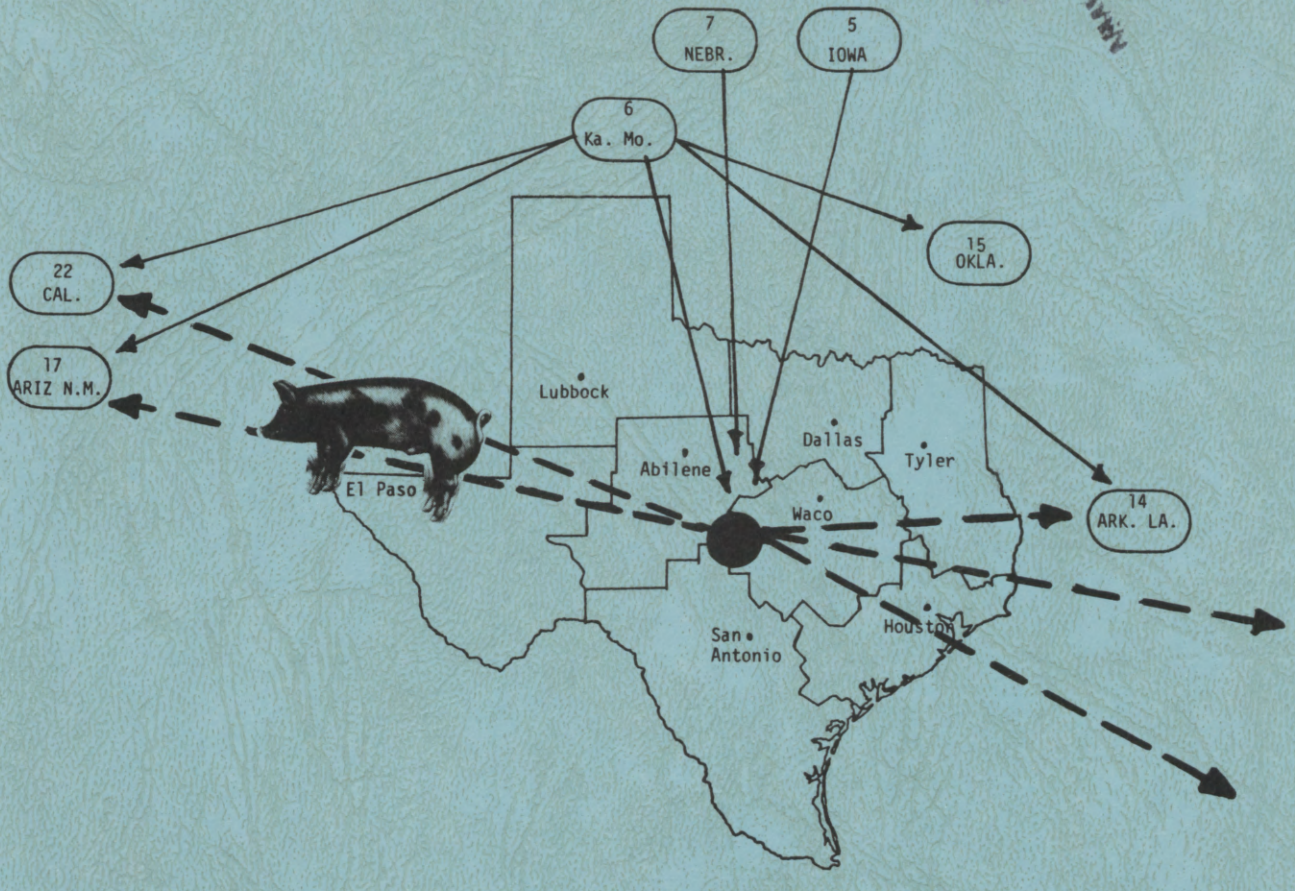
Interregional Analysis of Texas Swine-Pork Industry



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INTERREGIONAL ANALYSIS

OF

TEXAS SWINE-PORK INDUSTRY

BY

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SUMMARY

Texas has a tremendous potential for growth in swine production. It has readily available markets and abundant supply of feed grains. In fact, if the full growth potentials of the swine production in Texas were to be realized, the state would have a surplus of live hogs and/or pork which must be shipped to out-of-state markets in competition with other major swine producing areas of the nation, which is yet to be determined.

