Interregional Competition in the U.S. Swine-Pork Industry

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Table of Contents

LIST OF TABLES

Table **Page**

LIST OF FIGURES

APPENDIX TABLES

I. Introduction

Problem Statement

The structure of the U.S. swine-pork subsector is in a state of rapid transition as pork production shifts into the hands of fewer but larger swine farms with closer ties to processors and consumers (Barkema and Cook). In 1970 there were 1,265,000 U.S. hog farms. This number is expected to decrease to an estimated 35,000 by 2010, a decline of 97 percent. The December 1996 Hogs and Pigs indicates the number of operations with hogs totaled 157,450 during 1996, down 13 percent from 1995 and down 24 percent from 1994 (USDA). The report states that for the first time, hog farms with 2,000 or more hogs on hand accounted for over 50 percent of the U.S. hog inventory. Production is also shifting geographically. Midwestern states are being challenged to retain their rankings and in some cases are losing their rankings in terms of number of hogs. States outside the traditional cornbelt area and not usually considered to be major swine production states are showing significant increases in hog numbers.

The processing industry is experiencing changes similar to those observed in the production sector. Several of the old familiar major processors are no longer in business, while new mega processors are emerging. Economic factors such as economies of size and risk are driving forces for greater consolidation and integration in the U.S. swine-pork subsector. The trends observed in structure and concentration of both production and processing industries will likely continue.

These trends will result in a more integrated subsector of fewer and larger firms with closer market linkages (Hayenga, 1994).

Several questions arise given the observed changes in swine and pork industries. Where will future swine production be located? What regions will gain and lose swine numbers? Where will pork processing firms be located? What economic conditions must exist for expansion and/or contraction of swine and pork industries in specific regions given expanding world markets? What movements of swine and pork between production, processing, and consumption regions will maximize net social welfare? To address these and similar questions, a spatial equilibrium model for the swine-pork subsector was developed.

Research Objectives

The overall research objective is to develop, document, and illustrate an economic model suitable to address spatial equilibrium questions associated with the U.S. swine-pork subsector. This report includes documentation of the model, data needs, data sources, and interpretation of model output. The spatial equilibrium model determines the optimal production, processing, and shipping patterns for the swine-pork subsector, given available data for 1995. The model will be illustrated using two scenarios. The first scenario is a model depicting conditions known to exist in 1995, allowing for fixed quantities of swine-pork imports and exports. The second scenario allows for a 10 percent increase in pork exports to Japan.

II. The Model

Literature Review

Enke (1951) generalized the problem of an equilibrium among spatially separated markets. Since then, researchers have suggested using four basic mathematical programming techniques to empirically estimate spatial equilibrium models. These techniques include linear, reactive, quadratic, and linear complimentary programming models.

Using the linear programming framework, Samuelson (1952) computed spatial equilibrium solutions while maximizing net social payoff. Net social payoff is defined as the sum of the social surplus payoffs in all regions less transport costs.[1] Although Samuelson gave the first mathematical formulation of the spatial equilibrium model, his procedure for deriving a solution was essentially iteration by trial-and-error. Based on Samuelson's approach, Judge and Wallace (1958, 1960) investigated the optimal shipping pattern of the U.S. pork industry using a linear programming model to minimize transport costs of live hogs and pork from surplus regions to deficit regions. However, their study did not consider production and processing costs. In addition, the assumption of fixed demands in linear programming is a restrictive assumption that limits the empirical usefulness of the results in spatial equilibrium studies.

Tramel and Seale (1959) proposed reactive programming as a means of obtaining the equilibrium flows of a commodity between areas with given transportation cost functions and given supply and demand schedules in areas of production and consumption, respectively. King and Ho (1972) developed a modified computer program for Tramel and Seale's spatial equilibrium algorithm. The Tramel and Seale model accommodates a variety of independent functional forms.

As an extension of the Samuelson maximization approach, Takayama and Judge (1964a, 1964b, 1971) developed a routine for solving the spatial equilibrium problem using quadratic programming with endogenous supply and demand functions. The researchers' objective function, which is equivalent to Samuelson's net social payoff, was the maximization of the algebraic area between the excess demand and excess supply curve minus transportation costs. Numerous applications of the quadratic programming model have been developed and improved (Hall, et. al 1975, Martin, 1981, Hazell and Norton, 1986). More recently, Yavuz, et al. (1996) analyzed the impacts of changes in supply, demand, and policy variables on regional structural change of the U.S. dairy industry using a quadratic programming approach.

Meyer (1981), Meyer and Williams (1982), and Williams, Meyer, and Bullock (1983) analyzed the optimal swine production, shipping patterns, and spatial equilibrium swine-pork quantities using sequential reactive and linear programming models. Reactive programming was used to calculate spatial equilibrium quantities and prices for pork in each consumption region assuming that the total available supply of pork was fixed. Linear programming was used to develop a transhipment model for solving least-cost patterns of production, live hog shipments, processing, and meat shipments. The transhipment routine contained stepped supply functions for live hog production assuming that the total quantity of pork demanded was fixed. In essence the total quantity of hogs produced is fixed; however, the model allowed the use of inelastic supply and demand schedules to endogenously determine quantity and prices for each of the swine production and pork consumption regions. The research reported is an update and extension of Meyer (1981) using quadratic programming. The GAMS (General Algebraic Modeling System) (1996) computer routine is used to derive optimal solutions to maximize net social welfare.

Conceptual Framework of the Swine-Pork Spatial Equilibrium Model

The primary product (swine) is produced domestically or imported and is then transported to a processing facility or exported as live hogs. Swine at processing facilities are converted into a final commodity (pork). Pork can also be imported. Pork is transported to consumption regions and/or export destinations for consumption. The primary and final commodities (swine and pork, respectively) are assumed mobile between all possible pairs of regions

[1] The concept of Samuelson's net social payoff (NSP) was further developed by Smith (1963). An alternative to Samuelson's formulation of the NSP objective function, Smith showed that the competitive spatial equilibrium is identifiable with minimization of economic rent using a dual concept.

(production, processing, import, export, and consumption) and are separated by a transportation cost per physical unit for each type of product. The rate and quantities at which live-weight basis hogs may be transformed into pork are known for each region and given time period (i.e., 1995 base year). A non-negative quantity of pork is consumed in each consumption region, and the regional consumption is assumed known for the base year. Each region has some non-negative capacity for processing hogs, and these capacities are known and fixed for any time period. Each region has a unit processing cost for converting swine into pork. Production and processing costs and cost differentials are assumed known for the base time period considered.

Given the spatially separated markets, the spatial equilibrium price and quantity shipped are determined by the intersection of the markets' excess supply and demand curves.[2] A market's excess supply curve of the regional swine-pork market represents the amount by which the quantity offered for sale exceeds the quantity which would be purchased at various prices above the intra-market equilibrium price. Conversely, the excess demand curve shows the amount by which the quantity demanded exceeds the quantity supplied at various price levels below the intra-market equilibrium price.

Model Assumptions

Following are the basic assumptions made in modeling the swine-pork spatial equilibrium model:

i) The commodities (swine, pork) are traded in perfectly competitive markets. Each representative firm is assumed to maximize profit and thus will make shipment decisions which yield the greatest per unit net return.

ii) Each region—production, processing, and consumption—is separated by known transfer costs. Each region has one trade point which is specified as the center of activity in the region.

iii) Regional supply and demand functions are well-behaved and known for some time period-t. The functional forms of supply and demand are assumed to be linear.

iv) Transfer costs represent all costs between the points of origin and destination of shipments. All regions are connected by transfer costs that are independent of the direction and volume of trade.

v) The supply source and market for each geographical region are represented by a single point.

vi) The product is homogeneous. Processors and consumers are indifferent as to the origin of products received.

vii) Imports and exports of swine and pork outside the continental United States are allowed. Quantities of both swine and pork imported and/or exported are determined exogenous to the model.

Given the economic environment in the swine-pork subsector, the problem within a planning, evaluation, and decision context is to determine the levels of production, consumption, and prices in each region and the equilibrium trade flows between regions. In order to solve the spatial equilibrium problem, consideration is given to the spatially separated regions with production, processing, and consumption activities in the U.S. swine-pork subsector. In the context of spatial equilibrium, the movement of swine and pork is a function of differential responses of producers, processors, and consumers in different regions to changes in price, processing costs, and interregional transportation costs.

Data Requirements, Data Sources, and Procedures

Regional Demarcations

Tables and figures identifying regional demarcation and base points identified within each region for domestic swine production, processing consumption, and imports/exports are shown in Tables 1 through 3 and Figures 1 through 4. State lines are used to denote production, processing, and/or consumption borders for most states due to statistical data being available only on a state-wide basis. An exception to using state boundaries was made for two consumption regions, California and Texas.

Production. Thirty-one domestic production regions (PO1,...,P31) are identified. Two additional points for live hog imports are assumed, Nogales, AZ (P32) and Pembina, ND (P33).

Processing. Twenty-two domestic processing regions (S01,...,S22) are identified. Regional boundaries are based on the existence of current processing facilities as identified by Hayenga (1994) and/or what were observed as major growth areas of swine production. Two regions (S25 and S26) are identified for hog exports. Base points for live hog exports are considered the same as a processing region because this is equivalent to disposition and/or utilization of

[2] Spatial price relations are determined largely by transfer costs between regions provided competitive conditions prevail. Transfer costs include all transportation charges.

Table 1. Regions, State(s) and Base Cities for Production.

Region	State(s)	Base City
U.S. Produced Hogs		
P01	Idaho, Oregon, Washington	Portland, OR
P02	California	Fresno, CA
P03	Arizona, Nevada, Utah	Cedar City, UT
P04	Montana, Wyoming	Great Falls, MT
P05	Colorado	Sterling, CO
P06	New Mexico, Texas	Amarillo, TX
P07	North Dakota	Bismarck, ND
P08	South Dakota	Watertown, SD
P09	Nebraska	Norfolk, NE
P10	Kansas	Salina, KS
P11	Oklahoma	Guymon, OK
P12	Minnesota	Hutchinson, MN
P13	Iowa	Des Moines, IA
P14	Missouri	Columbia, MO
P15	Arkansas	Springdale, AR
P16	Louisiana, Mississippi	Jackson, MS
P17	Alabama, Florida	Montgomery, AL
P18	Tennessee	Nashville, TN
P19	Kentucky	Elizabethtown, KY
P20	Illinois	Peoria, IL
P21	Wisconsin	Madison, WI
P22	Michigan	Kalamazoo, MI
P23	Indiana	Indianapolis, IN
P24	Ohio	Springfield, OH
P25	Connecticut, Massachusetts, Maine, New Hampshire, New York, Rhode Island, Vermont	Syracuse, NY
P26	Pennsylvania	Reading, PA
P27	Delaware, Maryland, New Jersey, West Virginia	Georgetown, DE
P28	Virginia	Emporia, VA
P29	North Carolina	Goldsboro, NC
P30	South Carolina	Sumter, SC
P31	Georgia	Albany, GA
Hog Imports		
P32	Arizona	Nogales, AZ
P33	North Dakota	Pembina, ND

Table 2. Regions, State(s) and Base Cities for Slaughter.

Region	State(s)	Base City
U.S. Slaughter		
S01	Idaho, Oregon, Washington	Portland, OR
S02	California, Nevada	Los Angeles, CA
S03	Arizona, Utah	Cedar City, UT
S04	Montana, North Dakota, Wyoming	Great Falls, MT
S05	New Mexico, Oklahoma, Texas	Guymon, OK
S06	Nebraska	Norfolk, NE
S07	Colorada, Kansas	Oakley, KS
S08	Minnesota, Wisconsin	Albert Lea, MN
S09	Iowa	Des Moines, IA
S10	Illinois	Galesburg, IL
S11	Missouri	Cameron, MO
S12	Arkansas, Louisiana, Mississippi	West Point, MS
S13	Alabama, Florida, Georgia	Moultrie, GA
S14	Kentucky, Tennessee	Louisville, KY
S15	Indiana	Logansport, IN
S16	Michigan	Detroit, MI
S17	Ohio	Cincinnati, OH
S18	Virginia, West Virginia	Smithfield, VA
S19	North Carolina, South Carolina	Clinton, NC
S20	Delaware, Maryland, New Jersey, Pennsylvania	Hatfield, PA
S21	Connecticut, Massachusetts, Maine, New Hampshire, New York, Rhode Island, Vermont	Syracuse, NY
S22	South Dakota	Sioux Falls, SD
Hog Exports		
S23	North Dakota (Canada)	Pembina, ND
S24	Texas (Mexico)	Laredo, TX
Pork Imports		
Z23	New York (Europe)	New York, NY
Z24	New York (Eastern Canada)	Niagara Falls, NY
Z25	Idaho (Western Canada)	Bonners Ferry, ID

live hogs. Three additional regions (Z23,...,Z25) are identified for pork imports. Base points for pork imports are similar to a processing region in that they are a point of origin for pork destined for domestic consumption regions.

Consumption. Forty-four domestic consumption regions (C01,...,C44) are identified. State boundaries are used for each region except in California and Texas. California is divided into two consumption regions (C03, C04) and Texas is divided into two consumption regions (C15, C16). The regions are based on population distribution within each state. Approximately one half of each state's population resides in each respective region. Four additional locations (C45,...,C48) are identified as pork export sites or points of demarcation. Five destinations for pork exports are included (X01,...X05).

Regional Production Quantities and Weighed Production Costs

Base level production quantities for each region are based on 1995 data (Table 4). Cost information for each production region identified in Table 1 is not available from USDA. A 1994 University of Missouri enterprise budget for a 600 sow, farrow-to-finish enterprise is used as a base budget for production regions to achieve consistency and comparibility between budget data used to compute costs for re-

Table 3. Regions, State(s) and Base Cities for Consumption.

Region	State(s)	Base City
U.S. Consumption		
C01	Washington	Seattle, WA
C02	Oregon	Portland, OR
C03	N. California	San Francisco, CA
C04	S. California	Los Angeles, CA
C05	Idaho, Montana, Wyoming	Boise, ID
C06	Nevada	Las Vegas, NV
C07	Utah	Salt Lake City, UT
C08	Arizona	Phoenix, AZ
C09	Colorado	Denver, CO
C10	New Mexico	Albuquerque, NM
C11	North Dakota, South Dakota	Sioux Falls, SD
C12	Nebraska	Omaha, NE
C13	Kansas	Kansas City, KS
C14	Oklahoma	Oklahoma City, OK
C15	N. Texas	Dallas, TX
C16	S. Texas	Houston, TX
C17	Minnesota	Minneapolis, MN
C18	Iowa	Des Moines, IA
C19	Missouri	Kansas City, MO
C20	Arkansas	Little Rock, AR
C21	Louisiana	New Orleans, LA
C22	Wisconsin	Milwaukee, WI
C23	Illinois	Chicago, IL
C24	Kentucky	Louisville, KY
C25	Tennessee	Memphis, TN
C26	Mississippi	Jackson, MS
C27	Michigan	Detroit, MI
C28	Indiana	Indianapolis, IN
C29	Alabama	Birmingham, AL
C30	Ohio	Columbus, OH
C31	Georgia	Atlanta, GA
C32	Florida	Miami, FL
C33	New York	New York City., NY
C34	Pennsylvania	Philadelphia, PA
C35	West Virginia	Charleston, WV
C36	Virginia	Norfolk, VA
C37	North Carolina	Charlotte, NC
C38	South Carolina	Greenville, SC
C39	New Hampshire, Vermont	Manchester, NH
C40	Massachusetts	Boston, MA
C41	Connecticut, Rhode Island	Hartford, CT
C42	Maryland, Delaware	Baltimore, MD
C43	New Jersey	Newark, NJ
C44	Maine	Portland, ME
Demarcation for Pork Exports		
C45	Michigan (Canada)	Port Huron, MI
C46	South Carolina (Ocean Port)	Charleston, SC
C47	Texas (Mexico)	Laredo, TX
C48	California (Ocean Port)	Los Angeles, CA
Pork Exports via South Carolina or California		
X01	Japan	
X02	Korea	
X03	Other Asia	
X04	Russia	
X05	European Countries	

spective states and production regions. The 1994 Missiouri budget is updated to 1995 using price index numbers for feed and labor. Individual state production costs are computed using comparative feed and labor cost index numbers.

Individual states are grouped into seven regions to estimate production costs. Figure 5 shows the boundaries for the seven regions. A regional weighted production cost is computed by weighting state production costs by the quantity of pork produced in 1995. Individual state and weighted regional production costs are shown in Table 4. Increased levels of production and production costs within each region are assumed using the same assumptions used by Meyer (1981). Production quantities are allowed to vary for all production regions. Increased production can only occur at higher costs per unit.

Regional Processing Quantities, Capacities, and Costs

Estimated processing cost data provided by the National Pork Producers Council (NPPC) is used to assist in developing per unit processing costs as related to processing volume. NPPC data and data from Ward and Faminow (1991) provided base information useful in computing cost-volume relationships for processing swine. An average processing cost per head is estimated using a quadratic functional relationship.

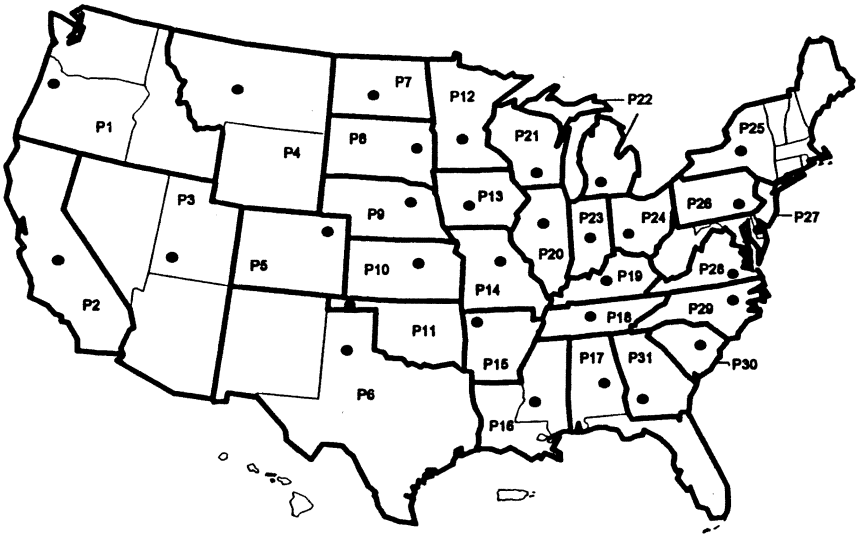
$$\text{Average cost/head} = f(\text{Annual Volume}, \text{Annual Volume}^2)$$

Plant capacity data obtained from Meyer (1996) and Smith (1996) was useful in identifying processing constraints for processing regions identified in this research. An average volume per region was calculated and used in the equation to estimate an average cost/head for each region. Regional costs are estimated for three regions which had no plants listed in the Smith (1996) article based on nearby and/or comparable processing regions.

