (B.9)$$

Where

$OF'S_i$ = unadjusted outshipments of fed steer beef cattle from region i,

OS_i = outshipments of steer beef from region i,

FMS_i = total marketings of fed steers in region i,

MS_i = total marketings of all steers for slaughter in region i.

Deficit Areas

An initial estimate of inshipments of fed beef to deficit regions was estimated as follows for steers:

$$-OF'S_j = (CS_j)(FMS_j/MS_j) - FMS_j \qquad j = 1\text{-}r' \qquad (B.10)$$

r' = number of deficit regions

where the negative sign refers to negative inshipments.

Final Adjustment for Surplus and Deficit Areas

The sums of inshipments and outshipments for the deficit and surplus regions, respectively, were not exactly equal, but were reasonably close and consistent with one another. Therefore, an average was taken of the two and each series was adjusted to the new total. This total represented the final estimate of fed beef movements. This procedure was then applied separately to both steer and heifer data, as illustrated below for steers.

$$\sum_{i=1}^{r} OFS_i' \neq \sum_{i=1}^{r'} - OFS_j \qquad (B.11)$$

so it was assumed that:

$$\frac{\sum_{i=1}^{r} OFS_i' + \sum_{i=1}^{r'} - OF'S_j = \sum_{i=1}^{r} OFS_i}{2} \qquad (B.12)$$

and that $\sum_{i=1}^{r} OFS_i = \sum_{i=1}^{r} - OFS_j$

The adjustment factors were:

surplus regions $A_i = \sum_{i=1}^{r} OFS_i / \sum_{i=1}^{r} OF'S$ (B.13)

deficit regions $A_j = \sum_{i=1}^{r} OFS_j / \sum_{ji=1}^{r} OF'S_j$ (B.14)

Final regional in or outshipment estimates of fed beef were computed by applying the above adjustment factors to the regional data.

Fed beef slaughter was computed by adjusting regional estimates of fed beef production by the estimates of fed beef movements.

$$FS_i = FMS_i \pm OFS_i \qquad (B.15)$$

Where

FS_i = fed steer slaughter in region i.

APPENDIX TABLE B-4

ESTIMATES OF COMMERCIAL SLAUGHTER OF FED STEERS AND HEIFERS AND RELATED DATA, BY REGION, 1960

	Steers							Heifers						
			Net Outshipments for Sltr.			Comm. Sltr.	Comm. Sltr.			Net Inshipments for Sltr.			Comm. Sltr.	Comm. Sltr.
Region	Mktgs. for Sltr.	Comm. Sltr.	Total	Fed Steers	Nonfed Steers	Fed Steers	Nonfed Steers	Mktgs. for Sltr.	Comm. Sltr.	Total	Fed Heifers	Nonfed Heifers	Fed Heifers	Nonfed Heifers
	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000
1	283	1524	-1241	-1050	-191	1181	343	144	35	109	0	109	11	24
2	160	154	16	0	6	46	108	69	87	-18	-13	-5	21	66
3	222	274	-52	-32	-20	133	141	83	147	-64	-59	-5	76	71
4	154	161	-7	-17	10	61	100	29	53	-24	-24	0	31	22
5	125	191	-66	-41	-25	75	116	87	118	-31	-17	-14	32	86
6	249	233	16	4	12	72	161	108	137	-29	-24	-5	49	88
7	4405	3383	1022	980	42	2296	1087	1320	1303	17	85	-68	1028	275
8	1005	1626	-619	-483	-136	1136	490	536	515	21	62	-41	226	289
9	1250	1365	-115	-149	34	821	544	399	410	-11	-11	0	282	128
10	51	50	1	0	1	15	35	31	32	-1	-1	0	11	21
11	561	590	-29	-19	-10	299	291	300	388	-88	-86	-2	278	110
12	265	131	134	38	96	48	83	99	84	15	25	-10	31	53
13	1790	1344	446	411	35	876	468	770	647	123	109	14	557	90
14	382	88	294	176	118	54	34	241	158	83	65	18	121	37
15	450	348	100	81	19	280	68	402	532	-130	-130	0	504	28
16	73	17	56	39	17	12	5	68	40	28	24	4	34	6
17	414	79	335	294	41	62	17	110	63	47	46	1	57	6
18	122	77	45	30	15	53	24	92	117	-25	-23	-2	97	20
19	316	406	-90	-64	-26	322	84	119	105	14	8	6	65	40
20	1452	1688	-236	-198	-38	1479	209	356	392	-36	-36	0	322	70
U.S.	13729	13729	0	0	0	9321	4408	5363	5363	0	0	0	3833	1530

Adjustment of Regional Average Liveweight of Fed Steers and Heifers

In the methodology chapter, page 72, footnote 17, mention was made of an adjustment in the average liveweights of fed steers and heifers in regions 16-20. The average liveweights in these regions were considered somewhat low. These weights were adjusted upward as described below.

$$\frac{X_1}{X_2} \cdot \sum_{i=1}^{5} X_{3_i} = X_i^* \qquad \text{(B.16)}$$

Where X_1 = average liveweight of fed steers and heifers at the Chicago terminal,

X_2 = average liveweight of steers and heifers on feed in the Corn Belt region,

X_3 = average liveweight of fed steers and heifers in region i,

X_i^* = adjusted average liveweight of fed steers and heifers in region i.

Accordingly, the average liveweights of nonfed steers and heifers were adjusted downward to compensate for the increase in fed steer and heifer liveweight.

APPENDIX TABLE B-5

ESTIMATES OF REGIONAL LIVE AND DRESSED WEIGHTS OF FED BEEF PRODUCTION AND SLAUGHTER

Region	Number Mktgs. Sltr.Steers and Heifers	Total Liveweight Steers and Heifers	Total Dressed Weight .601	Number Comm.Sltr. Steers and Heifers	Total Liveweight Steers and Heifers	Total Dressed Weight .601
	Thousand Head	Million Pounds	Million Pounds	Thousand Head	Million Pounds	Million Pounds
1	142	159	95	1,192	1,398	840
2	54	60	36	67	63	38
3	118	118	71	209	153	92
4	51	51	31	92	71	43
5	49	48	29	107	81	49
6	101	110	66	121	106	64
7	4,389	4,776	2,870	3,324	3,551	2,134
8	941	1,014	609	1,362	1,523	915
9	943	974	585	1,103	1,124	676
10	25	25	15	26	26	16
11	472	419	252	577	485	292
12	142	137	82	79	67	40
13	1,953	2,049	1,231	1,433	1,504	904
14	416	437	263	175	175	105
15	735	763	459	959	808	486
16	109	96	58	46	39	23
17	459	409	246	119	48	30
18	157	161	97	150	148	89
19	331	337	203	387	408	245
20	1,567	1,612	969	1,801	1,977	1,186
U.S.	13,154	13,755	8,267	13,154	13,755	8,267

APPENDIX TABLE B-6

REGIONAL POPULATION AND PER CAPITA REAL DISPOSABLE INCOME FOR 1960 (DEFLATED BY C.P.I. 1947-60 = 100)