The major objectives of this research were to determine the competitive position of Texas pork producers relative to other major pork producing areas and to determine the potential markets available to Texas pork producers. In order to achieve these objectives, 1970 estimates of hog production, slaughter, and pork consumption in Texas and 21 other geographical regions of the United States were developed. The estimates of 1970 and years prior to 1970 were used to obtain projections for 1975. A cost minimizing linear programming technique was used to simultaneously determine least-cost interregional shipments of hogs and pork for estimated 1970 and projected 1975 conditions.

In 1970, Texas produced 369 million pounds of live hogs, slaughtered 493 million pounds of live hogs, and consumed 1,115 million pounds liveweight equivalent of pork. This showed Texas to have a total deficit of 746 million pounds liveweight equivalent. The total deficit in pork in Texas was satisfied by importing 124 million pounds of live hogs plus 622 million pounds liveweight equivalent of pork. Based on the least-cost shipment pattern, Texas would receive its total requirement of deficit live hogs from region 6 (Kansas and Missouri). Region 5 (Iowa) would supply 56% of the pork imported into Texas with region 7 (Nebraska) supplying the other 44%.

The projection for 1975 showed a decrease in Texas production and slaughter. Based on 1951-1970 time-trend projections, Texas had a projected production of 219 million pounds of live hogs, a projected hog slaughter of 432 million pounds liveweight, and a projected consumption of 1,148 million pounds liveweight equivalent of pork for 1975.

Based on the 1975 optimum distribution pattern, Texas would import live hogs from region 6 (Kansas and Missouri). Two optimum shipment patterns were obtained for pork shipments in 1975. In the first solution which was based on a relatively low consumption estimate, Texas would import pork from region 5 (Iowa) and region 7 (Nebraska). In the second solution which was based on a higher consumption estimate, Texas would receive pork shipments from region 6 (Kansas and Missouri) and region 7 (Nebraska).

Marginal values were calculated for the production and slaughter activity in each region. The marginal values indicate the reduction in the total cost of transportation that could be obtained from an increase in either slaughter or porduction in any region. Texas had an initial marginal value of $8.89 per thousand pounds for production and $11.10 per thousand pounds liveweight equivalent for slaughter. The analysis indicated that the total cost of transportation could have been reduced with production increases in Texas of up to 546 million pounds liveweight in 1970, assuming no changes in the slaughter level. An increase in slaughter capacity in Texas which is not accompanied by an increased level of production would require increased imports of live hog but decreased imports of pork. However, the increased transportation costs of the additional imports of live hogs were more than offset by the savings in transportation costs resulting from the decreased imports of

pork. Consequently, increases in slaughter capacity in Texas resulted in a reduction in the total cost of transportation. The results of this study indicate further reductions in the total cost of transportation could be obtained by simultaneously increasing both production and slaughter of hogs in Texas.

Optimum solutions were obtained for selected alternative levels of Texas hog production to determine the competitive position of Texas as a surplus region for 1970 and 1975. The results showed Texas to have a locational advantage over regions in the midwest in supplying live hogs to regions along the Southern border of the United States from California to Florida.

INTRODUCTION

Swine production in a 39 county area in the Texas High Plains (Figure 1) has recently become a topic of growing interest. Of particular concern to those who are interested in the potentials of Texas swine production are the present and future markets available to them and their competitive position in relation to established pork producing regions. Currently, Texas provides a sizable market with other states supplying more than two-thirds of the pork consumed in Texas.

Interest in swine production on the High Plains has been stimulated by the use of S.P.F. (specific-pathogen-free) breeding stock and the development of large scale complete confinement swine production facilities. Growth in the Texas swine industry was encouraged by the availability of large quantities of feed grains at reasonable prices. Texas feed grain production supplies the needs of a large cattle feeding industry and still produces a large excess. In the 1969 feeding year,[1] the state marketed over three million head of fed cattle (3, p. 18) and still produced an excess of 2,777 thousand tons of feed grains (4, p. 111). This excess could have been used to feed enough hogs to make Texas a surplus hog producing state. Grain sorghum is the major feed grain produced in the state with more than half of the state's production centered on the High Plains in 1970 (1, p. 11-15).

Other favorable conditions for swine production on the Texas High Plains include a relatively mild climate and an advantageous location for supplying deficit pork areas of the South and West. The Texas High Plains area is served by a network of highways which allow easy access to major

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[1] October 1, 1969 to September 30, 1970.