Consumption Data

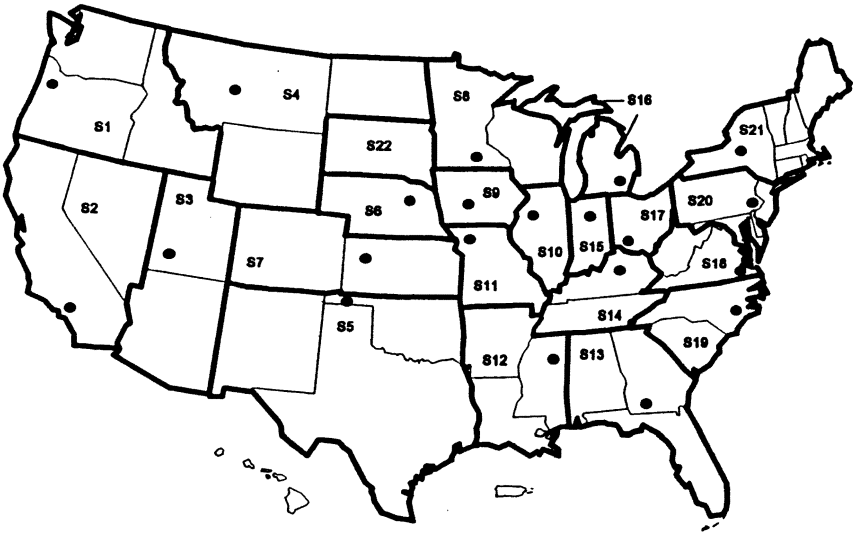
Regional consumption quantities for 1995 are derived using U.S. Bureau of Census (1995) data, national per capita consumption and regional consumption indexes. The amount of regional pork consumptions is estimated as follows:

$$\begin{bmatrix}\text{Regional Pork}\\ \text{Consumption}\end{bmatrix} = \begin{bmatrix}\text{Regional}\\ \text{Population}\end{bmatrix} \times \begin{bmatrix}\text{Per Capita Pork}\\ \text{Consumption}\end{bmatrix} \times \begin{bmatrix}\text{RegionalCon-}\\ \text{sumption Index}\end{bmatrix}$$



● - denotes base city in each region

Figure 1. Regional Production Demarcation of Contiguous United States



● - denotes base city in each region

Figure 2. Regional Slaughter Demarcation of Contiguous United States

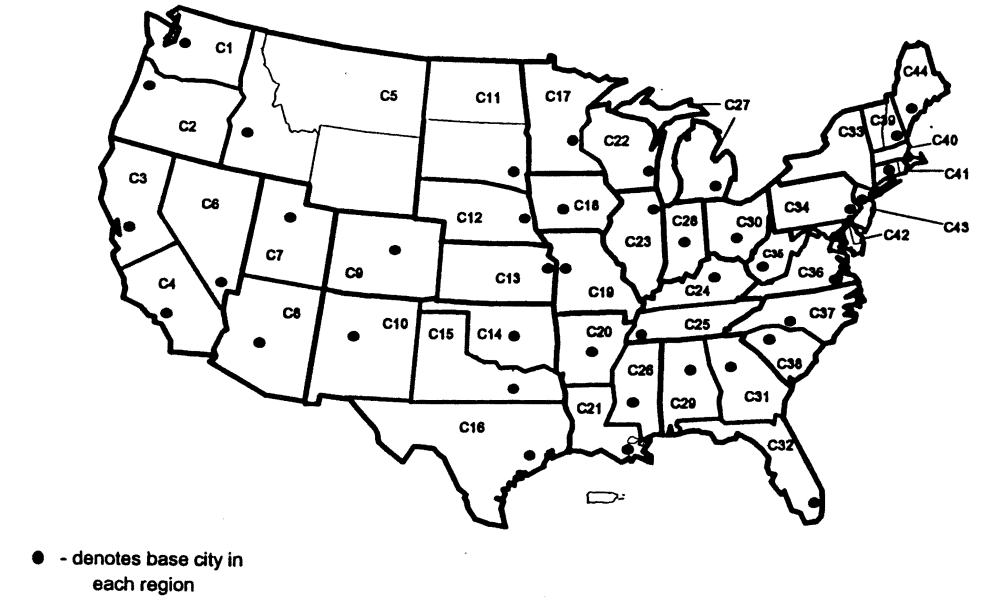


Figure 3. Regional Consumption Demarcation of Contiguous United States

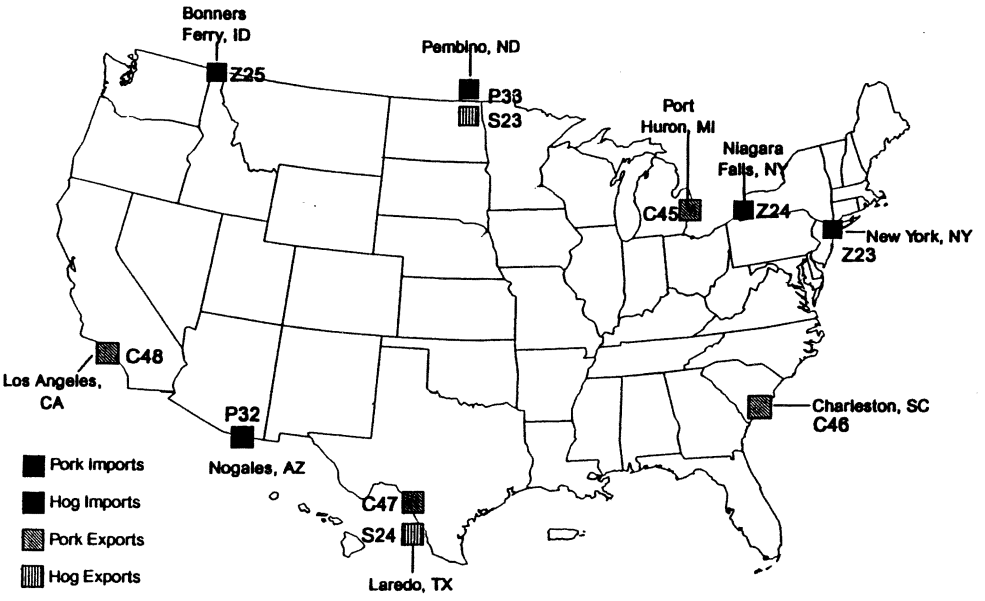


Figure 4. U.S. Entry-Exit Base Points for U.S. Swine-Pork Imports and Exports

Table 4. 1995 State and Weighted Regional Product Cost Estimates.

National Region	Production Region	Production State		Production Costs Liveweight State	Production Costs Liveweight Region	Production Costs Carcass State	Production Costs Carcass Region
			(1,000 lbs.)	(dol./cwt)	(dol./cwt.)	(dol./cwt.)	(dol./cwt.)
East Central	P25	RI	984	39.8		53.78	
East Central	P26	PA	324,959	39.76		53.73	
East Central	P27	MD	39,943	39.86		53.86	
East Central	P27	NJ	3,290	40.57		54.83	
East Central	P27	WV	11,293	41.91		56.63	
East Central	P28	VA	154,448	42.59		57.55	
East Central	P29	NC	3,156,715	42.31		57.18	
East Central	P30	SC	138,562	42.81		57.85	
Regional					42.1		56.89
North Central-East	P14	MO	1,479,750	40.03		54.09	
North Central-East	P19	KY	290,319	42.21		57.04	
North Central-East	P20	IL	1,606,475	40.49		54.72	
North Central-East	P21	WI	414,417	38.83		52.48	
North Central-East	P22	MI	450,382	39.25		53.04	
North Central-East	P23	IN	1,764,530	40.51		54.75	
North Central-East	P24	OH	737,491	40.23		54.36	
Regional					40.26		54.4
North Central-West	P07	ND	11,014	37.1		50.14	
North Central-West	P08	SD	692,114	36.65		49.53	
North Central-West	P09	NE	1,691,365	37.09		50.12	
North Central-West	P12	MN	2,007,316	39.46		53.33	
North Central-West	P13	IA	5,926,101	40.25		54.39	
Regional					39.31		53.13
Northeast	P25	CT	2,197	40.02		54.09	
Northeast	P25	MA	4,510	40.02		54.09	
Northeast	P25	ME	3,419	40.02		54.09	
Northeast	P25	NH	801	40.02		54.09	
Northeast	P25	NY	3,156,715	40.14		54.24	
Northeast	P25	VT	877	40.02		54.09	
Northeast	P27	DE	11,566	39.91		53.94	
Regional					40.13		54.24
Southeast	P16	LA	22,632	40.29		54.45	
Southeast	P16	MS	91,764	40.12		54.21	
Southeast	P17	AL	182,640	42.85		57.9	
Southeast	P17	FL	30,438	43.85		59.26	
Southeast	P18	TN	215,956	42.32		57.19	
Southeast	P31	GA	341,199	43.14		58.3	
Regional					42.52		57.46
Southwest	P05	CO	209,508	44.17		59.69	
Southwest	P06	NM	5,724	44.28		59.84	
Southwest	P06	TX	214,323	41.41		55.96	
Southwest	P10	KS	567,350	37.36		50.48	
Southwest	P11	OK	456,955	41.69		56.34	
Southwest	P15	AR	376,805	40.44		54.65	
Regional	54.53						40.35
West	P01	ID	21,700	44.23		59.77	
West	P01	OR	18,705	39.37		53.2	
West	P01	WA	14,664	40.02		54.08	
West	P02	CA	88,614	39.32		53.13	
West	P03	AZ	64,386	44.17	59.68		
West	P03	NV	4,057	43.9		59.32	
West	P03	UT	23,985	43.81		59.2	
West	P04	MT	87,880	43.95		59.39	
West	P04	WY	25,899	43.98		59.43	
Regional					42.42		57.32

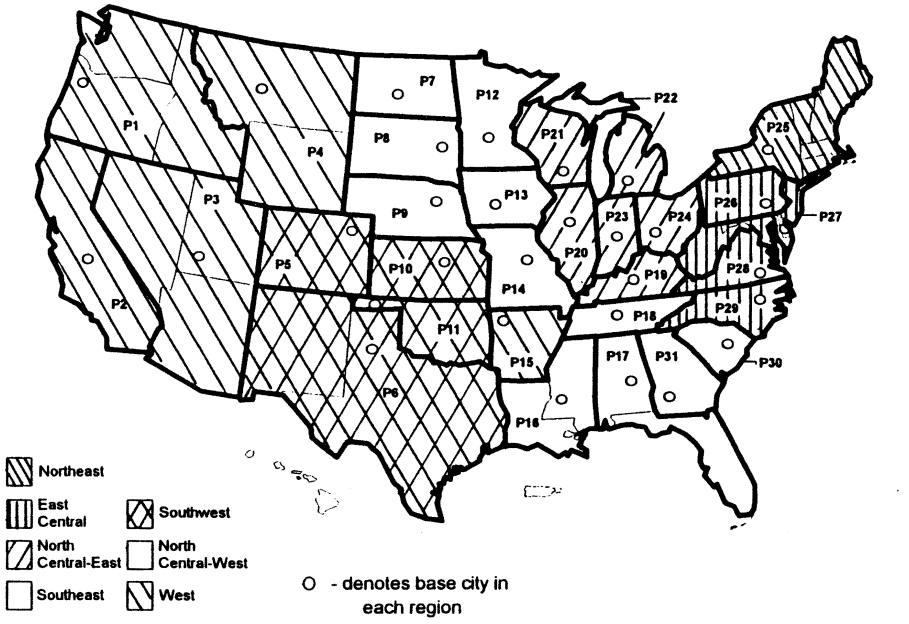


Figure 5. Regional Demarcation for Estimating Swine Production Costs

The regional consumption indexes are drawn from Meyer's (1981) work. Estimated quantities of pork consumed during 1995 in each consumption region are shown in Table 5.

Swine/Pork Imports and Exports

The model allows for both imports and exports of live hogs and pork. The exogenously specified quantities of hog and pork trade as shown in Table 6 are based on calendar year 1995. Import and export levels are obtained from USDA-FATUS reports. Live hog imports and exports are converted from metric tons to carcass hundredweights. Although no live hogs are imported from Mexico in 1995, the model includes an activity for importation of hogs from Mexico. The capability to include imports from Mexico is made because of the likelihood that parts of Mexico may soon be cleared to ship hogs to the U.S. The impacts of such shipments can be easily analyzed by increasing the constraint from zero to any desired level.

Pork imports included in the model originate in Canada and European countries. The imports can come into the U.S. through any of the import points designated in Table 2 and Figure 4. Pork exports are shipped through export points designated in Table 3 and Figure 4.

Transportation/Shipping Distances, Rates, and Costs

Live Hogs. Mileage between base cities in production regions and base cities in processing or hog export regions are computed using Microsoft Corporation (1995) software. The shortest distance between base cities is calculated and used. The shipping distance between each production point and processing destination is shown in Appendix Table 1. A rate of $1.95 per loaded mile is assumed for 48,000 pounds of live hogs. A minimum load charge of $150 is assumed. The transportation rate and minimum charge are based on input from three major hog shippers and/or major production firms that are knowledgeable of shipping costs and ship large quantities of live hogs in the United States. Live hog transportation costs are converted to a carcass weight equivalent. Transportation costs are shown in Appendix Table 2.

Pork. Shipping distances between processing and consumption regions are determined using the Microsoft Corporation (1995) software. Pork imports are assumed to arrive at one or more of the three designated pork import points, (Z23,...Z25), as shown in Table 2 and/or Figure 4. Distances for pork shipments are shown in Appendix Table 3. A major U.S. truck brokerage firm provided freight rates for pork between each possible processing/import point and

Table 5. 1995 Regional Pork Consumption Estimates.

Region	State(s)	Population	Consumption[1]	Regional Consumption	Consumption Retail	Consumption[2] Carcass	Consumption[3] Live
		(million)	(lbs./capita)	(Index)	(cwt.)	(cwt.)	cwt.)
C01	WA	5.49	52.5	0.88	2,536,380	3,264,324	4,411,249
C02	OR	3.14	52.5	0.88	1,450,680	1,867,027	2,523,009
C03	NCA	9.8	52.5	0.88	4,527,600	5,827,027	7,874,361
C04	SCA	21.7	52.5	0.88	10,025,400	12,902,703	17,436,085
C05	ID, MT, WY	2.51	52.5	0.99	1,304,573	1,678,986	2,268,901
C06	NV	1.47	52.5	0.99	764,033	983,311	1,328,798
C07	UT	1.94	52.5	0.99	1,008,315	1,297,703	1,753,652
C08	AZ	4.07	52.5	0.99	2,115,383	2,722,500	3,679,054
C09	CO	3.71	52.5	0.99	1,928,273	2,481,689	3,353,634
C10	NM	1.68	52.5	0.99	873,180	1,123,784	1,518,627
C11	ND, SD	1.37	52.5	1.11	798,368	1,027,500	1,388,514
C12	NE	1.64	52.5	1.11	955,710	1,230,000	1,662,162
C13	KS	2.6	52.5	1.11	1,515,150	1,950,000	2,635,135
C14	OK	3.27	52.5	1.11	1,905,593	2,452,500	3,314,189
C15	NTX	7.5	52.5	1.11	4,370,625	5,625,000	7,601,351
C16	STX	11.1	52.5	1.11	6,468,525	8,325,000	11,250,000
C17	MN	4.62	52.5	1.11	2,692,305	3,465,000	4,682,432
C18	IA	2.86	52.5	1.11	1,666,665	2,145,000	2,898,649
C19	MO	5.28	52.5	1.11	3,076,920	3,960,000	5,351,351
C20	AR	2.47	52.5	1.11	1,439,393	1,852,500	2,503,378
C21	LA	4.36	52.5	1.11	2,540,790	3,270,000	4,418,919
C22	WI	5.16	52.5	0.96	2,600,640	3,347,027	4,523,009
C23	IL	11.85	52.5	0.96	5,972,400	7,686,486	10,387,144
C24	KY	3.85	52.5	1.18	2,385,075	3,069,595	4,148,101
C25	TN	5.23	52.5	1.18	3,239,985	4,169,865	5,634,953
C26	MS	2.67	52.5	0.96	1,345,680	1,731,892	2,340,394
C27	MI	9.58	52.5	0.96	4,828,320	6,214,054	8,397,370
C28	IN	5.82	52.5	0.96	2,933,280	3,775,135	5,101,534
C29	AL	4.27	52.5	1.18	2,645,265	3,404,459	4,600,621
C30	OH	11.2	52.5	0.96	5,644,800	7,264,865	9,817,385
C31	GA	7.1	52.5	1.18	4,398,450	5,660,811	7,649,744
C32	FL	14.21	52.5	1.18	8,803,095	11,329,595	15,310,263
C33	NY	18.18	52.5	0.85	8,112,825	10,441,216	14,109,752
C34	PA	12.13	52.5	0.86	5,476,695	7,048,514	9,525,018
C35	WV	1.82	52.5	1.18	1,127,490	1,451,081	1,960,920
C36	VA	6.65	52.5	1.18	4,119,675	5,302,027	7,164,901
C37	NC	7.15	52.5	1.18	4,429,425	5,700,676	7,703,616
C38	SC	3.73	52.5	1.18	2,310,735	2,973,919	4,018,809
C39	NH, VT	1.71	52.5	0.85	763,534	982,669	1,327,931
C40	MA	5.98	52.5	0.85	2,666,790	3,432,162	4,638,057
C41	CT, RI	4.27	52.5	0.85	1,905,488	2,452,365	3,314,007
C42	DE, MD	5.78	52.5	1.18	3,580,710	4,608,378	6,227,538
C43	NJ	7.93	52.5	0.85	3,538,763	4,554,392	6,154,584
C44	ME	1.24	52.5	0.85	553,350	712,162	962,381
Total		260.09			37,346,326	176,764,899	238,871,485

[1] Per-capita pork consumption in 1995 was 52.5 pounds (USDA).
[2] The conversion factor from retail-level pork to carcass basis is assumed to be (1/0.777).
[3] The conversion factor from carcass basis to liveweight is assumed to be (1/0.74).

Source: USDA, ERS, Hog Outlook, April 12,1996.
U.S. Department of Commerce, Statistical Abstract of the United States 1995, 115th edition, p.34.

Table 6. Trade Volume of U.S. Swine-Pork Sector 1995.

	Liveweight (cwt.)	*Carcass (cwt.)*
	Hog Trade	
Hog Imports		
Canada	4,455,258	3,296,891
Mexico	0	0
Total	4,455,258	3,296,891
Hog Exports		
Canada	2,574	1,905
Mexico	92,000	68,080
Total	94,574	69,985
Deficit	4,360,684	3,226,906
	Pork Trade	
Pork Imports		
Canada (East)		2,782,246
Canada (West)		1,498,085
European Countries		1,467,485
Total		5,747,816
Pork Exports		
Japan		2,954,195
Korea		374,786
Other Asia		815,711
Russia		1,256,635
European Countries		286,601
Canada		462,971
Mexico		1,455,051
Total		7,605,950
Surplus		1,858,134

consumption region. Rates and minimum charges varied as a function of geographical location and direction of movement. Trucks are assumed to haul 43,500 pounds of pork. Transportation costs for pork between processing and consumption regions are shown in Appendix Table 4.

Pork Exports. Transportation rates for shipping pork are based on research work completed by Petersen (1996) for the NPPC. Transportation rates for pork exports originate at two export ports. The ports considered are Charleston, SC (C46) and Los Angeles, CA (C48). The freight rates are shown in Appendix Table 5.

III. Technical Data Requirements and the GAMS Program

Basic quantity and variables associated with the swine-pork interregional equilibrium model are discussed and illustrated in previous sections of this report. The interregional equilibrium model requires a supply equation for each production region, processing cost coefficients for each processing region, and a demand response equation for each consumption region. This section illustrates in a simplified manner how the supply and demand equations (responses) are determined. The assumptions and methodology used by Meyers (1981) provided the basis for this research.

Supply Sector

In basic microeconomics textbooks, the individual producer's short-run supply curve is identified as a portion of its short-run marginal cost curve which lies above its average variable cost curve.[3] The relevant portion of the marginal cost function with respect to the determination of product's supply function is dependent upon the time span in question. In long-run equilibrium in a perfectly competitive market, marginal costs and average costs are equal. By nature of these properties, the elasticity of supply can be employed to estimate the market supply function. The elasticity of supply assumed is 0.5 (Skold 1992).

In order to approximate the supply function for regional pork production, the approach employed by Meyer (1981) of using the stair step cost approach for approximating production quantities and costs is used. The basic idea of the stair step approach is that if the regional activities for swine production are arrayed in increasing order with respect to production cost, then they can be viewed as forming a sequence of steps on a stepped supply function.

Parameters for each region's supply function are shown in Table 7. The parameters are estimated using 1995 levels of swine production (column c) and production costs (column g) as a base point. Production quantities and costs are converted to a carcass weight basis assuming a conversion factor of 0.74 (columns d and h respectively). The supply response is estimated assuming production increases of two percent in each region (column e). Column f represents a second two percent increase in production. The elasticity of supply (0.50) was used in computing production costs (columns h and i) for quantities shown in columns e and f respectively.

Each region's supply response consists of a supply intercept and slope. The slope coefficient (column k) is:

$$\textit{supply curve slope} = k = \frac{(j-h)}{(f-d)}$$

The supply function intercept coefficient (column l) is:

$$\textit{supply intercept} = l = j - (f^{*}k)$$

The coefficients appearing in columns k and l are required in the GAMS program.

Processing Sector

Coefficients used in estimating regional processing quantities, constraints, and costs are shown in Table 8. First, a regional plant cost function is estimated using data provided by Meyer (1996) and Smith (1996). The NPPC also provided average cost and volume data in graphic form for selected plants. NPPC data supplemented similar cost-volume data collected by Ward and Faminow (1992). The quantities shown in columns c and d and cost figures shown in columns e, f, and, g represent weighted average volumes and costs for selected plants in each region. An average processing cost function is estimated using a quadratic functional relationship. The function used to estimate processing costs per head is:

$$\textit{slaughter costs (\$/hd)} = e = 33.106 - 6.3082\,(d) + 0.5629(d)^{2}$$

Processing costs per head are converted to dollars per hundred weight of carcass (column g). These costs are then used to represent regional processing costs.

Annual processing capacity for each region is calculated based on quantities processed during December 1995 as reported in Livestock Slaughter (USDA) and multiplied by 12 to determine annual

[3] For a detailed exposisiton of a supply function, see Henderson, J.M. and R.E. Quandt. *Microeconomic Theory: A Mathematical Approach.* 3rd edition, New York: McGraw-Hill Co., 1980, pp. 139-143.