Region		Population	Per Capita Real Disposable Income
		Million	Dollars
N.E.	(1)	49,097	1,765
Va., W.Va., N.C.	(2)	10,405	1,198
Ala., Ga., S.C.	(3)	9,627	1,066
Fla.	(4)	5,005	1,399
Miss., La.	(5)	5,443	1,022
Ky., Tenn.	(6)	6,613	1,089
Ohio, Ill., Ind., Ia.	(7)	27,252	1,662
Mich., Minn., Wis.	(8)	15,232	1,552
Kan., Mo.	(9)	6,501	1,509
Ark.	(10)	1,789	964
Tex.	(11)	9,643	1,348
Okla.	(12)	2,340	1,291
Neb., N.D., S.D.	(13)	2,740	1,359
Mont., Ida., Wyo.	(14)	1,686	1,389
Colo.	(15)	1,769	1,593
N. Mex.	(16)	958	1,263
Ariz.	(17)	1,326	1,386
Utah, Nev.	(18)	1,193	1,464
Wash., Ore.	(19)	4,649	1,564
Calif.	(20)	15,846	1,900
U. S.		179,114	1,545

APPENDIX TABLE B-7

LOWEST OF RAIL AND TRUCK RATES FOR FRESH BEEF

	New York 1	Rich-mond 2	At-lanta 3	Or-lando 4	Baton Rouge 5	Nash-ville 6	Chicago 7	Mil-waukee 8	Kansas City 9	Little Rock 10	Austin 11	Okla-homa City 12	Aber-deen 13	Butte 14	Den-ver 15	Albu-quer-que 16	Phoe-nix 17	Salt Lake City 18	Port-land 19	Fresno 20
1 New York		.90^T	1.96^T	2.46^T	2.92^R	2.06^T	1.92^T	2.08^T	2.60^T	2.72^T	3.44^R	3.07^T	3.14^R	4.21^R	3.59^R	3.73^R	4.27^R	4.14^R	5.06^R	5.09^R
2 Richmond			1.31^T	1.84^T	2.46^R	1.51^T	1.82^T	1.99^T	2.39^T	2.32^T	3.09^R	2.84^R	3.07^R	4.12^R	3.45^R	3.73^R	4.27^R	4.14^R	5.06^R	5.09^R
3 Atlanta				1.19^T	1.45^T	.75^T	1.65^T	1.83^T	1.85^T	1.30^T	2.10^T	1.97^T	2.89^R	3.88^R	2.97^T	2.98^T	3.55^R	3.88^T	4.69^R	4.40^R
4 Orlando					1.71^T	1.78^T	2.58^R	2.70^R	2.69^T	2.11^T	2.54^T	2.72^R	3.54^R	4.43^R	3.59^R	3.26^R	3.95^T	4.28^R	5.27^R	4.76^R
5 Baton Rouge						1.45^T	2.12^R	2.25^R	1.81^T	1.01^T	1.14^T	1.47^T	3.06^R	3.77^R	2.63^T	2.33^R	2.99^R	3.35^R	4.50^R	3.99^R
6 Nashville							1.15^T	1.32^T	1.36^T	.97^T	1.94^T	1.65^T	2.43^R	3.50^R	2.51^T	2.67^T	3.41^R	3.42^T	4.33^R	4.27^R
7 Chicago								.35^T	1.26^T	1.55^T	T=R 2.46	1.84^T	1.66^T	T=R 3.02	2.24^T	2.76^T	3.45^R	2.99^T	3.94^R	4.27^R
8 Milwaukee									1.36^T	1.69^T	2.59^R	1.91^R	1.53^T	2.88^T	2.22^T	2.84^T	3.56^T	3.05^T	3.84^R	4.38^R
9 Kansas City										1.06^T	1.76^T	.86^R	1.45^T	2.69^R	1.47^T	1.82^T	2.63^T	2.42^T	3.63^R	3.47^T
10 Little Rock											1.24^T	.95^T	2.22^T	3.42^T	2.15^T	2.02^T	2.83^T	3.05^T	4.30^R	3.61^T
11 Austin												1.07^T	2.66^T	3.57^T	2.04^T	1.66^T	2.22^T	2.75^T	4.19^T	3.31^T
12 Oklahoma City													1.91^T	3.05^T	1.48^T	1.36^T	2.19^T	2.41^T	3.84^T	3.03^T
13 Aberdeen														1.81^T	1.61^T	2.41^T	3.13^T	2.22^T	3.01^R	3.73^T
14 Butte															1.87^T	2.29^T	2.43^T	1.11^T	1.50^T	2.73^R
15 Denver																1.10^T	1.88^T	1.27^T	2.74^T	2.84^T
16 Albuquerque																	1.16^T	1.47^T	2.97^T	2.10^T
17 Phoenix																		1.62^T	2.72^T	1.47^T
18 Salt Lake City																			1.85^T	1.95^T
19 Portland																				1.94^T
20 Fresno																				