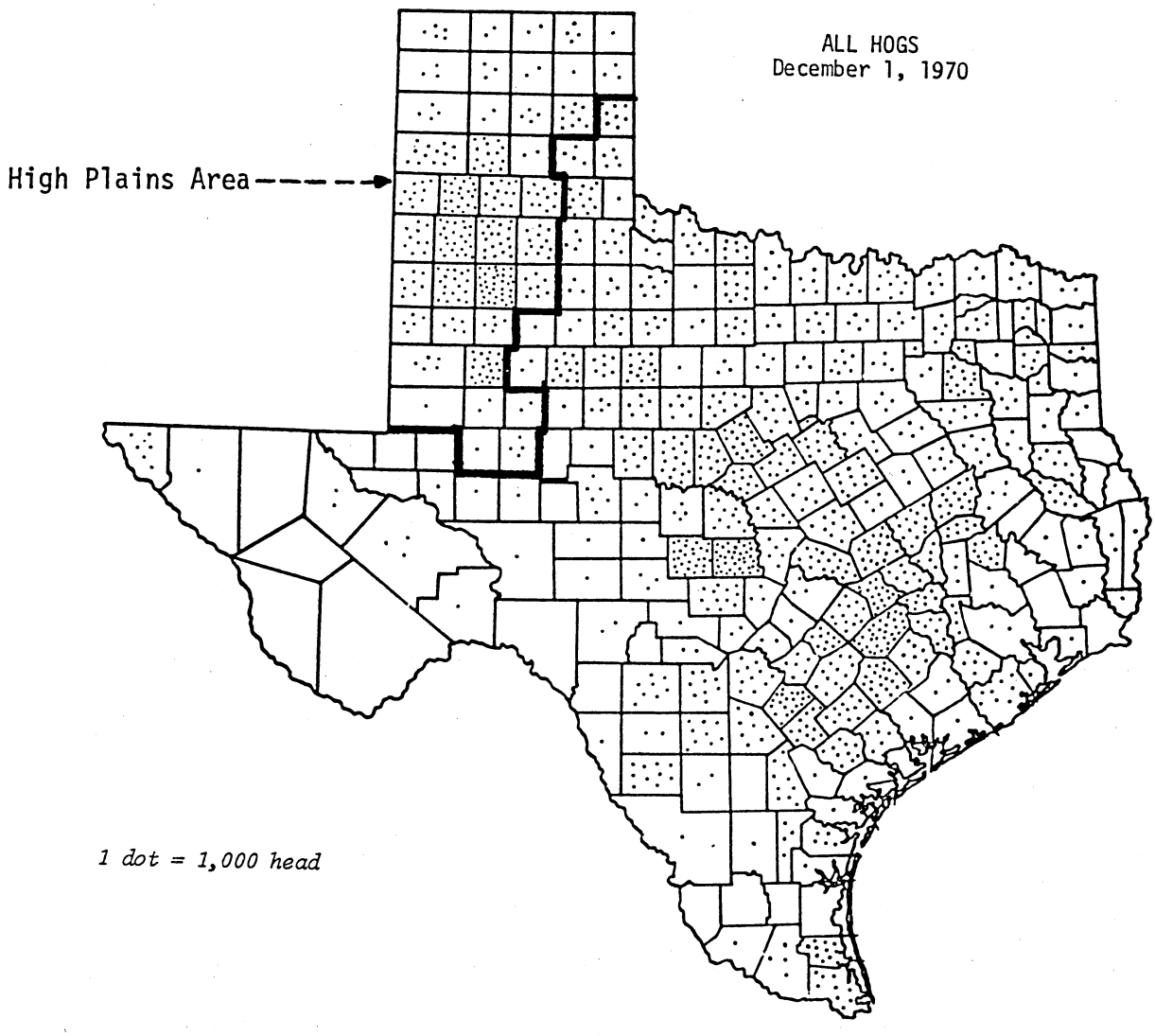

Figure 1. Thirty-nine County High Plains Area and Inventory of All Hogs, December 1, 1970.

market areas.

Although the potential for an expansion of hog production in Texas exists, very little actual growth has occurred. Currently, hog production is not a major livestock enterprise in Texas. In 1970, cash receipts from marketings of hogs accounted for less than five percent of the cash receipts from marketings of all meat animals in the state (2, p. 125).

If the full growth potentials of the Texas swine industry are realized in the future, and pork production is expanded to the point that the state has a surplus of live hogs and/or pork, the out-of-state markets in which Texas producers could best compete are unknown. Therefore, knowledge about the competitive position and market potentials of Texas as a pork producing center need to be determined for the benefit of current and prospective hog producers, packers, and processors.