Table 7. Estimation of Supply Response Coefficients.

a Region	b State(s)	c Liveweight Production	d Carcass[1] Production	e Increased[2] Production-1	f Increased Production-2	g Liveweight Production Cost	h Carcass[3] Production Cost	i Cost of Increased Production-1	j Cost of[4] Increased Production-2	k Linear Functional Form S-slopes	l S-intercepts
		(cwt.)	(cwt.)	(cwt.)	(cwt.)	(dol./cwt.)	(dol./cwt.)	(dol./cwt.)	(dol./cwt.)		
P01	ID,OR,WA	550,690	407,511	415,661	423,974	42.42	57.32	59.62	62.00	0.0002841	-58.459459
P02	CA	886,140	655,744	668,858	682,236	42.42	57.32	59.62	62.00	0.0001766	-58.459459
P03	AZ,NV,UT	924,280	683,967	697,647	711,599	42.42	57.32	59.62	62.00	0.0001693	-58.459459
P04	MT,WY	1,137,790	841,965	858,804	875,980	42.42	57.32	59.62	62.00	0.0001375	-58.459459
P05	CO	2,095,080	1,550,359	1,581,366	1,612,994	40.35	54.53	56.71	58.98	0.0000710	-55.606770
P06	NM,TX	2,200,470	1,628,348	1,660,915	1,694,133	40.35	54.53	56.71	58.98	0.0000676	-55.606770
P07	ND	1,101,470	815,088	831,390	848,017	39.31	53.12	55.25	57.46	0.0001316	-54.173535
P08	SD	6,921,140	5,121,644	5,224,076	5,328,558	39.31	53.12	55.25	57.46	0.0000209	-54.173535
P09	NE	16,913,650	12,516,101	12,766,423	13,021,751	39.31	53.12	55.25	57.46	0.0000086	-54.173535
P10	KS	5,673,500	4,198,390	4,282,358	4,368,005	40.35	54.53	56.71	58.98	0.0000262	-55.606770
P11	OK	4,569,550	3,381,467	3,449,096	3,518,078	40.35	54.53	56.71	58.98	0.0000326	-55.606770
P12	MN	20,073,160	14,854,138	15,151,221	15,454,246	39.31	53.12	55.25	57.46	0.0000072	-54.173535
P13	IA	59,261,010	43,853,147	44,730,210	45,624,815	39.31	53.12	55.25	57.46	0.0000024	-54.173535
P14	MO	14,797,500	10,950,150	11,169,153	11,392,536	39.31	53.12	55.25	57.46	0.0000098	-54.173535
P15	AR	3,768,050	2,788,357	2,844,124	2,901,007	40.35	54.53	56.71	58.98	0.0000395	-55.606770
P16	LA,MS	1,143,960	846,530	863,461	880,730	42.52	57.46	59.76	62.15	0.0001371	-58.597271
P17	AL,FL	2,130,780	1,576,777	1,608,313	1,640,479	42.52	57.46	59.76	62.15	0.0000736	-58.597271
P18	TN	2,159,560	1,598,074	1,630,036	1,662,637	42.52	57.46	59.76	62.15	0.0000726	-58.597271
P19	KY	2,903,190	2,148,361	2,191,328	2,235,154	40.26	54.41	56.58	58.84	0.0000511	-55.482740
P20	IL	16,064,750	11,887,915	12,125,673	12,368,187	40.26	54.41	56.58	58.84	0.0000092	-55.482740
P21	WI	4,144,170	3,066,686	3,128,020	3,190,580	40.26	54.41	56.58	58.84	0.0000358	-55.482740
P22	MI	4,503,820	3,332,827	3,399,483	3,467,473	40.26	54.41	56.58	58.84	0.0000330	-55.482740
P23	IN	17,645,300	13,057,522	13,318,672	13,585,046	40.26	54.41	56.58	58.84	0.0000084	-55.482740
P24	OH	7,374,910	5,457,433	5,566,582	5,677,914	40.26	54.41	56.58	58.84	0.0000201	-55.482740
P25	CT,MA,ME,NH	344,360	254,826	259,923	265,121	40.13	54.23	56.40	58.65	0.0004298	-55.303586
P25	NY,RI,VT										
P26	PA	3,249,590	2,404,697	2,452,791	2,501,846	42.10	56.89	59.17	61.53	0.0000478	-58.018464
P27	DE,MD,NJ,WV	660,920	489,081	498,862	508,840	42.10	56.89	59.17	61.53	0.0002350	-58.018464
P28	VA	1,544,480	1,142,915	1,165,774	1,189,089	42.10	56.89	59.17	61.53	0.0001005	-58.018464
P29	NC	31,567,150	23,359,691	23,826,885	24,303,423	42.10	56.89	59.17	61.53	0.0000049	-58.018464
P30	SC	1,385,620	1,025,359	1,045,866	1,066,783	42.10	56.89	59.17	61.53	0.0001121	-58.018464
P31	GA	3,411,990	2,524,873	2,575,370	2,626,877	42.52	57.46	59.76	62.15	0.0000460	-58.597271
Total		241,108,030	178,419,942	181,988,341	185,204,134						

[1] The conversion factor from liveweight basis to carcass basis is assumed to be 0.74
[2] The rate of increasing hog production is assumed to be 2 percent.
[3] In formulating the price of hog supply, the conversion factor from liveweight basis is assumed to be 0.74.
[4] The increase in hog production costs is assumed to be 4 percent for each 2 percent increase in production due to the supply elasticity of 0.5.

Source: The quantity of production is drawn from USDA (1996) and the elasticity of supply is drawn from Skold, et al. (1988).

Table 8. Estimation of Regional Processing Quantities, Costs, and Constraints.

a	b	c	d	e	f	g	h	i
Region	State(s)	Daily Plant Slaughter	Annual1 Plant Slaughter	Slaughter2 Cost	Slaughter3 Cost	Slaughter Constraint	Monthly 4 Processing Constraint	Annual Processing
		(hd./day.)	(mil.hd./yr.)	(dol./hd.)	(dol./lb.)	(dol./cwt.)	(cwt.)	(cwt.)
S01	ID, OR, WA	538	0.14	32.23	0.18	17.52	26,910	322,920
S02	CA, NV	5,196	1.35	25.61	0.14	13.92	404,900	4,858,800
S03	AZ, UT	961	0.24	31.65	0.17	17.2	2,540	30,480
S04	MT, ND, WY	920	0.24	31.63	0.17	17.19	31,090	373,080
S05	NM, OK, TX	9,000	2.34	21.43	0.12	11.65	188,180	2,258,160
S06	NE	8,735	2.27	21.68	0.12	11.78	2,001,038	24,012,456
S07	CO, KS	11,746	3.05	19.09	0.10	10.38	11,940	143,280
S08	MN, WI	15,850	4.12	16.67	0.09	9.06	1,777,930	21,335,160
S09	IA	12,339	3.21	18.66	0.10	10.14	7,431,550	89,178,600
S10	IL	11,200	2.91	19.51	0.11	10.6	2,240,960	26,891,520
S11	MO	9,788	2.54	20.70	0.11	11.25	766,936	9,203,231
S12	AR, LA, MS	6,028	1.57	24.60	0.13	13.37	105,400	1,264,800
S13	AL, FL, GA	4,700	1.22	26.24	0.14	14.26	69,940	839,280
S14	KY, TN	4,053	1.05	27.08	0.15	14.72	746,140	8,953,680
S15	IN	7,439	1.93	23.01	0.13	12.51	747,210	8,966,520
S16	MI	12,000	3.12	18.90	0.10	10.27	611,688	7,340,253
S17	OH	3,140	0.82	28.33	0.15	15.4	334,310	4,011,720
S18	VA, WV	4,760	1.24	26.16	0.14	14.22	1,003,200	12,038,400
S19	NC, SC	13,630	3.54	17.82	0.10	9.68	1,599,650	19,195,800
S20	MD, NJ, PA	6,380	1.66	24.19	0.13	13.15	621,480	7,457,760
S21	CT, MA, ME, NH	538	0.14	32.23	0.18	17.52	32,220	386,640
S22	SD	12,514	3.25	18.54	0.10	10.08	705,784	8,469,408
Total							20,755,212	249,062,540

1 Annual Slaughter is based on 260 days per year.
2 The quadratic functional form of processing cost is estimated as
ProcCost = 33.106 - 6.3082 *(Annual Slaughter) + 0.5629 (Annual Slaughter)2
3 The conversion factor for the pound unit is employed by the dressed weight in 1993, i.e., 184 pounds/head.
4 The monthly amount of processing capacity represents the amount of December of the yearly capacity.

Source: Ward and Faminow (1995), Meyer (1996), and NPPC Data.

capacity. These procedures are similar to those used by Meyer (1981).

Coefficients shown in columns g and i are used in the GAMS program.

Demand Sector

Regional demand functions are derived using the regional pork consumption data and the price elasticity of demand. Procedures similar to those used by Meyer (1981) are used to derive a demand response function. Each region's consumption (demand) response function is based on the initial quantity of pork consumed within the region (Table 5) and each consumption region's estimated price elasticity of demand (Column f, Table 9). Quantities of pork consumed are shown in colunm d. Price elasticities are shown in column f. Price elasticities estimated by Gao and Spreen (1994) for pork were used since their results showed similar regional groupings (Midwest, South, West, and Northeast).

The intercept of the regional demand function (column g) is:

$$\textit{Demand Intercept} = g = e * (1+(\frac{1}{f}))$$

The slope of the demand function is:

$$\textit{Demand Slope} = h = (\frac{e}{d}) * (\frac{1}{f})$$

Coefficients appearing in columns g and h are required in the GAMS program.

The GAMS Program

GAMS (*General Algebraic Modeling System*) was developed as a mathematical modeling of optimiza-

Table 9. Estimation of Demand Response Coefficients

a	b	c	d	e	f	g	h
		Regional	Regional[1,2]	Regional[3]	Regional[4]		
		Consumption	Consumption	Carcass	Demand	Functional Form	
Region	State(s)	Liveweight	Carcass	Pork Price	Elasticity	Intercept	Slope
		(cwt.)	(cwt.)	(dol./cwt.)			
C01	WA	4,411,249	3,264,324	112.50	0.58133	306.02175	0.0000593
C02	OR	2,523,009	1,867,027	112.50	0.58133	306.02175	0.0001037
C03	NCA	7,874,361	5,827,027	112.50	0.58133	306.02175	0.0000332
C04	SCA	17,436,085	12,902,703	112.50	0.58133	306.02175	0.0000150
C05	ID, MT, WY	2,268,901	1,678,986	100.00	0.58133	272.01933	0.0001025
C06	NV	1,328,798	983,311	100.00	0.58133	272.01933	0.0001749
C07	UT	1,753,652	1,297,703	100.00	0.58133	272.01933	0.0001326
C08	AZ	3,679,054	2,722,500	100.00	0.58133	272.01933	0.0000632
C09	CO	3,353,634	2,481,689	100.00	0.58133	272.01933	0.0000693
C10	NM	1,518,627	1,123,784	100.00	0.58133	272.01933	0.0001531
C11	ND, SD	1,388,514	1,027,500	89.19	0.54437	253.02847	0.0001595
C12	NE	1,662,162	1,230,000	89.19	0.54437	253.02847	0.0001332
C13	KS	2,635,135	1,950,000	89.19	0.54437	253.02847	0.0000840
C14	OK	3,314,189	2,452,500	89.19	0.41509	304.05630	0.0000876
C15	NTX	7,601,351	5,625,000	89.19	0.41509	304.05630	0.0000382
C16	STX	11,250,000	8,325,000	89.19	0.41509	304.05630	0.0000258
C17	MN	4,682,432	3,465,000	89.19	0.54437	253.02847	0.0000473
C18	IA	2,898,649	2,145,000	89.19	0.54437	253.02847	0.0000764
C19	MO	5,351,351	3,960,000	89.19	0.54437	253.02847	0.0000414
C20	AR	2,503,378	1,852,500	89.19	0.41509	304.05630	0.0001160
C21	LA	4,418,919	3,270,000	89.19	0.41509	304.05630	0.0000657
C22	WI	4,523,009	3,347,027	103.13	0.54437	292.56417	0.0000566
C23	IL	10,387,144	7,686,486	103.13	0.54437	292.56417	0.0000246
C24	KY	4,148,101	3,069,595	83.90	0.41509	286.01906	0.0000658
C25	TN	5,634,953	4,169,865	83.90	0.41509	286.01906	0.0000485
C26	MS	2,340,394	1,731,892	103.13	0.41509	351.56510	0.0001435
C27	MI	8,397,370	6,214,054	103.13	0.54437	292.56417	0.0000305
C28	IN	5,101,534	3,775,135	103.13	0.54437	292.56417	0.0000502
C29	AL	4,600,621	3,404,459	83.90	0.41509	286.01906	0.0000594
C30	OH	9,817,385	7,264,865	103.13	0.54437	292.56417	0.0000261
C31	GA	7,649,744	5,660,811	83.90	0.41509	286.01906	0.0000357
C32	FL	15,310,263	11,329,595	83.90	0.41509	286.01906	0.0000178
C33	NY	14,109,752	10,441,216	116.47	0.54265	331.10357	0.0000206
C34	PA	9,525,018	7,048,514	115.12	0.54265	327.25353	0.0000301
C35	WV	1,960,920	1,451,081	83.90	0.41509	286.01906	0.0001393
C36	VA	7,164,901	5,302,027	83.90	0.41509	286.01906	0.0000381
C37	NC	7,703,616	5,700,676	83.90	0.41509	286.01906	0.0000355
C38	SC	4,018,809	2,973,919	83.90	0.41509	286.01906	0.0000680
C39	NH, VT	1,327,931	982,669	116.47	0.54265	331.10357	0.0002184
C40	MA	4,638,057	3,432,162	116.47	0.54265	331.10357	0.0000625
C41	CT, RI	3,314,007	2,452,365	116.47	0.54265	331.10357	0.0000875
C42	DE, MD	6,227,538	4,608,378	83.90	0.54265	238.50681	0.0000335
C43	NJ	6,154,584	4,554,392	116.47	0.54265	331.10357	0.0000471
C44	ME	962,381	712,162	116.47	0.54265	331.10357	0.0003014
Total						238,871,485	176,764,899

[1] The conversion factor from retail-level pork to carcass basis is assumed to be 0.777.

[2] 52.5 pounds per capita was used in estimating the amount of regional pork consumption in 1955 (USDA).

[3] The price of pork at the wholesale level in 1995 is employed to $0.99/pound.

[4] The values of regional price elasticities of pork demand were used as -0.54437, -0.41509, -0.58133, and -0.54265 in Midwest, South, West and Northeast, respectively (Gao and Spreen, 1994).

Source: USDA, ERS, Hog Outlook, April 12, 1996.
U.S. Department of Commerce, Statistical Abstract of the United States 1995, 115th edition, p.34.

tion problems at the World Bank.[4] GAMS is designed to make construction of large, complex mathematical programming models more straightforward for programmers and more comprehensible to users of models from several disciplines. Brooke (1996) states that the GAMS system is designed to provide a system structure and programming language in which conciseness of expression, generality, and portability is easily maintained and allows the programmer to keep track of as many of the programming details as desired. GAMS has very useful features for data entry and program documentation as well as computation. The GAMS program allows data to be input in a more convenient and user-friendly way with comments on data content.

Using GAMS (1996), users write a model in computer code, which differs only slightly from standard mathematical notation, and submit the problem to be solved by one of several alternative solvers. For problem involving optimization of a non-linear function (quadratic function), subject to linear constraints, MINOS (Modular In-core Non-linear Optimization Systems) is used as the solver. The basic framework of a GAMS program regarding input and output is described in Table 10. Interested readers and potential GAMS useres are encouraged to review model construction, input, and output as described by Brooke, Kendrick, and Meeraus (1996), Thompson and Thore (1992), and Jefferson and Boisvert (1989).

Table 10. Basic Components of a GAMS Program.

Inputs of the Program	*Outputs of the Program*
	Echo Print
	Reference Maps
	Equation Listings
	Status Reports
	Results
SETS	
Declaration	
Assignmentof members	
Data	
(PARAMETERS, TABLES, SCALARS)	
Declaration	
Assignment of values	
VARIABLES	
Declaration	
Assignment of type	
Assignment of bounds (optional	
EQUATIONS	
Declaration	
Definition	
MODEL and SOLVE statements	
DISPLAY statements (optional)	

Note: The all capital characters in the words represents the GAMS language required for formulating the optimization problem.
Source: Brooke, Kendrick, and Meeraus (1996)

[4] See [Jefferson and Boisvert (1989), Thompson and thore (1992), and Brooke, Kendrick, and Meeraus (1996).]

IV. Results

This section presents results of the model described in earlier sections. Results deal primarily with quantities of swine produced by region, shipment patterns of live hogs to processing facilities, quantities of hogs processed by region, and shipment patterns of pork to the respective consumption regions. Two basic scenarios are described. The first is referred to as the "benchmark scenario." This scenario depicts production, processing, and consumption quantities and shipment patterns in an 'optimal' framework using 1995 data. Note that total production and consumption quantities are not fixed at 1995 levels but are allowed to increase or decrease to maximize net social welfare. A second scenario illustrates applicability of the model for analyzing industry issues and questions. Scenario two is based on assumptions used in the benchmark scenario but allows for a 10 percent increase in exports to Japan. The results will focus not only on quantities but also on shadow prices and/or marginal values associated with production, processing, and consumption quantities and a comparison of results between the two scenarios.

These results have limitations similar to those reported by Meyers (1981). The objective function of the model maximizes net social welfare to both consumers and producers. However, the objective function value itself is not the focus of this research; only production, processing, and consumption quantities and their respective marginal values and the shipment or resulting trade patterns are of interest. The model determined for all regions the cost-minimizing levels of production, processing, and consumption that satisfy spatial equilibrium supply and demands. The solution does not attempt to replicate actual production, processing, and/or consumption conditions known to have existed in 1995.

Production

Table 11 shows quantities and marginal values associated with both the benchmark scenario and the scenario assuming increased pork exports to Japan. Hog imports into the United States are set at the predetermined 1995 levels as reported by the United States Department of Agriculture. Given the benchmark scenario, an increase in production occurs in all regions of the U.S. when compared to 1995 levels. Production regions P13 (IA), P12 (MN), and P29 (NC) reflect the largest percentage increase in swine production compared to 1995 levels. P13 (IA) and P29 (NC) show the largest absolute increase in production quantities.

The marginal values (column f) reflect the value of the last unit of swine production in each of the respective regions. Marginal Values can be interpreted as the price of swine originating in each region. The marginal values of swine originating in P13 (IA), P02 (CA), P12 (MN), P20 (IL), and P26 (PA) are the highest. Three of the regions (P13, P12, and P20) are recognized as traditional hog production states (regions). The other two regions P02 (CA) and P26 (PA) appear in the top five region with respect to marginal values because of the excess processing capacity associated with each region. Marginal values of production, processing, and/or consumption are impacted by cost of production, transportation costs of live hogs, processing costs, and/or transportation costs of pork.

Each production region experiences an increase in production as a result of increased exports to Japan. The ranking of the top five swine production regions does not change. P13 (IA), P12 (MN), P29 (NC), P09 (NE), and P14 (MO) respond with the largest absolute increase in production to meet the increase demand (column j). Production region P08 (SD) is among the top five regions considering a percentage change in production. The marginal values of production (column l) are slightly higher for each production region as a result of increased demand. Rank ordering of the marginal values does not change.

Transportation quantities and flows of live hogs between each production region and processing region are shown in Appendix Table 6. Transportation flows of live hogs between each production region and processing region are shown in Appendix Table 7, given an assumed increase in pork exports to Japan. Transportation patterns do not change for any of the top five production regions assuming increased exports. All U.S. production regions benefit from increased exports. Figure 6 shows the shipment pattern for live hogs from the top five production regions to processing. The destination for shipped hogs assuming increased exports does not change.