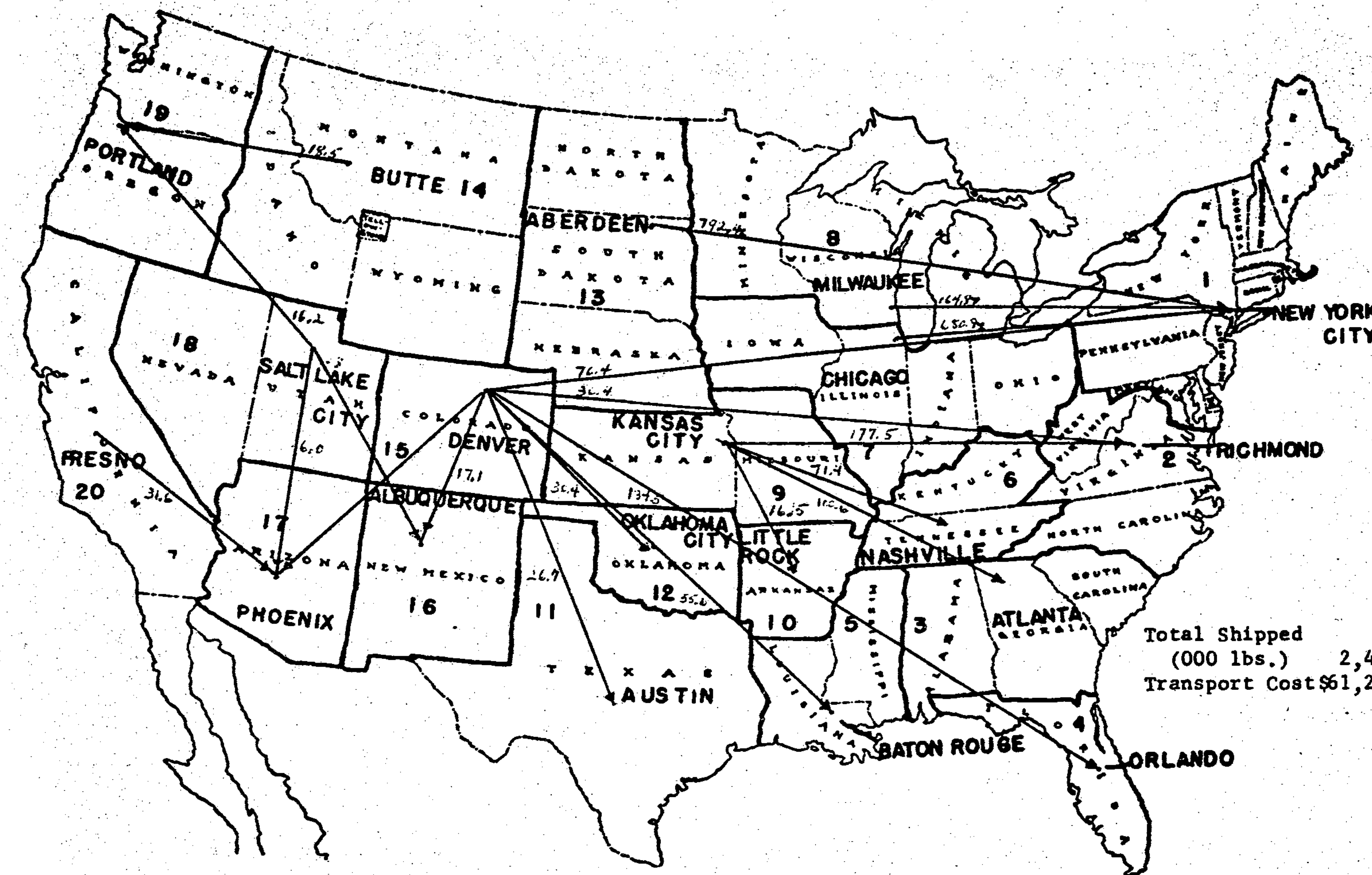
A P P E N D I X C

REGIONAL EQUILIBRIUM PRICES, CONSUMPTION, SURPLUS DEFICITS AND OPTIMUM FLOWS

APPENDIX TABLE C.1 (MODEL IA)

Region	Equil. Price Cents/ Lb.	Equil. Cons. 1,000 Lbs.	Surplus or Deficit 1,000 Lbs.	Origins and Quantities of Shipment (1,000 lbs.) 7	8	9	13	14	15	18	20	V_j
1	75.06	2,554,548	-1,714,548	680,961	164,848		792,361		76,378			3.14
2	74.92	251,854	-213,854			177,475			36,379			3.00
3	74.38	192,599	-100,599			100,599						2.46
4	75.06	177,483	-134,483						134,483			3.14
5	74.10	104,531	-55,531						55,531			2.18
6	73.89	135,433	-71,433			71,433						1.97
7	73.14	1,453,039	680,961									
8	72.98	750,152	164,848									
9	72.53	309,039	366,039									
10	73.59	32,532	-16,532			16,532						1.67
11	73.51	318,644	-26,644						26,644			1.59
12	72.95	70,371	-30,371						30,371			1.03
13	71.92	111,639	792,361									
14	71.45	86,467	18,533									
15	71.47	109,073	376,927									
16	72.57	40,938	-17,938						17,141	797		.65
17	72.72	67,622	-37,622							6,041	31,581	.80
18	72.74	65,950	23,050									
19	72.95	279,745	-34,745					18,533		16,212		1.03
20	71.25	1,154,419	31,581									
Dummy* 21												
			u_i	1.22	1.06	.61	0	-.47	-.45	-.82	-.67	

*Not used in this model.

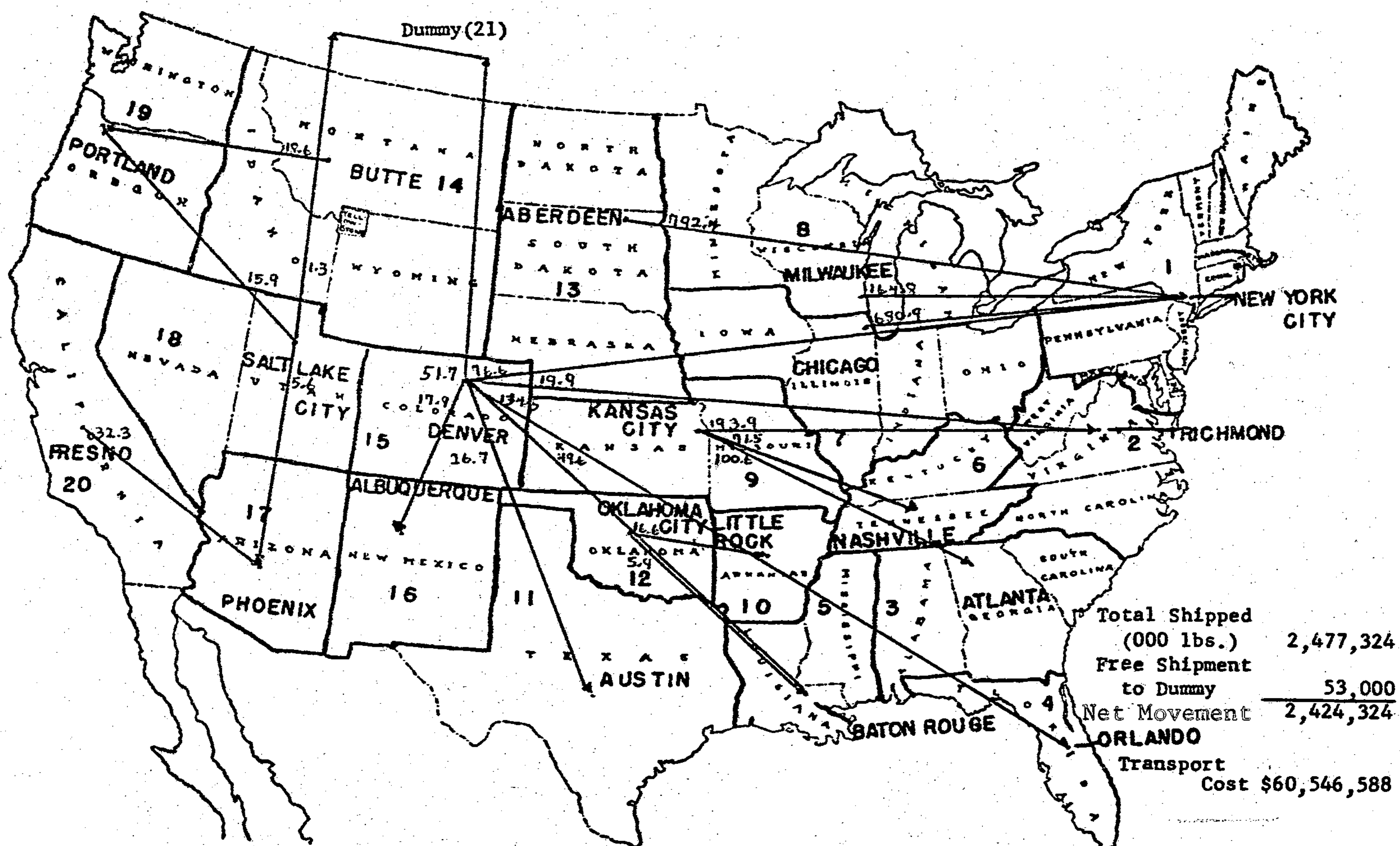


Total Shipped
(000 lbs.) 2,454,300
Transport Cost $61,251,649

INTERREGIONAL FLOWS OF FED BEEF (MODEL IA)
(Million lbs.)