Objectives

The major objectives of this research were to analyze the competitive position of pork producers in Texas and other major pork producing areas and to determine the potential markets available to Texas pork producers. The specific objectives of the research were:

1. To develop estimates of pork production, slaughter, and consumption in Texas and other major geographical regions of the United States for 1970 and 1975.

2. To determine the pattern and volume of shipments of live hogs and pork among regions of the United States that would result in the least total cost of transportation.

3. To determine the markets in which Texas producers can best compete, assuming Texas becomes a surplus hog producing state.

Procedures

The 48 contiguous states of the United States were aggregated into 22 regions as shown in Figure 2. Secondary information concerning live

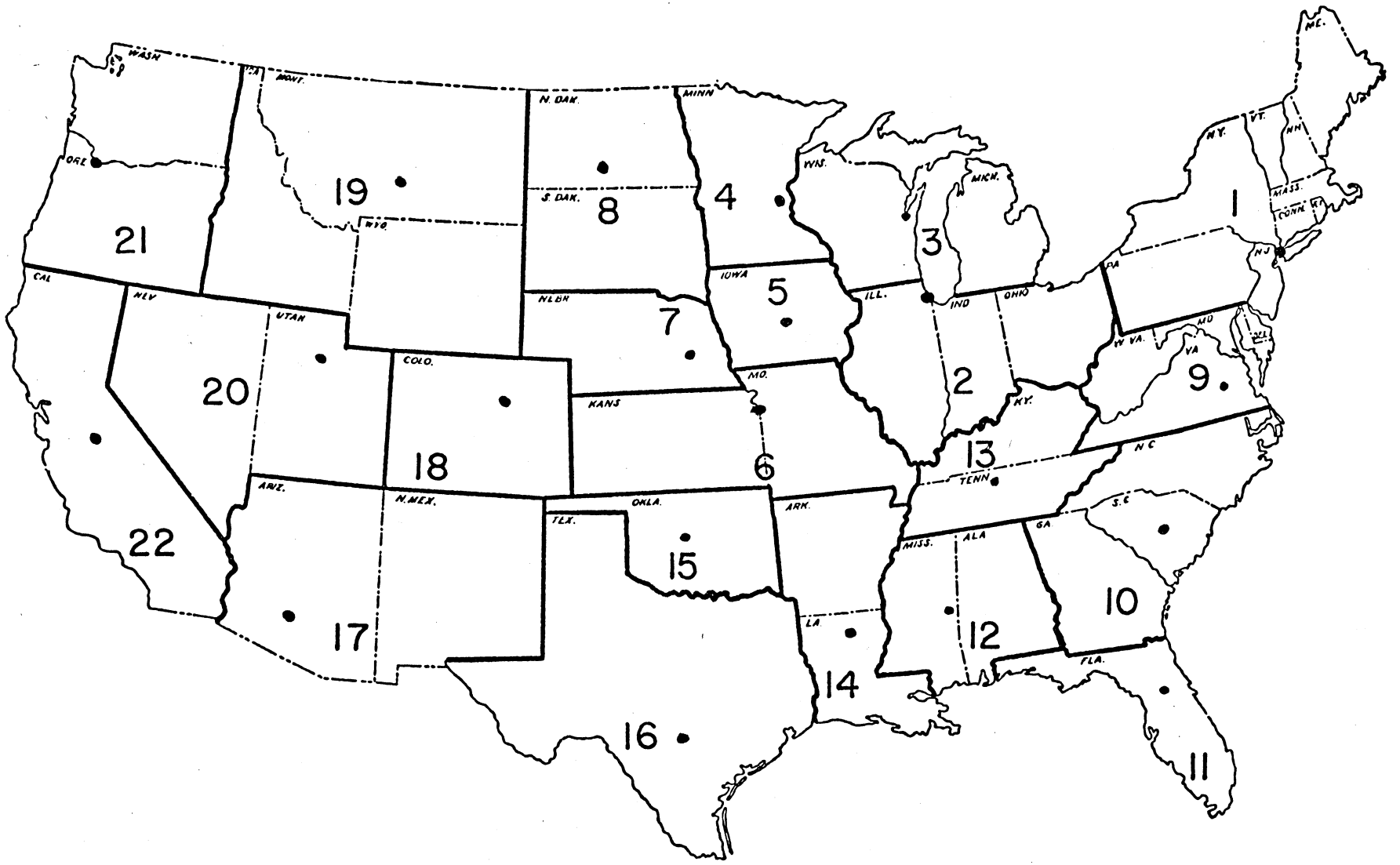

Figure 2. Twenty-two Regions of the United States.

hog production, slaughter, and pork consumption in 1970 was collected and analyzed for each of the 22 regions. Regional swine production and slaughter estimates were derived from published estimates of production and slaughter by states. Pork consumption estimates were derived by utilizing published per capita consumption estimates and the civilian resident population of each region.

