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To the Graduate Council:

I am submitting herewith a dissertation written by Joseph Webb McLeary entitled "Optimum Interregional Shipments of Beef, Pork, Broilers and Eggs, and the Predicted Effects of the Interstate Highway System on the Equilibrium Movement Patterns of These Commodities." I recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Agricultural Economics.

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OPTIMUM INTERREGIONAL SHIPMENTS OF BEEF, PORK, BROILERS AND
EGGS, AND THE PREDICTED EFFECTS OF THE INTERSTATE
HIGHWAY SYSTEM ON THE EQUILIBRIUM MOVEMENT
PATTERNS OF THESE COMMODITIES

A Dissertation
Presented to
the Graduate Council of
The University of Tennessee

In Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

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Joseph Webb McLeary
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CHAPTER I

INTRODUCTION

Changing patterns of production and consumption of agricultural commodities require continual adjustments at all levels of the marketing system. Some of these adjustments are intensified because of the changing competitive positions of producing areas in which improvements in technology have stimulated increased production and/or transportation efficiency. Increases in, and redistributions of population and income, and fluctuations in the level of output of the national economy also make such adjustments necessary.

Reliable information about the approximate magnitude and general direction of prospective changes in the patterns of production and consumption for a given industry is needed for long-run decision making in respect to resource allocation and capital-budgeting. Such information is required also for decisions affecting the location of production and processing facilities, their expansion or contraction, and the adoption of new methods of processing and distribution. The specific purpose of this study was to provide a subset of such information by attempting to estimate the effects of the Interstate Highway System on the optimum movement patterns and regional comparative advantages of beef, pork, broilers and eggs, and to estimate the 1972 equilibrium shipments of these commodities.

I. THE NATIONAL SYSTEM OF INTERSTATE AND DEFENSE HIGHWAYS

The national System of Interstate and Defense Highways, commonly called the Interstate System, was created by the Federal-Aid Highway Act of 1944.¹ This Act was later amended by the Federal-Aid Highway Act of 1956 which increased the original total mileage from forty thousand to forty-one thousand miles and authorized expenditures of forty-one billion dollars for construction of the Interstate System.²

When completed in 1972, the Interstate System will comprise little more than one per cent of the Nation's total road and street mileage, but is expected to carry over twenty per cent of all traffic. The system will connect and serve ninety-two per cent of all cities of over fifty thousand population and many smaller cities and towns.³

Approximately one-half of the total forty-one thousand mile Interstate System was open to traffic on December 31, 1964, and work is now in progress on another seventeen thousand miles.⁴ The complete

¹United States Department of Commerce, Bureau of Public Roads, Highway Progress, 1964: Annual Report of the Bureau of Public Roads, Fiscal Year 1964 (Washington: Government Printing Office, 1964), p. 14.

²Ibid.

³United States Department of Commerce, Bureau of Public Roads, Interstate System Route Log and Finder List (Washington: Government Printing Office, 1963), p. 1.

⁴United States Department of Commerce, Bureau of Public Roads 65-10, Quarterly Report of the Federal-Aid Highway Program (Washington: Government Printing Office, February, 1965), p. 1.

network of Interstate Highways and the present status of the system are shown in Figure 1 and Table I.

II. DIMENSIONS OF EFFECTS

A highway improvement program, such as the Interstate System, has many far-reaching effects and repercussions. While some of these effects may be obvious and readily observable, others may not be.

Some of the less obvious effects of such a program are of a social nature. Included in these social effects are factors which influence or change the relationship between people and such institutions as the family, community, government, schools, and churches. Changes in the rates of suburbanization and population mobility and relocation of residences can be cited as results of such changes.⁵

Aside from these indirect social effects which are difficult to measure precisely, there are other effects associated with highway improvement or construction projects. These may be labeled economic effects and can be conveniently separated into two broad categories: (1) expenditure effects and (2) locational effects.

Expenditures

A direct consequence of any large expenditures program, such as a highway improvement program, is its effect on aggregate effective demand.

⁵Floyd I. Theil, "Social Effects of Modern Highway Transportation," Indirect Effects of Highway Improvements, National Academy of Sciences, National Research Council Publication 1007 (Washington: Government Printing Office, 1962), p. 1.

PLANNED ROUTES OF
THE NATIONAL SYSTEM OF INTERSTATE AND DEFENSE HIGHWAYS

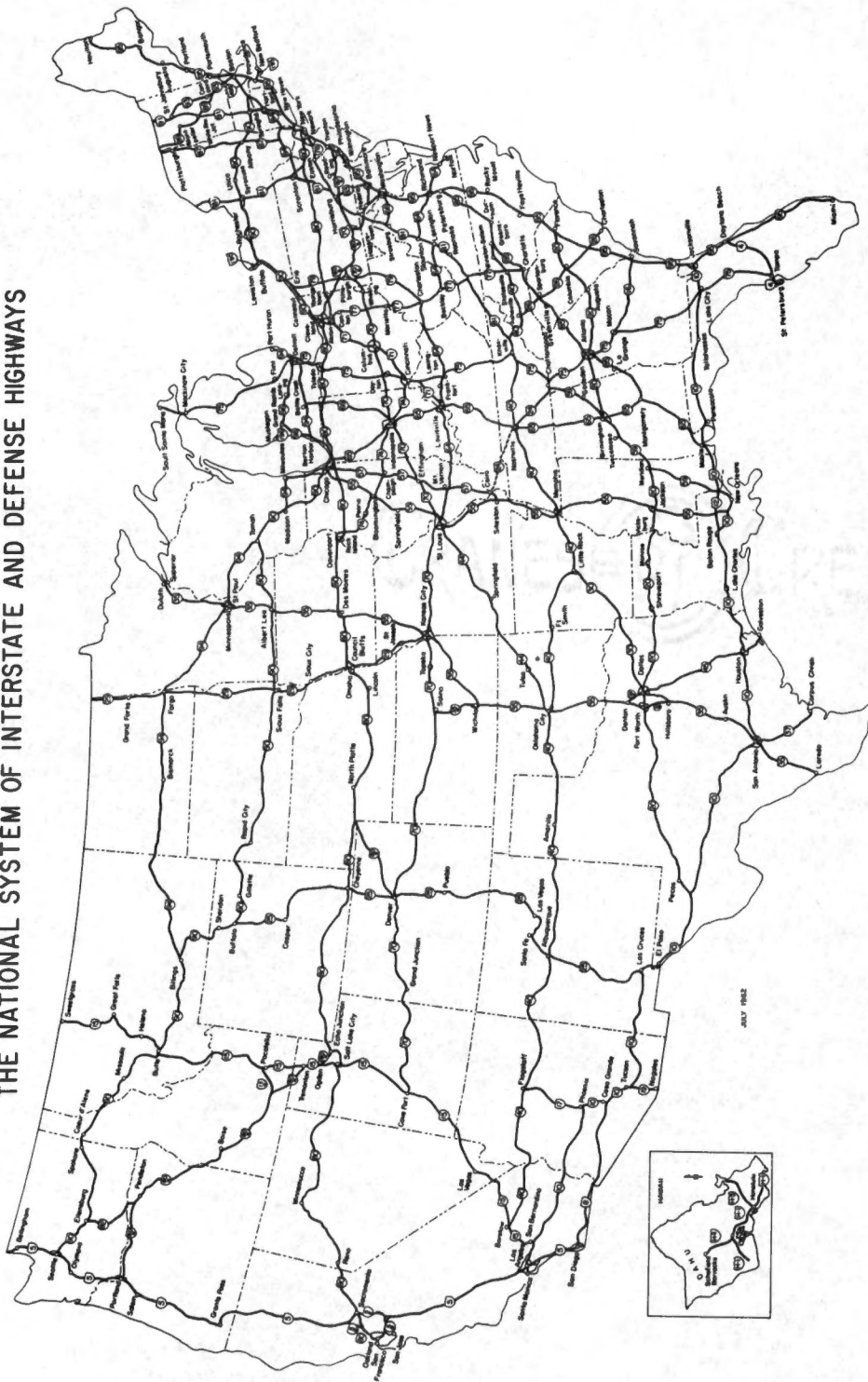


Figure 1. The planned network of Interstate and Defense Highways.

Source: United States Department of Commerce, Bureau of Public Roads, Interstate System Route Log and Finder List (Washington: Government Printing Office, 1963), p. 1.

TABLE I

THE NATIONAL SYSTEM OF INTERSTATE AND DEFENSE HIGHWAYS,
IMPROVEMENT STATUS OF SYSTEM MILEAGE, BY STATE, AS
OF DECEMBER 31, 1964

State	Preliminary status or not yet in progress ^a	Total work in progress	Total open to traffic	Total designated system mileage
Alabama	174.8	398.7	301.1	874.6
Alaska	--	--	--	--
Arizona	50.3	493.9	622.3	1,166.5
Arkansas	13.8	363.7	142.8	520.3
California	17.6	1,254.5	905.2	2,177.3
Colorado	251.2	288.1	406.6	945.9
Connecticut	--	97.0	199.8	296.8
Delaware	--	23.7	16.9	40.6
Florida	366.2	355.1	430.7	1,152.0
Georgia	27.8	670.3	407.2	1,105.3
Hawaii	14.6	33.8	--	48.4
Idaho	26.4	307.0	275.3	608.7
Illinois	105.7	727.4	798.5	1,631.6
Indiana	--	615.7	500.3	1,116.0
Iowa	72.2	305.1	332.1	709.4
Kansas	90.7	178.6	528.9	798.2
Kentucky	95.6	366.7	271.0	733.3
Louisiana	2.7	515.8	152.9	671.4
Maine	8.5	136.2	167.2	311.9
Maryland	19.9	96.7	238.3	354.9
Massachusetts	13.5	151.4	282.4	447.3
Michigan	122.6	169.7	789.3	1,081.6
Minnesota	96.3	567.0	241.6	904.9
Mississippi	--	422.1	255.9	678.0
Missouri	1.7	522.9	583.8	1,108.4
Montana	341.2	450.7	385.5	1,177.4
Nebraska	--	272.1	206.0	478.1
Nevada		303.1	231.6	534.7
New Hampshire	71.6	9.6	132.6	213.8
New Jersey	74.0	151.8	147.5	373.3
New Mexico	212.0	372.7	417.9	1,002.6
New York	47.1	312.1	875.6	1,234.8

TABLE I (continued)

State	Preliminary status or not yet in progress ^a	Total work in progress	Total open to traffic	Total designated system mileage
North Carolina	175.8	220.3	376.1	772.2
North Dakota	101.6	153.1	315.5	570.2
Ohio	51.0	578.5	896.7	1,526.2
Oklahoma	63.9	262.7	468.7	795.3
Oregon	72.9	78.7	579.5	731.1
Pennsylvania	92.2	669.5	822.9	1,584.6
Rhode Island	--	45.3	25.9	71.2
South Carolina	82.0	256.5	340.2	678.7
South Dakota	--	367.3	311.9	679.2
Tennessee	62.6	668.9	317.7	1,049.2
Texas	527.3	1,074.1	1,423.4	3,024.8
Utah	359.3	423.8	151.4	934.5
Vermont	--	233.6	87.0	320.6
Virginia	47.8	602.0	404.3	1,054.1
Washington	128.2	261.6	335.8	725.6
West Virginia	216.6	136.1	156.9	509.6
Wisconsin	3.3	147.0	308.4	458.7
Wyoming	294.6	180.9	441.8	917.3
Dist. of Col.	13.4	7.3	7.9	28.6
Pending ^b	70.3			70.3
Total	4,680.8	17,300.4	19,018.8	41,000.0

^aLocation studies and public hearings have been undertaken on many portions of the mileage in this column.

^bIncludes routes for which the final locations have not yet been determined.

Source: United States Department of Commerce, Bureau of Public Roads 65-10, Quarterly Report on the Federal-Aid Highway Program, December 31, 1964 (Washington: Government Printing Office, February, 1965), p. 3.

In this respect expenditures for a highway improvement program can influence the economic development of the regions where the investment will take place. Expenditures on road construction projects may, in fact, be a "leading sector" by which to initiate an overall regional economic development program.⁶ In any case, reliable estimates are needed of the impact of investments in various sectors on regional economic development.⁷

Comparative Advantage

Transportation is the most important element in the distribution process because of the spatial aspects of most economic activities. Ceteris paribus, the relative advantage of certain regions in the production and distribution of a given commodity is determined largely by a comparison of transportation costs over alternative routes.* Highway development or improvement projects which affect transportation costs, therefore, influence or change the comparative advantage relations

⁶Lloyd Rodwin, "Choosing Regions for Development," Regional Development and Planning, John Friedmann and William Alonso, editors (Cambridge: The Massachusetts Institute of Technology Press, 1964), p. 42.

⁷For a recent study in which road construction was included as a separate activity in solving for an optimum regional development program, see Robert G. Spriegelman, E. L. Baum, and L. E. Talbert, Application of Activity Analysis to Regional Development Planning, Resource Development Economics Division, Economic Research Service, United States Department of Agriculture, Technical Bulletin No. 1339 (Washington: Government Printing Office, 1965).

*The time element must also be included in such cost comparisons, as will be shown in Chapter III.

among regions. Such changes in the matrix of regional advantages or disadvantages are the location effects of highway improvement programs.

The Interstate System may be thought of as an increase in transportation efficiency. Reductions in travel time between origins and destinations, fuel and oil consumption per mile, average cost of repairs per mile, and tire wear all result in lower operating costs to users of the improved highways. Further, lower operating costs induce other changes which affect interregional movement patterns and locational advantages.

This study focused on these locational effects of the Interstate System. Unless otherwise stated, all institutional and social factors are assumed to remain constant. Community attitudes and cultural patterns can also influence the locational advantages of a given industry, but, in this study, these factors were assumed to be neutral.⁸

III. PROBLEM OF THESIS

As noted, changes in the structure of transfer costs cause changes in the relative locational advantages of producing and processing regions. Location advantages, as determined by the competitive position of regions in the production and distribution of various agricultural commodities, will affect the future development pattern of these industries.

⁸For a discussion of suggested ways of quantifying such effects, see Walter Isard, Methods of Regional Analysis: An Introduction to Regional Science (New York: John Wiley and Sons, Inc., 1960), pp. 281-293.

Objectives

The problem investigated in this study was to estimate the effects of the Interstate Highway System on the competitive position of several agricultural commodities produced in Tennessee.

The objectives were: (1) to describe the equilibrium shipments of beef, pork, broilers and eggs using 1962 demand, supply and transportation data; (2) to estimate the effects of the Interstate Highway System on these movement patterns; and (3) to estimate 1972 equilibrium shipments of these commodities, taking into account the improved highway system and changes in population and income.

Commodities Included in Study

The criterion used in selecting the commodities used in the analysis was their relative importance as a source of income derived from the sale of farm products produced in Tennessee. Table II shows the importance, according to this criterion, of the various commodities produced in Tennessee during the period 1954-63.

Cotton and tobacco were important sources of income, accounting for thirty-four per cent of total cash receipts in 1963 (Table II). However, since all of the cotton and tobacco produced in Tennessee is covered by government price-support programs, these two commodities were excluded from the analysis. It was thought that the lowering of transportation costs as a result of the Interstate Highway System would have its greatest effect on the competitive position of those commodities involved more directly in interregional competition.

CASH RECEIPTS BY COMMODITIES AND COMMODITY GROUPS, BY YEAR, AS PERCENTAGE
OF ALL AGRICULTURAL COMMODITIES, TENNESSEE, 1954-63

^bFood grains, field crops, oil crops, vegetables and fruits and nuts.

Source: Economic Research Service, United States Department of Agriculture, Farm Income Situation, Supplements 195, 187 and 179 (Washington: Government Printing Office, 1964, 1962 and 1960), pp. 97, 99 and 76, respectively; and Agricultural Marketing Service, United States Department of Agriculture, Cash Receipts from Major Farm Commodities by States, Statistical Bulletin No. 246 (Washington: Government Printing Office, 1959), p. 43.

Cattle, hogs, eggs and broilers--which accounted for approximately thirty-five per cent of the total value of farm products sold in Tennessee in 1963--were the commodities selected for analysis. Milk was excluded from the analysis because of the complex interrelationships among the various forms of milk and milk products marketed and the various milk marketing orders under which milk is sold.

A choice had to be made as to the form in which the products would be transported, i.e., would the analysis focus on shipments of the primary, secondary or final forms of the product? It is possible, of course, that some combination of these various forms would provide the most meaningful basis for the analysis, especially if slaughtering or processing took place at intermediate points between production and consumption. It was assumed, however, that slaughtering and processing were production oriented, and that the products were shipped in secondary or final form. For most agricultural products this is a realistic assumption. On an equivalent per unit basis it is usually cheaper to ship carcass beef, pork, or broilers than it is to ship live cattle, hogs, or chickens.⁹ For eggs there is very little change from primary to final product.

⁹Wilbur R. Maki, Charles Y. Liu, and William C. Motes, Inter-regional Competition and Prospective Shifts in the Location of Livestock Slaughter, Agricultural and Home Economics Experiment Station, Center for Agricultural and Economics Adjustment, Research Bulletin 511 (Ames: Iowa State University of Science and Technology, 1962), p. 736; T. D. Wallace and G. G. Judge, "Application of Spatial Analysis to Quarterly Models and Particular Problems Within the Beef Marketing System," Spatial Price Equilibrium Analyses of the Livestock Economy, Oklahoma State University Experiment Station, Technical Bulletin T-79 (Stillwater:

Procedure

The following procedure was necessary to reach the indicated objectives:

1. Specification of an appropriate theoretical and analytical framework for measuring the effects of the Interstate System.
2. Estimation of the transportation cost matrices for each commodity using the present highway system and using the completed Interstate System.
3. Specification of the input data required by the analytical framework used.
4. Estimation of the competitive equilibrium flows of products within the analytical framework selected under both the old and new highway systems.
5. Estimation of the 1972 equilibrium flow patterns for the selected commodities.

Oklahoma State University, 1959), p. 34; and R. L. Rizek, G. G. Judge, and J. Havlicek, "Joint Spatial Analysis of Regional Slaughter and the Flows and Pricing of Livestock and Meat," Spatial Structure of the Livestock Economy, North Central Regional Research Bulletin No. 157 (Brookings: South Dakota State University, 1964).

CHAPTER II

ANALYTICAL FRAMEWORK

I. ECONOMIC MODELS AS TOOLS OF ANALYSIS

In the language of present-day economists, the term "economic model" has, in most cases, come to refer to a set of simultaneous equations expressing the relationships among the relevant variables within a particular sector, or all sectors, of the economy. When used in this way, economists are usually referring to an "econometric model."¹ However, in its broadest sense, the term "economic model" can be used to refer to any theoretical structure involving economic magnitudes.² It is within this broader sense that the present discussion is couched.

In order to place a discussion of economic models in its proper perspective, a convenient point of departure would seem to be the inter-related activities of economic science. Ruggles suggests that economic research can be viewed as a process involving four consecutive stages of analysis. He defines these stages as: (1) the exploration of the problem, (2) the theoretical development of hypotheses, (3) the empirical

¹Wassily Leontief, "Econometrics," A Survey of Contemporary Economics, Vol. I, Howard S. Ellis, editor (Homewood: Richard D. Irwin, Inc., 1952), pp. 388-411.

²Richard Ruggles, "Methodological Developments," A Survey of Contemporary Economics, Vol. II, Bernard F. Haley, editor (Homewood: Richard D. Irwin, Inc., 1952), p. 408.

testing of hypotheses, and (4) the evaluation or conclusion.³ These four stages are useful for a vague generalization of the different processes involved in researching a problem. However, for purposes of delineating the specific activities involved in economic research, a different classification is called for. Such a classification might be: (1) theorizing, (2) model-building, and (3) empirical application.⁴

Model-building is, then, a separate but interrelated activity in applied economics. Model-building is the connecting link between theory and empirical verification or application of the theory. The aim of economic theory is to develop reliable explanations of economic phenomena. A formal representation of the theory is then structured into a simplified model which facilitates the testing of the theory.

Most economic theories are complex and include many variables that have varying degrees of relevance. It would be next to impossible to attempt a verification of a theory if all the interrelated variables were included. Some simplification is required to reduce the problem to manageable terms. Research models are constructed to bring about this simplification and, at the same time, to present in an orderly fashion the network of the significant "stimuli" and "responses"

³Ibid., p. 409.

⁴Irving Dubov, "Research Model Attributes and Data Needs Implied by Theory" (paper presented at the Southern Farm Research Committee Meeting, New Orleans, March 23, 1964).

that have relevance to the problem under study.⁵

In the next section the basic theoretical framework appropriate for this study will be presented. After this presentation, a summary of the development of the various analytical models which have been used within this theoretical framework will be discussed.

II. CONCEPTUAL FRAMEWORK

The development of the Interstate System is assumed to be a transport technology, resulting in lower operating costs to the users. Viewed in this manner, the following statement is relevant to the problem under consideration.

Suppose an advance in the state of transport technology pushes the supply curve of transport inputs to the right and results in a lower price. From the viewpoint of industrial (agricultural) production there will be both a scale and substitution effect. Historically we find that reduced transport rates have tended (1) to transform a scattered, ubiquitous pattern of production into an increasingly concentrated one, and (2) to effect progressive differentiation and selection between sites with superior and inferior resources and trade routes.⁶

The two effects of transport technologies suggested by Isard in the above statement pertain to the movement and location of production of commodities. It is assumed that the Interstate Highway System will affect the movement and location of production of commodities, and any

⁵Anthony S. Rojko, The Demand and Price Structure for Dairy Products, Agricultural Marketing Service, United States Department of Agriculture, Technical Bulletin No. 1168 (Washington: Government Printing Office, 1957), p. 45.

⁶Walter Isard, Location and Space-Economy (New York: John Wiley and Sons, 1956), p. 87.

attempt to measure the extent of these effects must recognize the fact that the problem is one involving "space."

In recent years procedural methods have been developed for handling problems of this nature. The spatial-equilibrium model is one such method. This particular model is appropriate for appraising the effects of changes in transportation costs in a "comparative statics" framework. King and Henry note the usefulness of the transportation model as a tool in studying the effects of changes in transport costs on changes in regional production and on interarea commodity flows.⁷

Judge and Wallace also note the application of these models for isolating the effects of changes in transport cost.⁸ In any case, given a framework of analysis which includes the relevant variables, a partial analysis of the effects of changes in any one of these variables may be studied by allowing it to change while holding the others constant.

Development of Trade Theory⁹

The basic conceptual framework used by King and Henry and by Judge and Wallace is based on the so-called theory of interregional

⁷Richard A. King and William R. Henry, "Transportation Models in Studies of Interregional Competition," Journal of Farm Economics, 41(5):1001, 1959.

⁸G. G. Judge and T. D. Wallace, "Methodological Development and Annual Spatial Analysis of the Beef Marketing Sector," Spatial Price Equilibrium Analysis of the Livestock Economy, Technical Bulletin TB-78 (Stillwater: Oklahoma State University, June, 1959), p. 6.

⁹Several reviews of the development of the theory and research in interregional trade theory have been made in the past. The following is

and international trade. The general principles underlying this trade theory date back to Adam Smith and his principles of specialization and absolute advantage. His explanation of the nature and causes of the wealth of nations was phrased mainly in terms of division of labor, and the resulting specialization which Smith said served to increase the national wealth. When this specialization process is applied by regions or nations, it provides the basic stimulus for interregional or international trade. In such a situation, each area produces only a few commodities--frequently only one--and sells its surplus of these to other areas and uses the proceeds to buy from other areas those products which it cannot produce itself.¹⁰

It was left to later generations of economist to identify and provide an explanation as to (1) what products would be produced in a region and what specific products would be bought, (2) what would be the influence of transportation and other transfer costs, and (3) what would

a list of reviews from which the author has drawn heavily in preparing this section: R. J. Amick, "A Review of Research in Interregional Competition," and Willard F. Williams, "Interregional Competition--The Relevant Theory" (papers presented at Southern Farm Management Research Committee meeting, New Orleans, March 23, 1964); Ronald L. Mighell and John D. Black, Interregional Competition in Agriculture (Cambridge: Harvard University Press, 1951), pp. 13-37; Stanley K. Seaver, "Spatial Research or Measurement for What?" Journal of Farm Economics, 46(5): 1365-1371, 1964; Isard, op. cit., pp. 24-54; and King and Henry, op. cit., pp. 997-998.

¹⁰Adam Smith, An Inquiry into the Nature and Causes of the Wealth of Nations (New York: The Modern Library, Copyright 1937 by Random House, Inc.), pp. 415-16.

be the role of prices in determining what would be produced, or how much would be produced.¹¹

Ricardo provided an explanation of what would be produced in a region. He observed that even if a country possessed an absolute advantage in the production of all commodities, trade would still occur because of one nation's comparative advantage in the production of certain commodities. In other words, comparison of returns from alternative products must be made not only between countries--as in Smith's absolute advantage--but also among different products within the same country. Thus, according to Ricardo's comparative advantage principle, each area tends to produce those products for which its ratio of advantage is greatest as compared with other areas, or its ratio of disadvantages is least.¹²

Von Thunen and Weber were among the first to consider the influence of transfer costs on location and trade. Von Thunen's exposition was made in terms of determining the location of agricultural production around a centrally located market. He assumed lands of homogenous fertility, and that location of production was determined, therefore, by differences in the cost of transporting the particular crop to market. He reasoned that different types of agriculture would be located in concentric rings around the city in order of decreasing intensiveness of

¹¹Mighell and Black, op. cit., p. 16.

¹²David Ricardo, On the Principles of Political Economy and Taxation (London: John Murray, 1817).

cultivation, except in the case of bulky or perishable crops.¹³ The added cost of transportation associated with bulky and perishable crops would place the production of them closer to the market.

Weber identified three general factors--(1) transportation costs, (2) labor costs, and (3) agglomerating forces--as affecting location decisions. Agglomerating forces included: proximity to auxiliary industries, better marketing outlets, or economics of scale (including adequate public facilities).¹⁴ If the net effects of labor costs and agglomerating forces are equal in all alternative locations, then transportation costs become the significant locational factor and the site with the lowest transportation cost will be selected. In the case where labor (and raw material) costs and agglomerating forces are not equal, transportation costs are changed to reflect these differences. Thus Weber's theory reduces mainly to a comparison of the transportation costs (where transportation costs may be adjusted to reflect regional differences in costs of production and other local forces) incurred in shipping the raw material and the finished product.

A more general explanation of location and trade was needed. It had to take account of both demand and supply factors and had to weld together both trade and location theories into a single framework.

¹³Arthur H. Leigh, "Von Thunen's Theory of Distribution and the Advent of Marginal Analysis," The Journal of Political Economy, 54:481-502, 1946.

¹⁴Alfred Weber, Theory of the Location of Industries, translated by Carl J. Friedrich (Chicago: University of Chicago Press, 1929), pp. 60-61.

Attempts to develop such a complete framework grew out of theorizing on the role of price in determining what, where, and how much of a particular commodity would be produced. In consequence, an equilibrium type of analysis--in the Marshallian tradition--evolved as the basis of modern trade and location theory.

Ohlin's Interregional and International Trade provided the framework for this equilibrium type of analysis.¹⁵ Ohlin was the first to attempt seriously to integrate the pure theory of trade with location theory developed by Von Thunen and Weber. His goal of a more general theory is explicitly noted in the following objective:

To demonstrate that the theory of international trade is only part of a general localization theory, wherein, the space aspects of pricing are taken into full account and to frame certain fundamentals of such a theory as a background for a theory of international trade, wherein, the influence of local differences in the supply of factors of production and transportation costs within each country is duly considered.¹⁶

The above objective is applicable equally to interregional trade theory since the basic principles of interregional and international trade are substantially the same. Ohlin pursued this objective within a framework of a multiple market system of mutually interdependent pricing. In this framework, the basic stimulant of trade between areas is the result of price differences between regions. The modern theory of interregional trade is based largely on this principle.

¹⁵Bertil Ohlin, Interregional and International Trade (Cambridge: Harvard University Press, 1935).

¹⁶Ibid., p. vii.

Modern Interregional Trade Theory

Trade between regions is induced because of the prospect of profit as a result of differences in prices between the regions greater than the cost of transfer. Given this necessary condition for trade, the questions of interest are concerned with: (1) the reasons for price differences between regions, and (2) the effects arising out of trade. In explaining price differences between regions, the concepts of supply and demand are the applicable tools of analysis.

The main factors influencing regional cost differences are:

(1) the relative scarcity of productive factors, (2) technical input-output relationships, (3) specialization, degree of integration and scale, and (4) factor prices. Other factors which affect costs include external as well as internal, economies and diseconomies of scale, taxes, insurance and rent. Cost differences for producing a particular product in different regions, however, is not the full story. Demand must also be considered for a full explanation of price differences which lead to the emergence of trade. Population, tastes and preferences, the level and distribution of income and prices of related products may, and most likely will, differ among regions and give rise to differences in price even if supply functions are identical everywhere.

Thus, in modern trade theory the initial condition necessary for trade to emerge is a differential price structure among regions which is analyzed with respect to factors affecting both demand and supply. Whether or not trade actually occurs depends upon a comparison of these price differences with all the costs associated with transferring the

product from the surplus to the deficit regions. It is the derived demand and supply functions in each market which finally determines the extent of trade, assuming no barriers to trade and perfect competition in all markets.