APPENDIX TABLE C.2 (MODEL IB)

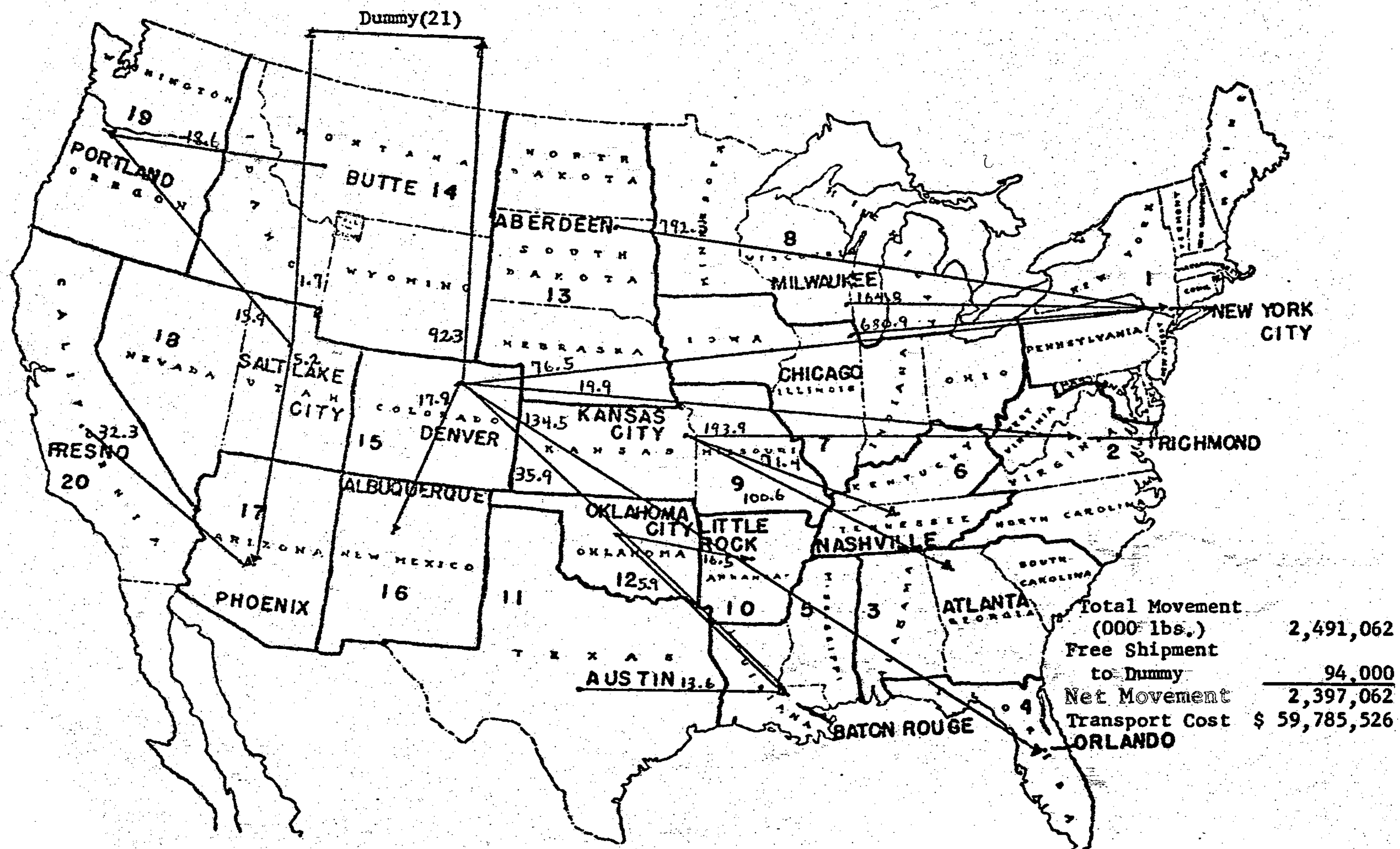
Region	Equil. Price Cents/ Lb.	Equil. Cons. 1,000 Lbs.	Surplus or Deficit 1,000 Lbs.	Origins and Quantities of Shipment (1,000 lbs.) 7	8	9	12	13	14	15	18	20	v_j
1	75.03	2,554,659	-1,714,659	680,898	164,811			792,353		76,597			3.14
2	74.89	251,887	-213,887			193,939				19,948			3.00
3	74.35	192,630	-100,630			100,630							2.46
4	75.03	177,497	-134,497							134,497			3.14
5	74.07	104,548	-55,548				5,985			49,563			2.18
6	73.86	135,455	-71,455			71,455							1.97
7	73.11	1,453,102	680,898										
8	72.95	750,189	164,811										
9	72.50	309,976	366,024										
10	73.55	32,540	-16,540				16,540						1.66
11	73.48	318,672	-26,672							26,672			1.59
12	72.60	70,475	22,525										
13	71.89	111,647	792,353										
14	71.79	86,389	18,611										
15	71.44	109,072	376,928										
16	72.54	40,940	-17,940							17,940			.65
17	70.72	67,968	-37,968								5,643	32,325	1.17
18	71.44	66,151	22,849										
19	73.29	279,528	-34,528						18,611		15,917		1.40
20	71.59	1,153,675	32,325										
Dummy 21			-53,000							51,711	1,289		-.45
			u_i	1.22	1.06	.61	.71	0	.10	-.45	-.45	-.30	



INTERREGIONAL FLOWS OF FED BEEF (MODEL IB)
(Million lbs.)

APPENDIX C.3 (MODEL IC)

Region	Equil. Price Cents/ Lbs.	Equil. Cons. 1,000 Lbs.	Surplus or Deficit 1,000 Lbs.	Origins and Quantities of Shipments (1,000 lbs.) 7	8	9	11	12	13	14	15	18	20	v_j
1	75.06	2,554,591	-1,714,591	680,934	164,834				792,359		76,464			3.14
2	74.92	251,858	-213,858			193,996					19,862			3.00
3	74.38	192,602	-100,602			100,602								2.46
4	75.06	177,486	-134,486								134,486			3.14
5	74.10	104,533	-55,533				13,653	5,995			35,885			2.18
6	73.89	135,435	-71,435			71,435								1.97
7	73.14	1,453,066	680,934											
8	72.98	750,166	164,834											
9	72.53	309,967	366,033											
10	73.58	32,535	-16,535					16,535						1.66
11	72.96	319,347	13,653											
12	72.63	70,470	22,530											
13	71.92	111,647	792,359											
14	71.82	86,387	18,613											
15	71.47	109,071	376,929											
16	72.57	40,939	-17,939								17,939			.65
17	73.09	67,559	-37,559									5,231	32,328	1.17
18	71.47	66,151	22,849											
19	73.32	279,524	-34,524							18,613		15,911		1.40
20	71.62	1,153,672	32,328											
Dummy 21			-94,000								92,293	1,707		-.45
			u_i	1.22	1.06	.61	1.04	.71	0	-.10	-.45	-.45	-.30	