Processing

Solutions to the processing sector of the interregional swine-pork trade model appear in Table 12. The five regions with the largest processing capacity are S09 (IA), S10 (IL), S06 (NE), S08 (MN, WI), and S19 (NC, SC) respectively (column d). Swine is pro-

Table 11. 1995 Regional Production; Optimal Production Levels and Marginal Values for Benchmark and Increased Exports Scenario.

a	b	c	d	e	f	g	h	i	j	k	l
			Benchmark				Increased Exports				
Region	State(s)	1995 Carcass Production	Production	Change From 1995 Production	Change From 1995 Production	Marginal Value	Production	Production Change From 1995	Change From Bench mark	Change From Bench mark	Marginal Value
		(cwt.)	(cwt.)	(cwt.)	(pct.)	(dol./cwt.)	(cwt.)	(cwt.)	(cwt.)	(pct.)	(dol./cwt.)
P01	ID,OR,WA	407,511	416,650	9,139	2.2	59.91	417,040	9,529	390	2.3	60.02
P02	CA	655,744	693,220	37,476	5.7	63.96	693,840	38,096	620	5.5	64.07
P03	AZ,NV,UT	683,967	716,270	32,303	4.7	62.81	716,910	32,943	640	4.6	62.91
P04	MT,WY	841,965	854,750	12,785	1.5	59.07	855,540	13,575	790	1.6	59.18
P05	CO	1,550,359	1,649,800	99,441	6.4	61.53	1,651,300	100,941	1,500	6.1	61.64
P06	NM,TX	1,628,348	1,719,200	90,852	5.6	60.61	1,720,800	92,452	1,600	5.4	60.72
P07	ND	815,088	880,320	65,232	8.0	61.68	881,150	66,062	830	7.5	61.79
P08	SD	5,121,644	5,629,200	507,556	9.9	63.48	5,634,400	512,756	5,200	9.1	63.59
P09	NE	12,516,101	13,655,000	1,138,899	9.1	63.26	13,667,000	1,150,899	12,000	8.4	63.37
P10	KS	4,198,390	4,508,900	310,510	7.4	62.53	4,513,100	314,710	4,200	7.0	62.64
P11	OK	3,381,467	3,573,900	192,433	5.7	60.90	3,577,200	195,733	3,300	5.5	61.01
P12	MN	14,854,138	16,391,000	1,536,862	10.3	63.85	16,407,000	1,552,862	16,000	9.5	63.95
P13	IA	43,853,147	49,287,000	5,433,853	12.4	64.11	49,332,000	5,478,853	45,000	11.1	64.22
P14	MO	10,950,150	11,970,000	1,019,850	9.3	63.14	11,982,000	1,031,850	12,000	8.6	63.25
P15	AR	2,788,357	2,981,800	193,443	6.9	62.18	2,984,600	196,243	2,800	6.6	62.29
P16	LA,MS	846,530	867,020	20,490	2.4	60.27	867,810	21,280	790	2.5	60.38
P17	AL,FL	1,576,777	1,611,000	34,223	2.2	59.98	1,612,500	35,723	1,500	2.2	60.08
P18	TN	1,598,074	1,654,800	56,726	3.5	61.54	1,656,300	58,226	1,500	3.5	61.65
P19	KY	2,148,361	2,297,400	149,039	6.9	61.91	2,299,500	151,139	2,100	6.6	62.02
P20	IL	11,887,915	12,961,000	1,073,085	9.0	63.76	12,973,000	1,085,085	12,000	8.4	63.87
P21	WI	3,066,686	3,312,500	245,814	8.0	63.10	3,315,500	248,814	3,000	7.5	63.21
P22	MI	3,332,827	3,575,200	242,373	7.3	62.50	3,578,500	245,673	3,300	6.9	62.61
P23	IN	13,057,522	14,076,000	1,018,478	7.8	62.76	14,089,000	1,031,478	13,000	7.3	62.87
P24	OH	5,457,433	5,853,100	395,667	7.3	62.17	5,858,500	401,067	5,400	6.9	62.27
P25	CT,MA,ME,NH	254,826	274,940	20,114	7.9	62.86	275,190	20,364	250	7.4	62.97
P25	NY,RI,VT							0	0		
P26	PA	2,404,697	2,546,500	141,803	5.9	63.70	2,548,800	144,103	2,300	5.7	63.81
P27	DE,MD,NJ,WV	489,081	516,420	27,339	5.6	63.34	516,890	27,809	470	5.4	63.45
P28	VA	1,142,915	1,200,500	57,585	5.0	62.63	1,201,600	58,685	1,100	4.9	62.74
P29	NC	23,359,691	24,518,000	1,158,309	5.0	62.12	24,541,000	1,181,309	23,000	4.8	62.23
P30	SC	1,025,359	1,067,700	42,341	4.1	61.67	1,068,600	43,241	900	4.0	61.78
P31	GA	2,524,873	2,573,200	48,327	1.9	59.77	2,575,600	50,727	2,400	2.0	59.88
Hog Imports											
P32	AZ			0		62.16		0	0		62.27
P33	ND	3,296,891	3,296,900	9		61.90	3,296,900	9	0		62.01

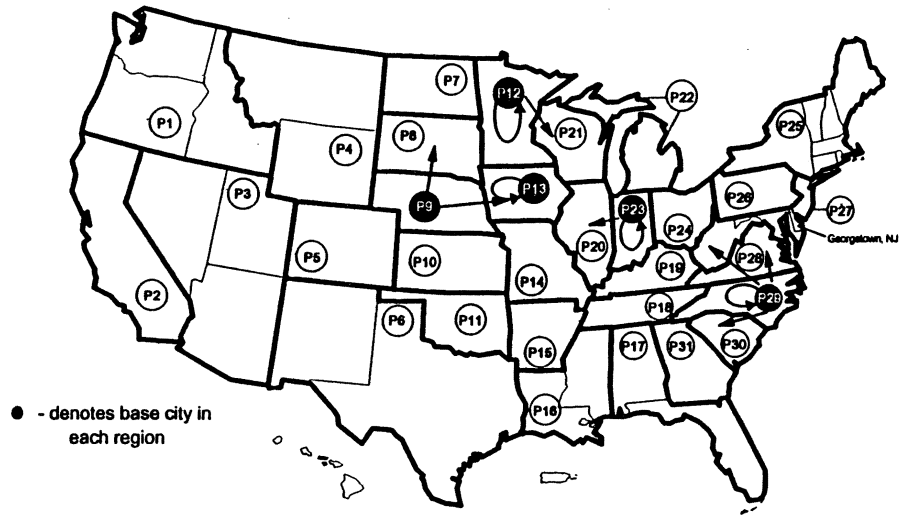


Figure 6. Shipment Pattern for Market Hogs from the Five Largest Production Regions -Benchmark Scenario

cessed in each of the top five processing regions except S06 (NE) in the benchmark scenario. Region S18 (VA, WA) is included in the top five processing regions. The fact that S06 (NE) does not appear in the optimal benchmark solution may be attributed to industry diseconomies and/or misspecification of data used in calculating costs associated with production, transportation, and/or processing. S18 (VA, WA) replaces S06 (NE) in the benchmark solution as the fifth largest processing region. Other processing regions not appearing in the benchmark solution include S03 (AZ, UT), S14 (KY, TN), S17 (OH), and S21 (CT, MA, ME, NH).

Eleven regions have excess processing capacity (column f). The five regions with greatest excess capacity are S06 (NE), S09 (IA), S14 (KY, TN), S20 (MD, NJ, PA), and S17 (OH) respectively. Excess processing capacity is shown in column f. The numbers near zero appear as a result of rounding errors.

Marginal values are shown in columns g and h. Marginal values in column g appear as negative numbers. These values are interpreted as a cost or input in the solution. Marginal value-in reflects the cost of production and transportation into the processing region. Marginal value-out reflects a positive contribution to net social welfare. The marginal value-out reflects the value of the last unit of pork leaving the respective processing region destined for a consumption region. Relative rankings of processing regions are the same when either marginal value is considered. Processing regions with the five largest (absolute) marginal value out values include S02 (CA,NV), S01 (ID,OR,WA), S03 (AZ, UT), S21 (CT, MA, ME, NH), and S04 (MT, ND, WY) respectively. Regions with the smallest absolute marginal values include S09 (IA), S08 (MN, WI) (MN, WI), S22 (SD), S11 (MO), and S06 (NE). These are the regions with greatest excess processing capacity.

The marginal value associated with processing capacity is presented in column I. Processing regions with the largest processing values include S19 (NC, SC), S07 (CO, KS), S05 (NM, OK, TX), S16 (MI), and S13 (AL, FL, GA). These regions all have zero excess processing capacity. Expansion of the processing capacity in any of these regions appears more likely from an economic standpoint of maximizing net social welfare.

Column j depicts optimal processing quantities in each of the regions given a ten percent increase in exports to Japan. None of the regions processed less pork than in the benchmark solution. The four regions experiencing an increase in pork processing include S09 (IA), S18 (VA, WV), S20 (MD, NJ, PA), and S02 (CA,NV). These are the regions where pork exports originate and/or replace pork in domestic consumption regions.

Table 12. 1995 Regional Slaughter Constraints, Optimal Slaughter Levels and Marginal Values for the Benchmark and Increased Exports Scenarios.

a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
				Benchmark					*Increased Exports*						
Region	*State(s)*	*Slaughter Cost*	*Annual Slaughter Constraint*	*Slaughter Level*	*Excess Slaughter Capacity*	*Marginal Values-in*	*Marginal Values-out*	*Slaughter Marginal Value*	*Slaughter Level*	*Change From Bench mark*	*Change From Bench mark*	*Excess Slaughter Capacity*	*Marginal Values-in*	*Marginal Values-out*	*Slaughter Marginal Value*
		(dol./cwt.)	*(cwt.)*	*(cwt.)*	*(dol./cwt.)*	*(dol./cwt.)*	*(dol./cwt.)*	*(cwt.)*	*(cwt.)*	*(pct.)*	*(cwt.)*	*(dol./cwt.)*	*(dol./cwt.)*	*(dol./cwt.)*	
S01	ID, OR, WA	17.52	322,920	322,920	0	-60.33	79.02	1.17	322,920	0		0	-60.44	79.13	1.17
S02	CA, NV	13.92	4,858,800	1,503,200	3,355,600	-65.22	79.13		1,504,900	1,700	0.11	3,353,900	-65.32	79.24	
S03	AZ, UT	17.20	30,480		30,480	-63.23	78.43		0	0		30,480	-63.34	78.54	
S04	MT, ND, WY	17.19	373,080	373,080	0	-59.49	77.48	0.80	373,080	0		0	-59.60	77.59	0.80
S05	NM, OK, TX	11.65	2,258,160	2,258,200	(40)	-61.33	76.44	3.47	2,258,200	0		(40)	-61.43	76.55	3.47
S06	NE	11.78	24,012,466		24,012,466	-63.68	75.24		0	0		24,012,466	-63.79	75.35	-0.22
S07	CO, KS	10.38	143,280	143,280	0	-62.01	76.12	3.74	143,280	0		0	-62.12	76.23	3.74
S08	MN, WI	9.06	21,335,160	21,335,000	160	-64.56	74.69	1.07	21,335,000	0		160	-64.67	74.79	1.07
S09	IA	10.14	89,178,600	76,291,000	12,887,600	-64.54	74.68		76,438,000	147,000	0.19	12,740,600	-64.65	74.79	
S10	IL	10.60	26,891,520	26,892,000	(480)	-64.18	75.25	0.47	26,892,000	0		(480)	-64.29	75.36	0.47
S11	MO	11.25	9,203,231	9,203,200	31	-63.76	75.14	0.13	9,203,200	0		31	-63.87	75.25	0.13
S12	AR, LA, MS	13.37	1,264,800	1,264,800	0	-61.04	76.83	2.42	1,264,800	0	0	-61.15	76.93	2.42	
S13	AL, FL, GA	14.26	839,280	839,280	0	-60.19	77.36	2.90	839,280	0		0	-60.30	77.68	3.11
S14	KY, TN	14.72	8,953,680		8,953,680	-62.34	76.43	-0.63	0	0		8,953,680	-62.44	76.57	-0.59
S15	IN	12.51	8,966,520	8,966,500	20	-63.21	75.83	0.12	8,966,500	0		20	-63.32	75.97	0.15
S16	MI	10.27	7,340,253	7,340,300	(47)	-63.26	76.58	3.05	7,340,300	0		(47)	-63.37	76.69	3.05
S17	OH	15.40	4,011,720		4,011,720	-62.62	76.54		0	0		4,011,720	-62.73	76.65	
S18	VA, WV	14.22	12,038,400	9,324,800	2,713,600	-63.06	77.27		9,351,400	26,600	0.29	2,687,000	-63.16	77.38	
S19	NC, SC	9.68	19,195,800	19,196,000	(200)	-62.54	76.81	4.58	19,196,000	0		(200)	-62.65	77.13	4.79
S20	MD, NJ, PA	13.15	7,457,760	3,337,900	4,119,860	-64.13	77.27		3,340,800	2,900	0.09	4,116,960	-64.24	77.38	
S21	CT, MA, ME, NH	17.52	386,640		386,640	-63.29	78.18		0	0		386,640	-63.39	78.29	
S22	SD	10.08	8,469,409	8,469,400	9	-64.06	74.96	0.83	8,469,400	0		9	-64.17	75.07	0.83
Hog Exports															
S23	ND			1,905		-62.32	78.04		1,905	0			-62.42	78.36	
S24	TX			68,080		-64.37	79.71		68,080	0			-64.48	79.82	
Pork Imports															
Z23	New York,NY			1,467,500			78.56		1,467,500	0				78.70	
Z24	Niagara Fall,NY			2,782,100			77.44		2,782,100	0				77.55	
Z25				1,498,100			78.26		1,498,100	0				78.37	

Regional processing rankings based on the four largest marginal value-out values are the same as in the benchmark scenario. S13 (AL, FL, GA) replaces S04 (MT, ND, WY) as the fifth largest absolute marginal value. Processing marginal values (column p) are highest for regions reflecting the greatest increase in processing. The higher the processing marginal value, the greater the value of increased processing capacity in the respective region.

Transportation quantities and flows of pork between each combination of processing region and consumption region for the benchmark scenario is presented in Appendix Table 8. Similar information is presented in Appendix Table 9 for the second scenario. Transportation patterns associated with processing regions are presented in two ways. The first presentation reflects where a processing region acquires swine or the source of market hogs, the second presentation reflects the destination of pork shipped for consumption purposes. Figure 7 depicts the source of market hogs for the five largest processing regions given the benchmark scenario. Arrows depict the production source (state) for hogs processed in each of the respective processing regions. Figure 8 depicts the source of hogs for the top five processing regions given increased exports to Japan. The only difference in flow patterns of live hogs from the benchmark solutions (not quantities) is that P11 (OK) is replaced by P15 (AR) as a source of hogs to region S09 (IA) given increased exports. P11 (OK) increases quantities of pork shipped to other processing regions as a result of an increase in pork exports.

Figure 9 shows the flow pattern of pork between the top five processing regions and the consumption regions supplied by the respective processing regions. Figure 10 depicts the flow pattern between processing regions and consumption regions given an increase in pork exports. Pork shipment patterns are the same for S10 (IL), S08 (MN, WI), and S18 (VA, WV). As a result of an increase in pork exports, S09 (IA) ships pork to C42 (DE) and S19 (NC, SC) discontinues supplying region C34 (PA). Changes in quantities of pork shipped are shown in Tables 20 and 21.

Consumption

Solutions to the consumption sector of the interregional swine-pork trade model appear in Table 13. The five largest consumption regions are C04 (SCA), C33 (NY), C32 (FL), C23 (IL), and C16 (STX) respec-

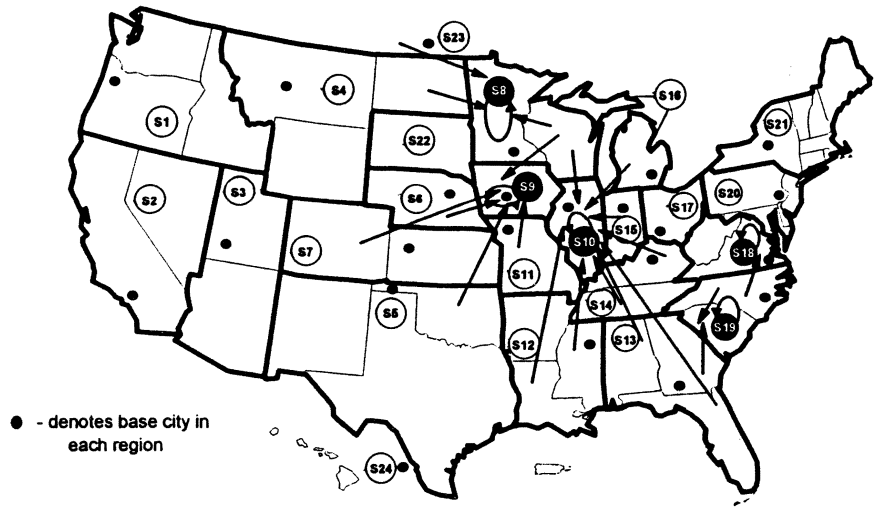


Figure 7. Sources of Market Hogs for the Five Largest Processing Regions-Benchmark Scenario

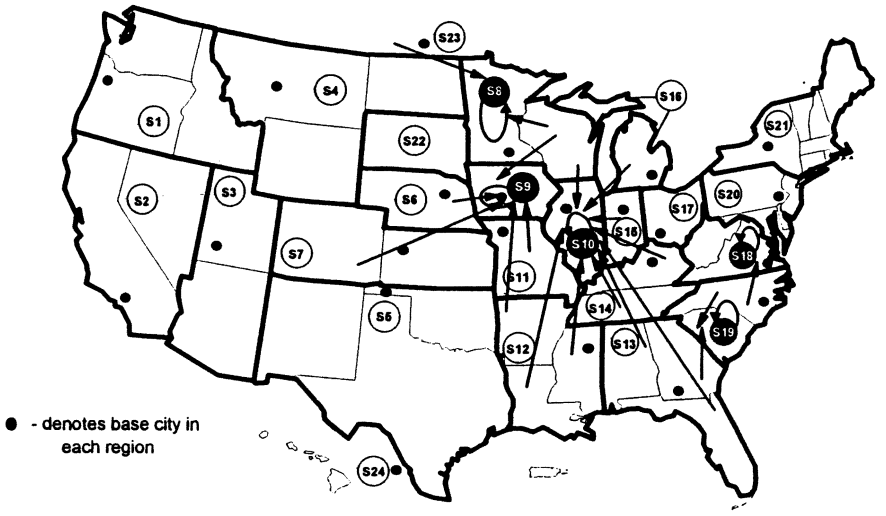


Figure 8. Sources of Hogs for the Five Largest Processing Regions- Increased Export Scenario

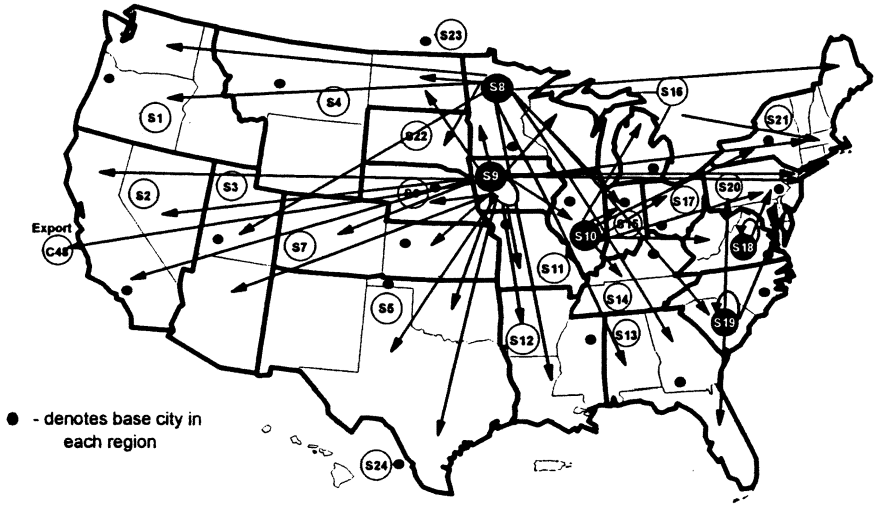


Figure 9. Destination of Pork Shipped from the Five Largest Processing Regions- Benchmark Scenario

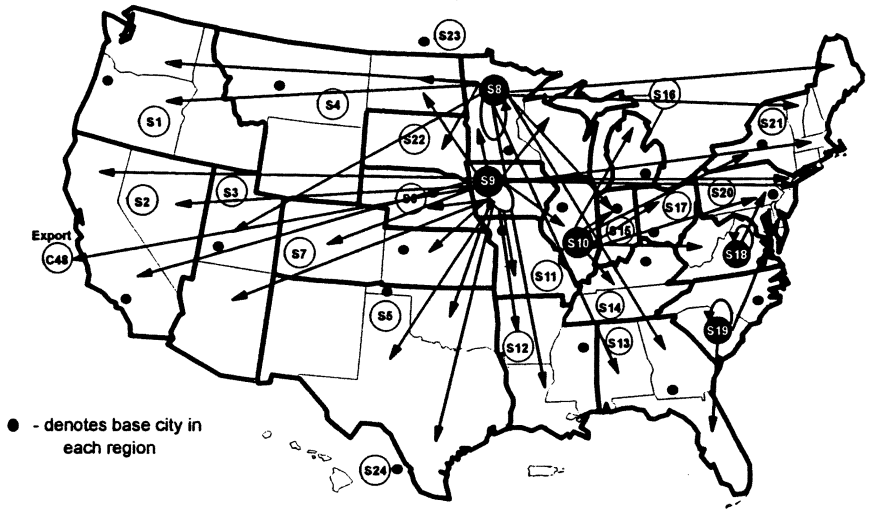


Figure 10. Destination of Pork Shipped from the Five Largest Processing Regions- Increased Export s Scenario

tively (column d). Greater quantities of pork are consumed in each consumption region given the assumptions stated for the benchmark scenario. Regions with the largest absolute increase in pork consumption are C04 (SCA), C33 (NY), C34 (PA), C23 (IL), and C30 (OH). The marginal value of pork consumed (column g) represents the accumulated cost of getting the last unit of pork to the consumption region. It is in effect the price of pork at each of the respective consumption regions. The consumption regions with the highest marginal value of pork are C03 (NCA), C44 (ME), C02 (OR), C04 (SCA), and C32 (FL). The regions with the lowest marginal values of pork are C18 (IA), C11 (ND, SD), C17 (MN), C12 (NE), and C19 (MO). The lower marginal values are attributed to lower cost of hog production, transportation to processing, processing costs, and finally transportation costs to consumption regions. The regions with lower marginal values are located nearer to major hog production and processing regions.