III. DEVELOPMENT OF ANALYTICAL MODELS

Research models which have been used in the application of inter-regional competition theory to specific problems may be grouped into two different, but related, categories: (1) standard equilibrium formulations using demand and supply relations, and (2) activity analysis models using physical production activities and demand relationships. The activity analysis-type model involves specification of the physical production activities as well as demand relationships. Programming techniques are used in solving for the least-cost production methods, given the relevant factor supplies and factor prices in the various regions. This information is then used--in a recursive-type system--in conjunction with the regional demands in solving for the optimum inter-regional shipping patterns and regional allocation of production.¹⁷

¹⁷For a detailed discussion of the activity analysis-type model see D. Lee Bawden, "An Evaluation of Alternative Spatial Models," Journal of Farm Economics, 46(5):1372-1379, 1964; Richard H. Day, Recursive Programming and Production Response (Amsterdam: North-Holland Publishing Co., 1963); and W. Neill Schaller and Gerald W. Dean, Predicting Regional Crop Production, Economic Research Service, United States Department of Agriculture, Technical Bulletin No. 1329 (Washington: Government Printing Office, 1965).

In the standard equilibrium-type model, discrete regions are defined and all production and/or consumption in each region is assumed to take place at one point. Quantities supplied and demanded in each region may be preassigned--as in the transportation model--or may be a function of local price--as in the spatial-equilibrium model. The present study involved the application of this type of model to a problem in interregional competition.

The Transportation Model

The transportation model has been widely used in studies of interregional competition, and was one of the first standard equilibrium models of interregional trade theory developed and applied. Formal specification of this model was first given by Hitchcock.¹⁸ Koopmans and Dantzig took Hitchcock's specification and developed the linear programming techniques for obtaining solutions.¹⁹ The problem as specified by Dantzig was:

. . . to determine the amounts of a homogeneous product to be shipped from each of several shipping origins to each of several

¹⁸Frank L. Hitchcock, "The Distribution of a Product from Several Sources to Numerous Localities," Journal of Mathematics and Physics, 20(4):224-230, 1941.

¹⁹T. C. Koopmans, "Optimum Utilization of the Transportation System," Econometrica, 17(3):136-146, 1949; and George B. Dantzig, "Application of the Simplex Method to a Transportation Problem," Activity Analysis of Production and Allocation, Tjalling C. Koopmans, editor (New York: John Wiley and Sons, 1962), pp. 359-373.

shipping destinations so as to minimize the total cost of transportation.²⁰

Explicitly stated, the problem is to

$$\text{Minimize} \quad C = \sum_{i=1}^n \sum_{j=1}^m c_{ij} x_{ij} \quad (1)$$

$$\text{Subject to} \quad \sum_{i=1}^n x_{ij} = d_j \quad (j = 1, \dots, m), \quad (2)$$

$$\sum_{j=1}^m x_{ij} = S_i \quad (i = 1, \dots, n), \quad (3)$$

$$\sum_{j=1}^m d_j = \sum_{i=1}^n S_i, \text{ and} \quad (4)$$

$$x_{ij} \geq 0, \quad (5)$$

Where

C = total cost of transportation.

c_{ij} = known cost of transporting a unit of the commodity from area i (the origin) to area j (the destination).

x_{ij} = unknown number of units of the commodity shipped from i to j .

d_j = known amount required in area j , and

S_i = known amount available in area i .

²⁰George B. Dantzig, "Application of the Simplex Method to a transportation Problem," Activity Analysis of Production and Allocation, Tjalling C. Koopmans, editor (New York: John Wiley and Sons, 1962), pp. 359-373.

Spatial Equilibrium Models

The spatial equilibrium model extends the transportation model to allow quantities demanded and supplied in the various regions to be functionally related to price. Enke presented the general problem of equilibrium among spatially separated markets as follows:

There are three (or more) regions trading a homogeneous good. Each region constitutes a single and distinct market. Each region is separated from the others by a transportation cost per unit which is independent of volume. There are no legal restrictions to limit the actions of the profit-seeking traders in each region. For each region the functions which relate local production and local use to local price are known; and consequently, the magnitude of the difference which will be exported or imported at each local price is known. Given these trade functions and transportation costs, we wish to ascertain: (1) the net price in each region; (2) the quantity of exports or imports for each region; (3) which regions import, export or do neither; (4) the aggregate trade in each commodity; (5) the volume and direction of trade between each possible pair of regions.²¹

Samuelson emphasized that the spatial-equilibrium problem was more general than the transportation model, since the latter is a special case of the former. In the spatial-equilibrium model, shipments in or out of any given area are unknown and must be determined as part of the problem, whereas in the transportation model they are already known.²²

Given the required data, the spatial-equilibrium model will determine the equilibrium prices, and the optimum (least cost) flows

²¹Stephen Enke, "Equilibrium Among Spatially Separated Markets--Solution by Electric Analogue," Econometrica, 19(1):41, 1953.

²²Paul A. Samuelson, "Spatial Price Equilibrium and Linear Programming," American Economic Review, 42(3):285, 1952.

of a commodity. This kind of model more closely approximates the empirical counterpart of the Ohlnean general equilibrium framework, and is useful in analyzing problems concerned with spatial pricing efficiency.

Various adaptations of the basic Samuelson-Enke model have been employed in solving spatial-equilibrium problems. Judge and Wallace used a modification of the Samuelson-Enke formulation of the spatial-equilibrium model in several studies.²³ They modified the analysis by assuming a fixed supply in each of the several regions for a given period of time. By making this simplifying assumption, surplus and deficit regions could be delineated, once the equilibrium price was established, and then the transportation model used in determining the optimum distribution.

Reactive Programming

Tramel and Seale introduced "Reactive Programming" as another computational technique for solving spatial-equilibrium problems.²⁴ This technique is more general than the procedure followed by Judge and

²³G. G. Judge and T. D. Wallace, "Methodological Development and Annual Spatial Analysis of the Beef Marketing Sector"; "Applications of Spatial Analysis to Quarterly Models and Particular Problems Within the Beef Marketing System"; and "Spatial Price Equilibrium Models of the Pork Marketing Sector," Spatial Price Equilibrium Analysis of the Livestock Economy, Technical Bulletins TB-78, T-79, and T-81, respectively (Stillwater: Oklahoma State University, 1959 and 1960).

²⁴Thomas E. Tramel and A. D. Seale, Jr., "Reactive Programming of Supply and Demand Relations--Applications to Fresh Vegetables," Journal of Farm Economics, 41(5):1012-1022, 1959.

Wallace in that it is not necessary to assume fixed supplies in each region. Supply can be a functional relationship as presented in the original Samuelson-Enke formulation of the spatial-equilibrium problem.

Reactive programming determines, simultaneously, the equilibrium quantities in each consuming area and the least-cost routes for satisfying this equilibrium from the supplies available in the producing areas. Because of its flexibility, this technique is a useful tool of analysis for evaluating the effects of changes in certain variables on the complete system formulated by the model, and was, therefore, selected for use in this study.

The original statement of reactive programming was presented in 1959 by Tramel and Seale.²⁵ They defined reactive programming to be:

. . . a means of obtaining the equilibrium flows of a commodity between areas with given transportation costs functions, given demand schedules in each of the several areas of consumption and given supply schedules in each of the several areas of production²⁶

This procedure was originally designed to handle problems involving only one product. Recent developments by the authors have extended the basic procedure to handle problems involving more than one product and more than one time period.²⁷

²⁵Ibid.

²⁶Ibid., p. 1012.

²⁷Thomas E. Tramel and A. D. Seale, Jr., "Reactive Programming--Recent Developments," Interregional Competition Research Methods, Richard A. King, editor (Raleigh: The Agricultural Policy Institute, 1964), pp. 59-68.

The Computational Scheme and Data Requirements

Explicitly stated, the scheme of calculations and the technique employed in reactive programming may be summarized in a series of statements as set forth below.*

Let $i = 1, 2, \dots, M$ denote the different producing areas and $j = 1, 2, \dots, N$ denote the different consuming areas. Next, let P_j denote price of the homogeneous product in the j th consuming area, Q_{ij} denote quantity purchased in the j th consuming area which was produced in the i th producing area, T_{ij} denote the constant unit cost of transporting the product from the i th producing area to the j th consuming area, S_i denote the fixed supply in the i th producing area for the fixed supply situation or total production where supply is to be determined, and R_{ij} denote the "net" average revenue per unit for the product produced in the i th producing area and sold in the j th consuming area.

As given data for the problem, the following N demand equations are specified:

$$P_j = F_j \left(\sum_{i=1}^m Q_{ij} \right), \quad j = 1, 2, \dots, n. \quad (6)$$

Supply can either be fixed or a functional relationship. In general a supply function for each region may be specified as:

$$C_i = G_i (S_i), \quad i = 1, 2, \dots, m, \quad (7)$$

*A detailed step by step outline of the procedure is presented in Appendix A.

where C_i denotes unit cost of production in the i th producing area, and S_i denotes either the fixed quantity for producing area (i) for the fixed supply situation, or the total production in producing area (i) for the situation in which supply is determined as a part of the solution.

Transportation costs per unit are specified as

$$T_{ij} = \text{constants}, \quad i = 1, 2, \dots, m, \quad j = 1, 2, \dots, n \quad (8)$$

Relations (6), (7), and (8) summarize the required data needs for the problem. With these data, the task is to find the perfect competition equilibrium flows of the product among areas.

From these data the following relations may be formed:

$$R_{ij} = P_j - C_i - T_{ij}, \quad i = 1, 2, \dots, M, \quad j = 1, 2, \dots, N \quad (9)$$

From this the weighted average net prices can be expressed as

$$\bar{R}_i = (\sum_j R_{ij} Q_{ij}) / \sum_j Q_{ij}, \quad i = 1, 2, \dots, M, \quad j = 1, 2, \dots, N. \quad (10)$$

and deviations of net prices from the average (D_{ij}) can be expressed as:

$$D_{ij} = R_{ij} - \bar{R}_i \quad i = 1, 2, \dots, M, \quad j = 1, 2, \dots, N. \quad (11)$$

A non-negativity restraint is also imposed as:

$$Q_{ij} \geq 0, \quad i = 1, 2, \dots, M, \quad j = 1, 2, \dots, N. \quad (12)$$

Other conditions which must hold depend upon whether supply is fixed or is to be determined as part of the solution. In this study supply was assumed to be fixed in which case the following conditions must hold:

$$Q_{ij} \neq 0 \rightarrow R_{ij} \geq 0, \text{ and}$$

$$Q_{ij} = 0 \rightarrow R_{ij} \leq \bar{R}_i, \quad i = 1, 2, \dots, M, \quad j = 1, 2, \dots, N, \quad (13)$$

i.e., all the net prices corresponding to active shipping routes used must be non-negative and equal to each other, and, in turn, not less than those corresponding to non-active routes.

Also for the fixed supply situation, all of the available supply for a given producing area must be allocated if net prices are positive but not necessarily so if they are zero, i.e.:

$$\bar{R}_i > 0 \rightarrow \sum_j Q_{ij} = S_i \text{ and } \bar{R}_i = 0 \rightarrow \sum_j Q_{ij} \leq S_i \quad (14)$$

$$i = 1, 2, \dots, M.$$

Given the data indicated above and the derived relationships from these data, the problem is to take each producing area, in turn, and obtain an equilibrium for that producing area, and reiterate. In obtaining this equilibrium, shipments from all other producing areas are held constant at their last obtained values. This reiterative process converges to a simultaneous equilibrium for all producing areas.²⁸

IV. BASIC ASSUMPTIONS OF THIS STUDY

Specific assumptions on which the present analysis was based and which apply generally are outlined below. Other assumptions which were made in the derivation of some of the data are discussed in connection with the presentation of these data. All data in the original formulation of the problem are on an annual basis for 1962. In the final

²⁸Ibid., p. 59.

formulation the data are based on predicted values of the variables for 1972.

1. All slaughter is production oriented. Each product shipped is in intermediate or final form.

2. Each product from any one area is a perfect substitute for each product from any other processing area.

3. Supplies are predetermined in each producing area.

4. Demand schedules are known for each product in each region and are derived from an aggregate demand schedule by adjusting for regional population and income differences.

5. Processing costs in each region reflect the general trend in regional differences, not necessarily absolute differences, in these costs.

6. Transportation costs derived from functional relationships accurately reflect the per unit cost of shipment. The estimation of transfer functions for Interstate Highway routes reflect the general trend in savings to the users of the new system of highways.

7. Net revenue is maximized under conditions of perfect competition.

CHAPTER III

DEVELOPMENT OF TRANSPORTATION COSTS

One of the key input data requirements for a reactive programming analysis is a matrix of transportation costs between each possible pair of producing and consuming regions. This chapter describes the derivation of these cost data for each of the commodities under study for (a) the present road system with only part of the Interstate System completed, and (b) the completed Interstate Highway System.

Some spatial-equilibrium studies consider both rail and truck costs for each alternative shipping route. It was assumed in this study, however, that motor trucks provide the most economical mode of transportation for each commodity included in the study. In recent years the share of farm food products hauled by truck has increased significantly.¹ During the period 1947-64 the proportion of freight hauled by motor trucks increased every year except 1954. These carriers (motor trucks) accounted for 24 per cent of the total intercity freight in 1964 compared with 10 per cent in 1947. At the same time the

¹Marketing Research Division, Agricultural Marketing Service, Food Transportation and What It Costs Us, United States Department of Agriculture, Miscellaneous Publication No. 738 (Washington: Government Printing Office, 1956), p. 10; and Economic Research Service, Marketing and Transportation Situation-155, United States Department of Agriculture (Washington: Government Printing Office, 1964), p. 21.

proportion of freight hauled by rail declined from 65 per cent to 43 per cent.²

Accurate figures are not presently available on how this shift in the proportion of freight hauled by motor truck was divided between agricultural and non-agricultural commodities. There is reason to believe, however, that the shift toward movement of agricultural commodities by motor truck has been greater than the shift for nonfarm products. The most important factors supporting this assumption are: (1) the exemption from economic regulation under the Interstate Commerce Act for truckers of farm products,³ (2) improvements in motor truck equipment used for hauling farm products, and (3) faster over-the-road service facilities and less direct handling between origins and destinations.

Finally, the shift to use of motor transportation should accelerate even more as the general network of highway transportation improves.

I. TRANSPORTATION COSTS UNDER THE PRESENT HIGHWAY SYSTEM

For purposes of this study it was neither necessary nor practical to obtain data on the absolute rates charged for transporting the

²Economic Research Service, United States Department of Agriculture, Marketing and Transportation Situation-157 (Washington: Government Printing Office, 1965), p. 1.

³T. Q. Hutchinson, "Trucking Under the Agricultural Exemption," Marketing and Transportation Situation-157, Economic Research Service, United States Department of Agriculture (Washington: Government Printing Office, 1965), p. 29.

various commodities studied between each possible pair of supply and demand points. Instead, transportation costs were estimated by means of regression techniques. The convenience and economy from use of regression techniques was assumed to more than outweigh any loss in precision of the data resulting from not using actual rates charged. Also, actual rates were not available for all the commodities studied for all routes, and other sources of data had to be used. Finally, the rates to be charged when using the completed Interstate System had to be estimated in any case. Thus, regression analysis was used to estimate all transportation costs to provide for comparability of data.

The Basic Data

The basic data used to derive the transportation cost functions by regression techniques were taken from tariff schedules published by the Interstate Commerce Commission.⁴ These data are available by commodity groups by regions. A complete enumeration of all the routes published in the Southern and Eastern region tariff schedules was made for each commodity in the study for purpose of the regression analysis. This information, along with highway mileages for these routes, was used to derive transportation cost regression equations for each of the commodities studied.

⁴The data were secured from the Navigation Economics Branch, Tennessee Valley Authority, Knoxville, Tennessee. The particular tariffs were: Southern Motor Carriers Rate Conference, 169-K (Edible Goods), MF-ICC, 1337; 169-K Supplement 3, effective March 24, 1965; and 8-E (South-East Commodities), MF-ICC, 1317.

It is recognized that regulated truck rates do not reflect the true absolute rate structure for agricultural commodities since most agricultural products are exempt from regulation under the Interstate Commerce Act.⁵ However, in spatial-equilibrium problems it is the relative differences in relationships between costs using alternative routes, and not the absolute differences of costs, that is important in determining the optimum movements. Thus, the use of data based on regulated rates in the regression equations is not as restrictive as it might first seem.

Functional Relationships and Estimating Equations

Three different functional relationships, using mileage as the independent variable, were postulated and fitted to the cost and mileage data for each commodity: (1) a simple first degree linear function, (2) a second degree parabola, and (3) a function with a square root term. The form of the equations is as follows:

$$\text{Linear:} \quad c_{ij} = b_0 + b_1 x_{ij} \quad (1)$$

$$\text{Second Degree:} \quad c_{ij} = b_0 + b_1 x_{ij} + b_2 x_{ij}^2 \quad (2)$$

$$\text{Square Root:} \quad c_{ij} = b_0 + b_1 x_{ij} + b_3 x_{ij}^{\frac{1}{2}} \quad (3)$$

where

c_{ij} = the cost per unit of shipping the
product from point i to point j.

x_{ij} = the mileage between i and j.

⁵T. Q. Hutchinson, loc. cit.

b_i = parameters to be estimated

($i = 0, 1, 2, \text{ or } 3$).

The results of the regression analysis for each commodity and for each of the three forms above are given in Table III. Carcass beef and pork are represented by the same equation since both were included as a single commodity group in the published tariff schedules.

With the exception of eggs, the second degree equation resulted in the highest R^2 for each commodity. For eggs the square root equation resulted in the highest R^2 value, but it was not significantly higher (at the 99 per cent level) than the R^2 value for the second degree equation. Thus, the second degree equations were used to estimate transportation costs for each commodity in programming for the initial optimum movement patterns.

II. DIFFERENCES IN TRANSPORTATION COSTS ON THE TWO HIGHWAY SYSTEMS

Motor truck operating costs which are susceptible to reduction through highway improvements are those affected by highway and/or traffic conditions. Fixed costs elements such as terminal and docking charges, insurance, and taxes and licenses are assumed to be unaffected by highway conditions.*

Factors which influence variable line-haul costs may be grouped into (1) those affecting mileage and (2) those affecting speed.

*It is possible, of course, that insurance rates might be lower due to the increased safety features of the Interstate Highways.

TABLE III

COEFFICIENTS OF TRANSPORTATION COST REGRESSION EQUATIONS, BY COMMODITY GROUP AND BY EQUATION FORM

Commodity and equation form	Unit of measure of c_{ij}	Regression coefficients ^a			Coefficient of determi- nation R^2
		b_0	b_1	b_2	b_3
Beef and pork	Dollars per hundred pounds				
Linear		.4732537	.0013030 (.00510)		.938
Second degree		.2682428	.0021216 (.0002528)	-.0000006 (.0000002)	.951
Square root		-.1916117	.001269 (.0004389)	.0585279 (.0216965)	.945
Broilers	Dollars per hundred pounds				
Linear		.3904372	.001507 (.0001017)		.883
Second degree		.4911752	.0010382 (.0004646)	.0000004 (.00000004)	.887
Square root		.7056178	.0021890 (.0007706)	-.0302272 (.0037885)	.886

TABLE III (continued)

Commodity and equation form	Unit of measure of c_{ij}	Regression coefficients ^a			Coefficient of determi- nation R^2
		b_0	b_1	b_2	b_3
Eggs	Cents per dozen				
Linear		1.4216393	.0016286 (.0001621)		.783
Second degree		.7910021	.0035720 (.0002561)	-.0000014 (.0000001)	.820
Square root		-1.3137911	-.0025530 (.0016797)	.2158296 (.086346)	.824

^a b_0 = constant term b_1 = distance in miles x_1 b_2 = distance in miles x_2 ---appearing in second degree equation only b_3 = distance in miles x_3 ---appearing in square root equation only

Numbers in parentheses below the coefficients are the standard errors of estimate.

These two components were investigated to estimate the effects of improved roads on operating costs.

Conventional and Interstate Mileage Comparisons

Differences in mileages over the conventional road network as compared to the Interstate System for a given set of points were automatically taken into account by the particular mileage estimate used in deriving transportation costs from the regression equations. Also, estimated mileages under the two highway systems were compared to determine if the mileage differences were significant.

Based on 170 routes between points in all parts of the nation, conventional and interstate miles were regressed separately on air miles using an equation of the following form:⁶

$$y_{ij} = b_1 x_{ij} \quad (4)$$

where

y_{ij} = conventional highway mileage between i and j

y'_{ij} = Interstate Highway mileage between i and j

x_{ij} = air mileage between i and j

b_1 = parameter to be estimated

The results of the regression analysis were:

$$y_{ij} = 1.241x_{ij} , \quad R^2 = .98 \quad (5)$$

$$y'_{ij} = 1.191x_{ij} , \quad R^2 = .96 \quad (6)$$

⁶Conventional road mileages and air mileages taken from The World Almanac and Book of Facts (New York: The New York World Telegram and The Sun, 1965), pp. 705-7 and 787; Interstate road mileages estimated using overlay map of completed Interstate System.

The difference between the coefficients of the two regression equations (5) and (6) was not significant at the 95 per cent level. Therefore, it was concluded that the Interstate System will not significantly affect the highway mileage for any given set of routes, and that any savings from use of the new highways will accrue from better road and driving conditions.*

Speed of Travel

The main factors which tend to reduce per mile operating costs on improved highway systems such as the Interstate Highway System are the reductions in fuel and oil consumption, lower tire wear, reduced maintenance and depreciation costs, and lower driver time requirements. The net value of reductions in these factors for different classifications of vehicles was estimated in a special study made by the Department of Commerce.⁷ Table IV shows the estimated savings (in cents per minute) reported from this study. The data show the average net value of time saved by using improved roads.

The next step in estimating the reductions in costs from using the Interstate Highway System is to estimate the amounts of time saved by using Interstate routes.

*It was assumed that the results of the regression analysis based on these 170 routes would also apply to all the routes specified in later chapters of this study.

⁷United States Department of Commerce, Final Report of the Highway Cost Allocation Study (Washington: Government Printing Office, 1961), p. 209.

TABLE IV

ESTIMATES OF THE VALUE OF A REDUCTION IN TIME CONSUMPTION
TO USERS OF HIGHWAY VEHICLES, 1961

Type of vehicle	Value of a reduction in time consumption per vehicle Cents per minute
Passenger car	2.37
Buses:	
Local and suburban	5.77
Intercity	7.52
Single unit trucks:	
2-axle, 4-tire	4.75
2-axle, 6-tire	5.02
3-axle	5.78
Tractor-semitrailer combinations:	
2-S1 (two-axle tractor, one-axle trailer)	5.53
2-S2 (two-axle tractor, two-axle trailer)	6.08
3-S2 (three-axle tractor, two-axle trailer)	6.50
Truck, full-trailer combinations:	
2-1 (two-axle tractor, one-axle trailer)	5.52
2-2 (two-axle tractor, two-axle trailer)	6.52
2-3 (two-axle tractor, three-axle trailer)	6.67
3-2 (three-axle tractor, two-axle trailer)	6.75
6 axles or more	6.87
Tractor-semitrailer and full-trailer combinations:	
All units	7.13

Source: United States Department of Commerce, Final Report of the Highway Cost Allocation Study (Washington: Government Printing Office, 1961), p. 209.

Since en route time is inversely related to average speed, differences in average speed were used to estimate the average time saved from use of the Interstate Highway routes. The time saved can then be multiplied by the estimated value of this time to arrive at a value of time saved. The procedure may be summarized as follows:

$$V_s = \left[\frac{x_{ij}}{s} - \frac{x_{ij}}{s'} \right] \cdot T_s \quad (7)$$

where

V_s = value of time saved from using Interstate Highway routes

x_{ij} = mileage between points i and j

s = estimated average speed on conventional highways

s' = estimated average speed on Interstate Highway routes

T_s = value per minute of time saved from using improved roads

It was shown above that there was no significant difference between the distances on conventional and Interstate Highways for a given sample of routes. Therefore, the mileage component of the value of time saved function was assumed to be the same for each set of routes, and speed, therefore, is the only relevant variable in determining time requirements under the two highway systems.

Average rates of speed for trucks using conventional and Interstate Highways were estimated to be 47.2 and 51.7 miles per hour, respectively.⁸ Since the value of time saved presented in Table IV,

⁸These speeds were estimated from weighted average speeds of trucks on different types of highways in 1963. Average speeds for trucks on completed rural Interstate routes and completed urban

page 41, is given in cents per minute, these average speeds must be converted to miles per minute. When this is done, an estimate of the value of savings per mile can be derived directly from equation (7).

As an example, consider a two-axle tractor and two-axle trailer combination (2-S2). The value of savings to this particular type of vehicle when used on the improved highway system is calculated as follows:

$$V_s = \left[\frac{x_{ij}}{.787} - \frac{x_{ij}}{.862} \right] \cdot 6.08 = .672 x_{ij} \quad (7')$$

III. TRANSPORTATION COSTS FOR INTERSTATE HIGHWAY SYSTEM

Following the discussion in the previous section, transfer functions for estimating costs on the Interstate System were derived by adjusting the original transfer functions for savings due to the improved roads. The appropriate adjustment factor for each commodity is the amount of savings in time as a result of using the Interstate System multiplied by the value of savings for the particular type of vehicle under consideration.

There is variability within each commodity class as to the type of vehicle used. However, a representative type of vehicle can

Interstate routes were 53.9 and 48.0 miles per hour, respectively. Average speeds of trucks on other highways (including Interstate not completed) ranged from 35.8 miles per hour for urban secondary to 49.6 miles per hour for rural Interstate not completed. The weights consisted of the proportion of the total national highway network included in the different types of highway groups for 1963. United States Department of Commerce, Traffic Speed Trends (Washington: Government Printing Office, 1964), p. 4.

be selected in dealing with practical problems.

The kind of information required to select "representative" types of vehicles is shown in Table V. The data in this table were compiled from information from a sample of for-hire truckers of agricultural commodities.⁹ The most common type of carrier reported for each commodity group is the tractor-semitrailer combination. However, there are three categories of vehicles within this group, each having a separate estimate of the value of a reduction in time (see Table IV, page 41). The weighted average of these values was 6.01 cents per minute of time saved for reductions in time consumption.¹⁰ This value was used in calculating the adjustment factor used to reflect savings from using the Interstate System.

Since the value 6.01 applies to each of the commodities under consideration, the value of time saved becomes:

$$V_s = \left[\frac{x_{ij}}{.787} - \frac{x_{ij}}{.862} \right] \cdot 6.01 = .664 x_{ij} \quad (8)$$

The adjusted transfer functions applicable to the Interstate System are presented below. The variables are the same as previously defined. Only the second degree equations are presented since these

⁹Bruce H. Wright, For-Hire Trucking of Exempt Farm Products, Operating Practices and Nature of Competition, U. S. Department of Agriculture, Economic Research Service (Washington: Government Printing Office, 1964), p. 19.

¹⁰The figures of 5.53, 6.08 and 6.50 from Table IV weighted by the estimated travel on the Interstate System at time of completion by these three types of vehicles.

TABLE V

EQUIPMENT OPERATED BY REGULAR FOR-HIRE CARRIERS OF EXEMPT
FARM PRODUCTS, BY KIND OF TRUCKER, 1961

Equipment operated on January 1, 1961	Kind of trucker							
	Produce		Milk		Livestock		Other	
	No.	%	No.	%	No.	%	No.	%
Straight trucks	35	9.3	76	29.2	83	17.4	13	5.3
Tractors	166	44.0	90	34.6	179	37.5	101	41.6
Semitrailers	172	45.6	93	35.8	201	42.1	123	50.6
Full trailers	4	1.1	1	0.4	14	3.0	6	2.5
Total	377	100.0	260	100.0	477	100.0	243	100.0

Source: Bruce H. Wright, For-Hire Trucking of Exempt Farm Products, Operating Practices and Nature of Competition, United States Department of Agriculture, Economic Research Service (Washington: Government Printing Office, 1964), p. 19.

were previously selected for use.

$$c_{ij} = .2682428 + .0014151X_{ij} - .0000004X_{ij}^2 \quad (9)$$

(Beef and pork)

$$c_{ij} = .4911752 + .0006925X_{ij} + .0000003X_{ij}^2 \quad (10)$$

(Broilers)

$$c_{ij} = .7910021 + .0023825X_{ij} - .0000009X_{ij}^2 \quad (11)$$

(Eggs)

These adjusted functions were used to estimate transportation costs in solving for the optimum movement patterns over the Interstate System. It is assumed that the completed Interstate System will result in lower transportation costs and that these lower costs are reflected in these adjusted transfer functions. A significant difference exists between the coefficients of the mileage variable in the original and adjusted function for each commodity.*

Transportation costs for each commodity between each of the areas delineated are given in Appendix B.¹¹

*A significant difference exists between the coefficients of the mileage variable for the adjusted and original function for each commodity at the .95 per cent level.