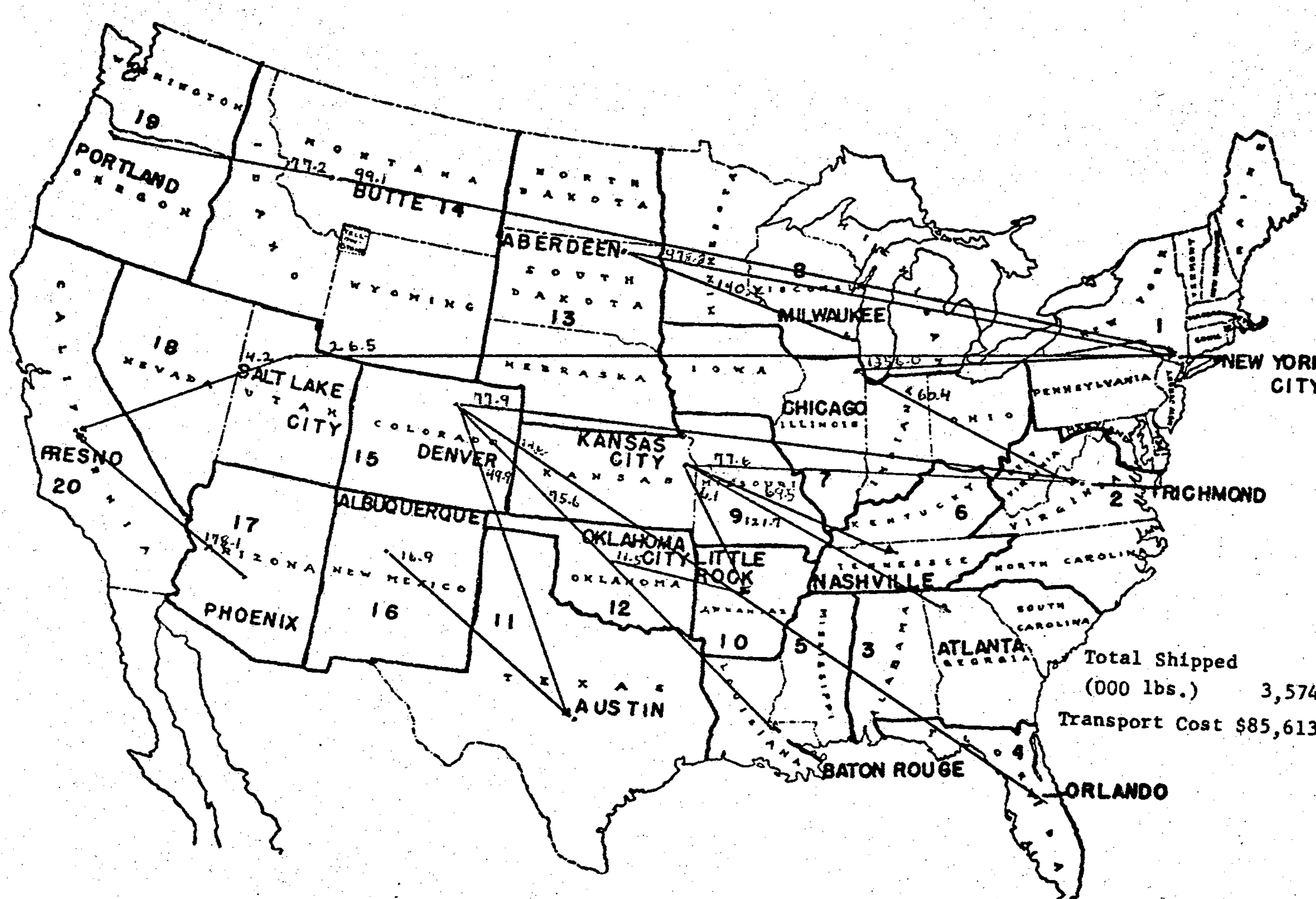


INTERREGIONAL FLOWS OF FED BEEF (MODEL IC)
(Million lbs.)

APPENDIX TABLE C.4 (MODEL IIA)

Region	Equil. Price Cents/ Lbs.	Equil. Cons. 1,000 Lbs.	Surplus or Deficit 1,000 Lbs.	Origins and Quantities of Shipments (1,000 lbs.) 7	9	12	13	14	15	16	17	18	v_j
1	74.92	2,555,492	-2,460,492	1,356,016			978,803	99,171				26,502	3.14
2	74.82	251,995	-215,995	60,419	77,643				77,933				3.04
3	74.28	192,728	-121,728		121,728								2.50
4	74.96	177,552	-146,552						146,552				3.18
5	74.00	104,603	-75,603						75,603				2.22
6	73.79	135,523	-69,523		69,523								2.01
7	73.00	1,453,565	1,416,435										
8	73.31	749,506	-140,506				140,506						1.53
9	72.43	310,052	274,948										
10	73.49	32,556	-17,556		6,054	11,502							1.71
11	73.41	318,777	-66,777						49,819	16,958			1.63
12	72.54	70,498	11,502										
13	71.78	111,691	1,119,309										
14	70.71	86,633	176,367										
15	71.37	109,093	349,907										
16	71.75	41,042	16,958										
17	71.26	67,877	178,123										
18	70.78	66,258	30,742										
19	72.21	280,196	-77,196					77,196					.43
20	72.73	1,151,363	-182,363								178,123	4,240	.95
Dummy* 21													
			u_i	1.22	.65	.76	0	-1.07	-.41	-.03	-.52	-1.00	

*Not used in this model.