Regional estimates of production and slaughter were projected to 1975 by extrapolating from twenty year linear trends of production and slaughter in each region. Pork consumption was projected to 1975 by using two alternative estimates of per capita pork consumption and a published Census Bureau population estimate for 1975. One of the two alternative estimates of per capita pork consumption was a relatively low estimate of 63.7 pounds per capita while the other estimate was a relatively high estimate of 70.6 pounds per capita.

Least-cost shipment patterns for live hogs and pork were determined simultaneously by linear programming. Optimum shipment patterns were developed for both 1970 and projected 1975 conditions. The transportation rates necessary for developing the least-cost shipments were estimated from data collected directly from trucking firms involved in shipping live hogs and pork.

The competitive position of Texas swine producers was analyzed by making Texas a hypothetical surplus hog producing state in which case it would compete with other surplus regions. Least-cost flows of live hogs and pork were determined for various hypothetical levels of live hog production and slaughter in Texas.

REGIONAL PRODUCTION, SLAUGHTER AND CONSUMPTION

Regional estimates of production, slaughter and consumption for 1970 are shown in Table 1. Regions 2, 5 and 6 led in production with approximately 58% of total production in 1970, while 55.8% of the hogs slaughtered in 1970 were slaughtered in regions 2, 3, 4 and 5. The production and slaughter of hogs were primarily concentrated in the Corn Belt regions.

Consumption was largest in the regions with large population centers. Regions 1, 2, 3 and 22 accounted for approximately 53% of total consumption in 1970 while the Southern regions (regions 10, 11, 12, 15, 16 and 17) accounted for only 23.5% of total consumption. The same Southern regions produced only 12.4% of total production and slaughtered only 12.1% of total slaughter.

As a region, Texas (region 16) ranked eleventh in production, thirteenth in total slaughter, and seventh in consumption. Texas accounted for 1.8% of total production, 2.4% of total slaughter, and 5.4% of total consumption in 1970.

Approximately 33% of the 1,115 million pounds of live weight needed to fulfill the consumption requirement of Texas was supplied by Texas production, leaving 67% to be supplied by other regions. In 1970, Texas slaughter was approximately 493 million pounds of live weight or 44% of the state's total consumption. Therefore, in 1970, the 746 million pound deficit in Texas hog production was satisfied by importing 124 million pounds of live hogs to be slaughtered and consumed in Texas, and by importing 622 million pounds of dressed pork (live weight equivalent) for Texas consumption.

The levels of regional live hog production and slaughter and pork consumption were estimated for 1975 based on 1950-69 trend and are shown in Table 2. As in 1970, the majority of hog production and slaughter is

TABLE 1

ESTIMATES OF REGIONAL PRODUCTION,
SLAUGHTER, AND CONSUMPTION, 1970

Region	Production	Slaughter	Consumption
	- 1000 Pounds Live Weight equivalent -		
1	249,171	1,203,150	4,655,233
2	5,058,393	3,364,815	3,071,431
3	931,849	1,511,828	1,517,146
4	1,252,685	1,398,160	434,254
5	5,863,281	5,394,771	322,719
6	2,339,135	1,133,524	782,914
7	1,306,409	655,726	168,217
8	873,112	682,638	144,789
9	257,978	872,659	1,247,689
10	1,316,840	956,057	1,317,812
11	82,452	120,984	735,689
12	487,321	601,918	616,909
13	800,956	1,185,896	778,182
14	150,422	159,928	607,221
15	149,543	227,027	255,055
16	369,076	492,998	1,115,119
17	45,276	69,599	253,071
18	112,956	222,997	199,006
19	121,374	120,691	159,150
20	19,104	28,256	141,620
21	67,377	215,996	500,791
22	43,873	378,965	1,804,525
TOTAL	20,898,583	20,898,583	20,828,542[1]

[1] Total consumption differs from the total production and slaughter due to import-export and storage activities.