¹¹For the results from a similar development of transportation costs for eggs, see Harry B. Strawn, "The Estimated Economic Impact of the Interstate Highway System on the Marketing of Tennessee Eggs" (unpublished Master's thesis, The University of Tennessee, Knoxville, 1964).

CHAPTER IV

AREA DELINEATIONS AND DERIVATION OF AREA DEMAND FUNCTIONS

I. AREA DELINEATIONS

The ideal criterion for specification of analytically meaningful producing and consuming areas in a spatial-equilibrium analysis is homogeneity in respect to producing and consuming characteristics. An ideal breakdown of a large geographic area into small individual producing and consuming units is limited by various factors: (1) data availability, and (2) capacity of analytical and computational tools of analysis. In this study thirty regions were considered to be a computational maximum for each commodity because of constraints imposed by computing time requirements and computer capacities.*

Delineation of Areas for Beef and Pork

Once the total number of regions is determined, special characteristics of the commodities studied and the availability of data determine the final area delineations. Because most of the data inputs required for this study are available only on state bases, an entire state was the smallest permissible geographic unit used in this study.

*Considerably more time is required in solving spatial-equilibrium problems by reactive programming than by other methods because of the iterative process of determining the equilibrium flows and then determining the least-cost routes.

After delineating the areas, a town or city near the geographical center of each area generally was selected as representative of the area. The specification of the regions and the central points for the beef-pork analysis are given in Table VI.

Delineation of Areas for Broilers

Twenty-two states produced 93 per cent of the nation's broilers in 1962.¹ These twenty-two states were used as the bases for dividing the United States into thirty separate areas. The specification of these thirty areas and the related demand and supply points are given in Table VII.

Delineation of Areas for Eggs

Each of the six grand divisions of the nation* produced and sold approximately the same quantity of eggs in 1962.² These six divisions make up the basic market areas for the egg model and, in turn, were delineated into the thirty regions used in this study. The state(s) included in each of the areas and the demand and supply point for each area are given in Table VIII.

¹Economic Research Service, United States Department of Agriculture, Poultry and Egg Situation 230 (Washington: Government Printing Office, 1964), p. 9.

²Economic Research Service, United States Department of Agriculture, Poultry and Egg Situation 225 (Washington: Government Printing Office, 1963), p. 47.

*These divisions were: North Atlantic, East North Central, West North Central, South Atlantic, South Central and Western.

TABLE VI

REGIONAL SPECIFICATION AND DEMAND AND SUPPLY
POINTS, BEEF AND PORK, 1962

Region	State(s) included	Demand and supply points
1	Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont	Boston, Mass.
2	Delaware, Maryland, New Jersey, New York, Pennsylvania, Washington, D. C.	Philadelphia, Pa.
3	Virginia, West Virginia	Charleston, W. Va.
4	North Carolina	Raleigh
5	Georgia	Atlanta
6	South Carolina	Columbia
7	Florida	Orlando
8	Alabama	Montgomery
9	Mississippi	Jackson
10	Tennessee	Nashville
11	Kentucky	Lexington
12	Ohio	Columbus
13	Indiana	Indianapolis
14	Michigan	Grand Rapids
15	Illinois	Springfield
16	Wisconsin	Milwaukee
17	Arkansas, Louisiana	El Dorado, Ark.
18	Missouri	Columbia
19	Iowa	Des Moines
20	Minnesota	Minneapolis
21	North Dakota, South Dakota	Bismarck, N. D.
22	Nebraska	Grand Island
23	Kansas	Wichita
24	Oklahoma, Texas	Dallas, Texas
25	Arizona, New Mexico	Albuquerque, N. Mex.
26	Colorado	Denver
27	Montana, Wyoming	Billings, Mont.
28	Idaho, Nevada, Utah	Salt Lake City, Utah
29	Washington, Oregon	Portland, Ore.
30	California	Fresno

TABLE VII

REGIONAL SPECIFICATION AND DEMAND AND
SUPPLY POINTS, BROILERS, 1962

Region	State(s) included	Demand and supply points
1	Maine, New Hampshire	Bangor, Maine
2	New York, Vermont	Syracuse, New York
3	Massachusetts, Connecticut, Rhode Island	Boston, Massachusetts
4	New Jersey, Delaware	Atlantic City, New Jersey
5	Pennsylvania	Harrisburg
6	Maryland, Washington, D. C.	Washington, D. C.
7	West Virginia	Charleston
8	Virginia	Richmond
9	North Carolina	Raleigh
10	South Carolina	Columbia
11	Georgia	Macon
12	Florida	Orlando
13	Alabama	Birmingham
14	Mississippi	Jackson
15	Tennessee	Nashville
16	Kentucky	Lexington
17	Ohio	Columbus
18	Indiana	Indianapolis
19	Illinois	Springfield
20	Michigan	Grand Rapids
21	Wisconsin, Minnesota, Iowa	St. Paul, Minnesota
22	Missouri	Columbia
23	Arkansas	Little Rock
24	Louisiana	Alexandria
25	Texas	Fort Worth
26	Oklahoma, Kansas	Wichita, Kansas
27	Nebraska, Idaho, North Dakota, South Dakota, Montana, Wyoming	Sheridan, Wyoming
28	Utah, Colorado, Arizona, New Mexico	Durango, Colorado
29	Washington, Oregon	Spokane, Washington
30	California, Nevada	Fresno, California

TABLE VIII
REGIONAL SPECIFICATION AND DEMAND AND
SUPPLY POINTS, EGGS, 1962

Region	State(s) included	Demand and supply points
1	Maine, New Hampshire, Vermont, Massachusetts, Connecticut, Rhode Island	Boston, Massachusetts New York
2	New York	Syracuse, New York
3	Pennsylvania, New Jersey	Philadelphia, Pennsylvania
4	West Virginia	Charleston
5	Virginia, Maryland, Delaware, Washington, D. C.	Richmond, Virginia
6	North Carolina	Raleigh
7	South Carolina	Columbia
8	Georgia	Atlanta
9	Florida	Orlando
10	Alabama	Montgomery
11	Mississippi	Jackson
12	Tennessee	Nashville
13	Kentucky	Lexington
14	Ohio	Columbus
15	Indiana	Indianapolis
16	Michigan	Flint
17	Illinois	Springfield
18	Wisconsin	Madison
19	Minnesota	Minneapolis
20	Iowa	Des Moines
21	Missouri	Columbia
22	Arkansas	Little Rock
23	Louisiana	Alexandria
24	Texas, Oklahoma	Forth Worth, Texas
25	Nebraska, Kansas	Grand Island, Nebraska
26	North Dakota, South Dakota	Bismarck, North Dakota
27	Idaho, Montana, Wyoming	Billings, Montana
28	Utah, Colorado, Arizona, New Mexico	Farmington, New Mexico
29	Washington, Oregon	Portland, Oregon
30	California, Nevada	Fresno, California

II. AREA DEMAND FUNCTIONS

Ideally, a spatial-equilibrium analysis should use a separate demand function for each consuming area derived from data pertaining to that area alone. However, there are no adequate time-series data available of the type needed in deriving such regional demand relationships. The next best alternative, followed in this study, was to develop area demand functions from aggregate relationships by adjusting the independent variables for area differences.

A linear demand function of the following form was approximated for 1962 for each of the commodities included in this study:

$$x_1 = b_0 + b_1 x_2 + b_2 x_3 \quad (1)$$

where:

x_1 = average per capita consumption of the particular commodity in 1962

b_0 = equation constant

x_2 = average price per unit of the particular commodity in 1962

x_3 = average per capita disposable personal income in 1962

Estimates of b_1 and b_2 were derived from the definitional formulas of the price and income elasticities of demand and the average 1962 values of the variables specified in equation (1). The procedure is conveniently summarized in the following way:

$$e_p = \frac{\frac{\partial x_1}{\partial x_2} \cdot \frac{\bar{x}_2}{\bar{x}_1}}{\frac{\partial x_1}{\partial x_2} \cdot \frac{\bar{x}_2}{\bar{x}_1}}, \text{ and} \quad (2)$$

$$e_I = \frac{\frac{\partial x_1}{\partial x_3} \cdot \bar{x}_3}{\bar{x}_1} \quad (3)$$

where

e_p = price elasticity of demand

e_I = income elasticity of demand

A bar over a variable indicates the average value of that variable for 1962.

Since the demand equation to be derived for each commodity is to be linear, estimates of b_1 and b_2 are:

$$b_1 = e_p \cdot \frac{\bar{x}_1}{\bar{x}_2}, \text{ and} \quad (4)$$

$$b_2 = e_I \cdot \frac{\bar{x}_1}{\bar{x}_3} \quad (5)$$

The constant term becomes:

$$b_0 = \bar{x}_1 - b_1 \bar{x}_2 - b_2 \bar{x}_3 \quad (6)$$

Demand Function for Beef

The average per capita consumption of beef (carcass weight) in 1962 was 89.1 pounds; the average 1962 retail price of beef was 82.4 cents per pound; and the average per capita disposable personal income in 1962 was 2,057.60 dollars.³ This information, and an estimated price

³Economic Research Service, Economic and Statistical Analysis Division, United States Department of Agriculture, Consumption of Food in the United States, 1909-52, Supplement for 1962 to Agricultural Handbook No. 62 (Washington: Government Printing Office, 1963), p. 9; Economic Research Service, Statistical Reporting Service, United States

and income elasticity of demand of -0.95 and 0.47, respectively, provided the necessary data for deriving the aggregate linear demand function for beef.⁴ Converting the demand function to the form required for reactive programming resulted in the following demand function for beef:

$$x_2 = 128.371 - 0.97348x_1 + 0.01982x_3 \quad (7)$$

Demand Function for Pork

The average per capita consumption of pork (carcass weight) in 1962 was 63.9 pounds, and the average 1962 retail price of pork was 59.5 cents per pound.⁵ Estimates of the price and income elasticities of demand for pork of -0.75 and 0.32, respectively,⁶ in conjunction with this information, resulted in the following linear demand function for pork:

$$x_2 = 113.447 - 1.24152x_1 + 0.01232x_3 \quad (8)$$

Department of Agriculture, Livestock and Meat Statistics, 1962, Supplement for 1963 to Statistical Bulletin No. 333 (Washington: Government Printing Office, 1964), p. 140; and United States Department of Commerce, Survey of Current Business, XLV:4 (Washington: Government Printing Office, 1965), pp. 21-22.

⁴G. E. Brandow, Interrelations Among Demands for Farm Products and Implications for Control of Market Supply, Bulletin No. 680 (University Park: Pennsylvania Agricultural Experiment Station, 1961), p. 17.

⁵Economic Research Service, Consumption of Food in the United States, 1909-52, and Livestock and Meat Statistics, 1962, loc. cit.; and United States Department of Commerce, loc. cit.

⁶Brandow, loc. cit.

Demand Function for Broilers

The average 1962 per capita consumption of broilers was 27 pounds, and the average retail price of broilers in 1962 was 40.7 cents per pound.⁷ The estimated price and income elasticities of demand for broilers were -1.16027 and 0.37000, respectively.⁸ Based on these data, the following linear demand function for broilers was derived:

$$x_2 = 62.81305 - 1.29919x_1 + 0.00630x_3 \quad (9)$$

Demand Function for Eggs

Brandow estimated the price and income elasticities of demand for eggs to be -0.30 and 0.16, respectively.⁹ The average per capita consumption of eggs in the United States in 1962 was 27 dozen, and the average 1962 retail price of eggs was 51.8 cents per dozen.¹⁰ Based on these data, the following linear demand function for eggs was derived:

$$x_2 = 196.84018 - 6.39508x_1 + 0.01336x_3 \quad (10)$$

price *consumption* *personal*

Total Area Demand Functions

The consumption and income regression coefficients for each of the aggregate demand functions were assumed to apply to each area. *wow!*

⁷Economic Research Service, United States Department of Agriculture, Poultry and Egg Situation 225 (Washington: Government Printing Office, 1963), p. 52; Leo R. Gray, "Marketing Spreads for Eggs and Frying Chickens in the United States and Selected Cities," Marketing and Transportation Situation 148, Economic Research Service, United States Department of Agriculture (Washington: Government Printing Office, 1963), p. 16.

⁸Brandow, loc. cit.

⁹Ibid.

¹⁰Poultry and Egg Situation 225, loc. cit.

Total area demand functions for each commodity were derived by the following procedures:

1. Derive area per capita demand functions by adjusting the aggregate demand function for each commodity for the 1962 average per capita income in each area (Table IX).

2. Include the influence of income in each area for each demand function with the constant term since income is taken as given for each area for the year under consideration. This reduces equation (1) to the following form:

$$x_{2i} = b'_{oi} + b_1 x_1 \quad (11)$$

where

$$b'_{oi} = b_0 + b_2 x_{3i}, \quad (12)$$

and the subscript i refers to the i th area.

3. Derive a total demand function for each commodity in each area by adjusting the per capita demand functions by population in each area (Table IX). The final total demand function for each commodity in each area, then becomes:

$$x_{2i} = N_i b'_{oi} + b_1 x'_1 \quad (13)$$

where

N_i = 1962 population in area i , and

x'_1 = total supplies of each commodity in area i .

Area population and per capita disposable personal income for 1962 and the equation constants derived by following the above procedures are given in Table IX.

TABLE IX

POPULATION, PER CAPITA DISPOSABLE PERSONAL INCOME AND EQUATION CONSTANTS FOR BEEF, PORK, BROILER AND EGG DEMAND FUNCTIONS, BY REGION, UNITED STATES, 1962

Region ^a	Population in areas delineated			Per capita disposable personal income in areas delineated			Equation constants ^b			
	Beef and pork regions	Broiler regions	Egg regions	Beef and pork regions	Broiler regions	Egg regions	Beef regions	Pork regions	Broiler regions	Egg regions
	Thousands				Dollars			Million pounds		Million dozens
1	10,678	1,600	10,678	\$2,315.51	\$1,827.50	\$2,315.51	1,860.5347	1,516.0624	118.9280	2,432.2348
2	39,726	17,885	14,498	2,343.91	2,456.92	2,471.31	6,944.1048	5,654.2016	1,400.2167	3,332.5103
3	6,044	8,691	17,739	1,684.48	2,428.03	2,208.86	977.5566	811.1048	678.8540	4,015.2227
4	4,704	6,824	1,796	1,545.49	2,473.18	1,590.20	747.8890	623.2330	534.9334	391.6896
5	4,083	11,382	8,737	1,547.15	2,064.49	2,061.69	649.2787	541.0383	862.9832	1,960.4081
6	2,448	4,022	4,704	1,369.28	2,361.01	1,545.49	380.6640	319.0234	312.4692	1,023.0730
7	5,434	1,796	2,448	1,824.07	1,590.20	1,369.28	893.8930	738.5893	130.8027	526.6382
8	3,317	4,248	4,083	1,381.07	1,724.34	1,547.15	516.5564	432.7358	312.9926	888.0933
9	2,261	4,704	5,434	1,166.30	1,545.49	1,824.07	342.4737	289.0010	341.2752	1,202.0551
10	3,652	2,448	3,317	1,486.31	1,369.28	1,381.07	576.3221	481.1875	174.8851	714.1169
11	3,084	4,083	2,261	1,511.67	1,547.15	1,166.30	488.2589	407.3039	296.2620	480.2816
12	10,038	5,434	3,652	2,101.02	1,824.07	1,486.31	1,706.3596	1,398.5945	403.7462	791.3884
13	4,663	3,317	3,084	2,080.85	1,381.08	1,511.67	790.7982	648.5767	237.1987	669.3514
14	8,029	2,261	10,038	2,085.07	1,166.30	2,101.02	1,362.3607	1,117.1551	158.6318	2,257.6466
15	10,098	3,652	4,663	2,481.58	1,486.31	2,080.85	1,792.6979	1,454.3140	263.6014	1,047.4963
16	4,019	3,084	8,029	2,000.75	1,511.67	2,085.07	675.1920	555.0239	223.0966	1,804.1163
17	5,213	10,038	10,098	1,449.07	2,101.02	2,481.58	818.8580	684.4669	763.3899	2,322.4390
18	4,316	4,663	4,019	2,107.28	2,080.85	2,000.75	734.2379	601.6936	354.0150	898.5278
19	2,774	10,098	3,461	1,939.08	2,481.58	1,930.94	462.6479	380.9812	792.1881	770.5570
20	3,461	8,029	2,774	1,930.94	2,085.07	1,939.08	576.6718	474.9876	609.8026	617.9085
21	1,354	10,254	4,316	1,931.31	1,960.50	2,107.28	225.6170	185.8230	770.6906	971.0568
22	1,446	4,316	1,842	2,047.03	2,107.28	1,352.33	244.2583	200.5168	328.4476	395.8642
23	2,215	1,842	3,371	1,950.79	1,352.33	1,501.93	369.9493	304.5182	131.3899	731.2036
24	12,570	3,371	12,570	1,757.28	1,501.93	1,757.28	2,051.1726	1,698.2070	243.6559	2,769.4224
25	2,483	10,122	3,661	1,799.03	1,776.03	1,988.80	407.2368	336.7196	749.0280	817.9040
26	1,893	4,663	1,354	2,110.41	1,808.49	1,931.31	322.1507	263.9789	346.0412	301.4546
27	1,029	4,529	1,729	2,044.70	1,956.72	1,901.10	173.7775	142.6606	340.3091	384.2530
28	2,008	5,334	5,334	1,939.74	1,916.76	1,916.76	334.9344	275.7988	399.4633	1,186.5483
29	4,817	4,817	4,817	2,111.69	2,111.69	2,111.69	819.8534	671.8270	366.6700	1,084.0659
30	17,029	17,379	17,397	2,483.00	2,487.66	2,487.66	3,023.6692	2,452.8572	1,364.0777	3,998.5603
United States	184,886	184,886	184,886	2,057.60	2,057.60	2,057.60	31,271.618	24,662.177	14,010.661	41,477.325

^aRefers to the specified region for beef and pork, broilers or eggs (see Tables VI, VII, and VIII).

^bRefers to the value of N_{i0i} , in demand function for each commodity, where N_i = population in Area i and b_{0i} is as defined in text.

Source: Bureau of the Census, United States Department of Commerce, Statistical Abstract of the United States 1964 (Washington: Government Printing Office, 1964), p. 11; and United States Department of Commerce, Survey of Current Business, Vol. 45:4 (Washington: Government Printing Office, 1965), pp. 21-22.

CHAPTER V

ANALYSIS OF THE BEEF AND PORK SECTORS OF THE LIVESTOCK ECONOMY

The reactive programming model specified in Chapter II was used to determine the optimal movement patterns for beef and pork under 1962 demand and supply conditions under two transportation cost situations: (1) estimated costs for movement over the pre-Interstate road system, and (2) estimated costs for movement over a completed Interstate system. The criterion for optimality of movement patterns is minimization of the total cost of moving the required amounts of a given product from all supply centers to all the consuming centers.

I. AVAILABLE SUPPLIES AND ESTIMATES OF PROCESSING COSTS

In addition to the required input data pertaining to transportation costs and area demand functions--which were discussed in Chapters III and IV, respectively--the reactive programming analysis also required data pertaining to area supplies and processing costs.

Available Supplies

The supplies available for shipment from each region were assumed to be fixed during the time period (calendar year 1962) considered in the analysis. It was assumed also that beef and pork slaughter would be

production oriented. Therefore, the supplies available for shipment or consumption in each region would be the quantities of commercially slaughtered beef and pork reported by the Statistical Reporting Service of the United States Department of Agriculture for each region in 1962. These available supplies, by region, are given in Table X.

Processing Costs

The reactive programming analysis also required estimates of slaughtering plant costs for each supply area as data inputs. These data were required to determine the optimum allocation of any surplus supplies--supplies in addition to those required for consumption and/or outshipments for a given area under the optimum conditions--in the supply areas. Transfer costs used alone would determine the optimum level of shipments among the supply and consuming areas; used in connection with processing costs, would also determine the optimum allocation of any surplus supplies among the supply areas.

The processing cost data used in the analysis are based on findings of a study made by the Economic Research Service of the United States Department of Agriculture.¹ This study estimated that average processing costs per 100 pounds of carcass beef and pork were \$3.14 and \$3.15, respectively, in 1962. The findings also indicated that about

¹Donald B. Agnew, "Meatpackers' Costs and Spreads for Beef" and "Meatpackers' Costs for Slaughtering Hogs and Distributing Pork," Marketing and Transportation Situation-150 and 152, Economic Research Service, United States Department of Agriculture (Washington: Government Printing Office, August, 1963 and February, 1964), p. 37 and pp. 20-21, respectively.

TABLE X

AVAILABLE SUPPLIES AND ESTIMATES OF PROCESSING COSTS FOR
BEEF AND PORK, UNITED STATES AND REGIONS, 1962

Region	Available supplies (carcass weight)		Processing costs ^a	
	Beef	Pork	Beef	Pork
	1,000 pounds		Dollars/100 pounds	
1	129,474	90,295	3.14	3.15
2	1,235,279	829,945	3.14	3.15
3	141,485	300,304	2.69	2.69
4	85,867	158,032	2.50	2.50
5	158,614	218,498	2.86	2.79
6	44,923	58,842	2.55	2.55
7	176,532	65,722	2.64	2.65
8	109,063	95,657	2.77	2.77
9	145,705	99,612	2.73	2.74
10	221,748	320,459	3.05	2.06
11	95,946	199,709	3.09	3.10
12	647,468	555,490	3.14	3.15
13	415,630	735,001	3.23	3.25
14	419,347	232,249	3.14	3.15
15	723,779	834,650	3.33	3.34
16	539,744	452,808	3.37	3.39
17	126,532	67,755	2.73	2.74
18	631,892	572,965	3.33	3.34
19	1,754,519	2,086,751	3.37	3.39
20	827,419	812,954	3.64	3.65
21	353,935	381,952	3.37	3.39
22	1,331,769	659,822	3.33	3.34
23	610,390	417,058	3.14	3.15
24	940,096	333,026	3.33	3.34
25	147,954	32,839	3.28	3.01

TABLE X (continued)

Region	Available supplies (carcass weight)		Processing costs ^a	
	Beef	Pork	Beef	Pork
	1,000 pounds		Dollars/100 pounds	
26	682,569	89,795	3.28	3.29
27	63,447	42,924	3.19	3.20
28	274,580	56,056	3.19	3.20
29	416,070	158,869	3.28	3.29
30	1,493,734	239,835	3.42	3.43
United States	14,945,510	11,199,869	3.14	3.15

^aThe details of the procedure used in deriving these costs are given in Appendix C.

Source: Statistical Reporting Service, Crop Reporting Board, U. S. Department of Agriculture, Livestock Slaughter 1962 (Washington: Government Printing Office, 1963), pp. 13 and 25; and Economic Research Service, Agricultural Marketing Service, U. S. Department of Commerce, Livestock and Meat Statistics, 1962, Statistical Bulletin No. 333 (Washington: Government Printing Office, 1963), pp. 158 and 205.

50 per cent of the slaughter costs for both species was accounted for by labor. It was reported also that variations in labor costs accounted for most of the differences in total slaughtering costs among regions.² It was assumed, therefore, that area differences in slaughter costs for both species could be obtained by adjusting the average slaughtering costs reported in the Department of Agriculture study for regional differences in wage rates. The wage rates used were those reported to have been paid in each region in 1962 by meat packing plants processing beef and pork. The details of the procedure used to estimate the slaughter costs by area are given in Appendix C. These slaughter cost estimates are given in Table X, page 60.

II. THE EMPIRICAL RESULTS--BEEF

Optimum Interregional Movements Over the Present Highway System

The detailed data pertaining to the results of the analysis for beef using the present highway system are given in Appendix D, Table XXX. Figure 2 summarizes these data in the form of a flow chart. The flow chart describes the interregional movements of beef which would have existed--under the assumed conditions--if least cost routes had been used in 1962 to meet all the demands specified in each of the consuming areas.

The optimal movement pattern would have resulted in a total shipment volume of 8,175 million pounds of beef. The total transfer cost

²Ibid.

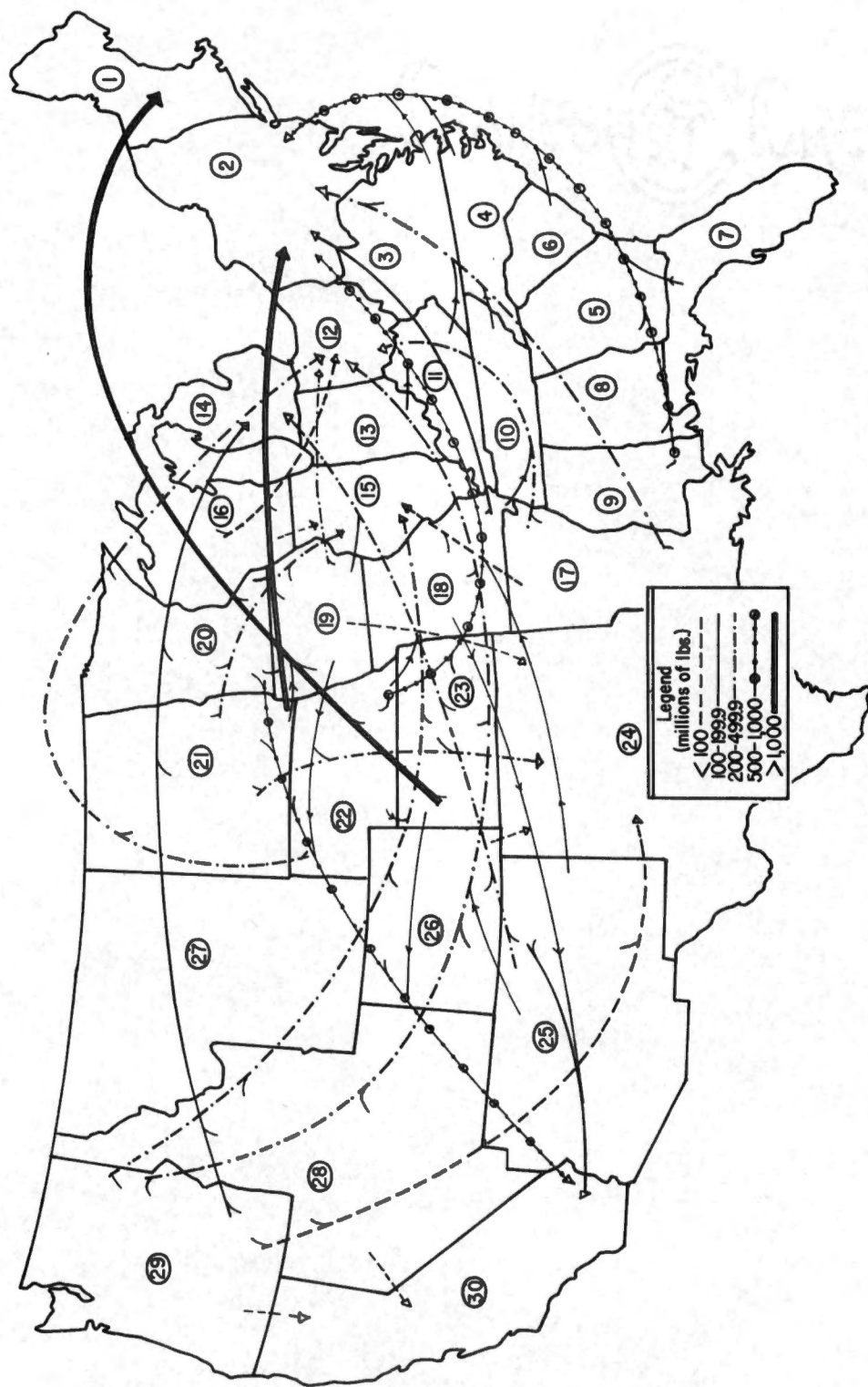


Figure 2. Optimum interregional shipment patterns of beef using estimated transportation costs over the pre-Interstate Highway system, United States, 1962.

bill for this "ideal" situation would have been approximately 139 million dollars.

Figure 2 shows that a few regions would have had large deficits and would have received all of the outshipments that would have occurred under the conditions specified. These regions--Region 1 (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont), 2 (Delaware, Maryland, New Jersey, New York, Pennsylvania, and Washington, D. C.), 12 (Ohio), 14 (Michigan), 15 (Illinois), 24 (Oklahoma and Texas), and 30 (California)--would have accounted for 100 per cent of the beef imports. Regions 19 (Iowa), 20 (Minnesota), 21 (North and South Dakota), 22 (Nebraska), and 23 (Kansas) would have supplied approximately 57 per cent of the beef shipped into these deficit areas.

Optimum Interregional Movements Over the Completed Interstate Highway System

The detailed data pertaining to the results of the analysis for beef using the completed Interstate Highway System are given in Appendix D, Table XXXIII. The same movement patterns summarized in Figure 2 generally describe the optimal shipping routes over the completed Interstate System. About 8,186 million pounds of beef would have been shipped in this situation at a total transfer cost of nearly 99 million dollars.

Comparison of the Optimal Beef Movement Patterns

The optimal movement patterns for the two situations indicate that the lower transportation costs associated with the Interstate System would have little effect on the general movement patterns of beef.