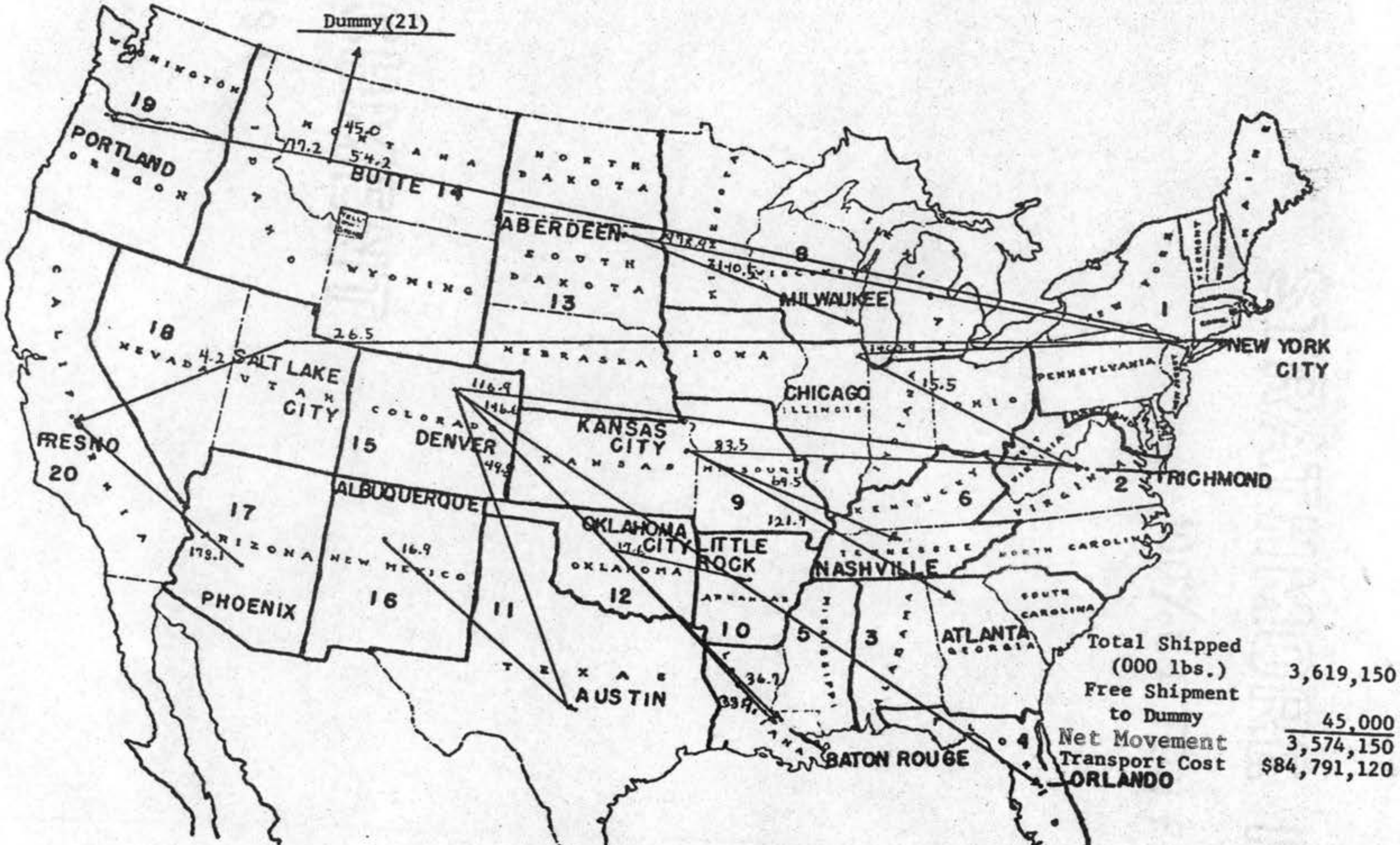


Total Shipped
(000 lbs.) 3,574,291
Transport Cost $85,613,248

INTERREGIONAL FLOWS OF FED BEEF (MODEL IIA)
(Million lbs.)

APPENDIX C.5 (MODEL IIB)

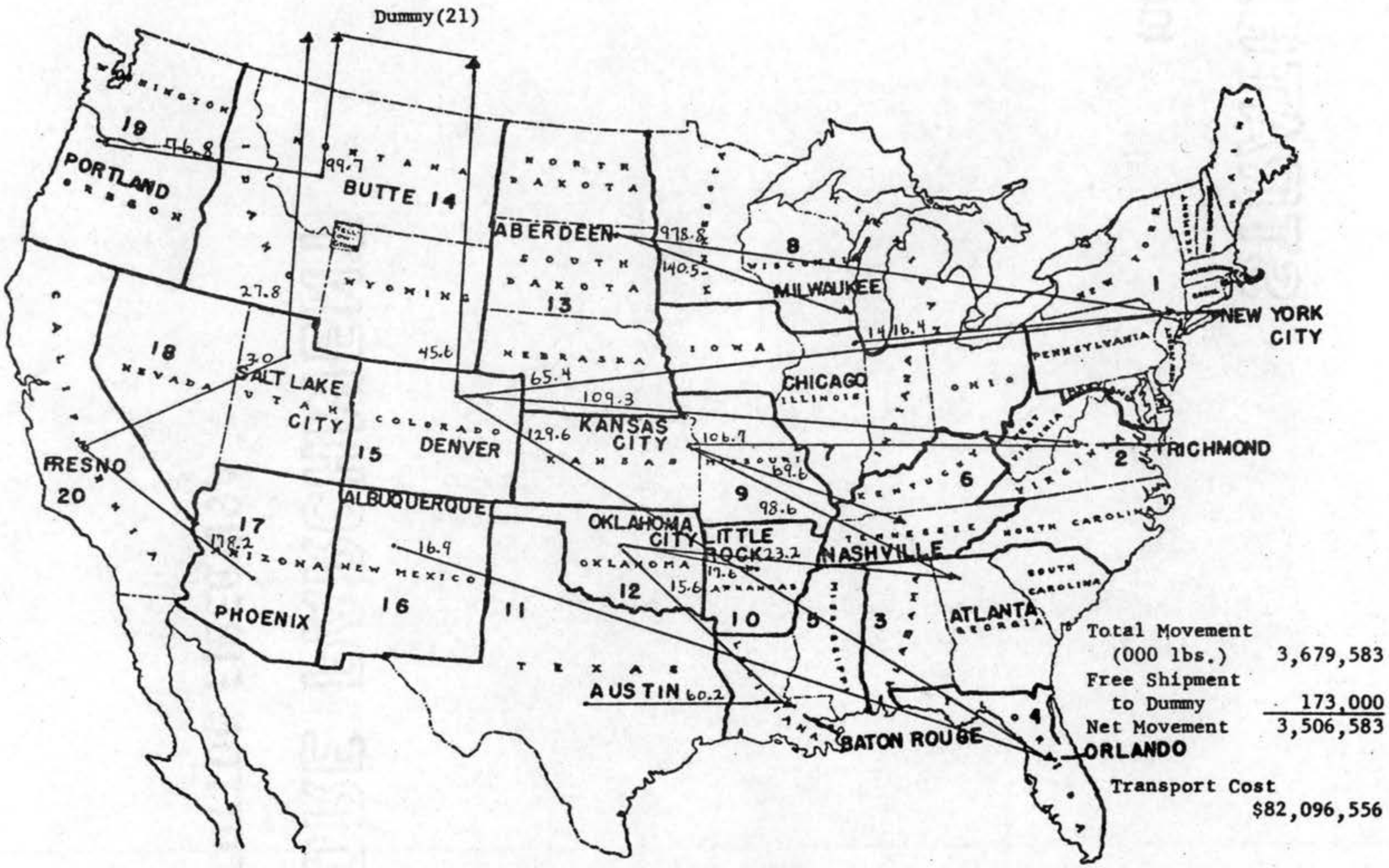
Region	Equil. Price Cents/ Lb.	Equil. Cons. 1,000 Lbs.	Surplus or Deficit 1,000 Lbs.	Origins and Quantities of Shipments (1,000 lbs.) 7	9	12	13	14	15	16	17	18	V_j
1	74.93	2,555,440	-2,460,440	1,400,923			978,822	54,174				26,521	3.14
2	74.83	251,982	-215,982	15,540	83,536				116,906				3.04
3	74.29	192,717	-121,717		121,717								2.50
4	74.97	177,545	-146,545						146,545				3.18
5	74.01	104,597	-75,597			38,946			36,651				2.22
6	73.80	135,515	-69,515		69,515								2.01
7	73.01	1,453,537	1,416,463										
8	73.32	749,490	-140,490				140,490						1.53
9	72.22	310,232	274,768										
10	73.49	32,556	-17,556			17,556							1.70
11	73.42	318,766	-66,766						49,806	16,960			1.63
12	72.54	70,498	56,502										
13	71.79	111,688	1,119,312										
14	70.72	86,630	176,370										
15	71.38	109,092	340,908										
16	71.76	41,040	16,960										
17	71.27	67,876	178,124										
18	70.79	66,257	30,743										
19	72.22	280,196	-77,196					77,196					.43
20	72.74	1,151,346	-182,346								178,124	4,222	.95
Dummy 21			-45,000					45,000					-1.07
			u_i	1.22	.43	.75	0	-1.07	-.41	-.03	-.52	-1.00	



INTERREGIONAL FLOWS OF FED BEEF (MODEL IIB)
(Million lbs.)