Domestic pork consumption decreases in every consumption region given increased export demand (column i). The decrease is relatively constant in percentage term across all regions (column j). Marginal values (column k) increase consistently in all consumption regions. The relative rank of marginal values is relatively constant when considering the two scenarios.

The flow pattern for pork from processing regions to the top five consumption regions is shown in Figure 11. Although the quantities of pork shipped decrease to the top five regions, assuming increased exports to Japan, the flow pattern from processing to consumption remains unchanged.

Table 13. 1995 Consumption Levels, Optimal Consumption Levels and Marginal Values for the Benchmark and Increased Exports Scenarios.

a	b	c	d	e	f	g	h	i	j	k
			Benchmark				Increased Exports			
Region	State(s)	1995 Consumption (cwt.)	Consumption (cwt.)	Change From 1995 (cwt.)	Change From 1995 (pct.)	Marginal Value (dol./cwt.)	Consumption (cwt.)	Change From Benchmark (cwt.)	Change From Benchmark (pct.)	Marginal Value (dol./cwt.)
C01	WA	3,264,324	3,821,400	557,076	17.1	-79.41	3,819,600	-1800	-0.05	-79.52
C02	OR	1,867,027	2,183,500	316,473	17	-79.71	2,182,400	-1100	-0.05	-79.71
C03	NCA	5,827,027	6,806,300	979,273	16.8	-80.05	6,803,000	-3300	-0.05	-80.16
C04	SCA	12,902,703	15,088,000	2,185,297	16.9	-79.71	15,080,000	-8000	-0.05	-79.82
C05	ID, MT, WY	1,678,986	1,887,800	208,814	12.4	-78.52	1,886,700	-1100	-0.06	-78.63
C06	NV	983,311	1,104,200	120,889	12.3	-78.9	1,103,600	-600	-0.05	-79.01
C07	UT	1,297,703	1,462,800	165,097	12.7	-78.06	1,461,900	-900	-0.06	-78.17
C08	AZ	2,722,500	3,056,000	333,500	12.2	-78.88	3,054,300	-1700	-0.06	-79
C09	CO	2,481,689	2,814,400	332,711	13.4	-76.98	2,812,800	-1600	-0.06	-77.1
C10	NM	1,123,784	1,270,300	146,516	13	-77.54	1,269,600	-700	-0.06	-77.64
C11	ND, SD	1,027,500	1,114,000	86,500	8.4	-75.35	1,113,300	-700	-0.06	-75.46
C12	NE	1,230,000	1,332,900	102,900	8.4	-75.48	1,332,100	-800	-0.06	-75.6
C13	KS	1,950,000	2,112,300	162,300	8.3	-75.6	2,111,000	-1300	-0.06	-75.71
C14	OK	2,452,500	2,596,700	144,200	5.9	-76.59	2,595,400	-1300	-0.05	-76.7
C15	NTX	5,625,000	5,939,100	314,100	5.6	-77.18	5,936,200	-2900	-0.05	-77.3
C16	STX	8,325,000	8,761,700	436,700	5.2	-78	8,757,500	-4200	-0.05	-78.11
C17	MN	3,465,000	3,754,100	289,100	8.3	-75.46	3,751,800	-2300	-0.06	-75.58
C18	IA	2,145,000	2,326,900	181,900	8.5	-75.25	2,325,500	-1400	-0.06	-75.36
C19	MO	3,960,000	4,285,700	325,700	8.2	-75.6	4,283,100	-2600	-0.06	-75.71
C20	AR	1,852,500	1,960,700	108,200	5.8	-76.61	1,959,800	-900	-0.05	-76.72
C21	LA	3,270,000	3,439,900	169,900	5.2	-78.06	3,438,200	-1700	-0.05	-78.17
C22	WI	3,347,027	3,829,100	482,073	14.4	-75.84	3,827,200	-1900	-0.05	-75.94
C23	IL	7,686,486	8,811,000	1,124,514	14.6	-75.81	8,806,600	-4400	-0.05	-75.92
C24	KY	3,069,595	3,182,300	112,705	3.7	-76.62	3,180,700	-1600	-0.05	-76.73
C25	TN	4,169,865	4,313,400	143,535	3.4	-76.82	4,311,200	-2200	-0.05	-76.93
C26	MS	1,731,892	1,910,000	178,108	10.3	-77.48	1,909,200	-800	-0.04	-77.59
C27	MI	6,214,054	7,074,200	860,146	13.8	-76.8	7,070,600	-3600	-0.05	-76.91
C28	IN	3,775,135	4,306,100	530,965	14.1	-76.4	4,303,900	-2200	-0.05	-76.51
C29	AL	3,404,459	3,508,900	104,441	3.1	-77.59	3,507,100	-1800	-0.05	-77.7
C30	OH	7,264,865	8,267,700	1,002,835	13.8	-76.78	8,263,500	-4200	-0.05	-76.89
C31	GA	5,660,811	5,832,900	172,089	3	-77.79	5,829,800	-3100	-0.05	-77.9
C32	FL	11,329,595	11,606,000	276,405	2.4	-79.43	11,588,000	-18000	-0.16	-79.75
C33	NY	10,441,216	12,249,000	1,807,784	17.3	-78.77	12,244,000	-5000	-0.04	-78.88
C34	PA	7,048,514	8,263,000	1,214,486	17.2	-78.54	8,259,400	-3600	-0.04	-78.65
C35	WV	1,451,081	1,498,100	47,019	3.2	-77.33	1,497,300	-800	-0.05	-77.44
C36	VA	5,302,027	5,463,800	161,773	3.1	-77.85	5,461,000	-2800	-0.05	-77.96
C37	NC	5,700,676	5,868,100	167,424	2.9	-77.7	5,864,100	-4000	-0.07	-77.84
C38	SC	2,973,919	3,062,200	88,281	3	-77.79	3,060,100	-2100	-0.07	-77.93
C39	NH, VT	982,669	1,152,800	170,131	17.3	-79.34	1,152,300	-500	-0.04	-79.45
C40	MA	3,432,162	4,027,300	595,138	17.3	-79.4	4,025,600	-1700	-0.04	-79.5
C41	CT, RI	2,452,365	2,879,600	427,235	17.4	-79.14	2,878,400	-1200	-0.04	-79.24
C42	DE, MD	4,608,378	4,786,500	178,122	3.9	-78.16	4,777,000	-9500	-0.2	-78.48
C43	NJ	4,554,392	5,358,600	804,208	17.7	-78.71	5,356,300	-2300	-0.04	-78.83
C44	ME	712,162	833,590	121,428	17.1	-79.86	833,220	-370	-0.04	-79.97
Pork Exports										
C45	MI	462,970	462,970	0	0	-77.1	462,970	0	0	-77.2
C46	SC	3,615,600	3,615,600	0	0	-78.04	3,911,000	295400	8.2	-78.36
C47	TX	1,455,100	1,455,100	0	0	-78.67	1,455,100	0	0	-78.78
C48	CA	2,072,300	2,072,300	0	0	-79.71	2,072,300	0	0	-79.82

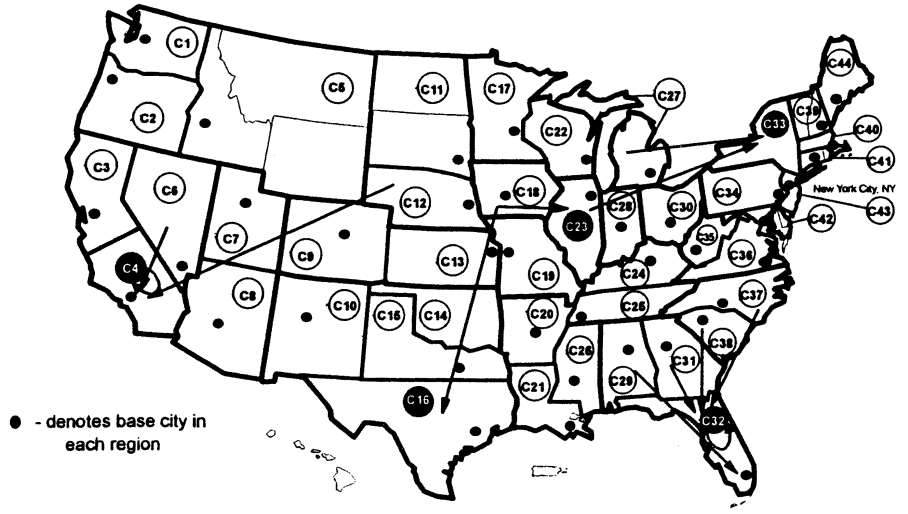


Figure 11. Sources of Pork for the Five Largest Consumption Regions- Benchmark Scenario

V. Summary

The swine industry is experiencing major changes as production and processing firms are becoming larger and more concentrated. Swine production is increasing in regions not in the traditional corn belt area. Several of the newer production regions are now major swine producing areas. Similar changes are occurring in the processing sector. In addition, the U.S. is now exporting more pork than it imports. This is a significant change in the industry. The realistic opportunities to export pork are expanding.

To address spatial equilibrium questions associated with the swine industry an economic model was developed. The model is illustrated using production, processing, and consumption data for 1995. The economic model utilizes the GAMS programming routine. The model is designed to answer questions relative to quantities of swine and pork production, processing, consumption, imports, xports and resulting trade patterns that will occur assuming several different scenarios. The model can be used to measure impacts on production and processing imposed as a result of environmental and/or size restrictions.

Two basic scenarios are presented. The first identifies optimal production, processing, and consumption patterns that maximize net social welfare using 1995 data. The second scenario assumes a ten percent increase in pork exports to Japan. Model results show optimal production, processing, and consumption quantities by region. Additional economic information provided shows marginal values of production, processing, and consumption. The marginal values are important in answering the "what if" questions related to location of production and processing units, costs of production and processing and quantity limits, and consumption trends.

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Appendix 1. Shipping Distance Between Production Regions and Processing Regions

Region	Base Point	P01 Portland OR	P02 Fresno CA	P03 Cedar City UT	P04 Great Falls MT	P05 Sterling CO	P06 Amarillo TX	P07 Bismarck ND	P08 Watertown SD	P09 Norfolk NE	P10 Salina KS	P11 Guymon OK
S01	Portland OR	0	766	1,012	732	1,301	1,713	1,308	1,551	1,646	1,677	1,625
S02	Los Angeles	966	228	439	1,268	1,133	1,085	1,618	1,700	1,529	1,442	1,148
S03	Cedar Cty UT	1,012	576	0	829	693	899	1,179	1,260	1,090	1,002	925
S04	Great Falls MT	732	1,267	829	0	824	1,240	569	903	974	1,216	1,164
S05	Guymon OK	1,625	1,286	925	1,164	397	130	866	782	552	303	0
S06	Norfolk NE	1,646	1,665	1,090	974	400	767	512	230	0	256	552
S07	Oakley KS	1,497	1,398	822	1,037	225	332	665	580	351	183	202
S08	Albert Lea MN	1,735	1,962	1,386	1,075	697	967	525	272	299	522	811
S09	Des Moines IA	1,794	1,813	1,238	1,189	548	818	671	386	233	374	662
S10	Galesburg IL	2,013	2,033	1,457	1,386	768	992	833	583	453	516	804
S11	Cameron MO	1,787	1,797	1,221	1,249	541	676	774	446	286	224	520
S12	West Point MS	2,475	2,105	1,744	1,937	1,229	886	1,427	1,134	973	845	903
S13	Moultrie GA	2,812	2,490	2,180	2,274	1,566	1,384	1,743	1,471	1,311	1,183	1,289
S14	Louisville KY	2,316	2,259	1,684	1,712	1,070	1,036	1,143	930	815	687	974
S15	Logansport IN	2,238	2,257	1,682	1,551	992	1,092	982	769	677	725	1,013
S16	Detroit MI	2,391	2,410	1,835	1,695	1,145	1,324	1,126	913	830	944	1,231
S17	Cincinnati OH	2,379	2,342	1,766	1,711	1,134	1,126	1,142	929	819	769	1,057
S18	Smithfield VA	2,952	2,827	2,320	2,320	1,707	1,637	1,751	1,538	1,420	1,323	1,611
S19	Clinton NC	2,902	2,723	2,269	2,289	1,656	1,526	1,720	1,508	1,394	1,272	1,522
S20	Hatfield PA	2,886	2,895	2,320	2,190	1,640	1,679	1,621	1,408	1,325	1,323	1,611
S21	Syracuse NY	2,820	2,840	2,264	2,125	1,575	1,678	1,556	1,343	1,259	1,322	1,610
S22	Sioux Falls SD	1,570	1,810	1,235	909	545	829	434	106	146	401	699
S26	Pembino ND	1,488	1,986	1,520	850	933	1,366	341	294	534	789	1,086
S27	Laredo TX	2,213	1,665	1,395	1,883	1,124	685	1,611	1,366	1,137	881	786

Appendix 1. (cont)

Region	Base Point	P12 Hutchinson MN	P13 Des Moines IA	P14 Columbia MO	P15 Springdale AR	P16 Jackson MS	P17 Montgomery AL	P18 Nashville TN	P19 Elizabethtown KY	P20 Peoria IL	P21 Madison WI	P22 Kalamazoo MI
S01	Portland OR	1,710	1,794	1,933	2,049	2,503	2,647	2,362	2,351	2,059	2,007	2,257
S02	Los Angeles CA	1,846	1,677	1,740	1,573	1,856	2,113	2,015	2,145	1,942	1,974	2,140
S03	Cedar City UT	1,407	1,238	1,300	1,389	1,651	1,930	1,729	1,719	1,503	1,535	1,701
S04	Great Falls MT	972	1,189	1,395	1,511	2,000	2,109	1,824	1,756	1,433	1,269	1,562
S05	Guymon OK	868	662	591	459	892	1,089	952	1,009	835	960	1,099
S06	Norfolk NE	326	233	431	547	983	1,146	861	850	498	513	696
S07	Oakley KS	668	499	481	570	1,008	1,195	910	899	725	797	963
S08	Albert Lea MN	130	149	402	579	968	1,076	791	722	359	265	557
S09	Des Moines IA	279	0	255	430	851	957	671	629	265	298	464
S10	Galesburg IL	442	219	246	541	712	766	481	413	49	196	306
S11	Cameron MO	424	144	157	288	762	872	587	576	317	443	609
S12	West Point MS	1,035	788	542	476	153	194	258	390	603	756	770
S13	Moultrie GA	1,381	1,121	879	862	467	213	452	567	885	1,053	952
S14	Louisville KY	780	585	384	585	574	461	176	44	322	453	322
S15	Logansport IN	619	444	422	630	741	655	369	238	187	292	138
S16	Detroit MI	763	596	640	870	940	827	542	410	415	436	138
S17	Cincinnati OH	779	585	466	675	677	563	278	146	322	452	287
S18	Smithfield VA	1,388	1,186	1,020	1,199	950	722	677	652	925	1,061	795
S19	Clinton NC	1,357	1,161	969	1,095	795	560	573	584	904	1,030	820
S20	Hatfield PA	1,258	1,092	1,020	1,228	1,146	982	824	698	870	931	665
S21	Syracuse NY	1,193	1,026	1,019	1,227	1,286	1,123	875	743	845	866	568
S22	Sioux Falls SD	201	286	492	608	1,097	1,207	921	896	533	436	730
S26	Pembino ND	363	631	880	996	1,451	1,539	1,254	1,147	841	660	954
S27	Laredo TX	1,463	1,184	1,046	779	801	997	1,100	1,229	1,252	1,451	1,496

Appendix 1. (cont)

Region	Base Point	P23 Indianapolis IN	P24 Springfield OH	P25 Syracuse NY	P26 Reading PA	P27 Georgetown MD	P28 Emporia VA	P29 Goldsboro NC	P30 Sumter SC	P31 Albany GA	P32 Nogales AZ	P33 Pembina ND
S01	Portland OR	2,268	2,397	2,820	2,854	2,914	2,925	2,899	2,840	2,798	1,531	1,488
S02	Los Angeles CA	2,096	2,230	2,703	2,712	2,747	2,628	2,590	2,465	2,271	557	1,948
S03	Cedar City UT	1,656	1,791	2,264	2,273	2,308	2,293	2,266	2,208	2,083	630	1,508
S04	Great Falls MT	1,601	1,727	2,125	2,159	2,238	2,282	2,286	2,286	2,261	1,442	850
S05	Guymon OK	947	1,081	1,610	1,563	1,598	1,565	1,527	1,402	1,242	816	1,086
S06	Norfolk NE	708	837	1,259	1,293	1,353	1,386	1,390	1,339	1,297	1,374	534
S07	Oakley KS	837	971	1,500	1,453	1,488	1,473	1,447	1,388	1,347	1,018	885
S08	Albert Lea MN	568	697	1,119	1,154	1,214	1,246	1,250	1,222	1,227	1,628	485
S09	Des Moines IA	475	604	1,026	1,061	1,121	1,153	1,157	1,128	1,108	1,478	631
S10	Galesburg IL	259	388	869	870	904	937	941	912	918	1,620	795
S11	Cameron MO	490	618	1,147	1,100	1,135	1,150	1,123	1,065	1,023	1,336	734
S12	West Point MS	547	617	1,133	995	990	774	718	541	355	1,543	1,388
S13	Moultrie GA	724	748	1,120	933	866	616	531	360	48	1,859	1,704
S14	Louisville KY	114	181	696	639	670	609	583	543	597	1,785	1,104
S15	Logansport IN	82	194	641	649	700	749	754	733	790	1,830	942
S16	Detroit MI	288	199	429	551	630	705	754	765	916	2,071	1,087
S17	Cincinnati OH	114	83	597	543	578	568	572	552	652	1,875	1,101
S18	Smithfield VA	715	604	552	325	199	70	170	341	687	2,321	1,713
S19	Clinton NC	695	591	682	456	390	139	38	160	505	2,184	1,681
S20	Hatfield PA	664	532	230	53	143	341	447	611	956	2,428	1,582
S21	Syracuse NY	663	531	0	233	365	545	650	814	1,123	2,427	1,516
S22	Sioux Falls SD	742	871	1,292	1,326	1,388	1,420	1,425	1,399	1,358	1,519	394
S26	Pembino ND	992	1,118	1,516	1,551	1,629	1,673	1,677	1,647	1,690	1,907	0
S27	Laredo TX	1,339	1,456	1,971	1,874	1,868	1,648	1,591	1,408	1,115	970	1,686

Appendix 2. Transportation Cost from Production Regions to Processing Regions (dol./cwt.)