Surplus and deficit regions would have been the same in both cases. However, the total shipments of beef for the optimum solution over the Interstate System would have been 11 million pounds greater than that for the pre-Interstate system. In relation to total shipments, however, this increase would have amounted to less than 1 per cent.

Total transfer costs would have been approximately 40 million dollars less for the optimal movement pattern over a completed Interstate Highway System than for the optimal movement pattern over the present highway system. This decrease would have been the result of lower transportation costs for shipping approximately the same quantity of beef over a completed Interstate Highway System as would have been shipped over the present highway system at higher transportation costs. This decrease of approximately 29 per cent in the total transfer costs, as compared to a less than 1 per cent increase in total shipments, indicates that the demand for beef transport services is highly inelastic.

Even though total shipments would have increased only slightly if there had been a completed Interstate Highway System, the amount of the outshipments from each of the surplus areas would have been different under the two alternative sets of conditions. The deficit regions would have been the same in the two situations. These changes in the origins of the outshipments to the various deficit regions indicates that a change would have occurred in the competitive positions of the shipping regions. This change in the competitive positions of the shipping regions would have been the result of the greater accessibility to the

deficit regions for certain of the shipping regions caused by the completed Interstate System.

Table XI shows the total amounts of beef that would have been shipped from areas specified as surplus under each of the two road systems. Also shown are the net differences in the outshipments that would have been made in each of the two alternative highway situations.

The changes in the accessibility to the deficit areas of certain of the shipping regions caused by a completed Interstate Highway System would, as discussed above, affect the competitive advantages of some of the shipping regions. The competitive advantages of Regions 7 (Florida), 17 (Arkansas and Louisiana), and 29 (Washington and Oregon) would have been increased as a result of their greater accessibility to the various consuming areas caused by a completed Interstate Highway System (see Table XI). The net effects of the greater accessibility of these shipping areas to the various consuming areas would have caused a decrease in the competitive advantages of Regions 25 (Arizona and New Mexico), and 28 (Idaho, Nevada, and Utah). There would also have been some minor shifts in the competitive advantages of other shipping regions (see Table XI).

A reactive programming solution to a distribution problem, as discussed in Chapter II and Appendix A, is obtained by evaluating the net price in each market and allocating shipments from each supply area to the markets returning the highest net price. In the final solution, each market to which outshipments are made from any given shipping area must provide approximately the same net revenue to shippers in those areas.

TABLE XI

TOTAL EQUILIBRIUM SHIPMENTS OF BEEF FROM SPECIFIED REGIONS,
AND NET CHANGE IN SHIPMENTS AND REVENUES FROM PRESENT
TO INTERSTATE HIGHWAY SYSTEM, UNITED STATES, 1962

Shipping region ^a	Total shipments		Net difference in shipments		Change in net price at point of shipment ^b (decrease)
	Present highway system	Interstate highway system			
	Million pounds		Absolute	Percentage	Dollars per million pounds
3	140.9	141.5	0.6	0.4	213
4	85.7	85.8	0.1	0.1	213
5	158.6	158.6	0.0	0.0	211
6	44.9	44.9	0.0	0.0	212
7	158.5	175.3	16.8	10.6	210
8	109.1	109.1	0.0	0.0	211
9	143.4	145.7	2.3	1.6	210
10	221.7	221.7	0.0	0.0	211
11	95.9	95.9	0.0	0.0	212
13	415.0	415.6	0.6	0.1	211
16	525.0	511.3	-13.7	-2.6	217
17	94.8	117.3	22.5	23.7	220
18	617.0	631.7	14.7	2.4	222
19	1738.6	1726.0	-12.6	-0.7	218
20	826.6	826.2	-0.4	0.0	217
21	353.8	343.0	-10.8	-3.1	216
22	1268.7	1266.3	-2.4	-0.2	225
23	474.8	473.9	-0.9	-0.2	219
25	72.7	62.1	-10.6	-14.6	223
26	357.9	353.9	-4.0	-1.1	223
28	134.6	121.1	-13.5	-10.0	224
29	137.0	159.8	22.8	16.6	224
United States	8175.0	8186.3	11.1	0.1	

^aThere was no change in surplus and deficit regions for the two situations.

^bChange from present to Interstate situation. Actual Revenues for each region are presented in Appendix D, Tables XXXI and XXXIII.

Net price in a reactive programming analysis is defined as the difference between (1) the price per unit in a particular consuming area, and (2) the per unit transfer and processing costs associated with processing the product and shipping it from the various shipping areas to the consuming area. Thus, the net price in each shipping area plus the costs of processing and transfer to the various consuming areas is equal to the final price in the consuming areas. The net prices associated with the optimal shipping routes (i.e., those that result in a minimum total transportation bill) for each of the alternative highway conditions are given in Appendix D.

The change in the weighted average net revenues from each shipping area between the two alternative situations are given in Table XI, page 67. For each of the shipping regions, the average net revenue for the optimum situation over a completed Interstate System would have been lower than for the optimum situation over the present highway system. Within the framework of the comparative statics analysis presented, it is concluded, therefore, that this decrease would result in a lower price in each market. This decrease would have amounted to only a fraction of a cent per pound. To regions shipping large quantities of beef, however, this would amount to around 220 dollars per million pounds. This decrease would have been the result of the lower transportation costs for shipping over this Interstate System.

III. THE EMPIRICAL RESULTS--PORK

Optimum Interregional Movements Over the Present Highway System

The detailed data pertaining to the results of the analysis for pork using the present highway system are given in Appendix D, Table XXXVI. Figure 3 summarizes these data in the form of a flow chart, which would describe the interregional movements of pork--under the assumed conditions--if least cost routes had been used in 1962 to meet all the demands specified in each of the consuming areas.

The optimal movement pattern would have resulted in a total shipment volume of 6,681 million pounds of pork. The total transfer cost bill for this optimum situation would have been about 113 million dollars.

Region 2 (Delaware, Maryland, New Jersey, New York, Pennsylvania, and Washington, D. C.) would have been the largest deficit area. The demand in this Region would have been large enough, mainly because of its population density, to elicit profitable shipments from all the regions specified as surplus. Region 19 (Iowa) would have supplied about one third of the net total 3,317 million pounds of pork that would have been imported by Region 2.

In total, Regions 1 (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, and Vermont), 2 (Delaware, Maryland, New Jersey, New York, Pennsylvania, and Washington, D. C.), 7 (Florida), 12 (Ohio), 14 (Michigan), 24 (Oklahoma and Texas), and 30 (California) would take 97 per cent of all the outshipments of pork that would have been made

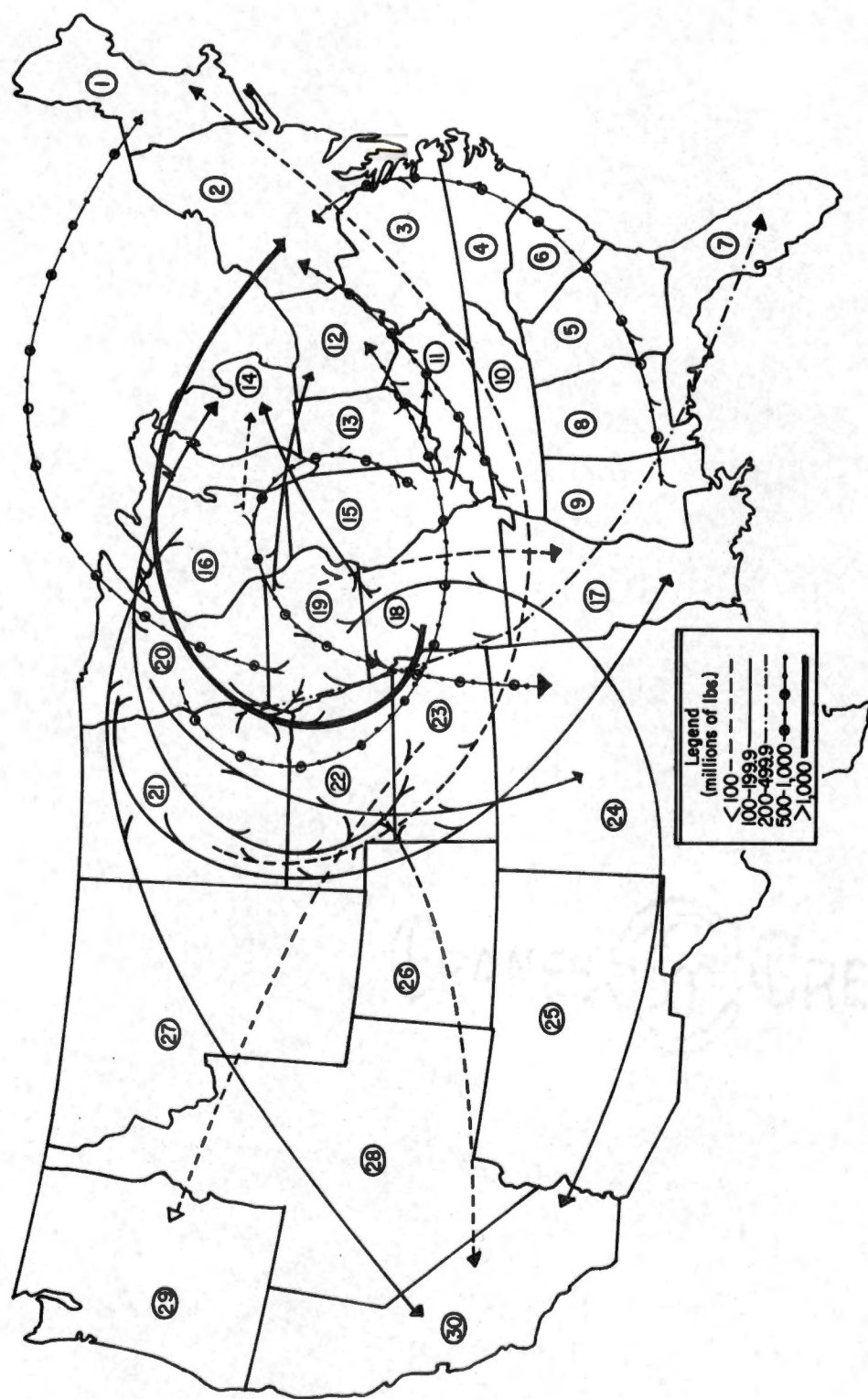


Figure 3. Optimum interregional shipment patterns of pork using estimated transportation costs over the pre-Interstate Highway system, United States, 1962.

over the pre-Interstate system. The North Central States (Iowa, Minnesota, North and South Dakota, Nebraska, and Kansas) would have supplied approximately 50 per cent of the pork imported by areas specified as deficit.

Optimum Interregional Movements Over the Completed Interstate Highway System

The detailed data pertaining to the results of the analysis for pork using the completed Interstate Highway System are given in Appendix D, Table XXXVIII. The same movement patterns summarized in Figure 3 generally describe the optimal shipping routes over the completed Interstate System. About 6,685 million pounds of pork would have been shipped in this situation at a total transfer cost of approximately 80 million dollars.

Comparison of the Optimal Pork Movements

The optimal movement pattern for the two situations indicate that the lower transportation costs associated with the Interstate System would have little effect on the general movement patterns of pork. Surplus and deficit regions would have been the same in both cases. However, the total shipments of pork for the optimum solution over the Interstate System would have been about 4 million pounds greater than that for the pre-Interstate system. In relation to total shipments, however, this increase would amount to less than 1 per cent.

Total transfer costs would have been approximately 33 million dollars less for the optimal movement pattern over a completed Interstate

Highway System than for the optimal movement pattern over the pre-Interstate System. This decrease would have been the result of lower transportation costs for shipping approximately the same quantity of pork over a completed Interstate System as would have been shipped over the present highway system at higher transportation costs. This decrease in total transfer costs of approximately 29 per cent, as compared to a less than 1 per cent increase in total shipments, indicates that the demand for pork transport services is highly inelastic.

The total quantities that would have been imported by each of the deficit regions would have been about the same with either road system (see Tables XXXVI and XXXVIII in Appendix D). The reason for the lack of change is that the magnitudes of the surpluses and deficits would have been too great to be affected by differences in transportation costs that would have existed between the alternative road systems.

Even though total shipments of pork would have increased only slightly if there had been a completed Interstate Highway System, there could have been some changes in the competitive positions of the shipping regions. Changes in the competitive positions of the shipping regions could occur because of the greater accessibility of some of the shipping regions to certain of the areas specified as deficit as a result of the completed Interstate System (see discussion entitled "Comparison of the Optimal Beef Movements" in a previous section of this chapter).

Table XII shows the amounts of pork that would have been exported by each surplus region over each highway system, and any differences in total shipments over the two alternative highway systems. The small

TABLE XII

TOTAL EQUILIBRIUM SHIPMENTS OF PORK FROM SPECIFIED REGIONS,
AND NET CHANGE IN SHIPMENTS AND REVENUES FROM PRESENT
TO INTERSTATE HIGHWAY SYSTEM, UNITED STATES, 1962

Shipping region ^a	Total shipments		Net difference in shipments		Change in net price at point of shipment ^b (decrease)
	Present highway system	Interstate highway system			
	Million pounds		Absolute	Percentage	Dollars per million pounds
3	300.3	296.2	-4.0	-1.3	169
4	158.0	157.6	-0.4	-0.3	169
5	218.4	212.2	-6.2	-2.8	170
6	58.8	58.8	0.0	0.0	170
8	95.6	95.6	0.0	0.0	171
9	99.6	99.2	-0.4	-0.4	171
10	160.2	160.1	-0.1	-0.1	171
11	199.1	199.6	0.5	0.3	169
13	735.0	734.0	-1.0	-0.1	169
15	350.0	355.2	5.2	1.5	168
16	374.0	373.5	-0.5	-0.1	170
18	484.9	485.2	0.3	0.1	170
19	2037.7	2037.3	-0.4	0.0	170
20	681.0	689.1	8.1	1.2	170
21	135.2	136.9	1.7	1.3	169
22	379.1	379.1	0.0	0.0	169
23	214.4	214.8	0.4	0.2	169
United States	6681.3	6684.5	3.2	0.04	

^aThere was no change in surplus and deficit regions for the two situations.

^bChange from present to Interstate situation. Actual revenues for each region are presented in Appendix D, Tables XXXVII and XXXIX.

percentage changes in the outshipments from the surplus regions suggest that there would have been no significant changes in the competitive positions among surplus regions as a result of the Interstate System. The regions specified as surplus and deficit in each situation would have been the same, and, thus, if the completed Interstate System had resulted in certain of the consuming areas becoming more accessible to certain of the shipping areas, then there would have been some changes in the amounts of the outshipments from the surplus to the deficit regions.

For each of the shipping regions, the average net revenue for the optimal movement pattern over a completed Interstate System would have been lower than for the optimal movement pattern over the pre-Interstate system (see discussion in previous section of this chapter entitled "Comparison of Optimal Beef Movements"). This decrease, however, would have amounted to less than one cent per pound in each market. With almost identical amounts of pork shipped into each of the consuming areas for both situations the prices in each market would have been almost identical also. The lower net price is, then, the result of lower transportation costs over the completed Interstate System.

CHAPTER VI

ANALYSIS OF THE BROILER SECTOR OF THE POULTRY INDUSTRY

The reactive programming model applied to the beef and pork sectors was also used to determine the optimal movement patterns for broilers under 1962 demand and supply conditions under two transportation cost situations: (1) estimated costs for movement over the pre-Interstate road system, and (2) estimated costs for movement over a completed Interstate Highway System. Again, the criterion for optimality of movement patterns is minimization of the total cost of moving the required amounts of a given product from all supply centers to all the consuming centers.

I. AVAILABLE SUPPLIES AND ESTIMATES OF PROCESSING COSTS

In addition to the required input data pertaining to transportation costs and area demand functions--which were discussed in Chapters III and IV, respectively--the reactive programming analysis also required data pertaining to area supplies and processing costs.

Available Supplies

The supplies of broilers available for shipment from each region were assumed to be fixed during the time period (calendar year 1962) considered in the analysis. It was assumed also that broiler slaughtering and processing would be production oriented. Therefore, the supplies

available for shipment or consumption in each region would be the quantities of commercially slaughtered broilers reported by the Economic Research Service of the United States Department of Agriculture for each region in 1962. These available supplies, by region, are given in Table XIII.

Processing Costs

The reactive programming analysis also required estimates of slaughtering plant costs for each supply area as data inputs. These data were required to determine the optimum allocation of any surplus supplies--supplies in addition to those required for consumption and/or outshipments for a given area under the optimum conditions--in the supply areas. Transfer costs used alone would determine the optimum level of shipments among the supply and consuming area; when used in connection with processing costs, they would also determine the optimum allocation of any surplus supplies in the supply areas.

The processing cost data used in the analysis are based on findings of a study by Henry, Chappell and Seagraves at the North Carolina Agricultural Experiment Station.¹ This study estimated that the average processing cost per 100 pounds of broilers (carcass weight) was 3.00 dollars. The findings of this study also indicated that about 50 per cent of the slaughter costs was accounted for by labor, and that

¹W. R. Henry, J. S. Chappell, and J. A. Seagraves, Broiler Production Density, Plant Size, Alternative Operating Plans, and Total Unit Costs, technical Bulletin No. 1144 (Raleigh: North Carolina Agricultural Experiment Station, 1960).

TABLE XIII

AVAILABLE SUPPLIES AND ESTIMATES OF PROCESSING COSTS FOR
BROILERS, UNITED STATES AND REGIONS, 1962

Region	Available supplies 1,000 pounds	Processing costs ^a Dollars per 100 pounds
1	190,625	2.91
2	22,495	3.05
3	60,274	3.09
4	265,013	3.05
5	106,570	3.00
6	326,078	2.96
7	50,595	2.87
8	105,561	2.87
9	499,324	2.87
10	49,520	2.73
11	843,654	2.82
12	27,428	2.73
13	512,809	2.82
14	333,083	2.73
15	81,949	2.87
16	38,520	2.96
17	28,016	3.00
18	77,540	3.00
19	8,108	3.00
20	9,171	3.00
21	88,225	2.91
22	91,199	2.82
23	561,858	2.82
24	57,331	2.82
25	299,922	2.78

TABLE XIII (continued)

Region	Available supplies	Processing costs ^a
	1,000 pounds	Dollars per 100 pounds
26	21,981	2.89
27	13,164	2.96
28	6,277	2.96
29	65,713	3.50
30	157,209	3.32
United States	4,998,214	3.00

^aThe details of the procedure used in deriving these costs are given in Appendix C.

Source: Economic Research Service, United States Department of Agriculture, Poultry and Egg Situation 225 (Washington: Government Printing Office, 1963), p. 52; and United States Department of Agriculture, Agricultural Statistics 1963 (Washington: Government Printing Office, 1963), p. 419.

variations in labor costs accounted for most of the differences in total slaughtering costs among regions.² It was assumed, therefore, that area differences in slaughter costs could be obtained by adjusting the average slaughtering costs reported in this study for regional differences in wage rates. The wage rates used were those reported to have been paid in each region in 1962 by poultry processing plants. The details of the procedure used to estimate the slaughter costs by area are given in Appendix C. These slaughter cost estimates are given in Table XIII, page 77.

II. THE EMPIRICAL RESULTS

Optimum Interregional Movements Over the Present Highway System

The detailed data pertaining to the results of the analysis for broilers using the present highway system are given in Appendix D, Table XLII. Figure 4 summarizes these data in the form of a flow chart. The flow chart describes the interregional movements of broilers which would have existed--under the assumed conditions--if least-cost routes had been used in 1962 to meet all the demands specified in each of the consuming areas.

The optimal movement pattern would have resulted in a total shipment volume of 3,021 million pounds of broilers. The total transfer cost bill for this optimum situation would have been approximately 49 million dollars.

²Ibid., p. 38.

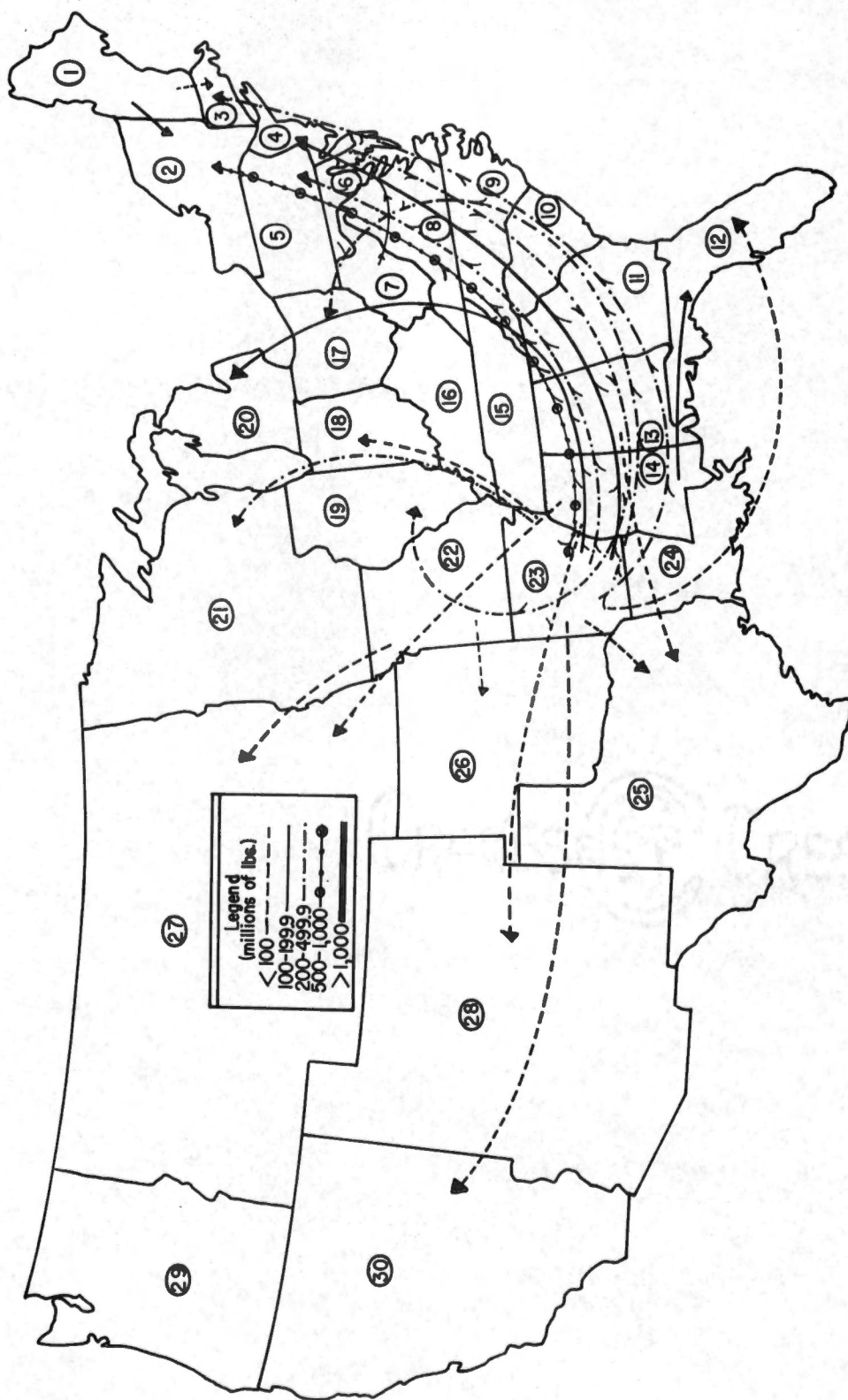


Figure 4. Optimum interregional shipment patterns of broilers using estimated transportation costs over the pre-Interstate Highway system, United States, 1962.

Regions 2 (New York and Vermont), 3 (Massachusetts, Connecticut, and Rhode Island), 4 (New Jersey and Delaware), 5 (Pennsylvania), 12 (Florida), 17 (Ohio), 19 (Illinois), 20 (Michigan), and 21 (Wisconsin, Minnesota, and Iowa) would have accounted for approximately 94 per cent of the broiler imports in this optimal situation. Regions 1 (Maine and New Hampshire), 6 (Maryland), 9 (North Carolina), 11 (Georgia), 13 (Alabama), 14 (Mississippi), and 23 (Arkansas) would have supplied 94 per cent of the broilers imported by these deficit areas in this equilibrium situation. The Southeastern states of Georgia, North Carolina, and Alabama would have supplied over one-half of the total interregional shipments of broilers in this optimal situation.

Optimum Interregional Movements Over the Completed Interstate Highway System

The detailed data pertaining to the results of the analysis for broilers using the completed Interstate Highway System are given in Appendix D, Table XLIV. Figure 5 summarizes these data in the form of a flow chart. About 3,010 million pounds of broilers would have been shipped in this optimal situation at a total transfer cost of approximately 37 million dollars. The same movement patterns summarized in the previous section generally apply to this situation also. In a few instances, however, there would have been some changes in the movement patterns for the two situations. These differences are discussed in the following section.

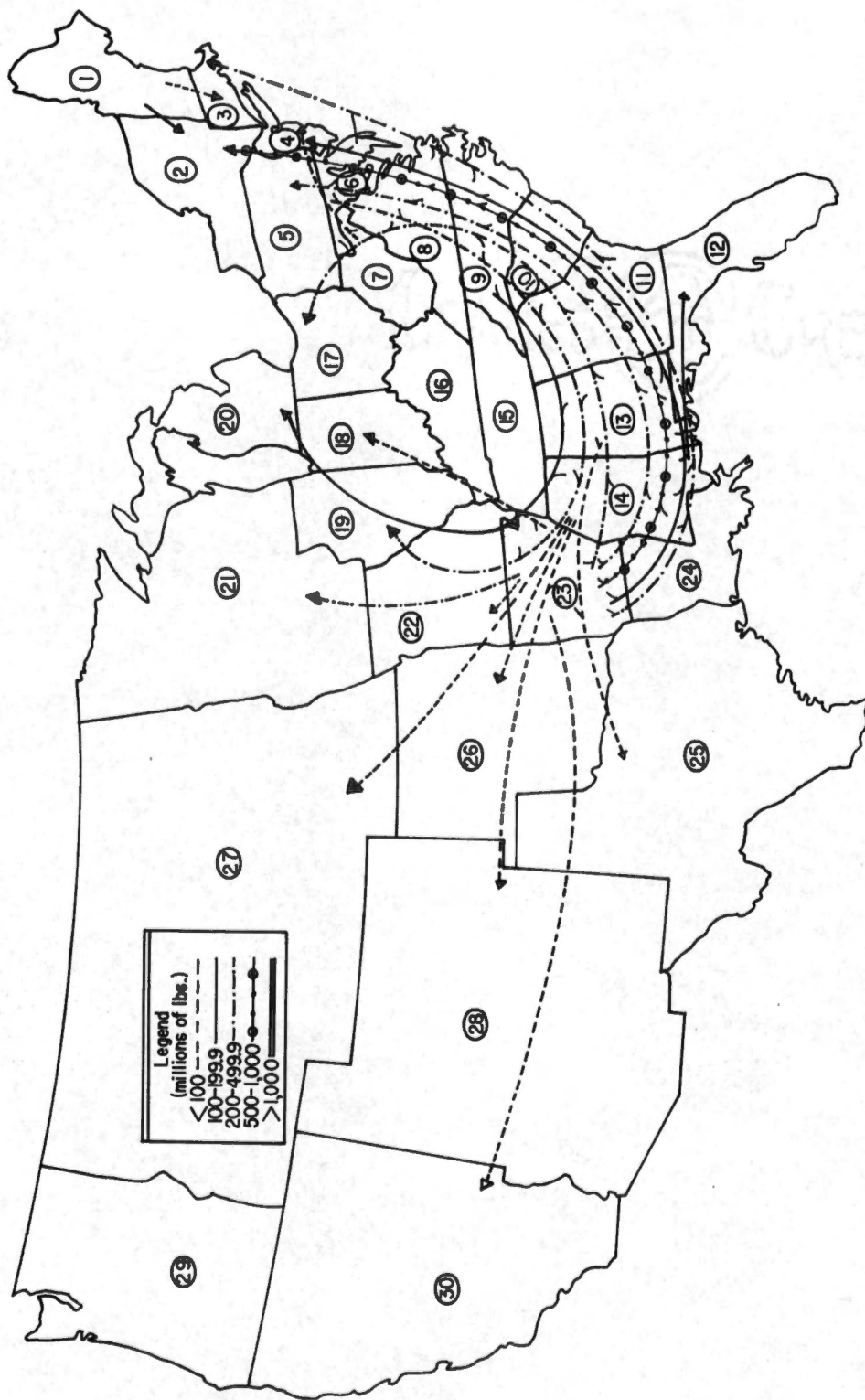


Figure 5. Optimum interregional shipment patterns of broilers using estimated transportation costs over a completed Interstate Highway system, United States, 1962.

Comparison of the Optimal Broiler Movement Patterns

the optimal movement patterns for the two situations indicate that the lower transportation costs associated with the Interstate System would have little effect on the total shipments of broilers, but would have a substantial effect on total transfer cost. Total shipments of broilers for the optimal situation over the Interstate System would have been 11 million pounds less than for the pre-Interstate system. In relation to total shipments, however, this decrease would have amounted to less than 1 per cent. This decrease would have been the result of changes in the outshipments from the various shipping regions for the two situations which will be discussed in more detail below.