APPENDIX TABLE C.6 (MODEL IIC)

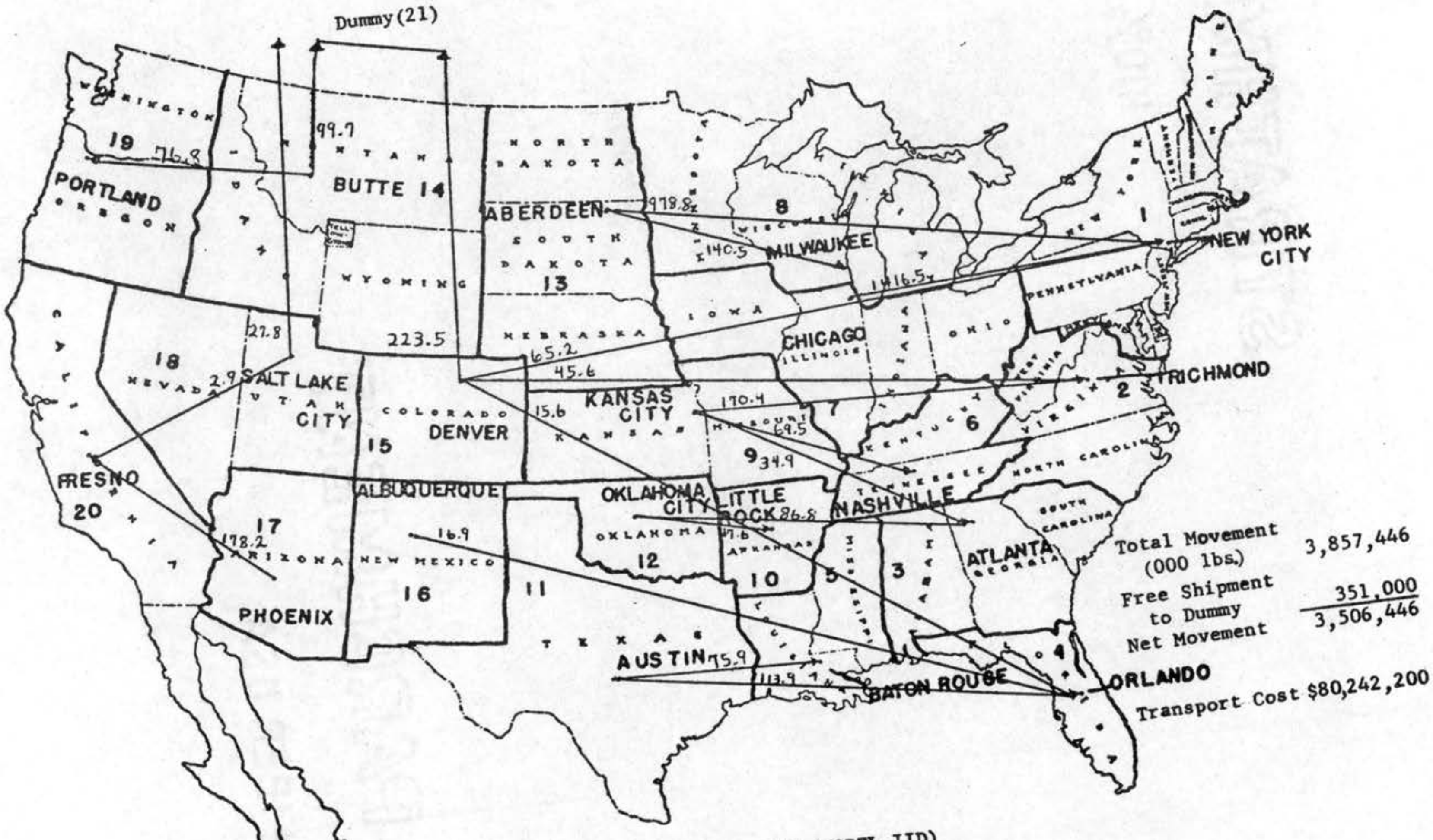
Region	Equil. Price Cents/ Lbs.	Equil. Cons. 1,000 Lbs.	Surplus or Deficit 1,000 Lbs.	Origins and Quantities of Shipments (1,000 lbs.) 7	9	11	12	13	14	15	16	17	18	V_j
1	74.91	2,555,561	-2,460,561	1,416,396				978,778		65,387				3.14
2	74.77	252,063	-216,063		106,730					109,333				3.00
3	74.23	192,792	-121,792		98,610		23,182							2.46
4	74.91	177,585	-146,585							129,639	16,946			3.14
5	73.73	104,797	-75,797			60,185	15,612							1.96
6	73.74	135,565	-69,565		69,565									1.97
7	72.99	1,453,604	1,416,396											
8	73.30	749,527	-140,527					140,527						1.53
9	72.38	310,095	274,905											
10	73.21	32,622	-17,622				17,622							1.44
11	72.59	319,815	60,185											
12	72.26	70,584	56,416											
13	71.77	111,695	1,119,305											
14	71.32	86,497	176,503											
15	71.32	109,105	349,895											
16	71.65	41,054	16,946											
17	71.80	67,794	178,206											
18	71.32	66,174	30,826											
19	72.82	279,829	-76,829						76,829					1.05
20	73.27	1,150,242	-181,242									178,206	3,036	1.50
Dummy 21			-173,000						99,674	45,536			27,790	-.45
			u_i	1.22	.61	.82	.49	0	-.45	-.45	-.12	.03	-.45	



INTERREGIONAL FLOWS OF FED BEEF (MODEL IIC)
(Million lbs.)

APPENDIX TABLE C.7 (MODEL IID)

Region	Equil. Price Cents/ Lb.	Equil. Cons. 1,000 Lbs.	Surplus or Deficit 1,000 Lbs.	Origins and Quantities of Shipments (1,000 lbs.) 7	9	11	12	13	14	15	16	17	18	v_j
1	74.93	2,557,031	-2,460,445	1,416,460				978,819		65,166				3.14
2	74.79	252,038	-216,038		170,407					45,631				3.00
3	74.25	192,768	-121,768		34,964		86,804							2.46
4	74.93	177,573	-146,573			113,991				15,635	16,947			3.14
5	73.53	104,940	-75,940			75,940								1.74
6	73.76	135,549	-69,549		69,549									1.97
7	73.01	1,453,540	1,416,460											
8	73.32	749,492	-140,492					140,492						1.53
9	72.40	310,082	274,920											
10	73.23	32,618	-17,618				17,618							1.44
11	72.39	320,069	189,931											
12	72.28	70,578	104,422											
13	71.79	111,689	1,119,311											
14	71.34	86,493	176,507											
15	71.34	109,101	349,899											
16	71.67	41,053	16,947											
17	71.82	67,780	178,220											
18	71.34	66,171	30,829											
19	72.84	279,818	-76,818						76,818					1.05
20	73.29	1,150,205	-181,205									178,220	2,985	1.50
Dummy 21			-351,000						99,689	223,804			27,844	-.45
			u_i	1.22	.61	.60	.49	0	-.45	-.45	-.12	.03	-.45	