Region	Base Point	P01 Portland OR	P02 Fresno CA	P03 Cedar City UT	P04 Great Falls MT	P05 Sterling CO	P06 Amarillo TX	P07 Bismarck ND	P08 Watertown SD	P09 Norfolk NE	P10 Salina KS	P11 Guymon OK
S01	Portland OR	0.42	4.21	5.56	4.02	7.14	9.40	7.18	8.51	9.04	9.21	8.92
S02	Los Angeles CA	5.30	1.25	2.41	6.96	6.22	5.96	8.88	9.33	8.39	7.92	6.30
S03	Cedar City UT	5.56	3.16	0.42	4.55	3.80	4.94	6.47	6.92	5.98	5.50	5.08
S04	Great Falls MT	4.02	6.96	4.55	0.42	4.52	6.81	3.12	4.96	5.35	6.68	6.39
S05	Guymon OK	8.92	7.06	5.08	6.39	2.18	0.71	4.75	4.29	3.03	1.66	0.42
S06	Norfolk NE	9.04	9.14	5.98	5.35	2.20	4.21	2.81	1.26	0.42	1.41	3.03
S07	Oakley KS	8.22	7.67	4.51	5.69	1.24	1.82	3.65	3.18	1.93	1.00	1.11
S08	Albert Lea MN	9.52	10.77	7.61	5.90	3.83	5.31	2.88	1.49	1.64	2.87	4.45
S09	Des Moines IA	9.85	9.95	6.80	6.53	3.01	4.49	3.68	2.12	1.28	2.05	3.63
S10	Galesburg IL	11.05	11.16	8.00	7.61	4.22	5.45	4.57	3.20	2.49	2.83	4.41
S11	Cameron MO	9.81	9.87	6.70	6.86	2.97	3.71	4.25	2.45	1.57	1.23	2.85
S12	West Point MS	13.59	11.56	9.57	10.63	6.75	4.86	7.83	6.23	5.34	4.64	4.96
S13	Moultrie GA	15.44	13.67	11.97	12.48	8.60	7.60	9.57	8.08	7.20	6.49	7.08
S14	Louisville KY	12.71	12.40	9.24	9.40	5.87	5.69	6.27	5.11	4.47	3.77	5.35
S15	Logansport IN	12.29	12.39	9.23	8.51	5.45	5.99	5.39	4.22	3.72	3.98	5.56
S16	Detroit MI	13.13	13.23	10.07	9.31	6.29	7.27	6.18	5.01	4.56	5.18	6.76
S17	Cincinnati OH	13.06	12.86	9.70	9.39	6.23	6.18	6.27	5.10	4.50	4.22	5.80
S18	Smithfield VA	16.21	15.52	12.74	12.74	9.37	8.99	9.61	8.44	7.80	7.26	8.84
S19	Clinton NC	15.93	14.95	12.46	12.57	9.09	8.38	9.44	8.28	7.65	6.98	8.36
S20	Hatfield PA	15.84	15.89	12.74	12.02	9.00	9.22	8.90	7.73	7.27	7.26	8.84
S21	Syracuse NY	15.48	15.59	12.43	11.67	8.65	9.21	8.54	7.37	6.91	7.26	8.84
S22	Sioux Falls SD	8.62	9.94	6.78	4.99	2.99	4.55	2.38	0.58	0.80	2.20	3.84
S26	Pembina ND	8.17	10.90	8.34	4.67	5.12	7.50	1.87	1.61	2.93	4.33	5.96
S27	Laredo TX	12.15	9.14	7.66	10.34	6.17	3.76	8.84	7.50	6.24	4.84	4.32

Appendix 2. (cont)

Region	Base Point	P12 Hutchinson MN	P13 Des Moines IA	P14 Columbia MO	P15 Springdale AR	P16 Jackson MS	P17 Montgomery AL	P18 Nashville TN	P19 Elizabethtown KY	P20 Peoria IL	P21 Madison WI	P22 Kalamazoo MI
S01	Portland OR	9.39	9.85	10.61	11.25	13.74	14.53	12.97	12.91	11.30	11.02	12.39
S02	Los Angeles CA	10.13	9.21	9.55	8.64	10.19	11.60	11.06	11.78	10.66	10.84	11.75
S03	Cedar City UT	7.72	6.80	7.14	7.63	9.06	10.60	9.49	9.44	8.25	8.43	9.34
S04	Great Falls MT	5.34	6.53	7.66	8.30	10.98	11.58	10.01	9.64	7.87	6.97	8.58
S05	Guymon OK	4.77	3.63	3.24	2.52	4.90	5.98	5.23	5.54	4.58	5.27	6.03
S06	Norfolk NE	1.79	1.28	2.37	3.00	5.40	6.29	4.73	4.67	2.73	2.82	3.82
S07	Oakley KS	3.67	2.74	2.64	3.13	5.53	6.56	5.00	4.94	3.98	4.38	5.29
S08	Albert Lea MN	0.71	0.82	2.21	3.18	5.31	5.91	4.34	3.96	1.97	1.45	3.06
S09	Des Moines IA	1.53	0.42	1.40	2.36	4.67	5.25	3.68	3.45	1.45	1.64	2.55
S10	Galesburg IL	2.43	1.20	1.35	2.97	3.91	4.21	2.64	2.27	0.42	1.08	1.68
S11	Cameron MO	2.33	0.79	0.86	1.58	4.18	4.79	3.22	3.16	1.74	2.43	3.34
S12	West Point MS	5.68	4.33	2.98	2.61	0.84	1.07	1.42	2.14	3.31	4.15	4.23
S13	Moultrie GA	7.58	6.15	4.83	4.73	2.56	1.17	2.48	3.11	4.86	5.78	5.23
S14	Louisville KY	4.28	3.21	2.11	3.21	3.15	2.53	0.97	0.42	1.77	2.49	1.77
S15	Logansport IN	3.40	2.44	2.32	3.46	4.07	3.60	2.03	1.31	1.03	1.60	0.76
S16	Detroit MI	4.19	3.27	3.51	4.78	5.16	4.54	2.98	2.25	2.28	2.39	0.76
S17	Cincinnati OH	4.28	3.21	2.56	3.71	3.72	3.09	1.53	0.80	1.77	2.48	1.58
S18	Smithfield VA	7.62	6.51	5.60	6.58	5.22	3.96	3.72	3.58	5.08	5.82	4.36
S19	Clinton NC	7.45	6.37	5.32	6.01	4.36	3.07	3.15	3.21	4.96	5.65	4.50
S20	Hatfield PA	6.91	5.99	5.60	6.74	6.29	5.39	4.52	3.83	4.78	5.11	3.65
S21	Syracuse NY	6.55	5.63	5.59	6.74	7.06	6.17	4.80	4.08	4.64	4.75	3.12
S22	Sioux Falls SD	1.10	1.57	2.70	3.34	6.02	6.63	5.06	4.92	2.93	2.39	4.01
S26	Pembina ND	1.99	3.46	4.83	5.47	7.97	8.45	6.88	6.30	4.62	3.62	5.24
S27	Laredo TX	8.03	6.50	5.74	4.28	4.40	5.47	6.04	6.75	6.87	7.97	8.21

Appendix 2. (cont)

Region	Base Point	P23 Indianapolis IN	P24 Springfield OH	P25 Syracuse NY	P26 Reading PA	P27 Georgetown MD	P28 Emporia VA	P29 Goldsboro NC	P30 Sumter SC	P31 Albany GA	P32 Nogales AZ	P33 Pembina ND
S01	Portland OR	12.45	13.16	15.48	15.67	16.00	16.06	15.92	15.59	15.36	8.40	8.17
S02	Los Angeles CA	11.51	12.24	14.84	14.89	15.08	14.43	14.22	13.53	12.47	3.06	10.69
S03	Cedar City UT	9.09	9.83	12.43	12.48	12.67	12.59	12.44	12.12	11.44	3.46	8.28
S04	Great Falls TX	8.79	9.48	11.67	11.85	12.29	12.53	12.55	12.55	12.41	7.92	4.67
S05	Guymon OK	5.20	5.93	8.84	8.58	8.77	8.59	8.38	7.70	6.82	4.48	5.96
S06	Norfolk NE	3.89	4.60	6.91	7.10	7.43	7.61	7.63	7.35	7.12	7.54	2.93
S07	Oakley KS	4.60	5.33	8.23	7.98	8.17	8.09	7.94	7.62	7.39	5.59	4.86
S08	Albert Lea MN	3.12	3.83	6.14	6.34	6.66	6.84	6.86	6.71	6.74	8.94	2.66
S09	Des Moines IA	2.61	3.32	5.63	5.82	6.15	6.33	6.35	6.19	6.08	8.11	3.46
S10	Galesburg IL	1.42	2.13	4.77	4.78	4.96	5.14	5.17	5.01	5.04	8.89	4.36
S11	Cameron MO	2.69	3.39	6.30	6.04	6.23	6.31	6.17	5.85	5.62	7.33	4.03
S12	West Point MS	3.00	3.39	6.22	5.46	5.43	4.25	3.94	2.97	1.95	8.47	7.62
S13	Moultrie GA	3.97	4.11	6.15	5.12	4.75	3.38	2.92	1.98	0.42	10.21	9.35
S14	Louisville KY	0.63	0.99	3.82	3.51	3.68	3.34	3.20	2.98	3.28	9.80	6.06
S15	Logansport IN	0.45	1.07	3.52	3.56	3.84	4.11	4.14	4.02	4.34	10.05	5.17
S16	Detroit MI	1.58	1.09	2.36	3.02	3.46	3.87	4.14	4.20	5.03	11.37	5.97
S17	Cincinnati OH	0.63	0.46	3.28	2.98	3.17	3.12	3.14	3.03	3.58	10.29	6.04
S18	Smithfield VA	3.93	3.32	3.03	1.78	1.09	0.42	0.93	1.87	3.77	12.74	9.4
S19	Clinton NC	3.82	3.24	3.74	2.50	2.14	0.76	0.42	0.88	2.77	11.99	9.23
S20	Hatfield PA	3.65	2.92	1.26	0.42	0.79	1.87	2.45	3.35	5.25	13.33	8.68
S21	Syracuse NY	3.64	2.92	0.42	1.28	2.00	2.99	3.57	4.47	6.17	13.32	8.32
S22	Sioux Falls SD	4.07	4.78	7.09	7.28	7.62	7.80	7.82	7.68	7.46	8.34	2.16
S26	Pembina ND	5.45	6.14	8.32	8.51	8.94	9.18	9.21	9.04	9.28	10.47	0.42
S27	Laredo TX	7.35	7.99	10.82	10.29	10.26	9.05	8.73	7.73	6.12	5.33	9.26

Note: The figures in this table are used for the Parameter 5 of the GAMS program

Appendix 3. Shipping Distance Between Processing Regions and Consumption Regions (miles)

Region	Base Point	S01 Portland OR	S02 Los Angeles CA	S03 Cedar City UT	S04 Great Falls MT	S05 Guymon OK	S06 Norfolk NE	S07 Oakley KS	S08 Albert Lea MN	S09 Des Moines IA	S10 Galesburg IL	S11 Cameron MO	S12 West Point MS
C01	Seattle WA	174	1,134	1,052	645	1,639	1,524	1,518	1,644	1,739	1,941	1,803	2,426
C02	Portland OR	1	960	978	710	1,585	1,578	1,464	1,709	1,771	1,970	1,763	2,386
C03	San Francisco CA	635	380	735	1,168	1,439	1,634	1,463	1,869	1,798	1,997	1,790	2,261
C04	Los Angeles CA	960	1	444	1,240	1,137	1,520	1,264	1,793	1,683	1,880	1,627	1,921
C05	Boise ID	424	846	579	572	1,166	1,159	1,045	1,373	1,352	1,551	1,344	1,967
C06	Las Vegas NV	973	272	172	968	919	1,248	992	1,521	1,411	1,608	1,355	1,741
C07	Salt Lake City UT	756	685	242	555	847	893	738	1,128	1,057	1,256	1,049	1,672
C08	Phoenix AZ	1,263	366	444	1,195	771	1,279	949	1,553	1,406	1,546	1,265	1,555
C09	Denver CO	1,227	1,015	572	776	364	505	249	783	668	865	612	1,200
C10	Albuquerque NM	1,359	797	567	1,158	340	858	527	1,122	975	1,115	834	1,162
C11	Sioux Falls SD	1,538	1,618	1,175	878	658	138	471	175	276	469	347	970
C12	Omaha NE	1,644	1,555	1,112	1,039	520	110	359	274	135	347	169	792
C13	Kansas City KS	1,783	1,579	1,170	1,228	442	299	351	343	196	336	55	609
C14	Oklahoma City OK	1,829	1,341	1,111	1,358	264	487	385	683	536	667	395	618
C15	Dallas TX	1,984	1,366	1,202	1,538	445	694	585	828	681	802	540	557
C16	Houston TX	2,176	1,503	1,394	1,777	684	935	824	1,051	904	968	763	578
C17	Minneapolis MN	1,669	1,854	1,411	974	857	341	670	98	243	373	385	956
C18	Des Moines IA	1,771	1,683	1,240	1,144	635	223	494	147	1	212	142	742
C19	Kansas City MO	1,783	1,579	1,170	1,228	442	299	355	343	196	336	55	609
C20	Little Rock AR	2,168	1,678	1,450	1,613	603	684	713	707	560	544	429	293
C21	New Orleans LA	2,475	1,849	1,693	2,022	928	1,107	1,049	1,128	983	863	852	315
C22	Milwaukee WI	1,998	2,042	1,599	1,297	994	558	853	321	359	235	501	728
C23	Chicago IL	2,070	2,012	1,569	1,369	944	530	823	377	329	180	458	644
C24	Louisville KY	2,288	2,091	1,686	1,656	954	796	867	664	573	373	534	425
C25	Memphis TN	2,227	1,800	1,570	1,672	723	743	794	737	594	472	488	159
C26	Jackson MS	2,384	1,766	1,602	1,865	830	936	951	949	806	684	681	157

Appendix 3. (cont)

Region	Base Point	S01 Portland OR	S02 Los Angeles CA	S03 Cedar City UT	S04 Great Falls MT	S05 Guymon OK	S06 Norfolk NE	S07 Oakley KS	S08 Albert Lea MN	S09 Des Moines IA	S10 Galesburg IL	S11 Cameron MO	S12 West Point MS
C27	Detroit MI	2,334	2,265	1,822	1,633	1,185	791	1,076	641	582	422	700	784
C28	Indianapolis IN	2,208	2,070	1,659	1,544	933	692	846	552	472	262	475	537
C29	Birmingham AL	2,479	2,000	1,822	1,924	975	995	1,046	936	805	649	740	136
C30	Columbus OH	2,375	2,243	1,832	1,682	1,106	838	1,019	690	629	429	648	634
C31	Atlanta GA	2,569	2,145	1,950	2,014	1,103	1,085	1,148	996	877	699	815	281
C32	Miami FL	3,223	2,654	2,490	2,668	1,718	1,739	1,790	1,651	1,532	1,354	1,470	846
C33	New York City NY	2,870	2,800	2,358	2,169	1,663	1,327	1,576	1,177	1,118	958	1,205	1,095
C34	Philadelphia PA	2,816	2,708	2,297	2,115	1,571	1,273	1,484	1,123	1,064	894	1,113	990
C35	Charleston WV	2,512	2,341	1,936	1,835	1,204	991	1,117	843	776	566	781	640
C36	Norfolk VA	2,911	2,665	2,335	2,223	1,588	1,381	1,516	1,231	1,172	965	1,180	816
C37	Charlotte NC	2,737	2,381	2,135	2,099	1,322	1,250	1,316	1,107	1,030	820	983	517
C38	Greenville SC	2,672	2,285	2,070	2,039	1,226	1,186	1,251	1,047	966	1,047	918	421
C39	Manchester NH	3,020	2,951	2,508	2,319	1,847	1,477	1,760	1,327	1,268	1,327	1,367	1,319
C40	Boston MA	3,034	2,965	2,522	2,333	1,855	1,491	1,768	1,341	1,282	1,341	1,381	1,295
C41	Hartford CT	2,953	2,884	2,441	2,252	1,756	1,410	1,669	1,260	1,201	1,260	1,297	1,196
C42	Baltimore MD	2,755	2,638	2,227	2,054	1,501	1,212	1,414	1,062	1,003	1,062	1,043	896
C43	Newark NJ	2,849	2,769	2,337	2,148	1,632	1,306	1,545	1,156	1,097	1,156	1,174	1,070
C44	Portland ME	3,100	3,031	2,588	2,399	1,927	1,557	1,840	1,407	1,348	1,188	1,447	1,394
C45	Port Huron MI	2,389	2,320	1,877	1,688	1,240	846	1,131	696	637	696	755	840
C46	Charleston SC	2,895	2,492	2,263	2,299	1,432	1,394	1,443	1,274	1,181	966	1,120	581
C47	Loredo TX	2,126	1,370	1,344	1,800	721	1,101	876	1,248	1,101	1,248	960	886
C48	Los Angeles CA	960	1	444	1,240	1,137	1,520	1,264	1,793	1,683	1,793	1,627	1,921

Appendix 3. (cont)

Region	Base Point	S13 Moultrie GA	S14 Louisville KY	S15 Logansport IN	S16 Detroit MI	S17 Cincinnati OH	S18 Smithfield VA	S19 Clinton NC	S20 Hatfield PA	S21 Syracuse NY	S22 Sioux Falls SD	S23 New York NY	S24 Niagara Falls NY	S25 Bonners Ferry ID
C01	Seattle WA	2,789	2,292	2,126	2,269	2,290	2,844	2,843	2,499	2,672	1,489	2,805	2,543	385
C02	Portland OR	2,749	2,288	2,184	2,334	2,318	2,892	2,884	2,564	2,737	1,570	2,870	2,608	450
C03	San Francisco CA	2,573	2,315	2,211	2,380	2,345	2,919	2,871	2,596	2,783	1,704	2,916	2,654	984
C04	Los Angeles CA	2,205	2,091	2,094	2,265	2,176	2,658	2,551	2,437	2,668	1,639	2,800	2,539	1,298
C05	Boise ID	2,330	1,869	1,765	1,934	1,899	2,473	2,465	2,150	2,337	1,240	2,470	2,208	476
C06	Las Vegas NV	2,053	1,857	1,822	1,993	1,940	2,440	2,351	2,197	2,396	1,366	2,529	2,267	1,099
C07	Salt Lake City UT	2,035	1,574	1,470	1,639	1,604	2,178	2,170	1,855	2,042	974	2,175	1,913	720
C08	Phoenix AZ	1,839	1,725	1,730	1,956	1,810	2,292	2,185	2,071	2,335	1,468	2,434	2,206	1,360
C09	Denver CO	1,563	1,114	1,079	1,250	1,197	1,744	1,714	1,454	1,653	654	1,786	1,524	1,106
C10	Albuquerque NM	1,474	1,294	1,299	1,525	1,379	1,861	1,772	1,640	1,904	1,043	2,003	1,775	1,323
C11	Sioux Falls SD	1,333	834	668	811	832	1,386	1,385	1,041	1,214	1	1,347	1,085	1,208
C12	Omaha NE	1,155	694	571	717	705	1,279	1,271	947	1,120	182	1,253	991	1,369
C13	Kansas City KS	972	516	520	746	601	1,146	1,116	862	1,126	366	1,225	997	1,558
C14	Oklahoma City OK	981	753	785	1,017	838	1,317	1,228	1,103	1,367	654	1,466	1,238	1,688
C15	Dallas TX	841	823	920	1,152	922	1,309	1,187	1,224	1,502	859	1,544	1,373	1,868
C16	Houston TX	751	931	1,042	1,267	1,030	1,317	1,184	1,332	1,612	1,099	1,606	1,483	2,107
C17	Minneapolis MN	1,271	688	522	665	686	1,240	1,239	895	1,068	244	1,201	939	1,337
C18	Des Moines IA	1,075	573	436	582	582	1,156	1,148	812	985	286	1,118	856	1,474
C19	Kansas City MO	972	516	520	746	601	1,146	1,116	862	1,126	367	1,225	997	1,558
C20	Little Rock AR	659	509	618	843	608	995	906	910	1,190	771	1,230	1,061	1,943
C21	New Orleans LA	426	695	881	1,054	794	1,001	859	1,049	1,358	1,209	1,302	1,247	2,352
C22	Milwaukee WI	967	374	208	351	372	926	925	581	754	502	887	625	1,660
C23	Chicago IL	880	287	121	264	285	839	838	494	667	567	800	538	1,732

Appendix 3. (cont)