Total transfer costs would have been approximately 12 million dollars less for the optimal movement pattern over a completed Interstate System than for the optimal movement pattern over the pre-Interstate system. This decrease would have been the result of the lower transportation costs for shipping approximately the same quantity of broilers over a completed Interstate Highway System as would have been shipped over the present highway system at higher transportation costs. This decrease of approximately 26 per cent in the total transfer costs, as compared to a less than 1 per cent decrease in total shipments, indicates that the demand for broiler transport services is highly inelastic.

Even though total shipments would have been approximately the same if there had been a completed Interstate System, the amount of the outshipments from the various surplus areas, and the areas specified as

surplus or deficit, would have been different under the two alternative sets of conditions. Region 22 (Missouri) would have shifted from a surplus area for the optimum situation over the pre-Interstate system to a deficit area for the optimum situation over a completed Interstate System. This region would have been surplus by only a small amount in the initial situation--exporting approximately 26 million pounds of broilers--and the difference in transportation costs for the two highway systems would have resulted in its becoming a deficit area for the situation based on a completed Interstate System--importing about 27 million pounds of broilers.

With the exception of Region 22 (Missouri), the same regions would have been either surplus or deficit in both cases. However, the amount of the outshipments from some of the surplus areas would have been different under the two alternative sets of conditions. These changes in the origins of the outshipments to the various deficit areas indicates that a change would have occurred in the competitive positions of the shipping regions. This change in the competitive positions of the shipping regions would have been the result of the greater accessibility to the deficit regions for certain of the shipping regions caused by the completed Interstate System.

Table XIV shows the total amounts of broilers that would have been shipped from areas specified as surplus under each of the two road systems. Also shown are the net differences in the outshipments that would have been made over each of the two road systems.

TABLE XIV

TOTAL EQUILIBRIUM SHIPMENTS OF BROILERS FROM SPECIFIED
REGIONS AND NET CHANGE IN SHIPMENTS AND REVENUES
FROM PRESENT TO INTERSTATE HIGHWAY SYSTEM,
UNITED STATES, 1962

Shipping region	Total shipments		Net difference in shipments		Change in net price at point of shipment ^a
	Present highway system	Interstate highway system	Absolute	Percentage	(decrease)
	Million pounds				Dollars per million pounds
1	177.5	181.7	4.2	2.4	90
6	247.0	258.2	11.2	4.5	100
7	12.8	14.2	1.4	10.9	119
8	76.0	77.5	1.5	2.0	90
9	420.9	419.1	-1.8	-0.4	100
11	749.5	742.7	-6.8	-0.9	113
13	489.9	485.9	-4.0	-0.8	113
14	293.9	299.8	5.9	2.0	114
22	26.3	b	b	b	b
23	526.9	530.5	3.6	0.7	110

^aChange from present to Interstate situation. Actual revenues from each region are presented in Appendix D, Tables XLIII and XLV.

^bThis area changed from surplus to deficit in moving from the present highway situation to the Interstate Highway situation.

Changes in the accessibility to the deficit areas of certain of the shipping areas caused by a completed Interstate Highway System would, as discussed above, affect the competitive advantages of some of the shipping regions. Measured in this way, the competitive advantages of Regions 9 (North Carolina), 11 (Georgia), and 13 (Alabama) would have been decreased as a result of the greater accessibility of other shipping areas to the various consuming areas caused by a completed Interstate System. These regions, however, would have been the largest exporters of broilers in both situations, and the decrease in quantities shipped would have been less than 1 per cent for each of these regions (see Table XIV, page 85). The competitive advantages of Regions 6 (Maryland) and 7 (West Virginia) would have been increased as a result of their greater accessibility to the specified deficit areas (see Table XIV, page 85).

The change in the weighted average net revenues from each shipping area for the two alternative situations are given in Table XIV, page 85.* For each of the shipping areas, this average net revenue for the optimum situation over a completed Interstate System would have been lower than for the optimum situation over the pre-Interstate system. This decrease would have been less than 1 cent per pound. Again, this is the result of almost identical shipments into each of the consuming areas for the two situations. The decrease in net prices was, therefore, the result of lower transportation costs associated with the Interstate Highway System.

*See discussion on page 66.

CHAPTER VII

ANALYSIS OF THE EGG SECTOR OF THE POULTRY INDUSTRY

The reactive programming model specified in Chapter II and applied to the beef, pork and broiler sectors was also used to determine the optimal movement patterns for eggs under 1962 demand and supply conditions for two alternative transportation costs situations: (1) estimated costs for movement over the pre-Interstate road system, and (2) estimated costs for movement over a completed Interstate Highway System. Again, the criterion for optimality of movement patterns is minimization of the total cost of moving the required amounts of a given product from all supply centers to all the consuming centers.

I. AVAILABLE SUPPLIES

It was assumed that transportation costs account for most of the producer-to-retailer marketing spreads for eggs, and, therefore, no attempt was made to estimate assembly or handling charges in addition to the transportation costs.

The supplies of eggs available for shipment from each region were assumed to be fixed for the time period (calendar year 1962) considered in the analysis. These supplies were the quantities of eggs available for shipment or consumption in each area as reported by the Economic Research Service of the United States Department of Agriculture for 1962 (see Table XV).

TABLE XV
AVAILABLE SUPPLIES OF EGGS BY AREA,
UNITED STATES, 1962

Region	Available supplies Million dozens
1	221.17
2	144.25
3	414.75
4	25.50
5	115.50
6	178.33
7	73.50
8	207.92
9	100.58
10	130.83
11	116.50
12	64.67
13	58.17
14	197.33
15	184.25
16	104.92
17	180.83
18	152.25
19	261.58
20	353.75
21	132.25
22	119.25
23	37.25
24	239.17
25	211.25
26	158.17
27	37.25
28	70.50
29	130.42
30	573.33
United States	4,995.41

Source: Economic Research Service, United States Department of Agriculture, Poultry and Egg Situation-225 (Washington: Government Printing Office, 1963), p. 47.

The required input data--for a reactive programming analysis--pertaining to transportation costs and area demand functions are given in Chapters III and IV, respectively.

II. THE EMPIRICAL RESULTS

Optimum Interregional Movements Over the Present Highway System

The detailed data pertaining to the results of the analysis for eggs using the present highway system are given in Appendix D, Table XLVIII. Figure 6 summarizes these data in the form of a flow chart which describes what the interregional movements of eggs would have been--under the assumed conditions--if least-cost routes had been used in 1962 to meet all the demands specified in each of the consuming areas.

The optimal movement pattern would have resulted in a total shipment volume of 1,133 million dozen eggs. The total transfer cost bill for this situation would have been approximately 28 million dollars.

Figure 6 shows that Region 17 (Illinois) would have imported the largest quantity of eggs (approximately 178 million dozen) in this optimal situation. The largest proportion of the imports into Illinois would have come from Regions 19 (Minnesota) and 20 (Iowa). Regions 1 (Maine, New Hampshire, Vermont, Massachusetts, Connecticut, and Rhode Island), 2 (New York), 3 (Pennsylvania and New Jersey), 5 (Virginia, Maryland, Delaware, and Washington, D. C.), 14 (Ohio), 15 (Michigan), 24 (Texas and Oklahoma), and 28 (Utah, Colorado, Arizona, and New Mexico) would also have been major egg markets in this optimal situation.

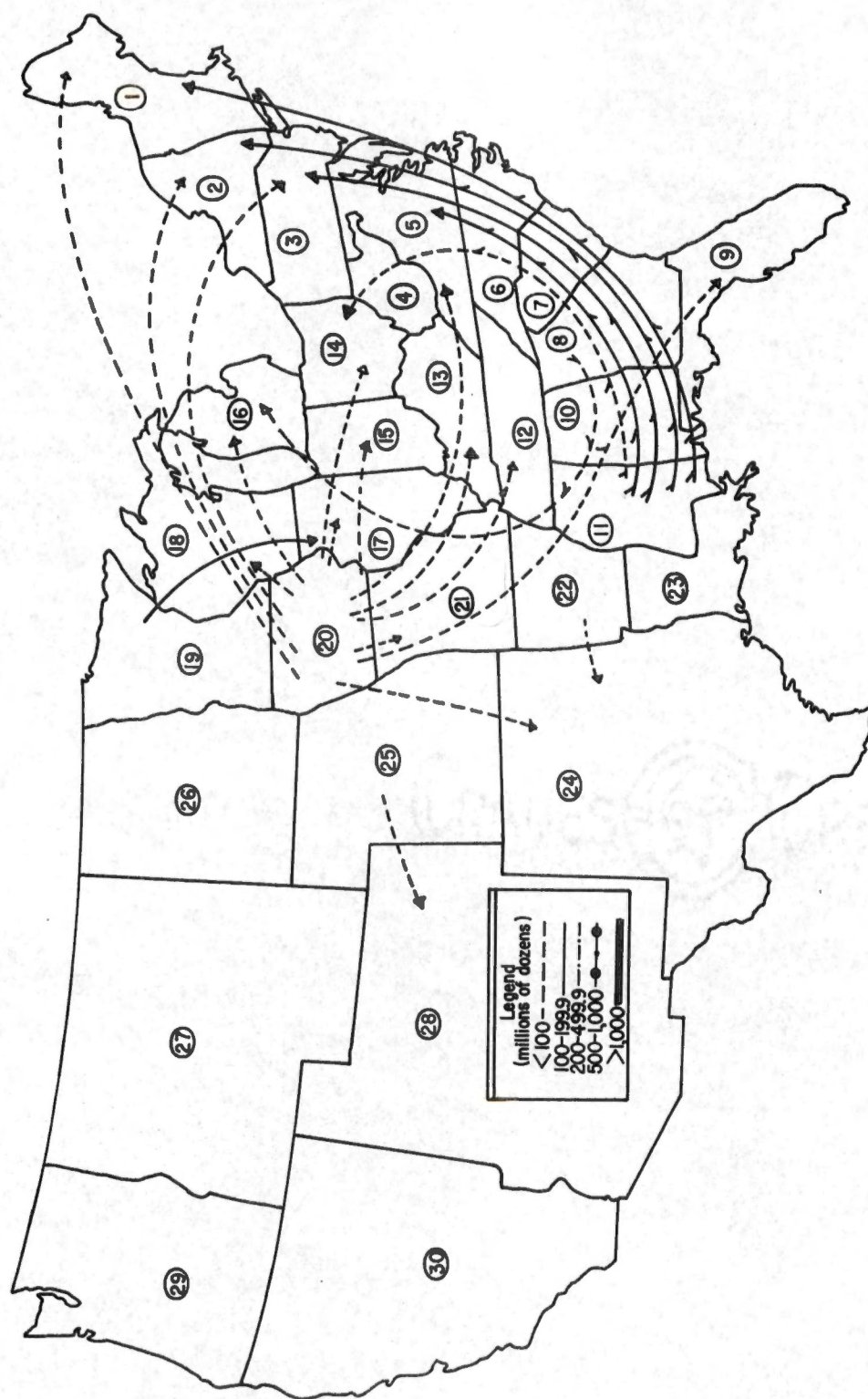


Figure 6. Optimum interregional shipment patterns of eggs using estimated transportation costs over the pre-Interstate Highway system, United States, 1962.

Regions 8 (Georgia), 19 (Minnesota), and 20 (Iowa) would have supplied over 50 per cent of all the egg shipments in this optimal situation. Georgia would have been the major supplier of eggs for the states in the Northeast. Minnesota would have been a major supplier for deficit regions in the Midwest, and Iowa would have shipped a large proportion of its surplus egg supply to the Southwest.

Optimum Interregional Movements Over the Completed Interstate Highway System

The detailed data pertaining to the results of the analysis for eggs over the completed Interstate Highway System are given in Appendix D, Table L. The same movement patterns summarized in Figure 6 generally describe the optimal shipping routes over the completed Interstate System. About 1,136 million dozen eggs would have been shipped in this situation at a total transfer cost of approximately 22 million dollars.

Comparison of the Optimal Egg Movement Patterns

The optimal movement patterns for the two situations indicate that the lower transportation costs associated with the Interstate System would have little effect on the general movement patterns of eggs. Surplus and deficit regions would have been the same in both cases. Also total shipments would have been approximately the same in both cases--increasing only about 3 million dozen for the optimal situation over the Interstate System as compared to the optimal situation over the pre-Interstate system.

Total transfer costs would have been approximately 6 million dollars less for the optimal movement pattern over a completed Interstate Highway System than for the optimal movement pattern over the pre-Interstate system. This decrease would have been the result of lower transportation costs for shipping approximately the same quantity of eggs over a completed Interstate System as would have been shipped over the present highway system at higher transportation costs. This decrease of approximately 23 per cent in the total transfer costs, as compared to a less than 1 per cent increase in total shipments, indicates that the demand for egg transport services is highly inelastic.

Table XVI shows the total amounts of eggs that would have been shipped from areas specified as surplus under each of the two road systems. Also shown are the net differences in the outshipments that would have been made in each of the two alternative highway situations.

There would have been no significant redistribution of the origins of outshipments to the various consuming areas for the two alternative situations. The increase in total shipments of about 3 million dozen eggs for the optimal situation over a completed Interstate System would have been the result of Regions 7 (South Carolina) and 10 (Alabama) exporting more eggs. None of the regions specified as surplus would have decreased outshipments, to any significant degree, as a result of the completed Interstate Highway System.

The change in the average net revenues from each shipping area for the two alternative situations are also given in Table XVI. For each of the shipping regions, the average net revenue for the optimum

TABLE XVI

TOTAL EQUILIBRIUM SHIPMENTS OF EGGS FROM SPECIFIED REGIONS
AND NET CHANGE IN SHIPMENTS AND REVENUE FROM PRESENT
TO INTERSTATE HIGHWAY SYSTEM, UNITED STATES, 1962

Shipping region ^a	Total shipments		Net difference in shipments		Change in net price at point of shipment ^b (decrease) Dollars per million dozen
	Present	Interstate			
	highway	highway	Absolute	Percentage	
	system	system			
	Million dozens				
6	160.8	161.4	0.6	0.4	11
7	54.4	55.2	0.8	1.5	8
8	202.3	202.7	0.4	0.2	8
10	96.5	98.3	1.8	1.9	8
11	80.5	80.4	-0.1	-0.1	8
19	165.1	165.2	0.1	0.0	12
20	239.5	239.7	0.2	0.0	14
22	71.2	71.3	0.1	0.1	10
25	62.2	62.0	-0.2	-0.3	22
United States	1132.5	1136.2	3.7	0.3	

^aThere was no change in surplus and deficit regions for the two situations.

^bChange from present to interstate. Actual revenues for each region are presented in Appendix D, Tables XLIX and LI.

situation over a completed Interstate System would have been lower than for the optimum situation over the present highway system.* This decrease would have been less than one cent per dozen. This decrease would have been the result of the lower transportation costs for shipping almost identical amounts of eggs over the completed Interstate System as would have been shipped over the pre-Interstate system.

*See discussion on page 66.

CHAPTER VIII

EQUILIBRIUM MOVEMENT PATTERNS UNDER CONDITIONS

ASSUMED FOR 1972

I. PROCEDURE

The purpose of this part of the analysis was: (a) to determine the equilibrium shipment patterns for each of the four commodities studied--using the completed Interstate Highway System--under conditions assumed for 1972, and (b) to compare these equilibrium shipment patterns for 1972 with what would have been the 1962 equilibrium shipment patterns over a completed Interstate Highway System.

The 1972 equilibrium shipment patterns were determined as follows:

1. The transportation costs used were those estimated for shipments over a completed Interstate Highway System. It was assumed that these costs would not have changed between 1962 and 1972.

2. Attention was focused on the effects of changes in the area demand functions (for each product) that were caused by anticipated changes in area incomes and populations. It was assumed that there would be no net changes in any of the other factors affecting the area demand functions, such as consumer preference patterns and prices of competing goods and services.

The demand functions used in solving for the equilibrium shipment patterns (of each of the commodities) under 1962 conditions were also assumed to apply to 1972. These functions were adjusted for the estimated regional levels of population and income for 1972 in order to determine the area demands of each of the commodities for that year. Per capita income in each area for 1972 was estimated by (1) assuming that the same percentage change in income for each area between 1952 and 1962 would also occur between 1962 and 1972, and (2) adjusting this percentage change for each area by a least-squares estimate of the United States average per capita income for 1972. Estimates of population in each area for 1972 were interpolations for 1972 of population projections (by state) for 1970 and 1975 made by the Bureau of the Census. The detailed procedures used in estimating income and population for 1972 are presented in Appendix E.

Based on these estimated levels of income and population for 1972, total area demand functions for each commodity were derived by the same procedures (as outlined in Chapter IV) that were followed in deriving the area demand functions under 1962 conditions. Table XVII gives the resulting estimated equation constants for each commodity included in the study.

3. Available supplies of each product in each area were assumed to be the same in 1972 as they were in 1962. This assumption simplifies the analysis, and makes it possible to determine the direction of shifts in comparative advantage among regions (for the various commodities) that would be expected to occur in response to the assumed shifts in the

TABLE XVII

ESTIMATED VALUES OF THE CONSTANT TERM IN DEMAND FUNCTIONS FOR
BEEF, PORK, BROILERS AND EGGS BASED ON ESTIMATED
1972 POPULATION AND INCOME^a

Region ^b	Equation constants ^c			
	Beef regions	Pork regions	Broiler regions	Egg regions
	Million pounds			Million dozens
1	2,293.236	1,835.149	139.376	2,888.202
2	8,427.273	6,745.309	1,664.350	4,697.610
3	1,160.524	951.126	822.204	4,599.298
4	921.418	754.029	683.670	391.272
5	824.228	676.138	943.657	2,463.328
6	466.365	386.551	407.918	1,215.061
7	1,303.408	1,059.315	132.044	631.075
8	621.112	512.362	386.614	1,092.338
9	409.062	340.306	411.391	1,694.889
10	700.787	575.578	211.420	832.388
11	563.505	463.452	369.108	557.719
12	1,971.693	1,601.157	577.196	931.002
13	946.755	765.565	279.975	750.735
14	1,554.866	1,262.587	186.281	2,559.620
15	2,201.062	1,754.946	314.269	1,218.279
16	793.125	644.055	253.125	2,018.169
17	1,008.172	830.612	872.243	2,750.897
18	865.036	695.496	416.696	1,029.537
19	496.630	403.505	952.534	885.427
20	685.223	555.196	687.788	645.427
21	271.027	216.319	872.786	1,100.085
22	281.661	227.509	378.113	466.389
23	405.712	330.476	157.062	880.539
24	2,495.155	2,039.788	296.274	3,283.374
25	577.401	471.251	911.636	891.346

TABLE XVII (continued)

Region ^b	Equation constants ^c			
	Beef regions	Pork regions	Broiler regions	Egg regions
	Million pounds			Million dozens
26	422.262	340.806	381.109	339.477
27	203.225	164.950	387.148	432.694
28	432.920	351.620	534.115	1,568.326
29	966.768	782.450	425.997	1,246.453
30	4,346.763	3,468.937	1,926.285	5,566.739
United States	38,637.299	31,219.143	16,990.315	49,644.747

^aThe constant term in each area is the value of $N_i b_{oi}'$ in the demand function ($x_{2i} = N_i b_{oi}' + b_1 x_1'$) for each commodity as explained in Chapter IV.

^bRefers to the specified area for beef and pork, broilers or eggs as presented in Chapter IV.

^cDerived from the aggregate demand functions developed in Chapter IV and the estimated levels of income and population for 1972 in the delineated areas for each of the commodities.

area demand functions. The results of this analysis, therefore, are not to be taken as a prediction of the precise regional export and import figures for 1972, but only as an indication of the probable general direction of change for each region in respect to its position as a major exporter or importer of the indicated commodities.

4. The same area delineations made for each commodity for determination of shipment patterns under 1962 conditions were used also for the analysis under conditions assumed for 1972.

II. THE EMPIRICAL RESULTS*

Beef

The detailed data pertaining to what the interregional movements of beef would be under the conditions assumed for 1972 are given in Appendix D, Table XXXIV. Interarea shipments of beef would be approximately 736 million pounds greater under conditions assumed for 1972 than they would have been under the conditions assumed for 1962. Most of this increase would result from the increases in demand assumed for all areas. In addition, changes would occur in the shipment patterns because of the differences in the relative population and income changes among the regions.

Region 14 (Michigan) would be the only region that would shift from a deficit position (under the conditions assumed for 1962) to a

*In the following discussion, any reference to 1962 shipment patterns will pertain to the optimum shipments that would have been made over a completed Interstate Highway System under conditions assumed for that year.

surplus situation (under conditions assumed for 1972). This "new" surplus would occur in response to the greater relative increases in population and income assumed for other areas for 1972. The level of demand for beef in this region (Region 14) would increase, but the increase would not be as great as the increase in Region 2 (Delaware, Maryland, New Jersey, New York, Pennsylvania, and Washington, D. C.). The net effect of this difference in the relative shift in demand under conditions assumed for 1972 would be that Michigan would ship approximately 419 million pounds of beef to Region 2.

The deficits of Regions 2 (Delaware, Maryland, New Jersey, New York, Pennsylvania, and Washington, D. C.), and 30 (California) would be greater under conditions assumed for 1972 than they would have been under the 1962 situation. The other deficit regions would show a decrease in their imports for the 1972 situation as compared to the 1962 situation. Again this indicates the influence of shifts in population and income assumed for 1972.

The changes in quantities imported and exported by each region can be noted from a comparison of Tables XXXII and XXXIV in Appendix D. Table XVIII gives a comparison of the exports of each of the shipping regions for the two situations. The imports to each of the deficit regions were discussed above.

One of two interpretations may be given to the results that indicate no changes in outshipments between the two situations: (1) these regions would be exporting their entire available supplies in either situation. In such a case, there would be no change in

TABLE XVIII

TOTAL EQUILIBRIUM SHIPMENTS OF BEEF FROM SPECIFIED REGIONS,
AND NET CHANGE IN SHIPMENTS AND REVENUES FROM 1962
SOLUTION TO ESTIMATED 1972 SOLUTION

Shipping region	Total shipments		Net change in shipments		Differences in average net revenues at point of shipment ^a (increase)
	Solution for conditions assumed for 1962	Solution for conditions assumed for 1972			
	Million pounds		Absolute	Percentage	Dollars per million pounds
3	141.5	141.5	0.0	0.0	539,486
4	85.8	85.9	0.1	0.0	539,486
5	158.6	158.6	0.0	0.0	539,486
6	44.9	44.9	0.0	0.0	539,486
7	175.3	176.5	1.2	0.7	539,486
8	109.1	109.1	0.0	0.0	539,485
9	145.7	145.7	0.0	0.0	539,485
10	221.7	221.7	0.0	0.0	539,485
11	95.9	95.9	0.0	0.0	539,486
13	415.6	415.6	0.0	0.0	539,486
14	b	419.3	419.3	b	b
16	511.3	539.7	28.4	5.6	539,487
17	117.3	126.5	9.2	7.8	539,491
18	631.7	631.8	0.1	0.0	539,491
19	1726.0	1744.6	18.6	1.1	539,492
20	826.2	821.4	-4.8	-0.1	539,489
21	343.0	327.0	-16.0	-4.7	539,490
22	1266.3	1296.5	30.2	2.4	539,491
23	473.9	577.2	103.3	21.8	539,492
25	62.1	67.2	5.1	8.2	539,492
26	353.9	389.6	35.7	10.1	539,492
28	121.1	156.8	35.7	29.5	539,492
29	159.8	229.2	69.4	43.4	539,492
United States	8186.3	8922.2	735.9	9.0	

^aNet revenues for each shipping route from each shipping region are presented in Appendix D, Tables XXXIII and XXXV.

^bThis area shifted from a deficit position in 1962 to a surplus one in 1972.

outshipments between the two situations even though the relative shifts in demand among the regions for conditions assumed for 1972 might favor a particular producing area over another; or (2) the effects of the relative shifts in demand on different producing regions where there was no change were offsetting. In any case, for those shipping regions where either a positive or negative change occurred in the amount of the outshipments, it is concluded that the change was a net result of the relative shifts in demands among the regions.

There would be a net increase in outshipments from each of the exporting regions--except Regions 20 (Minnesota) and 21 (North and South Dakota)--under conditions assumed for 1972. Large percentage increases would occur for Regions 23 (Kansas), 28 (Idaho, Nevada, and Utah), and 29 (Washington and Oregon) in the amounts of 22, 30, and 43 per cent, respectively. These seemingly large changes would occur mainly because the shipments under conditions assumed for 1962 would have been relatively small. Therefore, these percentage changes would not represent large absolute increases in outshipments (Table XVIII, page 101).

Net revenue for a particular shipping route in a reactive programming analysis is defined as the difference between (a) price per unit in the consuming area and (b) the transfer costs per unit for shipping the commodity over that route. A change in net revenue could occur because of (a) a change in demand in the consuming area(s), (b) a change in the elements of the transfer cost matrices for each possible pair of producing and consuming areas, or (c) some combination of these

two changes. The net revenues for a particular shipping area for all regions to which it ships are weighted by the associated quantities shipped to form a weighted average net revenue for that shipping area. These weighted average net revenues for each shipping area for the two situations are given in Appendix D, Tables XXXIII and XXXV. The net difference between these average net revenues are given in Table XVIII, page 101.

Weighted average net revenues for each of the specified regions increased for the 1972 situation as compared to the 1962 situation. Equilibrium net prices would increase by about fifty-four cents per pound for conditions assumed for 1972. The fairly even distribution of revenues among the export regions would be the result of the reactive programming technique used in obtaining an equilibrium solution.

The large increase in equilibrium net prices would be the result of the assumptions on which the analysis was based. Population and per capita incomes were assumed to increase for 1972, shifting the area demand curves for each commodity to the right. Supplies were assumed to remain fixed at their 1962 levels. The essential interpretation of this large increase in equilibrium net prices is that if population and per capita incomes increase to their estimated 1972 levels, and if total available supplies in each region remain at their 1962 levels, then an increase in net prices of this magnitude would be expected. Attention in this study was focused on the direction of shifts in movement patterns caused by such an increase in net prices.

Pork

The detailed data pertaining to what the interregional movements of pork would be under the conditions assumed for 1972 are given in Appendix D, Table XL. Interarea shipments of pork would be approximately 570 million pounds greater under conditions assumed for 1972 than they would have been under the conditions assumed for 1962.

In addition to this overall increase, changes would occur in the shipment patterns because of the differences in the relative population and income changes among the regions. These changes are summarized in Table XIX.

Region 15 (Illinois) would be the only region that would shift from a surplus position under the conditions assumed for 1962 to a deficit position under conditions assumed for 1972. The increased demand in Illinois under the conditions assumed for 1972 would result in this region becoming a major pork importer from the other North Central States. Regions 16 (Wisconsin), 18 (Missouri), 19 (Iowa), and 22 (Nebraska) would be major suppliers of pork to this region under the conditions assumed for 1972. These shipping regions would account for approximately 66 per cent of the imports of pork received by Region 15 in this situation.

Region 29 (Washington and Oregon) would be the only region that would shift from a deficit position under the conditions assumed for 1962 to a surplus position under the conditions assumed for 1972. This region would export approximately 102 million pounds of pork under the 1972 situation.

TABLE XIX

TOTAL EQUILIBRIUM SHIPMENTS OF PORK FROM SPECIFIED REGIONS,
AND NET CHANGE IN SHIPMENTS AND REVENUES FROM 1962
SOLUTION TO ESTIMATED 1972 SOLUTION

Shipping region	Total shipments		Net change in shipments		Differences in average net revenues at point of shipment ^a (increase) Dollars per million pounds
	Solution for conditions assumed for 1962	Solution for conditions assumed for 1972			
	Million pounds		Absolute	Percentage	
3	296.3	300.3	4.0	1.3	307,578
4	157.6	119.9	-37.7	-23.9	307,578
5	212.2	109.2	-103.0	-48.5	307,578
6	58.8	29.4	-29.4	-50.0	307,578
8	95.6	47.7	-47.9	-50.1	307,578
9	99.2	49.8	-49.4	-50.0	307,578
10	160.1	320.4	160.3	100.0	307,576
11	199.6	200.0	0.4	0.2	307,575
13	734.0	735.0	1.0	0.1	307,580
15	355.2	b	-355.2	b	b
16	373.5	434.0	60.5	16.2	307,577
18	485.2	558.6	73.4	15.1	307,577
19	2037.3	2087.0	49.7	2.4	307,578
20	689.1	813.0	123.9	18.0	307,578
21	136.9	378.4	241.5	176.4	307,577
22	379.1	597.6	218.5	57.6	307,578
23	214.8	372.0	157.2	73.2	307,575
29	b	102.1	102.1	b	b
United States	6684.5	7254.4	569.9	8.5	

^aNet revenues for each shipping route from each shipping region are presented in Appendix D, Tables XXXIX and XLI.

^bArea 15 shifted from a surplus position in 1962 to a deficit one in 1972; Area 19 shifted from a deficit position in 1962 to surplus one in 1972.