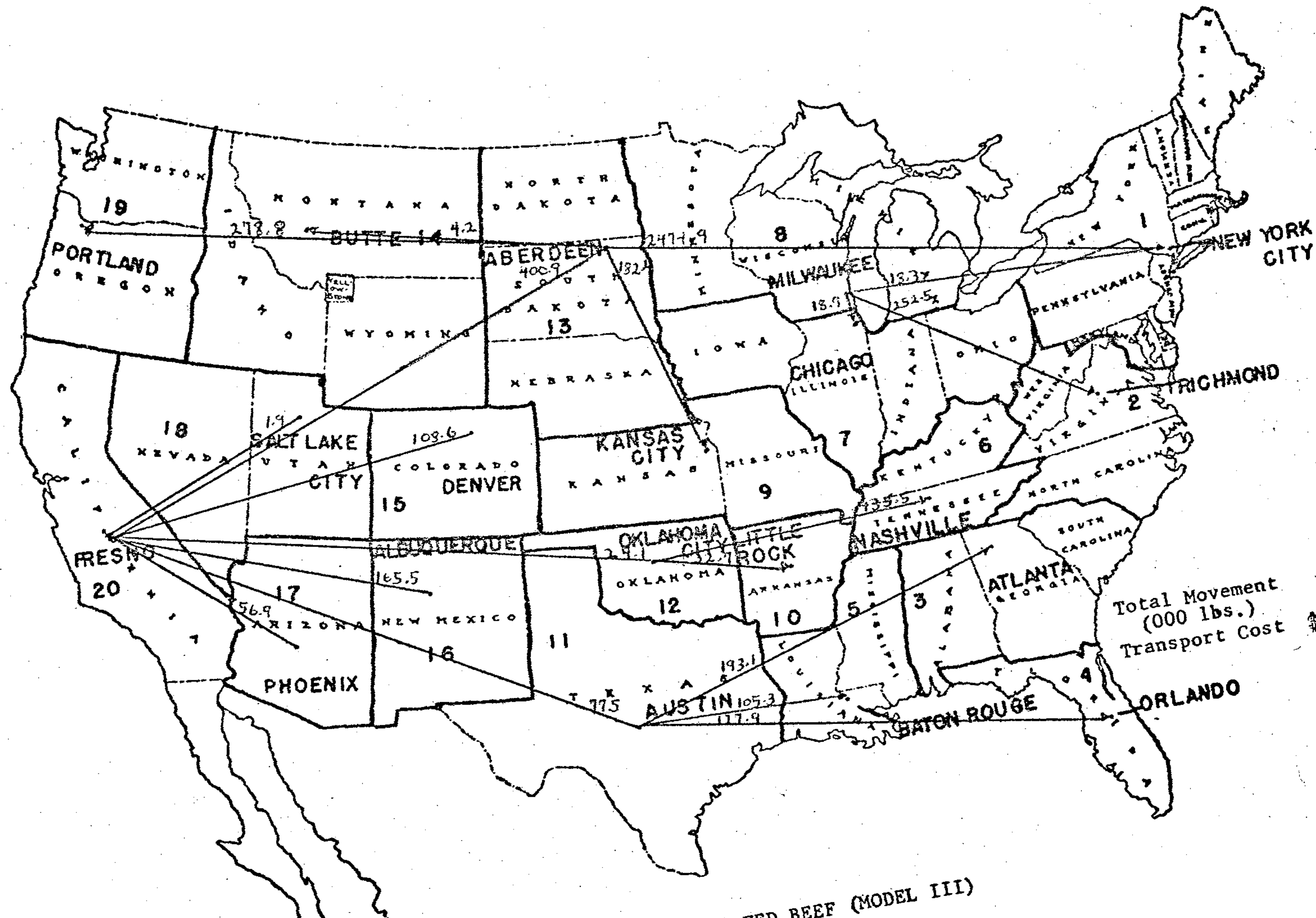


INTERREGIONAL FLOWS OF FED BEEF (MODEL IID)
(Million lbs.)

APPENDIX TABLE C.8 (MODEL III)

Region	Equil. Price Cents/ Lbs.	Equil. Cons. 1,000 Lbs.	Surplus or Deficit 1,000 Lbs.	Origins and Quantities of Shipments (1,000 lbs.) 8	11	12	13	15	16	17	18	v_j
1	74.58	2,557,714	-2,493,231	18,260			2,474,971					3.14
2	74.49	252,449	-252,449	252,449								3.05
3	73.96	193,135	-193,135		193,135							2.52
4	74.40	177,922	-177,922		177,922							2.96
5	73.00	105,319	-105,319		105,319							1.56
6	73.79	135,525	-135,525			135,525						2.35
7	72.85	1,454,122	-18,971	18,971								1.41
8	72.50	751,135	289,680									
9	72.89	309,663	-182,351				182,351					1.45
10	73.09	32,650	-32,650			32,650						1.65
11	71.86	320,742	553,907									
12	72.14	70,622	192,269									
13	77.44	111,815	3,341,311									
14	73.25	86,071	-4,228				4,228					1.81
15	72.33	108,872	108,550									
16	73.07	41,153	165,522									
17	73.70	67,071	56,934									
18	73.22	65,877	1,912									
19	74.45	278,838	-278,838				278,838					3.01
20	75.17	1,146,305	-835,466		77,531	24,094	400,923	108,550	165,522	56,934	1,912	3.73
Dummy* 21												
			u_i	1.06	.42	.70	0	.89	1.63	2.26	1.78	

*Not used in this model.



Total Movement (000 lbs.) 4,710,085

Transport Cost $132,303,460

INTERREGIONAL FLOWS OF FED BEEF (MODEL III)
(Million lbs.)

VITA

John W. Malone

Candidate for the Degree of

DOCTOR OF PHILOSOPHY

Thesis: A SPATIAL EQUILIBRIUM ANALYSIS OF THE FED BEEF ECONOMY

Major Field: Agricultural Economics

Biographical:

Personal Data: Born in Hartford, Connecticut, October 5, 1930, the son of John W. and Veronica M. Malone.

Education: Attended high school in Hartford, Connecticut, graduated from Weaver High School in June, 1949. Received the Bachelor of Science Degree from the University of Connecticut, Storrs, Connecticut in June, 1956, with a major in Business Administration. Received the Master of Science Degree from the University of Connecticut, Storrs, Connecticut in June, 1958, with a major in Agricultural Economics. Engaged in post graduate study toward the Degree of Doctor of Philosophy at Oklahoma State University, Stillwater, Oklahoma, from September, 1959, to August, 1962.

Professional Experience: Served with the United States Air Force from February, 1951, to September, 1952. Employed as Research Assistant in the Department of Agricultural Economics, University of Connecticut, Storrs, Connecticut from September, 1956 to May, 1958. Employed in Merchandising and Personnel Training Division of First National Food Stores, Inc., June, 1958 to September, 1959. Part-time employee and Research Assistant in The Department of Agricultural Economics, Oklahoma State University, Stillwater, Oklahoma from September, 1958 to August, 1962. Employed as Assistant Professor in the Department of Agricultural Economics, University of Nevada, Reno, Nevada from September, 1962, to present.