Region	Base Point	13 Moultrie GA	S14 Louisville KY	S15 Logansport IN	S16 Detroit MI	S17 Cincinnati OH	S18 Smithfield VA	S19 Clinton NC	S20 Hatfield PA	S21 Syracuse NY	S22 Sioux Falls SD	S23 New York NY	S24 Niagra Falls NY	S25 Bonners Ferry ID
C24	Louisville KY	601	1	186	361	101	630	600	403	683	845	766	554	2,019
C25	Memphis TN	522	372	497	720	471	858	769	773	1,053	842	1,093	924	2,002
C26	Jackson MS	441	565	709	924	664	910	787	946	1,246	1,043	1,199	1,117	2,195
C27	Detroit MI	896	361	241	1	260	674	722	329	502	765	635	373	1,996
C28	Indianapolis IN	713	112	74	281	110	686	678	367	631	733	730	502	1,907
C29	Birmingham AL	270	360	546	719	459	674	551	710	1,019	1,094	963	912	2,254
C30	Columbus OH	744	211	214	185	110	543	537	195	473	896	558	344	2,045
C31	Atlanta GA	196	400	586	695	435	529	402	634	922	1,160	838	885	2,344
C32	Miami FL	475	1,055	1,241	1,314	1,087	933	760	1,122	1,390	1,838	1,273	1,373	2,998
C33	New York City NY	978	766	736	635	665	399	534	372	260	1,374	1	393	2,532
C34	Philadelphia PA	873	674	667	581	573	295	429	280	253	1,356	107	378	2,478
C35	Charleston WV	640	250	363	350	196	381	373	202	546	1,041	547	435	2,198
C36	Norfolk VA	651	649	762	689	595	25	196	365	508	1,443	374	563	2,586
C37	Charlotte NC	376	459	627	614	460	298	172	422	699	1,289	610	673	2,462
C38	Greenville SC	303	395	569	652	397	392	269	504	785	1,240	701	755	2,402
C39	Manchester NH	1,202	966	889	785	865	623	758	588	286	1,442	239	447	2,682
C40	Boston MA	1,178	958	903	799	857	599	734	564	300	1,457	215	461	2,696
C41	Hartford CT	1,079	859	819	718	758	500	635	465	238	1,386	116	399	2,615
C42	Baltimore MD	779	604	606	520	503	214	335	203	319	1,274	200	375	2,417
C43	Newark NJ	953	735	715	614	634	374	509	341	239	1,365	33	372	2,511
C44	Portland ME	1,277	1,046	969	865	945	698	833	663	366	1,519	314	527	2,762
C45	Port Huron MI	952	417	297	56	316	730	778	385	558	773	691	429	2,024
C46	Charleston SC	321	600	789	797	611	412	209	678	882	1,442	743	878	2,666
C47	Loredo TX	1,059	1,219	1,328	1,553	1,318	1,625	1,492	1,620	1,900	1,282	1,914	1,771	2,090
C48	Los Angeles CA	2,205	2,091	2,094	2,265	2,176	2,658	2,551	2,437	2,668	1,639	2,800	2,539	1,298

Appendix 4. Transportation Cost Between Processing Regions and Consumption Regions (dol./cwt)

Region	Base Point	S01 Portland OR	S02 Los Angeles CA	S03 Cedar City UT	S04 Great Falls MT	S05 Guymon OK	S06 Norfolk NE	S07 Oakley KS	S08 Albert Lea MN	S09 Des Moines IA	S10 Galesburg IL	S11 Cameron MO	S12 West Point MS
C01	Seattle WA	1.15	3.39	3.14	1.93	5.09	4.55	4.71	4.72	5.20	6.02	5.39	7.25
C02	Portland OR	0.57	3.09	2.92	2.12	4.92	4.72	4.54	4.91	5.29	6.11	5.27	7.13
C03	San Francisco CA	1.90	1.31	2.11	3.36	4.14	4.88	4.20	5.37	5.37	5.97	5.14	6.50
C04	Los Angeles CA	2.87	0.57	1.28	3.56	3.40	4.54	3.78	5.15	5.03	5.62	4.68	5.52
C05	Boise ID	1.32	3.01	2.00	1.71	3.75	3.33	3.36	4.10	3.89	4.99	4.63	6.10
C06	Las Vegas NV	3.13	1.15	0.63	3.56	2.96	3.73	3.19	4.72	4.22	4.81	4.05	5.20
C07	Salt Lake City UT	2.35	2.52	1.26	1.66	2.73	2.87	2.38	3.37	3.40	4.48	3.62	5.19
C08	Phoenix AZ	4.06	1.15	1.33	3.57	2.48	3.82	3.05	5.00	4.20	4.62	3.93	4.83
C09	Denver CO	3.67	3.50	1.78	2.41	1.26	1.74	0.86	2.70	2.30	3.28	2.11	3.86
C10	Albuquerque NM	4.69	2.75	2.02	4.13	1.09	2.76	1.70	4.13	3.14	3.59	3.16	4.41
C11	Sioux Falls SD	4.42	4.28	3.24	2.42	2.27	0.80	1.62	0.66	1.15	1.46	1.04	3.34
C12	Omaha NE	4.16	4.11	2.81	2.63	1.79	0.80	1.24	0.91	0.80	1.26	1.26	2.55
C13	Kansas City KS	4.51	4.17	3.09	3.25	1.52	1.15	1.21	1.06	0.92	1.08	0.57	1.96
C14	Oklahoma City OK	4.63	3.55	3.06	3.75	0.91	1.74	1.33	2.12	1.91	2.38	1.45	1.99
C15	Dallas TX	5.70	3.93	3.59	4.60	1.53	2.39	2.02	2.76	2.50	2.77	2.17	2.05
C16	Houston TX	6.25	4.32	4.17	5.31	2.36	3.44	2.84	3.50	3.33	3.56	3.07	2.13
C17	Minneapolis MN	4.41	4.90	3.57	2.46	2.86	1.10	2.23	0.80	0.78	1.20	1.06	3.19
C18	Des Moines IA	4.48	4.45	3.14	2.89	2.19	1.15	1.70	1.15	0.57	1.26	1.26	2.39
C19	Kansas City MO	4.51	4.17	3.09	3.25	1.52	1.15	1.22	1.06	0.92	1.08	0.57	1.75
C20	Little Rock AR	5.73	4.63	3.67	4.08	2.08	2.36	2.46	2.11	1.93	1.88	1.73	1.15
C21	New Orleans LA	6.83	5.10	4.48	5.35	3.20	4.07	3.62	3.37	3.62	3.17	3.43	1.23
C22	Milwaukee WI	5.28	5.40	4.23	3.43	3.31	1.80	2.84	1.18	1.16	1.03	1.44	2.43
C23	Chicago IL	5.47	5.32	4.15	3.62	3.26	1.83	2.84	1.30	1.13	1.26	1.47	2.15
C24	Louisville KY	6.31	5.53	4.65	4.57	3.29	2.74	2.99	2.06	1.98	1.37	1.84	1.56
C25	Memphis TN	6.14	4.76	4.15	4.42	2.49	2.73	2.74	2.29	2.18	1.74	1.68	1.26
C26	Jackson MS	6.58	4.87	4.42	5.14	2.77	3.34	3.17	2.95	2.87	2.44	2.35	1.26

Appendix 4. (cont)

Region	Base Point	S01 Portland OR	S02 Los Angeles CA	S03 Cedar City UT	S04 Great Falls MT	S05 Guymon OK	S06 Norfolk NE	S07 Oakley KS	S08 Albert Lea MN	S09 Des Moines IA	S10 Galesburg IL	S11 Cameron MO	S12 West Point MS
C27	Detroit MI	6.17	6.25	5.24	4.69	4.09	2.91	3.71	2.28	2.14	1.55	2.41	2.70
C28	Indianapolis IN	5.84	5.47	4.39	4.08	3.22	2.55	2.92	1.71	1.74	1.15	1.64	1.79
C29	Birmingham AL	6.84	5.29	4.82	5.09	3.25	3.66	3.49	2.90	2.96	2.39	2.55	1.26
C30	Columbus OH	6.28	6.19	4.84	4.45	3.81	2.99	3.51	2.22	2.24	1.53	2.23	2.26
C31	Atlanta GA	7.09	5.67	5.16	5.32	3.68	3.99	3.83	3.10	3.23	2.57	2.81	1.26
C32	Miami FL	9.78	7.63	6.87	7.36	5.73	6.40	5.97	5.69	5.63	4.82	4.90	3.50
C33	New York City NY	8.58	7.72	6.78	6.23	5.93	4.88	5.62	4.33	4.11	3.52	4.16	4.28
C34	Philadelphia PA	8.09	7.47	6.60	6.08	5.24	4.68	5.29	4.00	3.91	3.29	3.84	3.87
C35	Charleston WV	7.22	6.46	5.12	4.85	4.29	3.65	3.98	3.00	2.85	2.08	2.69	2.50
C36	Norfolk VA	8.36	7.35	6.17	5.88	5.66	5.08	5.40	4.39	4.18	3.44	4.20	3.19
C37	Charlotte NC	7.86	6.57	5.89	5.79	4.41	4.60	4.39	3.44	3.79	3.02	3.39	1.90
C38	Greenville SC	7.68	5.52	5.71	5.62	4.09	4.36	4.17	3.25	3.33	3.85	3.17	1.65
C39	Manchester NH	8.68	7.12	7.50	6.40	6.58	5.43	6.27	4.88	4.81	5.19	5.19	5.15
C40	Boston MA	8.72	7.16	7.54	6.44	6.61	5.48	6.30	4.93	4.72	5.09	5.08	5.06
C41	Hartford CT	8.49	6.96	7.29	6.21	6.26	5.19	5.95	4.63	4.56	4.92	4.92	4.67
C42	BaltimoreMD	7.92	6.37	6.66	5.67	5.35	4.46	5.04	3.91	3.69	4.03	3.84	3.50
C43	Newark NJ	8.19	6.68	6.72	6.17	5.82	4.80	5.51	4.25	4.03	4.25	4.32	4.18
C44	Portland ME	9.26	8.01	7.73	7.45	6.87	5.73	6.56	5.18	5.42	4.92	5.82	5.61
C45	Port Huron MI	6.32	5.60	5.39	4.85	4.28	3.11	3.90	2.48	2.42	2.48	2.69	2.90
C46	Charleston SC	8.32	6.02	5.98	6.08	5.10	5.13	5.14	4.54	4.21	3.44	3.99	2.27
C47	Loredo TX	6.11	3.78	4.02	5.38	2.49	4.05	3.02	4.16	4.05	4.30	3.53	3.46
C48	Los Angeles CA	2.87	0.57	1.33	3.56	3.27	4.54	3.63	5.15	5.03	5.36	4.86	5.52

Appendix 4. (cont)

Region	Base Point	S13 Moultrie GA	S14 Louisville KY	S15 Logansport IN	S16 Detroit MI	S17 Cincinnati OH	S18 Smithfield VA	S19 Clinton NC	S20 Hatfield PA	S21 Syracuse NY	S22 Sioux Falls SD	S23 New York NY	S24 Niagra Falls NY	S25 Bonners Ferry ID
C01	Seattle WA	7.69	6.32	5.86	6.26	6.32	7.85	7.84	6.32	6.45	4.45	6.77	6.14	1.15
C02	Portland OR	7.58	6.31	6.02	6.44	6.39	7.98	7.96	6.48	6.61	4.69	6.93	6.30	1.34
C03	San Francisco CA	7.10	6.39	6.10	6.57	6.47	8.05	7.92	6.27	6.72	5.09	7.04	6.41	2.83
C04	Los Angeles CA	6.08	5.77	5.78	6.25	6.00	7.33	7.04	5.88	6.44	4.90	6.76	6.13	3.73
C05	Boise ID	6.43	5.59	5.27	5.78	5.68	7.39	7.37	5.44	6.72	3.56	7.10	6.34	1.42
C06	Las Vegas NV	5.66	5.34	5.24	5.73	5.57	7.01	6.76	5.56	6.33	4.08	6.69	5.99	4.04
C07	Salt Lake City UT	5.85	4.70	4.39	4.90	4.79	6.51	6.49	4.69	5.16	3.13	5.50	4.84	2.15
C08	Phoenix AZ	5.07	4.96	4.97	5.62	5.20	6.59	6.28	5.24	5.90	4.39	6.15	5.58	4.06
C09	Denver CO	4.67	3.33	3.22	3.74	3.58	5.21	5.12	3.68	4.18	2.26	4.52	3.85	3.43
C10	Albuquerque NM	4.74	4.46	3.88	4.56	4.76	5.99	5.70	4.15	5.69	3.36	5.99	5.30	4.71
C11	Sioux Falls SD	3.98	2.40	2.00	2.42	2.39	3.98	3.98	2.63	3.07	0.57	3.41	2.74	3.33
C12	Omaha NE	3.19	1.99	1.64	2.06	2.03	3.68	3.65	2.39	2.78	1.33	3.11	2.46	3.46
C13	Kansas City KS	2.79	1.54	1.55	2.23	1.80	3.42	3.34	2.18	2.72	1.41	2.96	2.41	4.12
C14	Oklahoma City OK	3.04	2.60	2.71	3.51	2.89	4.54	4.23	2.92	3.46	2.33	3.71	3.13	4.66
C15	Dallas TX	2.80	2.84	3.07	3.71	3.18	3.91	4.09	3.38	3.80	2.96	3.90	3.47	5.58
C16	Houston TX	2.50	3.21	3.59	4.08	3.55	3.94	4.08	3.67	4.08	4.04	4.06	3.75	6.30
C17	Minneapolis MN	3.51	1.98	1.50	1.91	1.97	3.56	3.56	2.26	2.58	0.79	2.90	2.27	3.38
C18	Des Moines IA	2.97	1.71	1.30	2.01	1.74	3.45	3.43	2.05	2.38	1.47	2.70	2.07	3.73
C19	Kansas City MO	3.13	1.54	1.55	2.23	1.80	3.42	3.34	2.18	2.72	1.41	2.96	2.41	4.12
C20	Little Rock AR	2.35	1.76	2.13	2.91	2.10	3.43	3.12	2.41	3.01	2.66	3.11	2.68	4.91
C21	New Orleans LA	1.62	2.40	3.04	3.15	2.74	2.99	2.96	2.89	3.43	4.45	3.29	3.15	6.22
C22	Milwaukee WI	2.89	1.07	1.26	1.26	1.07	2.66	2.66	1.47	1.91	1.62	2.24	1.58	4.39
C23	Chicago IL	2.93	1.15	1.26	1.26	1.15	2.41	3.37	1.31	1.61	1.96	1.93	1.30	4.58
C24	Louisville KY	2.21	0.57	1.26	1.26	0.57	2.32	2.21	1.11	1.73	2.91	1.94	1.40	5.57
C25	Memphis TN	2.04	1.54	1.90	2.65	1.95	3.16	2.83	2.04	2.78	3.10	2.89	2.44	5.29
C26	Jackson MS	1.72	1.95	2.44	3.19	2.29	3.14	2.71	2.50	3.15	3.72	3.03	2.82	6.06

Appendix 4. (cont)

Region	Base Point	S13 Moultrie GA	S14 Louisville KY	S15 Logansport IN	S16 Detroit MI	S17 Cincinnati OH	S18 Smithfield VA	S19 Clinton NC	S20 Hatfield PA	S21 Syracuse NY	S22 Sioux Falls SD	S23 New York NY	S24 Niagara Falls NY	S25 Bonners Ferry ID
C27	Detroit MI	2.88	1.49	1.26	0.57	1.08	2.79	1.99	0.91	1.33	2.81	1.68	0.99	5.74
C28	Indianapolis IN	2.38	0.58	0.57	1.26	0.57	2.84	2.81	0.97	1.60	2.70	1.85	1.27	5.04
C29	Birmingham AL	1.26	1.24	1.88	2.48	1.58	2.32	1.90	1.96	2.58	4.02	2.44	2.31	5.96
C30	Columbus OH	2.74	1.09	1.26	1.26	0.57	2.25	2.22	0.58	1.25	3.19	1.48	0.91	5.41
C31	Atlanta GA	1.26	1.38	2.02	2.40	1.50	1.82	1.39	1.75	2.33	4.27	2.12	2.24	6.20
C32	Miami FL	2.07	3.64	4.14	4.38	3.75	3.22	2.62	3.35	3.99	6.76	3.66	3.95	8.27
C33	New York City NY	3.82	3.08	3.05	2.19	2.68	1.61	2.15	2.57	1.08	5.05	0.57	1.63	7.28
C34	Philadelphia PA	3.41	2.71	2.76	2.40	2.31	1.26	1.73	1.26	1.05	4.99	0.57	1.56	7.12
C35	Charleston WV	2.50	1.01	1.50	0.97	0.79	1.53	1.50	1.26	2.26	3.83	1.76	1.80	5.81
C36	Norfolk VA	2.54	2.61	3.15	2.93	2.39	0.57	1.15	1.80	1.52	5.31	1.12	1.68	6.84
C37	Charlotte NC	1.47	1.58	1.87	2.12	1.59	1.26	1.26	1.31	1.85	4.74	1.61	1.78	6.79
C38	Greenville SC	1.18	1.36	1.96	2.55	1.37	1.80	1.55	1.56	2.08	4.56	1.85	2.00	6.63
C39	Manchester NH	4.28	3.89	3.68	3.43	3.48	2.51	3.05	2.70	1.22	5.30	1.26	1.90	7.40
C40	Boston MA	3.93	3.85	3.74	3.40	3.45	2.34	2.87	2.59	1.28	5.36	1.26	1.96	7.44
C41	Hartford CT	3.84	3.46	3.39	3.14	3.05	2.01	2.55	2.14	1.01	5.10	0.57	1.70	7.21
C42	BaltimoreMD	2.60	2.43	2.51	2.27	2.02	1.15	1.35	1.26	1.32	4.69	1.26	1.55	6.67
C43	Newark NJ	3.18	2.87	2.96	2.61	2.48	1.46	1.99	1.96	0.99	5.02	0.57	1.54	7.22
C44	Portland ME	4.84	4.45	4.12	3.88	4.13	2.81	3.64	3.05	1.68	5.59	1.44	2.42	8.57
C45	Port Huron MI	3.06	1.73	1.47	1.03	1.31	3.02	3.22	1.06	1.48	2.84	1.83	1.13	5.82
C46	Charleston SC	1.25	2.41	3.26	3.39	2.46	9.47	1.23	3.35	2.64	5.30	2.22	2.62	7.05
C47	Loredo TX	4.14	4.20	4.58	5.36	4.54	5.60	5.14	4.84	4.80	4.72	4.84	4.48	6.25
C48	Los Angeles CA	6.08	5.77	5.78	6.51	6.00	7.33	7.04	5.88	6.44	4.90	6.76	6.13	3.73

Appendix 5. Ocean Freight Rates (dol./cwt.)

	Origin	
Destination	Charleston-SC	Los Angeles - CA
Japan	12.77	11.64
Korea	9.55	8.40
Hong Kong	9.24	12.17
Russia	16.33	17.01
European Countries	15.39	17.57

Source: Peterson, Catherine J., "Understanding The Global Ocean Transportation Network for Pork Producers," Final report prepared for the NPPC by C J Petersen & Associates, May 1996.

Appendix 6. Optimal Shipping Patterns from Production Regions to Processing Regions for the Benchmark Scenario (cwt.)

Region	State(s)	S01 ID,OR,WA	S02 CA,NV	S03 AZ,UT	S04 MT,ND,WY	S05 NM,OK,TX	S06 NE	S07 CO,KS	S08 MN,WI	S09 IA	S10 IL	S11 MO	S12 AR,LA,MS
P01	ID,OR,WA	322,920	93,733										
P02	CA		693,220										
P03	AZ,NV,UT		716,269										
P04	MT,WY				373,080								
P05	CO									1,649,790			
P06	NM,TX					1,651,119							
P07	ND								880,320				
P08	SD												
P09	NE									12,273,020			
P10	KS											4,508,941	
P11	OK					607,041		143,280		1,111,138		1,712,445	
P12	MN								16,391,470				
P13	IA									49,286,670			
P14	MO									11,970,450			
P15	AR											2,981,846	
P16	LA,MS										867,020		
P17	AL,FL										346,232		1,264,800
P18	TN										1,654,774		
P19	KY										2,297,365		
P20	IL										12,960,910		
P21	WI								1,745,133		1,567,343		
P22	MI										2,088,111		
P23	IN										5,109,765		
P24	OH												
P25	CT,MA,ME,NH, NY,RI,VT												

Appendix 6. (cont)

Region	State(s)	S01 ID,OR,WA	S02 CA,NV	S03 AZ,UT	S04 MT,ND,WY	S05 NM,OK,TX	S06 NE	S07 CO,KS	S08 MN,WI	S09 IA	S10 IL	S11 MO	S12 AR,LA,MS
P26	PA												
P27	DE,MD,NJ,WV												
P28	VA												
P29	NC												
P30	SC												
P31	GA												
P32	AZ												
P33	ND								2,318,237				
	Total	322,920	1,503,222	0	373,080	2,258,160	0	143,280	21,335,160	76,291,068	26,891,520	9,203,232	1,264,800

Appendix 6. (cont)

Region	State(s)	S13 AL,FL,GA	S14 KY,TN	S15 IN	S16 MI	S17 OH	S18 VA,WV	S19 NC,SC	S20 DE,MD,NJ, PA	S21 CT ~ VT	S22 SD	S23 ND	S24 TX	Total
P01	ID,OR,WA													416,653
P02	CA													693,220
P03	AZ,NV,UT													716,269
P04	MT,WY										481,671			854,751
P05	CO													1,649,790
P06	NM,TX												68,080	1,719,199
P07	ND													880,320
P08	SD										5,629,223			5,629,223
P09	NE										1,381,766			13,654,786
P10	KS													4,508,941
P11	OK													3,573,904
P12	MN													16,391,470
P13	IA													49,286,670
P14	MO													11,970,450
P15	AR													2,981,846
P16	LA,MS													867,020
P17	AL,FL													1,611,032
P18	TN													1,654,774
P19	KY													2,297,365
P20	IL													12,960,910
P21	WI													3,312,476
P22	MI				1,487,124									3,575,235
P23	IN			8,966,520										14,076,285

Appendix 6. (cont)

Region	State(s)	S13 AL,FL, GA	S14 KY,TN	S15 IN	S16 MI	S17 OH	S18 VA,WV	S19 NC,SC	S20 DE,MD,NJ, PA	S21 CT~VT	S22 SD	S23 ND	S24 TX	Total
P24	OH				5,853,129									5,853,129
P25	CT,MA,ME, NH,NY,RI,VT								274,935					274,935
P26	PA								2,546,493					2,546,493
P27	DE,MD,NJ, WV								516,424					516,424
P28	VA						1,200,513							1,200,513
P29	NC						8,124,307	16,394,180						24,518,487
P30	SC							1,067,658						1,067,658
P31	GA	839,280						1,733,965						2,573,245
P32	AZ													0
P33	ND										976,749	1,905		3,296,891
TOTAL		839,280	0	8,966,520	7,340,253	0	9,324,820	19,195,803	3,337,852	0	8,469,409	1,905	68,080	197,130,364

Appendix 7. Optimal Shipping Pattern from Production Regions to Processing Regions with Increased Exports (cwt.)