The relative shifts in demands among regions for the conditions assumed for 1972 would result in most of the shipping regions in the Southeast decreasing their exports to other areas. However, Region 10 (Tennessee) would increase its outshipments of pork from around 160 million pounds to approximately 320 million pounds. This "new" surplus from Tennessee would be shipped to Region 7 (Florida).

Weighted average net revenues for each of the shipping regions (Table XIX, page 105) would increase for the 1972 situation as compared to the 1962 situation. Equilibrium prices would increase by approximately thirty-one cents per pound for the conditions assumed for 1972.

Again, these large increases in equilibrium net prices must be interpreted in light of the assumptions on which the analysis was based. These increases were caused by the assumed increase in demand for each area, and the same fixed supplies as were available in 1962.

Broilers

The detailed data pertaining to what the interregional movements of broilers would be under the conditions assumed for 1972 are given in Appendix D, Table XLVI. Interarea shipments of broilers would be approximately 392 million pounds greater under conditions assumed for 1972 than they would have been under the conditions assumed for 1962.

In addition to this overall increase, changes would also occur in the shipment patterns of broilers because of the differences in the relative population and income changes among regions. These changes are summarized in Table XX.

TABLE XX

TOTAL EQUILIBRIUM SHIPMENTS OF BROILERS FROM SPECIFIED REGIONS,
AND NET CHANGE IN SHIPMENTS AND REVENUES FROM 1962
SOLUTION TO ESTIMATED 1972 SOLUTION

Shipping region	Total shipments		Net change in shipments		Differences in average net revenues at point of shipment ^a (increase) Dollars per million pounds
	Solution	Solution			
	for	for			
	conditions assumed for 1962	conditions assumed for 1972	Absolute	Percentage	
	Million pounds				
1	181.7	169.6	-12.1	-6.7	134,344
6	258.2	320.7	62.5	24.2	134,339
7	14.2	39.7	25.5	179.6	134,344
8	77.5	87.8	10.3	13.3	134,340
9	419.1	497.6	78.5	18.7	134,352
11	742.7	838.3	95.6	12.9	134,345
13	485.9	507.9	22.0	4.5	134,339
14	299.8	328.4	28.6	9.5	134,340
23	530.5	562.0	31.5	5.9	134,345
29	b	50.1	50.1	b	b
United States	3009.6	3402.1	392.5	13.0	

^aNet revenues for each shipping route from each shipping region are presented in Appendix D, Tables XLV and XLVII.

^bThis area shifted from a deficit position in 1962 to a surplus one in 1972.

Region 29 (Washington and Oregon) would have been a self-sufficient region under the conditions assumed for 1962, but would become a surplus region under the conditions assumed for 1972. This "new" surplus region would ship approximately 15 and 35 million pounds of broilers to Regions 28 (Utah, Colorado, Arizona, and New Mexico) and 30 (California and Nevada), respectively. There would be no other changes in the regions indicated as surplus in the movement patterns derived for both 1962 and 1972 conditions.

Regions 18 (Indiana), 22 (Missouri), 26 (Oklahoma and Kansas), and 27 (Nebraska, Idaho, North and South Dakota, Montana, and Wyoming) would have been deficit regions under the conditions assumed for 1962, but would become self-sufficient under conditions assumed for 1972. This change would result from the relative shifts in population and income among the regions.

Table XX, page 107, shows the net change in optimum shipments of broilers from specified regions between the conditions assumed for 1962 and those assumed for 1972. Under 1972 conditions, outshipments from Region 1 (Maine and New Hampshire) would be 7 per cent less than the outshipments that would have been made for that region under conditions assumed for 1962. Most all of the areas in the Middle Atlantic states and the South which were exporters in the solution based on assumed 1962 conditions--Regions 6 (Maryland and Washington, D. C.), 7 (West Virginia), 8 (Virginia), 9 (North Carolina), 13 (Alabama), 14 (Mississippi), 11 (Georgia), and 23 (Arkansas)--would increase their outshipments under the conditions assumed for 1972.

Weighted average net revenues for each of the shipping regions would increase under conditions assumed for the 1972 situation as compared with what they would have been under the 1962 situation. Equilibrium prices of broilers would increase by approximately thirteen cents per pound for the conditions assumed for 1972. This increase would be the result of an assumed increase in demand for broilers in each area, and the same fixed supplies in each area as were available in 1962.

Eggs

The detailed data pertaining to the interregional movements of eggs that would be made under the conditions assumed for 1972 are given in Appendix D, Table LII. Under conditions assumed for 1972, interarea shipments of eggs would be approximately 281 million dozen greater than they would have been under the conditions assumed for 1962.

Region 15 (Indiana), which would have been an importer of approximately 13 million dozen eggs under conditions assumed for 1962, would export approximately 101 million dozen eggs under the conditions assumed for 1972. The shipment of this "new" surplus would result from the increases in demand for eggs in the Northeast.

Region 26 (North and South Dakota), which would have been self-sufficient in respect to egg production and consumption in the 1962 situation, would export approximately 111 million dozen eggs to Region 30 (California and Nevada) under the conditions assumed for 1972. On the other hand, Regions 12 (Tennessee), 13 (Kentucky), and 21 (Missouri),

which would have been net deficit areas in the 1962 situation, would become self-sufficient in the situation assumed for 1972. Region 20 (Iowa), which would have supplied the deficits to these 1962 importing regions, would redirect and increase its outshipments to other areas under the conditions assumed for 1972.

Table XXI shows the net change between optimum shipments of eggs from specified regions under the conditions assumed for 1962 and those assumed for 1972. Region 6 (North Carolina) would be the only egg surplus region whose volume of shipments would be less under conditions assumed for 1972 than they would have been under conditions assumed for 1962. This decrease in outshipments from North Carolina would amount to approximately 10 million dozen eggs, and would be mainly the result of Ohio not importing any eggs from North Carolina for the 1972 situation. Ohio would have imported approximately 12 million dozen eggs from North Carolina under the conditions assumed for 1962, but under conditions assumed for 1972, would receive its total import volume of 18 million dozen from Region 20 (Iowa).

Weighted average net revenues for each of the shipping regions would increase for the 1972 situation over the 1962 situation. Equilibrium prices of eggs would increase by approximately thirty-two cents per dozen for the conditions assumed for 1972. Again, this large increase in equilibrium net revenues would be the result of an assumed increase in demand for each area, and the same fixed supplies in each area as were available in 1962.

TABLE XXI

TOTAL EQUILIBRIUM SHIPMENTS OF EGGS FROM SPECIFIED REGIONS,
AND NET CHANGE IN SHIPMENTS AND REVENUES FROM 1962
SOLUTION TO ESTIMATED 1972 SOLUTION

Shipping region	Total shipments		Net change in shipments		Differences in average net revenues at point of shipment ^a (increase) Dollars
	Solution for conditions assumed for 1962	Solution for conditions assumed for 1972			
	Million pounds		Absolute	Percentage	
6	161.4	151.6	-9.8	-6.1	323,972
7	55.2	69.6	14.4	26.1	232,971
8	202.7	205.6	2.9	1.4	323,972
10	98.3	104.7	6.4	6.5	323,972
11	80.4	91.2	10.8	13.4	323,972
15	b	100.7	100.7	b	b
19	165.2	169.1	3.9	2.4	323,971
20	239.7	269.5	29.8	12.4	323,971
22	71.3	72.1	0.8	1.1	323,968
25	62.0	72.6	10.6	17.1	323,978
26	b	110.6	110.6	b	b
United States	1136.2	1417.3	281.1	24.7	

^aNet revenues for each shipping route from each shipping region are presented in Appendix D, Tables LI and LIII.

^bArea 15 shifted from a deficit position in 1962 to a surplus one in 1972; Area 26, which would have been self-sufficient in 1962, would be a surplus region in the 1972 solution.

CHAPTER IX

SUMMARY AND CONCLUSIONS

I. REVIEW OF THE PROCEDURE

The objectives of this study were: (1) to describe the optimal (least cost) interregional movement patterns of beef, pork, broilers and eggs using estimates of 1962 demand and supply conditions, and transportation costs estimated for shipments made over the pre-Interstate road system; (2) to estimate what the effects of a completed Interstate Highway System would have been on these movement patterns under the same 1962 demand and supply conditions by using transportation costs estimated for shipments over a completed Interstate Highway System; and (3) to estimate the 1972 equilibrium shipments of these commodities over the completed Interstate Highway System, taking into account projected changes in population and income.

It was assumed that all slaughter and processing was production oriented. This simplified the analysis so that it was necessary to consider only the final form of each of the commodities. For most agricultural commodities, and especially livestock products, this assumption corresponds closely to the actual situations described.

Economically meaningful supply and demand areas were delineated for each commodity. The capacity of the available computer facilities permitted the delineation of thirty of these areas. Given these areas,

the input data required for solving a distribution problem by reactive programming were: (1) a demand function for each commodity in each area delineated; (2) the available supplies in each area; and (3) the matrix of transportation costs between each possible pair of points representing the producing and consuming areas delineated.

A demand function for each commodity for each of the consuming areas was derived from an aggregate United States function for the commodity by adjusting for regional differences in population and income. The available supply of each commodity in each area was assumed fixed for the time period (calendar year 1962) considered in the analysis.

In deriving the two sets of transportation costs required in the analysis, a transportation cost regression equation for each commodity was derived and used to estimate the transportation costs for movement between each possible pair of producing and consuming centers over the pre-Interstate system. These transportation costs equations were then adjusted for savings anticipated from using the improved Interstate System to yield estimates of transportation costs for movements between the same set of producing and consuming centers over the completed Interstate Highway System.

The least cost shipping patterns in 1972 for each of the commodities were determined under the following conditions: (1) the transportation costs used were those estimated for shipments, in 1962, over a completed Interstate Highway System; (2) the demand function for each commodity in each area would change in accord with the estimated changes in population and income in each area; (3) the available

supplies of each commodity in each area would be the same as in 1962; and (4) the same area delineations used to analyze the 1962 situation would apply also to the 1972 situation.

II. SUMMARY OF THE RESULTS

Under 1962 Conditions

Using the 1962 demand and supply data and the two alternative sets of transportation costs, it was found that the demand for beef, pork, broiler and egg transport services would be highly inelastic. Total shipments in the optimal (least cost) movement pattern for each commodity would have been approximately the same using either the pre-Interstate or the post-Interstate routings and transportation cost data. Total transfer costs, on the other hand, would have been substantially less for each commodity for movement over a completed Interstate Highway System. The decrease in transfer costs for beef and pork would have amounted to approximately 29 per cent in each case; for broilers, approximately 26 per cent; and, for eggs, approximately 23 per cent. The source of these savings would have been the reductions in transportation costs resulting from improvements in the road system.

The Interstate Highway System would not have had any significant effect on the general movement patterns for each of the commodities. With the exception of broilers, the areas specified as surplus or deficit for each commodity would have been the same for both of the transportation cost situations under conditions for 1962. In the case of broilers, Region 22 (Missouri) would have shifted from a surplus position

with the pre-Interstate road system to a deficit situation in an optimal (least cost) movement pattern over a completed Interstate Highway System.

Even though total shipments would have been approximately the same in 1962 for the optimal movement patterns of each of the commodities over either highway system, the amounts of outshipments from the various shipping areas would have been different. These changes in outshipments made to the various deficit areas indicate that changes would have occurred in the competitive positions of the shipping regions. The shifts in competitive positions would have resulted from greater accessibility to the deficit regions from some of the surplus regions over the completed Interstate System.

The competitive advantages of Regions 7 (Florida), 17 (Arkansas and Louisiana), and 29 (Washington and Oregon) as exporters of beef would have been increased by the use of a completed Interstate Highway System. The increased accessibility of these shipping areas to the various consuming areas would have caused, also, a decrease in the competitive advantages of Regions 25 (Arizona and New Mexico) and 28 (Idaho, Nevada, and Utah).

The competitive advantages of Regions 9 (North Carolina), 11 (Georgia), and 13 (Alabama) as exporters of broilers would have been slightly decreased by availability in 1962 of the completed Interstate Highway System. On the other hand, Regions 6 (Maryland) and 7 (West Virginia) would have gained a competitive advantage as a result of their greater accessibility to the specified consuming areas.

There would have been no significant differences between the competitive situations of any of the areas making outshipments of either pork or eggs using either the pre-Interstate or the post-Interstate Systems.

Under 1972 Conditions

The least cost movements for each of the commodities under the conditions assumed for 1972 would be influenced significantly by the estimated increases in demands along the Eastern seaboard, and in California. In the case of beef, Region 14 (Michigan) would shift from a deficit position under 1962 conditions to a surplus position under 1972 conditions, and would make outshipments of approximately 419 million pounds to Region 2 (Delaware, Maryland, New Jersey, New York, Pennsylvania, and Washington, D. C.). Regions 23 (Kansas), 28 (Idaho, Nevada, and Utah), and 29 (Washington and Oregon) would gain a competitive advantage as indicated by the 22, 30, and 40 per cent increases, respectively, in their outshipments that would take place under 1972 conditions. On the other hand, Regions 20 (Minnesota) and 21 (North and South Dakota) would lose some competitive advantage as a result of the relative changes in demand among areas from 1962 to 1972, and because of the greater accessibility to the various deficit areas given to other exporting areas by the completed Interstate Highway System.

Several changes in the competitive advantages among regions would be associated with the optimal movement pattern for pork under the conditions assumed for 1972. Illinois would become a deficit region and

would become a major market for exports from Wisconsin, Missouri, Iowa, and Nebraska. Region 29 (Washington and Oregon) would become a surplus region, and would export approximately 102 million pounds of pork.

Tennessee would gain a substantial advantage as an exporter of pork, and would become a major supplier to Florida as well as to Region 2 (Delaware, Maryland, New Jersey, New York, Pennsylvania, and Washington, D. C.). Other states in the Southeast would lose some of their competitive advantage as exporting areas because of their relatively small surpluses in relation to the estimated increases in demand in these areas.

Total shipments of broilers under the conditions assumed for 1972 would be approximately 13 per cent greater than for 1962. Maryland, West Virginia, and North Carolina would gain a considerable advantage as exporters from this increase. Georgia, Alabama, Mississippi, and Arkansas also would be favored as exporters. Outshipments from Region 1 (Maine and New Hampshire) would decline under the 1972 situation.

Total shipments of eggs under the conditions assumed for 1972 would be nearly 25 per cent greater than the shipments that would have been made under 1962 conditions. Region 15 (Indiana) would shift to a surplus position and would export approximately 101 million dozen eggs. North and South Dakota, which would have been self-sufficient in the 1962 situation, would make outshipments to the California-Nevada market in the 1972 situation. Tennessee, Kentucky, and Missouri would have been deficit areas under the conditions assumed for 1962, but would be self-sufficient in the 1972 situation.

III. IMPLICATIONS OF THE RESULTS

The results of this study are not precise predictions of what is going to occur. Rather, they indicate what would be expected to happen under each set of conditions used as input data in the reactive programming model. Thus, the implications of the results of this kind of an analysis depend heavily on the validity of the input data that are used. In addition, any "normative" elements in the analytical model should be identified explicitly. In the present study, such an element appears in the form of the optimality criterion of minimum total transportation costs for total interarea shipments made of each commodity.

The Interstate Highway System, by itself, probably would not have had any significant effect on the competitive position of Tennessee as an exporting area for any of the commodities studied under 1962 conditions. Region 2 (Delaware, Maryland, New Jersey, New York, Pennsylvania, and Washington, D. C.) would have been a major consuming center for both beef and pork that would have been shipped from Tennessee under the conditions assumed for 1962 under both the pre-Interstate and post-Interstate Highway Systems. Also there would be no change in Tennessee's position as an exporter of beef under the conditions assumed for 1972. However, the state's competitive advantage in respect to outshipments of pork would increase under the conditions assumed for 1972. The increased exports would be made in response to the increase in demand estimated for Region 7 (Florida).

Tennessee would have been self-sufficient in the broiler analysis for assumed 1962 conditions, and no outshipments would have been made over either of the two road systems for that year. The analysis indicated that Tennessee would also be self-sufficient under the conditions assumed for 1972.

In respect to eggs, Tennessee would have been a deficit area (under the conditions assumed for 1962) for both the pre-Interstate and post-Interstate transportation cost situations. Shipments to Tennessee from Region 20 (Iowa) would have been the same (13.3 million dozen) in both situations. However, under conditions assumed for 1972, Tennessee would become self-sufficient in respect to eggs.

In summary, the results of the analysis indicate that the Interstate Highway System would not be expected to have any appreciable immediate effects on the competitive position of Tennessee in respect to production and outshipments of beef, pork, broilers and eggs. The completion of the Interstate Highway System, however, and the estimated changes in area populations and incomes for 1972, would be expected to have effects on these commodities as noted above.

Finally, the analysis was made on the basis of a spatial-equilibrium model that divided the United States into thirty relatively large producing and consuming areas. The analysis of the effects of the Interstate Highway System in terms of the relatively larger areas was the logical first step in assessing the impact of this great change in the transportation system for farm commodities. To carry this work further, the results and kinds of research models used in the present

study should be applied in more detailed investigations of the effects of the system on movement patterns and competitive location advantages within the relatively large areas delineated in this study.

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APPENDIXES



APPENDIX A

REACTIVE PROGRAMMING--SCHEME OF CALCULATIONS

The scheme of calculations used in a reactive programming model depends on whether supply is fixed or is to be determined as part of the problem. The procedures are practically the same in each case. Since the fixed supply situation was used in this study, the following outline pertains to that case.¹ All variables and notation are as defined below:

i = the different producing areas. ($i = 1, 2, \dots, m$)

j = the different consuming areas. ($j = 1, 2, \dots, n$)

P_j = price of product in j th consuming area.

Q_{ij} = quantity purchased in the j th consuming area which was produced in the i th producing area.

T_{ij} = constant unit cost of transporting the product from the i th producing area to the j th consuming area.

S_i = the fixed supply in the i th producing area.

R_{ij} = the net average revenue per unit for the product produced in the i th producing area and sold in the j th consuming area.

$\bar{R}_i$ = the weighted averages of net prices from the i th producing area.

D_{ij} = the deviations of net prices of product produced in the i th producing area and sold in the j th consuming area from the average net price of the product in the i th producing area.

¹The 27 steps outlined below were taken directly from Thomas E. Tramel and A. D. Seale, Jr., "Reactive Programming--Recent Developments," Interregional Competition Research Methods, Richard A. King, editor (Raleigh: The Agricultural Policy Institute, 1964), pp. 63-64.

1. Form an arbitrary starting basis such that no X_j is zero and such that $\sum_j Q_{ij} \leq S_i$. Calculate X_j , $i = 1, 2, \dots, n$.
2. Select limits within which deviations of net prices from the average can hold and for all practical purposes be satisfied.
3. Evaluate all P_j .
4. Set $i = 1$.
5. Calculate R_i for the given i . If $\bar{R}_i$ is negative, set it equal to zero. Save $\sum_j Q_{ij}$ for later use.
6. Set $j = 1$.
7. Calculate D_{ij} for the given i and given j .
8. Check whether $\sum_i Q_{ij}$ equals S_i . If so, perform step 10; if not, perform step 9.
9. Check whether $\bar{R}_i$ equals zero for the given i . If so, perform step 10; if not, perform step 13.
10. Check whether D_{ij} for the given i and given j is within the limits specified in step 2. If so, perform step 14; if not, perform step 11.
11. Check whether D_{ij} for the given i and given j is negative or positive. If negative, perform step 12; if positive, perform step 13.
12. Check whether Q_{ij} for the given i and given j equals zero. If so, perform step 14; if not, perform step 13.
13. Calculate a new approximation to Q_{ij} for the given i and given j . Several different ways of doing this could be employed. However, having D_{ij} from the above calculations

makes Newton's method of approximation a very efficient procedure. Let Q'_{ij} denote the new approximation and F'_j the derivative of F_j . Then $Q'_{ij} = Q_{ij} - D_{ij}/F'_j$.

14. Check whether $j = N$. If so, perform step 16; if not, perform step 15.
15. Increase j by 1 and perform step 7.
16. Check whether any new approximations to the Q_{ij} 's were calculated for the given i . If so, perform step 17; if not, perform step 25.
17. Check whether $\sum_j Q'_{ij} = S_i$ for the given i . If so, perform step 21; if not, perform step 18.
18. Check whether $\bar{R}_i = 0$ for the given i . If so, perform step 19; if not, perform step 20.
19. Check whether $\sum_j Q_{ij} - S_i$ is positive. If so, perform step 20; if not, perform step 21.
20. Balance the sum of indicated shipments with the available supply for the given i in such a manner as to approximate restrictions so that all net prices corresponding to shipping routes used must be non-negative and equal to each other, and, in turn, not less than those corresponding to non-active routes.

A convenient means of doing this is as follows: Let Q''_{ij} denote a newer approximation, then,

$$Q''_{ij} = Q'_{ij} - \left(\frac{\frac{1}{F'_j}}{\sum_j \frac{1}{F'_j}} \right) (\sum_j Q'_{ij} - S_i), \quad Q'_{ij} \neq 0$$

$$j = 1, 2, \dots, n.$$

21. Update X_j and P_j , $j = 1, 2, \dots, n$.
22. Check if any Q_{ij}'' was set to zero or to one-half Q_{ij} for the given i . If so, perform step 20; if not, perform step 23.
23. Check if the new $\bar{R}_i$ is negative for the given i . If negative, set it equal to zero and perform step 6; if non-negative, perform step 24.
24. Check whether the new $\sum_i Q_{ij} - S_i$ is negative. If so, perform step 6; if not, perform step 25.
25. Check whether $i = M$. If so, perform step 27, if not, perform step 26.
26. Increase i by 1. Perform step 5.
27. Check whether a new approximation to at least one Q_{ij} was calculated during the iteration. If so, perform step 4; if not, the problem is solved.

Most of the steps above are for the purpose of "checking." This "checking" procedure can be done rather quickly when the calculations are performed on a computer, such as an IBM 7040 which was used to perform the calculations necessary for this study.

APPENDIX B

TRANSPORTATION COST MATRICES

TABLE XXII
ESTIMATES OF TRANSPORTATION COSTS FOR CARCASS BEEF AND PORK BETWEEN SPECIFIED
REGIONS, PRESENT HIGHWAY SYSTEM, UNITED STATES, 1962^a

Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	(Dollars per 100 pounds)																													
1	0																													
2	.91	0																												
3	1.40	1.11	0																											
4	1.53	1.07	.87	0																										
5	1.92	1.61	1.10	1.09	0																									
6	1.79	1.41	.98	.73	.75	0																								
7	2.08	1.88	1.65	1.42	1.19	1.15	0																							
8	2.05	1.81	1.35	1.36	.62	1.02	1.17	0																						
9	2.12	1.98	1.57	1.67	1.06	1.42	1.50	.82	0																					
10	1.93	1.64	1.02	1.28	.79	1.10	1.55	.89	1.03	0																				
11	1.75	1.40	.66	1.10	.98	1.06	1.66	1.18	1.37	.71	0																			
12	1.59	1.21	.60	1.13	1.25	1.22	1.80	1.45	1.60	1.04	.64	0																		
13	1.79	1.49	.90	1.34	1.22	1.34	1.82	1.36	1.45	.87	.61	.68	0																	
14	1.73	1.51	1.13	1.56	1.58	1.62	2.01	1.70	1.75	1.30	1.05	.86	.81	0																
15	1.97	1.75	1.25	1.61	1.37	1.55	1.91	1.43	1.39	.95	.97	1.08	.71	.97	0															
16	1.85	1.66	1.28	1.67	1.62	1.69	2.03	1.71	1.72	1.30	1.13	1.04	.84	.55	.84	0														
17	2.14	2.03	1.67	1.80	1.30	1.61	1.71	1.11	.64	1.14	1.46	1.67	1.48	1.74	1.32	1.68	0													
18	2.07	1.92	1.49	1.77	1.47	1.68	1.95	1.47	1.30	1.09	1.23	1.36	1.04	1.25	.64	1.09	1.16	0												
19	2.08	1.95	1.62	1.89	1.71	1.86	2.07	1.73	1.61	1.40	1.42	1.47	1.19	1.21	.85	.99	1.48	.73	0											
20	2.06	1.96	1.73	1.97	1.90	1.98	2.13	1.94	1.88	1.65	1.60	1.57	1.37	1.19	1.17	.97	1.79	1.20	.84	0										
21	2.14	2.14	2.06	2.14	2.12	2.14	2.09	2.12	2.07	2.00	1.99	1.98	1.87	1.76	1.70	1.63	2.00	1.63	1.35	1.13	0									
22	2.14	2.11	1.89	2.06	1.90	2.02	2.13	1.88	1.72	1.66	1.74	1.79	1.57	1.60	1.28	1.44	1.55	1.06	.85	1.10	1.21	0								
23	2.14	2.10	1.85	2.10	1.75	1.94	2.06	1.70	1.44	1.51	1.66	1.77	1.54	1.67	1.25	1.54	1.20	.93	1.04	1.43	1.58	.82	0							
24	2.13	2.13	1.93	2.02	1.69	1.91	1.95	1.54	1.15	1.54	1.76	1.91	1.74	1.91	1.55	1.84	.87	1.34	1.56	1.85	1.97	1.47	1.06	0						
25	1.87	2.04	2.14	2.12	2.12	2.14	2.13	2.09	1.95	2.06	2.12	2.14	2.08	2.11	1.97	2.07	1.81	1.82	1.82	1.96	1.85	1.53	1.43	1.50	0					
26	2.04	2.12	2.12	2.14	2.10	2.14	2.13	2.08	1.96	1.99	2.05	2.08	1.98	2.00	1.80	1.90	1.81	1.63	1.53	1.66	1.40	1.10	1.24	1.61	1.04	0				
27	1.97	2.06	2.14	2.08	2.14	2.09	1.93	2.14	2.14	2.13	2.14	2.14	2.10	2.07	2.01	2.00	2.10	1.94	1.78	1.71	1.13	1.53	1.78	2.04	1.71	1.27	0			
28	1.73	1.91	2.11	1.99	2.12	2.04	1.90	2.13	2.14	2.14	2.14	2.13	2.14	2.14	2.09	2.12	2.10	2.01	1.94	1.97	1.66	1.68	1.79	1.98	1.33	1.12	1.15	0		
29	1.00	1.25	1.65	1.31	1.63	1.36	.95	1.64	1.86	1.87	1.80	1.78	1.95	1.78	2.06	2.06	1.99	2.11	2.14	2.14	2.02	2.12	2.14	2.10	2.05	1.96	1.64	1.57	0	
30	.85	1.23	1.73	1.44	1.83	1.59	1.42	1.90	2.06	1.98	1.90	1.83	1.98	1.97	2.10	2.05	2.12	2.14	2.14	2.14	2.10	2.10	2.11	2.14	1.71	1.83	1.86	1.38	1.60	0

^aThese costs were estimated from regression equations developed in Chapter III.

TABLE XXIII
ESTIMATES OF TRANSPORTATION COSTS FOR CARCASS BEEF AND PORK BETWEEN SPECIFIED
REGIONS, INTERSTATE HIGHWAY SYSTEM, UNITED STATES, 1962^a

Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	(Dollars per 100 pounds)																													
1	0																													
2	.68	0																												
3	1.00	.81	0																											
4	1.08	.78	.65	0																										
5	1.35	1.14	.80	.80	0																									
6	1.26	1.01	.73	.56	.58	0																								
7	1.46	1.32	1.17	1.01	.86	.84	0																							
8	1.44	1.27	.97	.97	.49	.75	.85	0																						
9	1.49	1.39	1.11	1.18	.78	1.02	1.06	.63	0																					
10	1.35	1.16	.75	.92	.60	.81	1.10	.67	.76	0																				
11	1.23	1.00	.52	.80	.72	.78	1.17	.86	.98	.55	0																			
12	1.12	.88	.48	.82	.90	.88	1.26	1.03	1.13	.76	.51	0																		
13	1.26	1.06	.67	.96	.88	.96	1.28	.98	1.03	.66	.49	.53	0																	
14	1.22	1.07	.83	1.10	1.14	1.14	1.41	1.20	1.23	.93	.77	.65	.61	0																
15	1.38	1.23	.90	1.14	.98	1.10	1.34	1.02	.99	.71	.72	.79	.55	.72	0															
16	1.30	1.17	.92	1.18	1.14	1.19	1.43	1.20	1.21	.94	.83	.76	.63	.45	.63	0														
17	1.51	1.43	1.18	1.27	.93	1.14	1.20	.81	.51	.83	1.04	1.18	1.05	1.23	.95	1.18	0													
18	1.46	1.34	1.06	1.25	1.05	1.19	1.37	1.04	.94	.80	.86	.98	.76	.90	.51	.80	.85	0												
19	1.46	1.37	1.15	1.33	1.20	1.30	1.45	1.22	1.14	1.00	1.01	1.05	.86	.88	.64	.73	1.05	.57	0											
20	1.44	1.38	1.22	1.38	1.33	1.39	1.50	1.36	1.32	1.17	1.13	1.11	.98	.86	.85	.72	1.26	.87	.63	0										
21	1.52	1.51	1.45	1.51	1.49	1.51	1.50	1.49	1.45	1.40	1.40	1.39	1.31	1.24	1.20	1.15	1.40	1.15	.97	.82	0									
22	1.52	1.48	1.33	1.45	1.33	1.42	1.50	1.32	1.21	1.17	1.22	1.26	1.11	1.13	.92	1.02	1.10	.78	.64	.81	.87	0								
23	1.52	1.47	1.30	1.41	1.23	1.36	1.45	1.20	1.02	1.07	1.17	1.25	1.09	1.18	.90	1.09	.87	.70	.77	1.02	1.12	.62	0							
24	1.52	1.50	1.35	1.42	1.19	1.34	1.36	1.09	.84	1.09	1.24	1.34	1.22	1.34	1.10	1.29	.65	.96	1.11	1.30	1.38	1.04	.78	0						
25	1.39	1.48	1.52	1.52	1.49	1.52	1.52	1.47	1.37	1.44	1.49	1.51	1.46	1.49	1.38	1.45	1.27	1.28	1.28	1.38	1.30	1.08	1.02	1.06	0					
26	1.47	1.51	1.49	1.52	1.48	1.51	1.52	1.46	1.37	1.40	1.44	1.46	1.39	1.40	1.27	1.33	1.27	1.15	1.08	1.17	1.00	.80	.90	1.14	.77	0				
27	1.44	1.49	1.52	1.49	1.52	1.50	1.42	1.52	1.51	1.50	1.51	1.51	1.47	1.45	1.41	1.40	1.48	1.36	1.25	1.21	.82	1.09	1.25	1.43	1.21	.91	0			
28	1.31	1.41	1.51	1.45	1.51	1.48	1.41	1.52	1.51	1.51	1.52	1.52	1.51	1.51	1.47	1.49	1.47	1.41	1.36	1.38	1.17	1.19	1.26	1.39	.95	.82	.84	0		
29	.89	1.03	1.26	1.07	1.25	1.10	.86	1.26	1.38	1.39	1.35	1.34	1.43	1.34	1.49	1.49	1.45	1.51	1.52	1.52	1.42	1.50	1.52	1.51	1.44	1.38	1.16	1.11	0	
30	.80	1.02	1.31	1.14	1.36	1.23	1.13	1.40	1.49	1.45	1.40	1.37	1.45	1.44	1.50	1.48	1.51	1.52	1.52	1.52	1.48	1.47	1.49	1.51	1.21	1.28	1.30	.99	1.13	0

^aThese costs were estimated from regression equations developed in Chapter III.