Region	State(s)	S01 ID,OR,WA	S02 CA,NV	S03 AZ,UT	S04 MT,ND,WY	S05 NM,OK,TX	S06 NE	S07 CO,KS	S08 MN,WI	S09 IA	S10 IL	S11 MO	S12 AR,LA,MS
P01	ID,OR,WA	322,920	94,116										
P02	CA		693,835										
P03	AZ,NV,UT		716,911										
P04	MT,WY				373,080								
P05	CO									1,651,320			
P06	NM,TX					1,652,726							
P07	ND												
P08	SD												
P09	NE									12,349,910			
P10	KS											4,513,087	
P11	OK					605,434		143,280				2,828,522	
P12	MN								16,406,560				
P13	IA									49,331,930			
P14	MO									11,981,530			
P15	AR									1,122,973		1,861,623	
P16	LA,MS										867,812		
P17	AL,FL										347,708		1,264,800
P18	TN										1,656,270		
P19	KY										2,299,491		
P20	IL										12,972,720		
P21	WI								1,787,492		1,528,018		
P22	MI										2,096,807		
P23	IN										5,122,697		

Appendix 7. (cont)

Region	State(s)	S01 ID,OR,WA	S02 CA,NV	S03 AZ,UT	S04 MT,ND,WY	S05 NM,OK,TX	S06 NE	S07 CO,KS	S08 MN,WI	S09 IA	S10 IL	S11 MO	S12 AR,LA,MS
P24	OH												
P25	CT,MA,ME, NH,NY,RI, VT												
P26	PA												
P27	DE,MD,NJ, WV												
P28	VA												
P29	NC												
P30	SC												
P31	GA												
P32	AZ												
P33	ND								3,141,111				
	Total	322,920	1,504,862	0	373,080	2,258,160	0	143,280	21,335,163	76,437,663	26,891,523	9,203,232	1,264,800

Appendix 7. (cont)

Region	State(s)	S13 AL,FL,GA	S14 KY,TN	S15 IN	S16 MI	S17 OH	S18 VA,WV	S19 NC,SC	S20 DE,MD, NJ,PA	S21 CT~VT	S22 SD	S23 ND	S24 TX	Total
P01	ID,OR,WA													417,036
P02	CA													693,835
P03	AZ,NV,UT													716,911
P04	MT,WY										482,461			855,541
P05	CO													1,651,320
P06	NM,TX												68,080	1,720,806
P07	ND										881,145			881,145
P08	SD										5,634,420			5,634,420
P09	NE										1,317,507			13,667,417
P10	KS													4,513,087
P11	OK													3,577,236
P12	MN													16,406,560
P13	IA													49,331,930
P14	MO													11,981,530
P15	AR													2,984,596
P16	LA,MS													867,812
P17	AL,FL													1,612,508
P18	TN													1,656,270
P19	KY													2,299,491
P20	IL													12,972,720
P21	WI													3,315,510
P22	MI				1,481,720									3,578,527
P23	IN			8,966,520										14,089,217
P24	OH				5,858,533									5,858,533

Appendix 7. (cont)

Region	State(s)	S13 AL,FL,GA	S14 KY,TN	S15 IN	S16 MI	S17 OH	S18 VA,WV	S19 NC,SC	S20 DE,MD,NJ,PA	S21 CT~VT	S22 SD	S23 ND	S24 TX	Total
P25	CT,MA,ME,NH, NY,RI,VT								275,188					275,188
P26	PA								2,548,765					2,548,765
P27	DE,MD,NJ,WV								516,886					516,886
P28	VA						1,201,594							1,201,594
P29	NC						8,149,806	16,390,850						24,540,656
P30	SC							1,068,627						1,068,627
P31	GA	839,280						1,736,327						2,575,607
P32	AZ													0
P33	ND										153,875	1,905		3,296,891
	Total	839,280	0	8,966,520	7,340,253	0	9,351,400	19,195,804	3,340,839	0	8,469,408	1,905	68,080	197,308,172

Appendix 8. Optimal Pork Shipping Patterns from Processing Regions to Consumption Regions for the Benchmark Scenario (cwt.)

Region	State(s)	C01 WA	C02 OR	C03 NCA	C04 SCA	C05 ID,MT,WY	C06 NV	C07 UT	C08 AZ	C09 CO	C10 NM	C11 ND,SD	C12 NE
S01	ID,OR,WA		322,920										
S02	CA,NV				1,503,223								
S03	AZ,UT												
S04	MT,ND,WY	373,080											
S05	NM,OK,TX										1,270,304		
S06	NE												
S07	CO,KS									143,280			
S08	MN,WI	1,418,249	1,860,542					1,462,764				1,113,974	
S09	IA			756,693	13,584,310		1,104,193		3,055,986	2,671,103			1,332,918
S10	IL												
S11	MO												
S12	AR,LA,MS												
S13	AL,FL,GA												
S14	KY,TN												
S15	IN												
S16	MI												
S17	OH												
S18	VA,WV												
S19	NC,SC												
S20	DE,MD,NJ,PA												
S21	CT,MA,ME,NH, NY,RI,VT												
S22	SD	532,033		6,049,610		1,887,766							
S23	NY-1												
S24	NY-2												
S25	ID	1,498,085											
	Total	3,821,447	2,183,462	6,806,303	15,087,533	1,887,766	1,104,193	1,462,764	3,055,986	2,814,383	1,270,304	1,113,974	1,332,918

Appendix 8. (cont)

Region	State(s)	C13 KS	C14 OK	C15 NTX	C16 STX	C17 MN	C18 IA	C19 MO	C20 AR	C21 LA	C22 WI	C23 IL	C24 KY
S01	ID,OR,WA												
S02	CA,NV												
S03	AZ,UT												
S04	MT,ND,WY												
S05	NM,OK,TX												
S06	NE												
S07	CO,KS												
S08	MN,WI									2,175,070			
S09	IA	2,112,259	1,071,853	5,939,066	8,761,709	3,754,064	2,326,893	4,285,743	1,960,742		3,829,145	8,810,997	
S10	IL												3,182,335
S11	MO		1,524,805										
S12	AR,LA,MS									1,264,800			
S13	AL,FL,GA												
S14	KY,TN												
S15	IN												
S16	MI												
S17	OH												
S18	VA,WV												
S19	NC,SC												
S20	DE,MD,NJ,PA												
S21	CT,MA,ME,NH, NY,RI,VT												
S22	SD												
S23	NY-1												
S24	NY-2												
S25	ID												
	Total	2,112,259	2,596,658	5,939,066	8,761,709	3,754,064	2,326,893	4,285,743	1,960,742	3,439,870	3,829,145	8,810,997	3,182,335

Appendix 8. (cont)

Region	State(s)	C25 TN	C26 MS	C27 MI	C28 IN	C29 AL	C30 OH	C31 GA	C32 FL	C33 NY	C34 PA	C35 WV	C36 VA
S01	ID,OR,WA												
S02	CA,NV												
S03	AZ,UT												
S04	MT,ND,WY												
S05	NM,OK,TX												
S06	NE												
S07	CO,KS												
S08	MN,WI				3,346,443	3,508,896		5,832,859					
S09	IA												
S10	IL			7,074,180	959,638		8,267,665			4,908,795	1,037,081	1,461,826	
S11	MO	4,313,405	1,909,970										
S12	AR,LA,MS												
S13	AL,FL,GA								839,280				
S14	KY,TN												
S15	IN											36,291	
S16	MI									7,340,253			
S17	OH												
S18	VA,WV										3,861,016		5,463,804
S19	NC,SC								10,766,700		27,033		
S20	DE,MD,NJ,PA										3,337,852		
S21	CT,MA,ME,NH, NY,RI,VT												
S22	SD												
S23	NY-1												
S24	NY-2												
S25	ID												
	Total	4,313,405	1,909,970	7,074,180	4,306,081	3,508,896	8,267,665	5,832,859	11,605,980	12,249,048	8,262,982	1,498,117	5,463,804

Appendix 8. (cont)

Region	State(s)	C37 NC	C38 SC	C39 NH	C40 MA	C41 CT,RI	C42 DE,MD	C43 NJ	C44 ME	C45 MI	C46 SC	C47 TX	C48 CA	Total
S01	ID,OR,WA													322,920
S02	CA,NV													1,503,223
S03	AZ,UT													0
S04	MT,ND,WY													373,080
S05	NM,OK,TX												987,856	2,258,160
S06	NE													0
S07	CO,KS													143,280
S08	MN,WI								616,364					21,335,161
S09	IA				4,027,344			5,358,588		462,971			1,084,490	76,291,067
S10	IL													26,891,520
S11	MO											1,455,051		9,203,231
S12	AR,LA,MS													1,264,800
S13	AL,FL,GA													839,280
S14	KY,TN													0
S15	IN	5,868,056	3,062,172											8,966,519
S16	MI													7,340,253
S17	OH													0
S18	VA,WV													9,324,820
S19	NC,SC						4,786,484				3,615,582			19,195,799
S20	DE,MD,NJ,PA													3,337,852
S21	CT,MA,ME,NH, NY,RI,VT													0
S22	SD													8,469,409
S23	NY-1					1,467,485								1,467,485
S24	NY-2			1,152,768		1,412,157			217,221					2,782,146
S25	ID													1,498,085
	Total	5,868,056	3,062,172	1,152,768	4,027,344	2,879,642	4,786,484	5,358,588	833,585	462,971	3,615,582	1,455,051	2,072,346	202,808,090

Appendix 9. Optimal Pork Shipping Patterns from Processing Regions to Consumption Regions with Increased Exports (cwt.)

Region	State(s)	C01 WA	C02 OR	C03 NCA	C04 SCA	C05 ID,MT,WY	C06 NV	C07 UT	C08 AZ	C09 CO	C10 NM	C11 ND,SD	C12 NE
S01	ID,OR,WA		322,920										
S02	CA,NV				1,504,862								
S03	AZ,UT												
S04	MT,ND,WY	373,080											
S05	NM,OK,TX										1,269,594		
S06	NE												
S07	CO,KS									143,280			
S08	MN,WI	1,419,715	1,859,495					1,461,945				1,113,293	
S09	IA			749,064	13,575,430		1,103,572		3,054,268	2,669,535			1,332,103
S10	IL												
S11	MO												
S12	AR,LA,MS												
S13	AL,FL,GA												
S14	KY,TN												
S15	IN												
S16	MI												
S17	OH												
S18	VA,WV												
S19	NC,SC												
S20	DE,MD,NJ,PA												
S21	CT,MA,ME,NH, NY,RI,VT												
S22	SD	528,735		6,053,967		1,886,707							
S23	NY-1												
S24	NY-2												
S25	ID	1,498,085											
	Total	3,819,615	2,182,415	6,803,031	15,080,292	1,886,707	1,103,572	1,461,945	3,054,268	2,812,815	1,269,594	1,113,293	1,332,103

Appendix 9. (cont)

Region	State(s)	C13 KS	C14 OK	C15 NTX	C16 STX	C17 MN	C18 IA	C19 MO	C20 AR	C21 LA	C22 WI	C23 IL	C24 KY
S01	ID,OR,WA												
S02	CA,NV												
S03	AZ,UT												
S04	MT,ND,WY												
S05	NM,OK,TX												
S06	NE												
S07	CO,KS												
S08	MN,WI									2,173,417			
S09	IA	2,110,966	1,067,616	5,936,222	8,757,499	3,751,768	2,325,471	4,283,120	1,959,806		3,827,226	8,806,582	
S10	IL												3,180,684
S11	MO		1,527,802										
S12	AR,LA,MS									1,264,800			
S13	AL,FL,GA												
S14	KY,TN												
S15	IN												
S16	MI												
S17	OH												
S18	VA,WV												
S19	NC,SC												
S20	DE,MD,NJ,PA												
S21	CT,MA,ME,NH, NY,RI,VT												
S22	SD												
S23	NY-1												
S24	NY-2												
S25	ID												
	Total	2,110,966	2,595,418	5,936,222	8,757,499	3,751,768	2,325,471	4,283,120	1,959,806	3,438,217	3,827,226	8,806,582	3,180,684

Appendix 9. (cont)

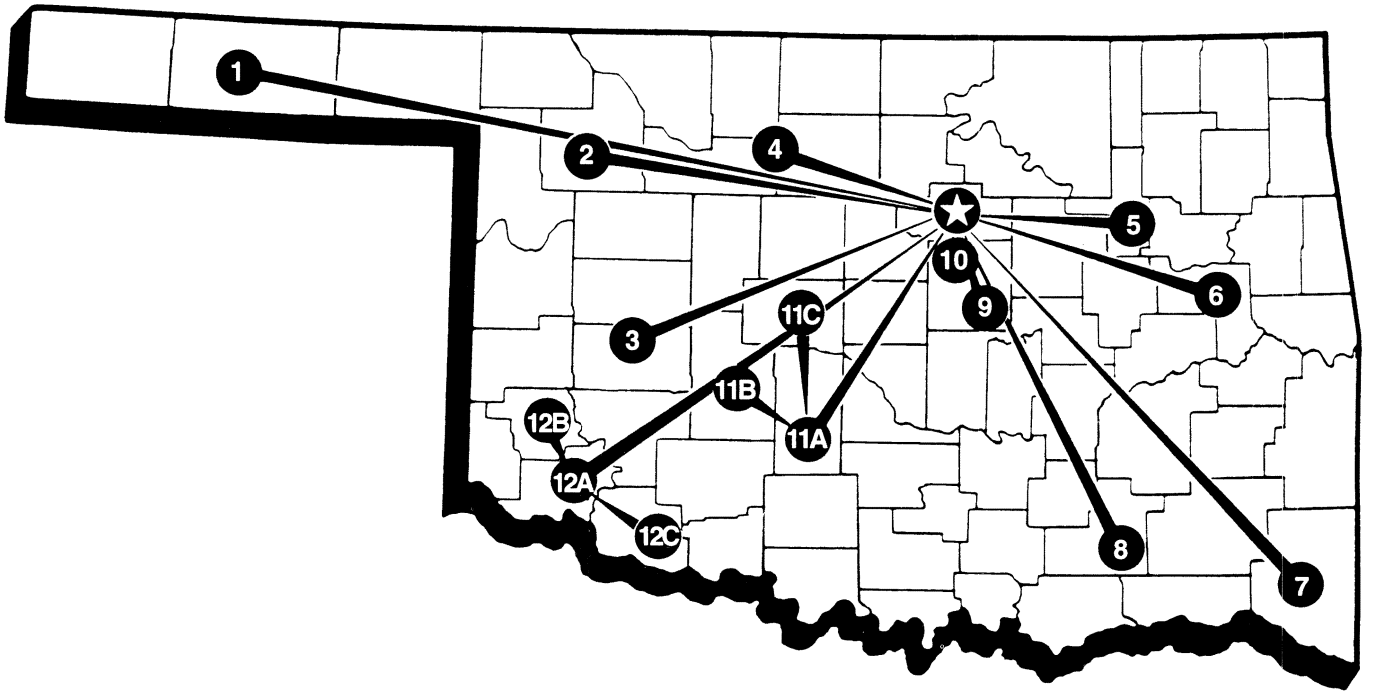
Region	State(s)	C25 TN	C26 MS	C27 MI	C28 IN	C29 AL	C30 OH	C31 GA	C32 FL	C33 NY	C34 PA	C35 WV	C36 VA
S01	ID,OR,WA												
S02	CA,NV												
S03	AZ,UT												
S04	MT,ND,WY												
S05	NM,OK,TX												
S06	NE												
S07	CO,KS												
S08	MN,WI				3,356,149	3,507,067		5,829,815					
S09	IA												
S10	IL			7,070,619	947,768		8,263,503			4,903,522	1,028,087	1,497,337	
S11	MO	4,311,165	1,909,213										
S12	AR,LA,MS												
S13	AL,FL,GA								839,280				
S14	KY,TN												
S15	IN												
S16	MI									7,340,253			
S17	OH												
S18	VA,WV										3,890,447		5,460,953
S19	NC,SC								10,748,870				
S20	DE,MD,NJ,PA										3,340,839		
S21	CT,MA,ME,NH, NY,RI,VT												
S22	SD												
S23	NY-1												
S24	NY-2												
S25	ID												
	Total	4,311,165	1,909,213	7,070,619	4,303,917	3,507,067	8,263,503	5,829,815	11,588,150	12,243,775	8,259,373	1,497,337	5,460,953

Appendix 9. (cont)

Region	State(s)	C37 NC	C38 SC	C39 NH	C40 MA	C41 CT,RI	C42 DE,MD	C43 NJ	C44 ME	C45 MI	C46 SC	C47 TX	C48 CA	Total
S01	ID,OR,WA													322,920
S02	CA,NV													1,504,862
S03	AZ,UT													0
S04	MT,ND,WY													373,080
S05	NM,OK,TX												988,566	2,258,160
S06	NE													0
S07	CO,KS													143,280
S08	MN,WI								614,265					21,335,161
S09	IA				4,025,606		198,784	5,356,281		462,971			1,083,780	76,437,670
S10	IL													26,891,520
S11	MO											1,455,051		9,203,231
S12	AR,LA,MS													1,264,800
S13	AL,FL,GA													839,280
S14	KY,TN													0
S15	IN	5,864,109	3,060,112				42,299							8,966,520
S16	MI													7,340,253
S17	OH													0
S18	VA,WV													9,351,400
S19	NC,SC						4,535,927				3,911,001			19,195,798
S20	DE,MD,NJ,PA													3,340,839
S21	CT,MA,ME,NH, NY,RI,VT													0
S22	SD													8,469,409
S23	NY-1					1,467,485								1,467,485
S24	NY-2			1,152,271		1,410,916			218,960					2,782,147
S25	ID													1,498,085
	Total	5,864,109	3,060,112	1,152,271	4,025,606	2,878,401	4,777,010	5,356,281	833,225	462,971	3,911,001	1,455,051	2,072,346	202,985,900

THE OKLAHOMA AGRICULTURAL EXPERIMENT STATION

SYSTEM COVERS THE STATE



✪ MAIN STATION—*Stillwater and adjoining areas*

1. Panhandle Research Station—*Goodwell*
2. Southern Great Plains Research Station—*Woodward*
3. Marvin Klemme Range Research Station—*Bessie*
4. North Central Research Station—*Lahoma*
5. Vegetable Research Station—*Bixby*
6. Eastern Research Station—*Haskell*
7. A. Kiamichi Forestry Research Station—*Idabel*
   B. Broken Bow Field Research Facility
8. Wes Watkins Agricultural Research and Extension Center—*Lane*
9. Pecan Research Station—*Sparks*
10. A. Agronomy Research Station—*Perkins*
    B. Fruit Research Station—*Perkins*
11. A. South Central Research Station—*Chickasha*
    B. Caddo Research Station—*Ft. Cobb*
    C. Forage and Livestock Research Laboratory—*El Reno*
12. A. Cotton Research and Extension Center—*Altus*
    B. Sandyland Research Station—*Mangum*
    C. Southwest Agronomy Research Station—*Tipton*