TABLE XXIV
ESTIMATES OF TRANSPORTATION COSTS FOR BROILERS BETWEEN SPECIFIED REGIONS,
PRESENT HIGHWAY SYSTEM, UNITED STATES, 1962^a

Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	(Dollars per 100 pounds)																													
1	0																													
2	1.09	0																												
3	.79	.87	0																											
4	1.27	.89	.89	0																										
5	1.34	.77	.99	.69	0																									
6	1.49	.92	1.09	.70	.63	0																								
7	1.94	1.17	1.55	1.10	.92	.85	0																							
8	1.68	1.10	1.26	.79	.77	.62	.83	0																						
9	1.99	1.32	1.50	1.01	.98	.82	.85	.68	0																					
10	2.43	1.68	1.94	1.35	1.29	1.12	.94	.97	.75	0																				
11	2.86	1.99	2.32	1.69	1.59	1.42	1.12	1.26	1.03	.73	0																			
12	3.40	2.59	2.80	2.10	2.10	1.87	1.69	1.66	1.37	1.09	.98	0																		
13	3.09	2.09	2.53	1.93	1.75	1.61	1.19	1.48	1.27	.99	.75	1.24	0																	
14	3.68	2.60	3.12	2.44	2.23	2.09	1.56	1.95	1.72	1.37	1.07	1.46	.80	0																
15	2.74	1.78	2.25	1.73	1.52	1.42	.97	1.35	1.21	1.04	.91	1.54	.75	.98	0															
16	2.27	1.41	1.86	1.40	1.18	1.12	.71	1.09	1.04	1.00	1.06	1.69	1.00	1.31	.74	0														
17	1.94	1.16	1.59	1.22	.98	.98	.67	1.01	1.07	1.15	1.30	1.94	1.28	1.61	.98	.70	0													
18	2.31	1.42	1.93	1.55	1.29	1.28	.88	1.29	1.28	1.27	1.31	2.00	1.16	1.40	.85	.68	.72	0												
19	2.73	1.78	2.38	1.96	1.66	1.65	1.18	1.65	1.63	1.54	1.47	2.00	1.22	1.33	.92	.93	1.02	.74	0											
20	2.06	1.27	1.81	1.57	1.28	1.36	1.07	1.44	1.54	1.63	1.73	2.50	1.60	1.86	1.23	1.00	.85	.80	.93	0										
21	2.93	2.06	2.72	2.50	2.13	2.23	1.80	2.31	2.39	2.39	2.35	3.26	2.05	2.12	1.66	1.58	1.53	1.29	1.09	1.09	0									
22	3.18	2.15	2.79	2.32	2.00	1.98	1.45	1.96	1.90	1.73	1.59	2.31	1.27	1.24	1.03	1.15	1.30	.99	.70	1.18	1.12	0								
23	3.61	2.49	3.09	2.50	2.23	2.13	1.57	2.04	1.86	1.58	1.32	1.86	.97	.78	.97	1.27	1.54	1.26	1.06	1.62	1.70	.91	0							
24	4.13	2.98	3.55	2.58	2.60	2.45	1.89	2.31	2.06	1.69	1.35	1.68	1.05	.70	1.23	1.59	1.92	1.66	1.50	2.11	2.24	1.34	.83	0						
25	4.66	3.40	4.11	3.38	3.10	2.99	2.33	2.87	2.65	2.28	1.92	2.39	1.53	1.14	1.59	1.96	2.27	1.89	1.59	2.27	2.07	1.31	.97	.93	0					
26	3.99	2.85	3.57	3.09	2.72	2.67	2.06	2.65	2.51	2.29	2.03	2.73	1.60	1.39	1.47	1.70	1.90	1.53	1.17	1.72	1.37	.90	1.01	1.33	1.00	0				
27	5.06	3.95	4.84	4.52	4.03	4.12	3.45	4.19	4.20	4.04	3.82	4.83	3.31	3.06	2.96	3.08	3.13	2.70	2.28	2.57	1.65	2.03	2.50	2.98	2.35	1.68	0			
28	5.94	4.55	5.47	4.90	4.43	4.42	3.62	4.39	4.26	3.91	3.54	4.33	3.00	2.55	2.86	3.17	3.38	2.90	2.41	3.03	2.23	2.05	2.14	2.33	1.64	1.44	1.33	0		
29	6.79	5.56	6.57	6.42	5.83	5.91	5.21	6.09	6.06	5.99	5.73	6.96	5.03	4.76	4.63	4.76	4.78	4.27	3.77	4.05	2.87	3.50	4.04	4.62	3.75	3.00	1.38	2.11	0	
30	8.50	6.94	8.04	7.47	6.84	6.87	5.89	6.85	6.71	6.30	5.83	6.76	5.11	4.54	4.95	5.32	5.55	4.95	4.30	5.01	3.85	3.87	4.00	4.19	3.24	3.03	2.11	1.61	1.91	0

^aThese costs were estimated from regression equations developed in Chapter III.

TABLE XXV

ESTIMATES OF TRANSPORTATION COSTS FOR BROILERS BETWEEN SPECIFIED REGIONS,
INTERSTATE HIGHWAY SYSTEM, UNITED STATES, 1962^a

Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	(Dollars per 100 pounds)																													
1	0																													
2	.88	0																												
3	.69	.74	0																											
4	1.00	.75	.75	0																										
5	1.04	.67	.81	.62	0																									
6	1.14	.77	.88	.62	.58	0																								
7	1.44	.93	1.18	.89	.77	.72	0																							
8	1.27	.88	.99	.68	.67	.57	.71	0																						
9	1.47	1.03	1.15	.82	.81	.71	.72	.61	0																					
10	1.77	1.27	1.44	1.05	1.01	.90	.78	.80	.66	0																				
11	2.05	1.47	1.69	1.27	1.20	1.10	.90	.99	.84	.64	0																			
12	2.41	1.87	2.01	1.54	1.54	1.39	1.27	1.26	1.06	.88	.81	0																		
13	2.20	1.54	1.83	1.43	1.31	1.22	.94	1.14	1.00	.81	.66	.98	0																	
14	2.60	1.88	2.22	1.77	1.63	1.54	1.19	1.44	1.29	1.06	.87	1.12	.69	0																
15	1.97	1.33	1.65	1.30	1.16	1.10	.80	1.05	.96	.85	.76	1.17	.66	.81	0															
16	1.66	1.09	1.38	1.08	.94	.90	.63	.88	.84	.82	.86	1.28	.82	1.02	.65	0														
17	1.44	.92	1.21	.96	.80	.80	.60	.82	.86	.92	1.02	1.44	1.01	1.22	.81	.62	0													
18	1.69	1.10	1.43	1.18	1.01	1.00	.74	1.01	1.00	1.00	1.02	1.48	.93	1.08	.72	.61	.64	0												
19	1.97	1.34	1.73	1.45	1.25	1.25	.94	1.25	1.23	1.17	1.13	1.61	.96	1.03	.77	.77	.83	.65	0											
20	1.52	1.00	1.36	1.20	1.01	10.5	.87	1.11	1.18	1.23	1.30	1.81	1.21	1.38	.97	.82	.72	.69	.77	0										
21	2.10	1.52	1.96	1.81	1.57	1.63	1.34	1.69	1.74	1.74	1.71	2.32	1.51	1.56	1.26	1.20	1.17	1.01	.88	.88	0									
22	2.26	1.58	2.00	1.69	1.58	1.47	1.12	1.45	1.41	1.30	1.20	1.68	1.00	.97	.84	.92	1.02	.81	.63	.94	.90	0								
23	2.55	1.80	2.20	1.81	1.63	1.56	1.19	1.50	1.38	1.20	1.03	1.39	.80	.68	.80	1.00	1.17	.99	.86	1.23	1.28	.76	0							
24	2.90	2.13	2.51	1.86	1.88	1.77	1.41	1.69	1.52	1.27	1.05	1.27	.85	.62	.97	1.21	1.43	1.25	1.15	1.55	1.64	1.04	.71	0						
25	3.26	2.41	2.89	2.40	2.21	2.14	1.70	2.06	1.91	1.66	1.43	1.74	1.17	.91	1.20	1.45	1.66	1.41	1.20	1.66	1.53	1.02	.80	.78	0					
26	2.81	2.04	2.53	2.20	1.95	1.92	1.52	1.91	1.81	1.67	1.50	1.96	1.22	1.07	1.13	1.28	1.41	1.17	.93	1.29	1.06	.76	.83	1.03	.82	0				
27	3.53	2.78	3.37	3.16	2.83	2.90	2.44	2.94	2.95	2.84	2.69	3.37	2.35	2.19	2.12	2.20	2.23	1.95	1.66	1.86	1.25	1.50	1.81	2.13	1.71	1.27	0			
28	4.12	3.18	3.80	3.42	3.10	3.10	2.56	3.07	2.99	2.75	2.50	3.03	2.14	1.84	2.05	2.26	2.40	2.08	1.75	2.17	1.63	1.51	1.57	1.70	1.24	1.11	1.04	0		
29	4.69	3.86	4.54	4.44	4.04	4.10	3.62	4.22	4.20	4.15	3.98	4.80	3.51	3.32	3.24	3.33	3.34	2.99	2.66	2.85	2.06	2.48	2.84	3.23	2.65	2.14	1.07	1.55	0	
30	5.85	4.79	5.54	5.15	4.73	4.74	4.08	4.73	4.63	4.36	4.04	4.67	3.56	3.18	3.45	3.70	3.86	3.45	3.02	3.49	2.71	2.72	2.81	2.94	2.30	2.17	1.55	1.22	1.42	0

^aThese costs were estimated from regress equations developed in Chapter III.

TABLE XXVI
ESTIMATES OF TRANSPORTATION COSTS FOR EGGS BETWEEN SPECIFIED REGIONS,
PRESENT HIGHWAY SYSTEM, UNITED STATES, 1962^a

Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	(Cents per dozen)																													
1	0																													
2	1.81	0																												
3	1.83	1.66	0																											
4	2.73	2.32	2.12	0																										
5	2.43	2.21	1.63	1.71	0																									
6	2.69	2.51	2.06	1.76	1.37	0																								
7	2.97	2.83	2.54	1.94	1.99	1.54	0																							
8	3.05	2.94	2.79	2.11	2.41	2.10	1.57	0																						
9	3.04	3.06	3.03	2.83	2.81	2.56	2.19	2.25	0																					
10	3.06	3.05	2.98	2.46	2.71	2.48	1.99	1.37	2.22	0																				
11	2.94	3.06	3.07	2.74	2.98	2.85	2.56	2.05	2.65	1.70	0																			
12	3.05	2.89	2.81	1.99	2.53	2.37	2.12	1.64	2.72	1.80	2.01	0																		
13	2.93	2.61	2.52	1.43	2.19	2.11	2.05	1.93	2.84	2.23	2.49	1.51	0																	
14	2.76	2.29	2.27	1.33	2.06	2.16	2.29	2.32	2.97	2.60	2.78	2.02	1.41	0																
15	2.96	2.61	2.65	1.81	2.47	2.46	2.44	2.29	2.99	2.48	2.59	1.77	1.35	1.46	0															
16	2.75	2.18	2.43	2.03	2.47	2.63	2.75	2.75	3.07	2.90	2.98	2.47	2.05	1.63	1.79	0														
17	3.07	2.89	2.93	2.33	2.81	2.79	2.72	2.49	3.04	2.57	2.51	1.89	1.92	2.08	1.52	2.94	0													
18	3.05	2.81	2.93	2.51	2.89	2.93	2.93	2.84	3.05	2.91	2.89	2.45	2.29	2.21	1.86	1.90	1.66	0												
19	3.05	3.01	3.07	2.91	3.06	3.07	3.07	3.04	2.88	3.06	3.03	2.83	2.77	2.74	2.49	2.48	2.22	1.71	0											
20	3.03	3.03	3.06	2.80	3.04	3.03	3.02	2.89	3.04	2.91	2.78	2.52	2.56	2.62	2.25	2.52	1.73	1.72	1.71	0										
21	3.04	3.03	3.05	2.64	2.97	2.95	2.86	2.62	3.06	2.62	2.40	2.10	2.29	2.48	2.02	2.55	1.41	1.98	2.26	1.55	0									
22	2.96	3.07	3.07	2.75	3.00	2.93	2.75	2.36	2.93	2.17	1.61	2.00	2.44	2.72	2.43	2.88	2.15	2.65	2.85	2.42	1.89	0								
23	2.74	2.99	3.04	2.95	3.06	3.01	2.83	2.47	2.83	2.14	1.41	2.39	2.76	2.96	2.81	3.05	2.68	2.98	3.05	2.85	2.53	1.71	0							
24	2.38	2.82	2.86	3.06	3.02	3.06	3.06	2.91	3.07	2.76	2.27	2.76	2.97	3.06	2.95	3.07	2.76	2.98	3.01	2.75	2.49	2.00	1.93	0						
25	2.76	3.04	2.99	3.04	3.04	3.05	3.07	3.04	2.92	3.03	2.90	2.84	2.92	2.97	2.74	2.92	2.38	2.41	2.13	1.74	2.05	2.56	2.89	2.62	0					
26	2.61	2.97	2.84	3.05	2.84	2.80	2.83	2.96	2.24	2.95	3.04	3.07	3.07	3.07	3.02	3.02	2.88	2.70	2.16	2.47	2.81	3.05	3.04	3.07	2.27	0				
27	1.58	2.37	2.02	2.64	2.09	2.11	2.19	2.55	1.41	2.57	2.85	2.90	2.86	2.84	3.00	2.97	3.07	3.06	2.89	2.95	3.06	3.04	2.88	3.06	2.70	2.15	0			
28	.94	1.92	1.75	2.66	2.10	2.21	2.48	2.83	2.19	2.92	3.07	3.01	2.90	2.79	2.99	2.82	2.80	3.06	3.06	3.00	3.02	3.04	3.06	2.80	2.69	2.95	2.73	0		
29	b	b	b	b	b	b	b	b	b	2.81	1.13	1.17	.87	.82	1.49	1.28	2.01	2.20	2.73	2.64	2.32	1.85	1.37	2.29	2.93	3.07	2.82	3.07	0	
30	b	b	b	b	b	b	b	b	b	1.28	2.03	1.65	1.27	1.01	1.65	1.16	2.23	2.18	2.59	2.69	2.55	2.46	2.32	2.90	3.00	3.00	3.01	2.76	2.77	0

^aThese costs were estimated from regression equations developed in Chapter III.

^bThese calculated costs were not applicable due to the nature of the estimating equation. The cost for the immediately preceding route was used in each of these cases.

TABLE XXVII

ESTIMATES OF TRANSPORTATION COSTS FOR EGGS BETWEEN SPECIFIED REGIONS,
INTERSTATE HIGHWAY SYSTEM, UNITED STATES, 1962^a

Region	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
	(Cents per dozen)																													
1	0																													
2	1.45	0																												
3	1.47	1.35	0																											
4	2.07	1.79	1.66	0																										
5	1.86	1.71	1.33	1.39	0																									
6	2.04	1.92	1.62	1.42	1.16	0																								
7	2.25	2.14	1.95	1.54	1.57	1.27	0																							
8	2.33	2.23	2.11	1.65	1.85	1.64	1.30	0																						
9	2.37	2.37	2.31	2.15	2.14	1.95	1.70	1.74	0																					
10	2.37	2.33	2.26	1.89	2.06	1.90	1.57	1.16	1.72	0																				
11	2.34	2.37	2.35	2.08	2.26	2.16	1.95	1.61	2.02	1.38	0																			
12	2.33	2.19	2.14	1.57	1.94	1.82	1.66	1.34	2.07	1.45	1.58	0																		
13	2.22	1.99	1.93	1.20	1.70	1.65	1.61	1.53	2.15	1.73	1.91	1.26	0																	
14	2.10	1.77	1.76	1.14	1.62	1.68	1.77	1.79	2.25	1.98	2.11	1.59	1.19	0																
15	2.25	1.99	2.01	1.45	1.89	1.88	1.87	1.77	2.27	1.90	1.98	1.42	1.15	1.22	0															
16	2.09	1.69	1.88	1.60	1.89	2.00	2.08	2.09	2.36	2.20	2.26	1.89	1.61	1.33	1.44	0														
17	2.35	2.19	2.22	1.79	2.13	2.12	2.07	1.91	2.32	1.96	1.92	1.51	1.52	1.63	1.26	2.23	0													
18	2.33	2.13	2.23	1.92	2.19	2.22	2.22	2.15	2.37	2.21	2.19	1.88	1.77	1.71	1.48	1.51	1.35	0												
19	2.37	2.29	2.35	2.21	2.35	2.35	2.35	2.31	2.31	2.33	2.30	2.15	2.10	2.08	1.91	1.90	1.72	1.38	0											
20	2.36	2.31	2.34	2.12	2.32	2.31	2.29	2.19	2.37	2.21	2.11	1.93	1.95	2.00	1.74	1.92	1.40	1.39	1.39	0										
21	2.37	2.31	2.33	2.01	2.26	2.24	2.17	2.00	2.34	1.99	1.85	1.64	1.77	1.90	1.59	1.94	1.19	1.56	1.75	1.28	0									
22	2.34	2.36	2.35	2.08	2.28	2.22	2.09	1.82	2.22	1.69	1.32	1.58	1.87	2.07	1.86	2.18	1.68	2.02	2.16	1.86	1.50	0								
23	2.25	2.35	2.37	2.23	2.34	2.29	2.15	1.89	2.15	1.67	1.19	1.84	2.10	2.25	2.13	2.33	2.04	2.26	2.33	2.16	1.93	1.39	0							
24	2.07	2.29	2.30	2.34	2.36	2.37	2.34	2.21	2.35	2.10	1.76	2.09	2.26	2.33	2.24	2.35	2.09	2.27	2.29	2.08	1.91	1.58	1.53	0						
25	2.25	2.37	2.35	2.31	2.37	2.37	2.36	2.32	2.33	2.31	2.20	2.15	2.21	2.25	2.08	2.21	1.83	1.85	1.66	1.40	1.61	1.95	2.19	1.99	0					
26	2.19	2.35	2.29	2.37	2.29	2.28	2.29	2.34	2.00	2.34	2.37	2.36	2.36	2.35	2.30	2.30	2.19	2.05	1.68	1.89	2.13	2.33	2.37	2.35	1.75	0				
27	1.65	2.06	1.89	2.20	1.92	1.93	1.97	2.16	1.56	2.17	2.30	2.32	2.30	2.29	2.36	2.34	2.36	2.34	2.19	2.24	2.33	2.37	2.31	2.37	2.05	1.68	0			
28	1.31	1.83	1.75	2.21	1.93	1.99	2.12	2.29	1.97	2.33	2.37	2.36	2.32	2.27	2.35	2.28	2.28	2.37	2.34	2.28	2.30	2.32	2.35	3.12	2.05	2.24	2.07	0		
29	b	b	b	b	b	b	b	b	b	.94	1.41	1.43	1.27	1.24	1.61	1.49	1.88	1.98	2.24	2.20	2.04	1.80	1.54	2.02	2.33	2.36	2.14	2.35	0	
30	b	b	b	b	b	b	b	b	b	1.49	1.89	1.65	1.49	1.35	1.69	1.43	1.99	1.97	2.18	2.22	2.16	2.11	2.04	2.32	2.36	2.36	2.29	2.09	2.10	0

^aThese costs were estimated from regression equations developed in Chapter III.

^bThese calculated costs were not applicable due to the nature of the estimating equations. The cost for the immediately preceding route was used in each of these cases.

APPENDIX C

ESTIMATES OF REGIONAL PROCESSING COSTS

Processing costs for beef, pork and broilers were estimated by adjusting a United States Average cost per pound for each product by regional wage rate differentials reported for plants processing each of these products. The procedure followed was to: (1) derive an average labor cost per pound of product for each region based on the wage rate in that region, and the average carcass weight reported handled per man-hour in 1962 for the United States as a whole; (2) determine the regional percentage deviation from the aggregate labor cost per pound using the same procedure; (3) use this percentage deviation for each region to adjust the national average labor cost per pound as determined in a separate analysis for each product;¹ and (4) add this adjusted labor cost per pound to the non-labor costs for each product.

Explicitly stated, the procedure can be outlined as follows:

$$P_i = 100 - \frac{W_i}{H/A} \quad (1)$$

$$C_i = [L \pm (P_i \cdot L)] + L', i = 1, 2, \dots 30 \quad (2)$$

¹For beef a cost of \$.0156 per pound was used: See Donald B. Agnew, "Meat Packers' Costs and Spreads for Beef," Marketing and Transportation Situation - 150, Economic Research Service, United States Department of Agriculture (Washington: Government Printing Office, August, 1963), p. 37.

For pork a cost of \$.0158 per pound was used: See Donald B. Agnew, "Meat Packers' Cost for Slaughtering Hogs and Distributing Pork," Marketing and Transportation Situation - 152, Economic Research Service, United States Department of Agriculture (Washington: Government Printing Office, February, 1964), pp. 20-21.

For broilers a cost of \$.0300 per pound was used: See W. R. Henry, J. S. Chappell and J. A. Seagraves, Broiler Production Density, Plant Size, Alternative Operating Plans, and Total Unit Costs, Technical Bulletin No. 144 (Raleigh: North Carolina Agricultural Experiment Station, 1960), p. 38.

where

P_i = the regional percentage deviation from the aggregate labor cost per pound.

W_i = the regional average hourly wage rate for the specified product.

H = the national average weight (carcass) handled per man-hour for the specified product.

A = the national average labor cost per pound as determined by (H) , and the national average hourly wage rate in processing plants (W) for the specified product.

L = Labor cost per pound based on a separate analysis for each product.²

L' = non-labor costs as determined by the same studies.³

C_i = an estimate of processing cost per pound, by region, for the specified product.

The necessary data for deriving these estimates of regional processing costs are given in Tables XXVIII and XXIX.

²Ibid.

³Ibid.

TABLE XXVIII

HOURS WORKED, WAGE RATES, QUANTITIES PROCESSED AND
PROCESSING COSTS FOR BEEF, PORK AND BROILER
PLANTS, UNITED STATES, 1962

Type information	Symbol	Type of processing plant		
		Beef	Pork	Broilers
Man-hours worked (1,000)		323,678 ^a	323,678 ^a	115,234
Wage rate per hour (dollars)	W	2.77 ^a	2.77 ^a	1.43
Carcass weight processed				
Total (million pounds)		14,946	11,200	4,998
Per man-hour (pounds)	H	80.8 ^a	80.8 ^a	43.4
Average cost per pound	A	.034	.034	.033
Labor cost per pound	L	.0156	.0158	.015
Non-labor cost per pound	L'	.0158	.0158	.015

^aIncludes meat packing plants processing beef and pork.

Source: Bureau of Labor Statistics, Employment and Earnings, Vol. 10, No. 3, United States Department of Labor (Washington: Government Printing Office, 1963), pp. 119 and 139-41; Economic Research Service, Marketing and Transportation Situation - 150 and 152, United States Department of Agriculture (Washington: Government Printing Office, 1963 and 1964), pp. 37 and 20-21, respectively; and Henry et al., Broiler Production Density, Plant Size, Alternative Operating Plans and Total Unit Costs, Technical Bulletin No. 144 (Raleigh: North Carolina Agricultural Experiment Station, 1960), p. 38.

TABLE XXIX

REGIONAL WAGE RATES AND ESTIMATED PROCESSING COST
FOR BEEF, PORK AND BROILERS, 1962

Region ^a	Wage rate per hour ^b		Estimated processing cost per pound		
	Beef and pork	Broilers	Beef	Pork	Broilers
1	2.77	1.35	.0314	.0315	.0291
2	2.76	1.46	.0314	.0315	.0305
3	1.95	1.52	.0269	.0269	.0309
4	1.60	1.49	.0250	.0250	.0305
5	2.23	1.43	.0286	.0279	.0300
6	1.66	1.41	.0255	.0255	.0296
7	1.88	1.29	.0264	.0265	.0287
8	2.13	1.29	.0277	.0277	.0287
9	1.98	1.29	.0273	.0274	.0287
10	2.58	1.17	.0305	.0306	.0273
11	2.63	1.25	.0309	.0310	.0282
12	2.78	1.19	.0314	.0315	.0273
13	2.93	1.26	.0323	.0325	.0282
14	2.76	1.17	.0314	.0315	.0273
15	3.07	1.29	.0333	.0334	.0287
16	3.14	1.37	.0337	.0339	.0296
17	2.00	1.44	.0273	.0274	.0300
18	3.03	1.45	.0333	.0334	.0300
19	3.18	1.44	.0337	.0339	.0300
20	3.67	1.44	.0364	.0365	.0300
21	3.18	1.36	.0337	.0339	.0291
22	3.06	1.25	.0333	.0334	.0282
23	2.77	1.28	.0314	.0315	.0282
24	2.42	1.25	.0333	.0334	.0282
25	2.48	1.22	.0328	.0301	.0278
26	3.00	1.29	.0328	.0329	.0389
27	2.80	1.41	.0319	.0320	.0296
28	2.82	1.38	.0319	.0320	.0296
29	2.98	1.93	.0328	.0329	.0350
30	3.27	1.75	.0342	.0343	.0332

^aRefers to the specified region for beef, pork and broilers as specified in Chapter IV.

^bEstimated for 1962 by ratio method from 1954 and 1958 data.

Source: United States Bureau of the Census, United States Census of Manufacturers: 1958, Vol. II, Part I, United States Department of Commerce (Washington: Government Printing Office, 1961), pp. 20A6-20A8, and 20B7.

APPENDIX D

EQUILIBRIUM SHIPMENTS AND NET REVENUES



TABLE XXX
OPTIMUM INTERREGIONAL FLOWS FOR BEEF,
PRESENT HIGHWAY SYSTEM, 1962

From region	To region						Total	
	1	2	12	14	15	24		30
	Million pounds							
3		140.9						140.9
4		85.7						85.7
5		158.6						158.6
6		44.9						44.9
7		158.5						158.5
8		109.1						109.1
9		143.4						143.4
10		221.7						221.7
11		95.9						95.9
13		415.0						415.0
16		334.3	48.8		141.9			525.0
17		31.5	31.2		32.1			94.8
18		176.4	176.4		178.8		85.4	617.0
19	638.8	224.6	220.4	126.5	226.2	82.5	219.6	1738.6
20	98.1	327.7	100.3	100.2	100.3		100.0	826.6
21	23.3	159.9	25.1	24.3	25.4	70.3	25.5	353.8
22	199.9	200.1	200.1	200.0	200.1	68.5	200.0	1268.7
23	67.5	67.7	67.6	67.5	67.7	69.2	67.6	474.8
25			12.1	10.2	11.5	13.9	25.0	72.7
26			71.3	71.2	71.3	71.7	72.4	357.9
28			23.7	23.2	22.8	23.7	41.2	134.6
29			33.8	30.0	12.5	24.2	36.5	137.0
Total	1027.6	3095.9	1010.8	653.1	1090.6	424.0	873.2	8175.2

TABLE XXXI

ESTIMATED NET PRICES FOR BEEF FOR EQUILIBRIUM SHIPPING
ROUTES, PRESENT HIGHWAY SYSTEM, 1962

From region	To region						Average net revenue ^a
	1	2	12	14	15	30	
	Dollars per million pounds						
3		712,702					712,702
4		712,704					712,704
5		712,695					712,695
6		712,700					712,700
7		712,694					712,694
8		712,694					712,694
9		712,693					712,693
10		712,693					712,693
11		712,695					712,695
13		712,692					712,692
16		712,689					712,694
17		712,692					712,698
18		712,687					712,695
19		712,686	712,698		712,703	712,690	712,688
20		712,684	712,698	712,696	712,704	712,691	712,687
21	712,680	712,677	712,690	712,694	712,705	712,687	712,687
22	712,680	712,679	712,689	712,689	712,691	712,690	712,695
23	712,682	712,687	712,691	712,693	712,701	712,692	712,692
25			712,688	712,688	712,692	712,695	712,692
26			712,688	712,689	712,689	712,694	712,692
28			712,689	712,689	712,692	712,689	712,693
29			712,691	712,691	712,691	712,687	712,692

^aA weighted average of the net revenues from specified shipping regions to specified markets.

TABLE XXXII
OPTIMUM INTERREGIONAL FLOWS FOR BEEF,
INTERSTATE HIGHWAY SYSTEM, 1962

From region	To region							Total
	1	2	12	14	15	24	30	
Million pounds								
3		141.5						141.5
4		85.8						85.8
5		158.6						158.6
6		44.9						44.9
7		175.3						175.3
8		109.1						109.1
9		145.7						145.7
10		221.7						221.7
11		95.9						95.9
13		415.6						415.6
16		329.7	44.5		137.1			511.3
17		39.1	39.1		39.1			117.3
18		175.0	175.0		175.0		106.7	631.7
19	641.0	219.3	219.3	125.7	219.6	81.8	219.3	1726.0
20	99.7	327.8	99.8	99.8	99.8		99.8	826.2
21	23.5	157.5	23.5	23.5	23.5	68.0	23.5	343.0
22	199.7	199.7	199.7	199.7	199.8	68.0	199.7	1266.3
23	67.7	67.7	67.7	67.7	67.7	67.7	67.7	473.9
25			12.4	12.4	12.4	12.4	12.5	62.1
26			70.7	70.7	70.7	70.7	70.7	353.5
28			24.0	23.9	24.0	24.0	25.2	121.1
29			31.8	31.7	31.0	32.4	32.9	159.8
Total	1031.6	3109.4	1007.5	655.1	1099.7	425.0	858.0	8186.3

TABLE XXXIII

ESTIMATED NET PRICES FOR BEEF FOR EQUILIBRIUM SHIPPING
ROUTES, INTERSTATE HIGHWAY SYSTEM, 1962

From region	To region						Average net revenue ^a
	1	2	12	14	15	30	
	Dollars per million pounds						
3		712,489					712,489
4		712,491					712,491
5		712,484					712,484
6		712,488					712,488
7		712,484					712,484
8		712,483					712,483
9		712,483					712,483
10		712,482					712,482
11		712,483					712,483
13		712,481					712,481
16		712,479					712,477
17		712,482					712,478
18		712,477					712,473
19		712,477			712,474		712,470
20		712,474			712,469		712,470
21		712,475			712,468		712,471
22		712,476			712,471		712,470
23		712,478			712,473		712,473
25				712,472	712,467		712,469
26				712,468	712,468		712,469
28				712,467	712,467		712,469
29				712,468	712,466		712,468
	712,467		712,473				
	712,464		712,475				
	712,466		712,471				
	712,467		712,470				
	712,469		712,471				
			712,470				
			712,466				
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			712,466				
			712,467				
			712,468				
			712,470				
			712,466				

TABLE XXXIV
OPTIMUM INTERREGIONAL FLOWS FOR BEEF, PREDICTED
1972 EQUILIBRIUM SOLUTION

From region	To region						Total
	1	2	12	15	24	30	
	Million pounds						
3		141.5					141.5
4		85.9					85.9
5		158.6					158.6
6		44.9					44.9
7		176.5					176.5
8		109.1					109.1
9		145.7					145.7
10		221.7					221.7
11		95.9					95.9
13		415.6					415.6
14		419.3					419.3
16		539.7					539.7
17		90.6				35.9	126.5
18		315.9				315.9	631.8
19	335.2	591.4		226.6		591.4	1744.6
20	118.8	346.2	118.8	118.8		118.8	821.4
21	38.6	172.6	38.6	38.6		38.6	327.0
22	259.3	259.3	259.3	259.3		259.3	1296.5
23	96.2	96.2	96.2	96.2	96.2	96.2	577.2
25			16.8	16.8	16.8	16.8	67.2
26			97.4	97.4	97.4	97.4	389.6
28			39.2	39.2	39.2	39.2	156.8
29			57.3	57.3	57.3	57.3	229.2
Total	848.1	4426.6	723.6	905.2	306.9	1666.8	8922.2

TABLE XXXV

ESTIMATED NET PRICES FOR BEEF, PREDICTED 1972 EQUILIBRIUM SOLUTION

From region	To region					Average net revenue ^a
	1	2	12	15	24	30
	Dollars per million pounds					
3		1,251,975				1,251,975
4		1,251,977				1,251,977
5		1,251,970				1,251,970
6		1,251,974				1,251,974
7		1,251,970				1,251,970
8		1,251,968				1,251,968
9		1,251,968				1,251,968
10		1,251,967				1,251,967
11		1,251,969				1,251,969
13		1,251,967				1,251,967
14		1,251,967				1,251,967
16		1,251,964				1,251,964
17		1,251,968				1,251,968
18		1,251,963				1,251,963
19		1,251,962				1,251,962
20		1,251,959				1,251,959
21		1,251,961				1,251,961
22		1,251,961				1,251,961
23		1,251,964				1,251,964
25						1,251,964
26						1,251,961
28						1,251,961
29						1,251,960
	1,251,962		1,251,957	1,251,962	1,251,967	1,251,970
	1,251,960		1,251,957	1,251,957	1,251,963	1,251,964
	1,251,962		1,251,957	1,251,957	1,251,961	1,251,962
	1,251,962		1,251,959	1,251,960	1,251,964	1,251,961
	1,251,964		1,251,961	1,251,962	1,251,964	1,251,961
			1,251,957	1,251,956	1,251,966	1,251,964
			1,251,957	1,251,956	1,251,967	1,251,961
			1,251,957	1,251,957	1,251,962	1,251,961
			1,251,958	1,251,956	1,251,961	1,251,961
			1,251,959	1,251,955	1,251,959	1,251,960

^aA weighted average of the net revenues from specified shipping regions to specified markets.

TABLE XXXVI

OPTIMUM INTERREGIONAL FLOWS FOR PORK, PRESENT HIGHWAY SYSTEM, 1962

From region	To region										Total
	1	2	7	12	14	17	24	29	30		
Million pounds											
3		300.0									300.0
4		158.0									158.0
5		218.4									218.4
6		58.8									58.8
8		95.6									95.6
9		99.6									99.6
10		160.2									160.2
11		99.2		99.9							199.1
13		183.7		183.7			367.6				735.0
15		70.0		70.0	70.0		140.0				350.0
16		74.8		74.8	74.8		74.8		74.8		374.0
18		145.3		72.3	72.3		72.3		72.3		484.9
19	713.7	1120.6	50.4	33.9	33.9	33.9	33.9		33.9		2037.7
20	33.5	446.5	33.5	33.5	33.5	33.5	33.5		33.5		681.0
21	16.9	16.9	16.9	16.9	16.9	16.9	16.9		16.9		135.2
22	45.0	45.0	45.0	45.0	45.0	45.0	45.0	19.1	45.0		379.1
23	24.5	24.5	24.5	24.5	24.5	24.5	24.5	18.4	24.5		214.4
Total	833.6	3317.4	204.2	654.5	370.9	153.8	808.5	37.5	300.9		6681.3

TABLE XXXVII

ESTIMATED NET PRICES FOR PORK FOR EQUILIBRIUM SHIPPING ROUTES, PRESENT HIGHWAY SYSTEM, 1962

From region	To region									Average net revenue
	1	2	7	12	14	17	24	29	30	
Dollars per million pounds										
3		456,704								456,704
4		456,706								456,706
5		456,699								456,699
6		456,703								456,703
8		456,698								456,698
9		456,697								456,697
10		456,697								456,697
11		456,698								456,702
13		456,696								456,695
15		456,693								456,694
16		456,693								456,694
18		456,692		456,705						456,692
19		456,691		456,703						456,692
20		456,688		456,700						456,689
21		456,690		456,698						456,687
22		456,690		456,697						456,688
23		456,687		456,692						456,689
		456,684		456,698						456,692
		456,682		456,686						456,693
		456,684		456,683						456,689
		456,685		456,685						456,692
		456,685		456,686						456,693
		456,687		456,688						456,695
				456,692						456,692
				456,691						456,692
				456,697						456,689
				456,693						456,687
				456,695						456,688
				456,695						456,692
				456,697						456,693
				456,697						456,695
				456,698						456,692
				456,697						456,693
				456,698						456,695
				456,696						456,692
				456,693						456,693
				456,693						456,695
				456,692						456,692
				456,691						456,692
				456,688						456,689
				456,688						456,692
				456,685						456,693
				456,686						456,695
				456,688						456,692
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				456,698						456,693
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				456,696						456,693
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				456,698						456,692
				456,696						456,693
				456,693						456,695
				456,693						456,692
				456,692						456,693
				456,691						456,695
				456,688						456,692
				456,688						456,693
				456,685						456,695
				456,686						

^aA weighted average of the net revenues from specified shipping regions to specified markets.

TABLE XXXVIII

OPTIMUM INTERREGIONAL FLOWS FOR PORK, INTERSTATE HIGHWAY SYSTEM, 1962

From region	1	2	7	12	To region				Total
					14	17	24	29	
					Million pounds				
3		296.3							296.3
4		157.6							157.6
5		212.2							212.2
6		58.8							58.8
8		95.6							95.6
9		99.2							99.2
10		160.1							160.1
11		99.8		99.8					199.6
13		183.5		185.3			367.0		734.0
15		70.9		71.4	71.8		141.1		355.2
16		74.7		74.7	74.7		74.7	74.7	373.5
18		145.4		72.4	72.4		72.4	72.4	485.2
19		1120.5	50.2	33.8	33.9	33.8	34.0	34.0	2037.3
20	713.4	447.5	33.9	34.8	35.1	34.1	34.8	34.7	689.1
21	33.6	16.7	19.0	16.7	16.7	16.7	16.8	17.6	136.9
22	16.7	45.0	45.0	45.0	45.0	45.0	45.0	19.1	379.1
23	45.0	24.5	24.5	24.5	24.5	24.5	25.2	18.2	214.8
Total	833.1	3308.3	207.1	656.6	374.1	154.1	811.0	37.3	6684.5

TABLE XXXIX
ESTIMATED NET PRICES FOR PORK FOR EQUILIBRIUM SHIPPING
ROUTES, INTERSTATE HIGHWAY SYSTEM, 1962

From region	To region										Average net revenue ^a
	1	2	7	12	14	17	24	29	30		
	Dollars per million pounds										
3		456,535								456,535	
4		456,537								456,537	
5		456,529								456,529	
6		456,533								456,533	
8		456,527								456,527	
9		456,526								456,526	
10		456,526								456,526	
11		456,528								456,533	
13		456,525								456,526	
15		456,522								456,526	
16		456,522								456,526	
18		456,520		456,537						456,524	
19		456,519		456,534						456,522	
20		456,517		456,527						456,519	
21	456,517	456,518	456,519	456,527	456,530	456,524	456,523	456,518	456,516	456,517	
22	456,517	456,518	456,517	456,522	456,525	456,524	456,524	456,516	456,516	456,520	
23	456,519	456,520	456,519	456,524	456,525	456,530	456,531	456,516	456,518	456,523	

^aA weighted average of the net revenues from specified shipping regions to specified markets.

TABLE XL

OPTIMUM INTERREGIONAL FLOWS FOR PORK, PREDICTED 1972 EQUILIBRIUM SOLUTION

From region	To region									Total
	1	2	7	12	14	15	17	24	30	
Million pounds										
3		300.3								300.3
4		119.9								119.9
5		109.2								109.2
6		29.4								29.4
8		47.7								47.7
9		49.8								49.8
10		160.2	160.2							320.4
11		100.0		100.0						200.0
13		367.5		367.5						735.0
16		84.6		84.6				84.6	84.6	173.8
18		165.6		92.6				92.6	92.6	350.8
19	590.5	1155.0		68.3				68.3	68.3	2087.0
20	54.1	476.1	21.3	54.1	11.0	84.6		54.1	54.1	813.0
21	47.3	47.3	47.3	47.3	22.6	92.6		47.3	47.3	378.4
22	74.7	74.7	74.7	74.7	68.3	68.3		74.7	74.7	597.6
23	44.6	44.6	44.6	44.6	54.1	54.1	15.2	44.6	44.6	372.0
29			14.7	14.7	14.7	14.7	13.9	14.7	14.7	102.1
Total	811.2	3322.9	362.8	948.4	337.3	480.9	29.1	480.9	480.9	7254.4

TABLE XLII

OPTIMUM INTERREGIONAL FLOWS FOR BROILERS, PRESENT HIGHWAY SYSTEM, 1962

From region	To region														Total
	2	3	4	5	12	17	18	19	20	21	25	26	27	28	30
	Million pounds														
1	158.4	19.1													177.5
6		48.8	27.8	57.2		57.2		56.0							247.0
7			12.8												12.8
8	15.2	15.2		15.2		15.2		15.2							76.0
9	233.9	34.5	15.0	34.6		34.6		34.6	33.7						420.9
11	454.2	53.5	21.1	54.2		56.1		56.2	54.2						749.5
13	61.4	61.4	32.1	61.4	77.8	61.4		62.1	61.4		10.9				489.9
14	25.5	24.0	27.1	27.9	62.8	27.9		28.4	27.9			12.1	12.0	30.4	293.9
22												12.1	14.2		26.3
23	19.2	19.2	18.8	19.3	22.5	19.5	19.4	20.5	19.3	281.2	25.8			21.3	526.9
Total	967.8	275.7	154.7	267.8	163.1	271.9	19.4	273.0	196.5	281.2	36.7	12.1	26.2	51.7	3020.7

TABLE XLIII
ESTIMATED NET PRICES FOR BROILERS FOR EQUILIBRIUM SHIPPING
ROUTES, PRESENT HIGHWAY SYSTEM, 1962

From region	To region														Average net revenue ^a	
	2	3	4	5	12	17	18	19	20	21	25	26	27	28		30
	Dollars per million pounds															
1	277,949	277,954														277,949
6		277,951	277,344	277,956		277,942		277,937								277,956
7			277,941													277,979
8	277,949	277,950		277,956		277,942		277,938								277,946
9	277,947	277,948	277,942	277,954		277,942		277,938	277,944							277,956
11	277,941	277,940	277,935	277,948		277,940		277,941	277,943							277,966
13	277,940	277,938	277,933	277,946	277,932	277,940		277,943	277,944		277,935					277,966
14	277,936	277,933	277,942	277,931	277,931	277,938		277,943	277,943				277,934	277,944		277,965
22												277,944	277,944			277,943
23	277,936	277,932	277,927	277,941	277,926	277,938	277,943	277,945	277,944	277,940	277,940			277,942	277,942	277,959

^aA weighted average of the net revenues from specified shipping regions to specified markets.

TABLE XLIV
OPTIMUM INTERREGIONAL FLOWS FOR BROILERS, INTERSTATE HIGHWAY SYSTEM, 1962

From region	To region																Total
	2	3	4	5	12	17	18	19	20	21	22	25	26	27	28	30	
	Million pounds																
1	159.8	21.9															181.7
6		55.0	28.9	58.1		58.1		58.1									258.2
7			14.2														14.2
8	15.5	15.5		15.5		15.5		15.5									77.5
9	233.7	34.3	14.7	34.3		34.3		34.3	33.5								419.1
11	453.6	53.6	20.7	53.6		53.6		54.0	53.6								742.7
13	61.3	54.4	32.2	61.3	82.1	61.3		61.3	61.3			10.7					485.9
14	27.0	23.1	27.6	27.6	59.0	27.6		27.6	27.6				10.1	11.8	30.8		299.8
23	19.3	19.7	19.6	19.7		19.8	19.9	20.0	19.7	281.6	26.5	23.4			20.5	20.8	530.5
Total	970.2	277.5	157.9	270.1	141.1	270.2	19.9	270.8	195.7	281.6	26.5	34.7	10.1	11.8	51.3	20.8	3009.6

TABLE XLV
ESTIMATED NET PRICES FOR BROILERS FOR EQUILIBRIUM SHIPPING
ROUTES, INTERSTATE HIGHWAY SYSTEM, 1962

From region	To region															Average net revenue ^a	
	2	3	4	5	12	17	18	19	20	21	22	25	26	27	28		30
Dollars per million pounds																	
1	277,858	277,865															277,859
6	-	277,862	277,862	277,850		277,858		277,850									277,856
7			277,860														277,860
8	277,858	277,862		277,850		277,858		277,851									277,856
9	277,857	277,861	277,861	277,849		277,858		277,852	277,851								277,856
11	277,854	277,856	277,857	277,846		277,857		277,853	277,850								277,853
13	277,852	277,854	277,855	277,844	277,853	277,857		277,855	277,851			277,855					277,853
14	277,849	277,851	277,853	277,842	277,853	277,856		277,855	277,850				277,850	277,845	277,850		277,851
23	277,849	277,850	277,851	277,841		277,855	277,851	277,856	277,850	277,847	277,849	277,859			277,852	277,858	277,849

^aA weighted average of the net revenues from specified shipping regions to specified markets.

TABLE XLVI
OPTIMUM INTERREGIONAL FLOWS FOR BROILERS, PREDICTED
1972 EQUILIBRIUM SOLUTION

From region	To region												Total
	2	3	4	5	12	17	19	20	21	25	28	30	
	Million pounds												
1	128.1	28.9		12.6									196.6
6	52.3	87.1		83.0		15.4	82.9						320.7
7			28.7					11.0					39.7
8	14.9	14.9		14.9		14.9	14.9	13.3					87.8
9	285.9	43.1	23.6	43.1		43.1	43.2	15.6					497.6
11	468.2	68.0		68.2		145.8	73.8	14.3					838.3
13	62.5	59.3	62.5	62.5	84.6	62.5	63.8	34.7		15.5			507.9
14	35.7	31.7	35.6	35.8	81.3	35.8	36.7	35.8					328.4
23	23.8	24.1	23.9	24.2	28.0	24.3	24.5	24.2	286.0	28.8	25.0	25.2	562.0
29											15.4	34.7	50.1
Total	1071.4	357.1	174.3	344.3	193.9	341.8	339.8	148.9	286.0	44.3	40.4	59.9	3402.1

TABLE XLVII
ESTIMATED NET PRICES FOR BROILERS, PREDICTED 1972 EQUILIBRIUM SOLUTION

From region	To region												Average net revenue ^a
	2	3	4	5	12	17	19	20	21	25	28	30	
	Dollars per million pounds												
1	412,207	412,190		412,191									412,203
6	412,208	412,188		412,196		412,197	412,192						412,195
7			412,192					412,198					412,194
8	412,207	412,188		412,196		412,197	412,192	412,195					412,196
9	412,208	412,186	412,194	412,194		412,197	412,193	412,195					412,208
11	412,202	412,181		412,191		412,196	412,194	412,194					412,198
13	412,201	412,180	412,187	412,190	412,194	412,196	412,196	412,195		412,188			412,192
14	412,199	412,177	412,184	412,187	412,193	412,195	412,196	412,194					412,191
23	412,199	412,176	412,184	412,186	412,190	412,194	412,197	412,190	412,199	412,186	412,186	412,190	412,194
29											412,179	412,197	412,191

^aA weighted average of the net revenues from specified shipping regions to specified markets.

TABLE XLVIII

OPTIMUM INTERREGIONAL FLOWS FOR EGGS, PRESENT HIGHWAY SYSTEM, 1962

From region	To region															Total
	1	2	3	5	9	12	13	14	15	16	17	18	21	24	28	
	Million dozens															
6	37.4	37.4	37.4	37.4				11.2								160.8
7	13.6	13.6	13.6	13.6												54.4
8	40.8	40.8	40.8	40.8						39.1						202.3
10	14.1	14.1	14.1	14.1	11.9			14.1		14.1						96.5
11	11.5	11.5	11.5	11.5	11.5			11.5		11.5						80.5
19											165.1					165.1
20	13.1	13.2	13.3	13.3	13.3	13.3	12.2	13.3	13.3	13.3	13.3	17.0		64.1		239.5
22														71.2		71.2
25															62.2	62.2
Total	130.7	130.6	130.7	130.7	36.7	13.3	12.2	50.1	13.3	78.0	178.4	13.3	17.0	135.3	62.2	1132.5

TABLE XLIX

ESTIMATED NET PRICES FOR EGGS FOR EQUILIBRIUM SHIPPING
 ROUTES, PRESENT HIGHWAY SYSTEM, 1962

From region	To region														Average net revenue ^a	
	1	2	3	5	9	12	13	14	15	16	17	18	21	24		28
	Dollars per million dozens															
6	294,838	294,852	294,857	294,863				294,855								294,853
7	294,835	294,849	294,852	294,857												294,848
8	294,835	294,848	294,850	294,853						294,845						294,846
10	294,834	294,847	294,848	294,850	294,845			294,851		294,843						294,845
11	294,835	294,847	294,847	294,847	294,840			294,849		294,843						294,844
19											294,849					294,849
20	294,834	294,847	294,847	294,846	294,836	294,850	294,851	294,850	294,855	294,847	294,853	294,864	294,864	294,847		294,849
22														294,849		294,849
25															294,848	294,848

^aA weighted average of the net revenues from specified shipping regions to specified markets.

TABLE I

OPTIMUM INTERREGIONAL FLOWS FOR EGGS, INTERSTATE HIGHWAY SYSTEM, 1962

From region	To region															Total
	1	2	3	5	9	12	13	14	15	16	17	18	21	24	28	
	Million dozen															
6	37.4	37.4	37.4	37.4				11.8								161.4
7	13.8	13.8	13.8	13.8												55.2
8	40.9	40.9	40.9	40.9												202.7
10	14.1	14.1	14.1	14.1	13.7			14.1								98.3
11	11.5	11.5	11.5	11.5	11.4			11.5								80.4
19											165.2					165.2
20	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	13.3	16.0	64.1		239.7
22														71.3		71.3
25															62.0	62.0
Total	131.0	131.0	131.0	131.0	38.4	13.3	13.3	50.7	13.3	78.0	178.5	13.3	16.0	135.4	62.0	1136.2

TABLE LI
ESTIMATED NET PRICES FOR EGGS FOR EQUILIBRIUM SHIPPING
ROUTES, INTERSTATE HIGHWAY SYSTEM, 1962

From region	To region															Average net revenue ^a
	1	2	3	5	9	12	13	14	15	16	17	18	21	24	28	
	Dollars per million dozens															
6	294,839	294,839	294,845	294,846				294,838								294,842
7	294,837	294,837	294,842	294,842												294,840
8	294,836	294,836	294,840	294,839						294,838						294,838
10	294,835	294,835	294,838	294,837	294,842			294,835		294,837						294,837
11	294,836	294,835	294,837	294,835	294,839			294,833		294,837						294,836
19											294,837					294,837
20	294,835	294,835	294,838	294,835	294,835	294,827	294,828	294,834	294,839	294,840	294,840	294,837	294,840	294,834		294,835
22														294,839		294,839
25															294,826	294,826

^aA weighted average of the net revenues from specified shipping regions to specified markets.

TABLE LII

OPTIMUM INTERREGIONAL FLOWS FOR EGGS, PREDICTED 1972 EQUILIBRIUM SOLUTION

From region	To region												Total
	1	2	3	5	9	14	16	17	18	24	28	30	
	Million dozens												
6	37.9	37.9	37.9	37.9									151.6
7	17.4	17.4	17.4	17.4									69.6
8	51.4	51.4	51.4	51.4									205.6
10	21.0	21.0	21.0	21.0	20.7								104.7
11	15.3	15.2	15.2	15.2	15.1		15.2						91.2
15	14.4	14.4	14.4	14.4	14.2		14.5					14.4	100.7
19								169.1					169.1
20	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	18.0	89.5		18.0	269.5
22										72.1			72.1
25											72.6		72.6
26												110.6	110.6
Total	175.4	175.3	175.3	175.3	68.0	18.0	47.7	187.1	18.0	161.6	72.6	143.0	1417.3

TABLE LIII

ESTIMATED NET PRICES FOR EGGS, PREDICTED 1972 EQUILIBRIUM SOLUTION

From region	To region											Average net revenue ^a	
	1	2	3	5	9	14	16	17	18	24	28		30
	Dollars per million dozens												
6	618,810	618,812	618,815	618,819									618,814
7	618,808	618,810	618,812	618,815									618,811
8	618,807	618,809	618,810	618,812									618,810
10	618,806	618,808	618,809	618,810	618,812								618,809
11	618,807	618,808	618,808	618,808	618,809		618,805						618,808
15	618,808	618,804	618,811	618,812	618,806		618,813					618,811	618,809
19								618,808					618,808
20	618,806	618,808	618,808	618,808	618,805	618,807	618,808	618,811	618,810	618,802		618,806	618,806
22										618,807			618,807
25											618,804		618,804
26												618,804	618,804

^aA weighted average of the net revenues from specified shipping regions to specified markets.

APPENDIX E

PROCEDURES FOR ESTIMATING POPULATION

AND INCOME FOR 1972

Population estimates for 1972 were derived from the Bureau of the Census, Current Population Reports. The estimates were interpolations for 1972 of the Series I-B projections for 1970 and 1975.¹

An adjusted ratio method was used to estimate the 1972 regional per capita incomes. First, a simple ratio estimate for 1972 was made from 1952 and 1962 data. This estimate for each region was then adjusted by a factor derived from a comparison of the aggregate ratio estimate and a least squares estimate. This procedure may be outlined as follows:

$$I_i = \frac{\bar{I}_i}{I_i} \cdot (\bar{I}_i), i = 1, 2, \dots, 30 \quad (1)$$

where

I_i = simple ratio estimate of 1972 per capita income for the
ith region.

$\bar{I}_i$ = 1962 per capita income for ith region.

I_i' = 1952 per capita income for ith region.

The simple ratio estimate derived from equation (1) for each region was then adjusted by,

$$\frac{I_{l.s.}}{I_R} \quad (2)$$

where,

¹Bureau of the Census, United States Department of Commerce, Current Population Reports, Series P-25, No. 301 (Washington: Government Printing Office, February 26, 1965).

$I_{l.s.}$ = 1972 least squares estimate of United States per capita income.²

I_R = 1972 ratio estimate of United States per capita income.

The least squares estimate was 2,642 dollars, and the ratio estimate was 2,807 dollars. Thus equation (2) becomes 0.94, and this factor was used to adjust each regional ratio method estimate. The 1972 per capita income estimates for each region are given in Table LIV.

²The least squares regression was per capita income (Y) on time (X). The fitted equation was $Y = 1656 + 58X$ with an R^2 value of 0.942. This gives an estimate for 1972 of 2,642 dollars.

TABLE LIV
ESTIMATED 1972 PER CAPITA INCOMES, BY REGION

Region ^a	Per capita income estimates ^b		
	Beef and pork regions	Broiler regions	Egg regions
	Dollars		
1	3034.15	2382.66	3034.15
2	2027.30	3256.40	3273.16
3	2105.94	3172.46	2776.06
4	2158.80	3101.27	2020.95
5	2072.41	2573.26	2608.53
6	1719.60	3047.17	2518.80
7	2412.48	2020.95	1719.60
8	1881.10	2121.73	2072.41
9	1598.44	2158.80	2412.48
10	2030.03	1719.60	1881.10
11	1980.83	2072.41	1598.44
12	2443.02	2412.48	2030.03
13	2609.30	1881.11	1980.83
14	2446.04	1598.44	2443.02
15	3193.44	2030.03	2609.30
16	2444.92	1980.83	2446.04
17	1920.60	2443.02	3193.44
18	2838.55	2609.30	2444.92
19	2422.42	3193.44	2430.23
20	2530.23	2446.04	2422.42
21	3147.96	2465.76	2838.54
22	2651.56	2838.55	1929.67
23	2328.85	1929.67	1897.47
24	2196.95	1897.47	2196.95
25	2254.22	2212.05	2452.75
26	2684.06	2218.48	3147.96
27	2464.03	2604.48	2232.00
28	2436.00	2416.16	2416.16
29	2572.54	2572.54	2572.54
30	3153.26	3161.52	3161.52
United States	2638.18	2638.18	2638.18

^aRefers to the specified region for beef and pork, broilers or eggs as specified in Chapter IV.

^bRefers to the adjusted income estimate.