TABLE 2

ESTIMATES OF PROJECTED REGIONAL PRODUCTION, SLAUGHTER, AND CONSUMPTION, 1975

Region	Production	Slaughter	Consumption[1]	Consumption[2]
	- 1000 Pounds Live Weight Equivalent -			
1	164,119	1,169,204	4,710,613	5,578,841
2	5,496,249	3,046,168	3,042,543	3,277,284
3	859,093	1,237,406	1,468,632	1,579,239
4	1,217,831	1,416,755	415,062	446,145
5	5,049,353	5,315,512	301,083	323,437
6	2,229,639	1,254,671	766,032	831,409
7	1,226,200	1,016,234	162,986	176,496
8	934,152	654,545	146,026	149,118
9	185,446	884,909	1,287,966	1,411,340
10	1,111,754	917,957	1,357,452	1,490,823
11	74,569	104,008	761,790	828,425
12	363,043	506,149	655,812	711,136
13	807,382	1,289,425	785,871	852,452
14	57,421	124,778	640,323	693,257
15	76,699	129,782	246,666	268,858
16	218,840	432,023	1,147,824	1,254,392
17	32,815	67,781	278,639	302,917
18	71,976	144,688	195,866	213,874
19	104,386	125,472	160,035	173,505
20	14,474	31,688	154,612	167,110
21	68,863	210,880	470,059	510,491
22	685	284,954	2,004,176	2,186,744
TOTAL	20,364,989	20,364,989	21,160,068	23,437,293

[1] Based on per capita consumption of 63.7 pounds of pork with a dressing percentage of 64.248 percent.

[2] Based on per capita consumption of 70.6 pounds of pork with a dressing percentage of 64.248 percent.

estimated to be centered in the Corn Belt regions (regions 2, 4, 5 and 6). Regions 2, 5 and 6 are expected to have the greatest increase in production while regions 4 and 14 are expected to have the greatest decrease in production. The greatest increase in slaughter is expected to be in regions 5, 9 and 13 with the greatest decreases in regions 1, 2 and 6. Texas is expected to have a decrease in both production and slaughter with a larger decrease in production than in slaughter.

Consumption estimates for 1975 showed the highest concentration of consumption to be in regions 1, 2, 3 and 22. Some regions will consume less pork in 1975 than in 1970 with the use of the lower estimate of per capita consumption, 63.7 pounds of pork. The regions with an expected decrease in consumption are regions with declining populations. Regions 2, 3, 4, 5, 6, 7, 15, 18 and 21 will have a decrease in consumption from 1970 while the other 13 regions will have an increase. On the other hand all regions will have an increase in consumption when pork consumption estimate was based on the higher per capita consumption estimate of 70.6 pounds for 1975.

The 1975 projections indicates Texas to have an increase in total imports by approximately 200 million pounds of liveweight equivalent above the 1970 level. Only 20% of the projected Texas consumption would be supplied by Texas production. Of the total Texas imports, approximately 23% was estimated to be live hogs with dressed pork accounting for the other 77%.

OPTIMUM SHIPMENTS OF LIVE HOGS AND PORK

Simultaneous least-cost distribution patterns of live hogs and dressed pork were calculated and analyzed for 1970 and 1975 using the regional excesses and deficits of live hogs and pork shown in Tables 3 and 4.

TABLE 3

ESTIMATED REGIONAL EXCESSES AND DEFICITS: LIVE HOGS, PORK, AND TOTAL, 1970

Region	Live Hogs		Pork		Total	
	Excess	Deficit	Excess	Deficit	Excess	Deficit
	- 1000 Pounds Live Weight Equivalent -					
1		953,979		3,452,083		4,406,062
2	1,693,578		293,384		1,986,962	
3		579,979		5,318		585,297
4		145,475	963,906		818,431	
5		531,490	5,072,052		4,540,562	
6	1,205,611		350,610		1,556,221	
7	650,683		487,509		1,138,192	
8	190,474		537,849		728,323	
9		614,681		375,030		989,711
10	360,783			361,755		972
11		38,532		614,705		653,237
12		14,597		114,991		129,588
13		384,940	407,714		22,774	
14		9,506		447,293		456,799
15		77,484		28,028		105,512
16		123,922		622,121		746,043
17		24,323		183,472		207,795
18		110,041	23,991			86,050
19	683			38,459		37,776
20		9,152		113,364		122,516
21		148,619		284,795		433,414
22		335,092		1,425,560		1,760,652
TOTAL	4,101,812	4,101,812	8,137,015	8,066,974	10,791,465	10,721,424

TABLE 4

ESTIMATES OF PROJECTED REGIONAL EXCESSES AND DEFICITS:
LIVE HOGS, PORK AND TOTAL, 1975

Region	Live Hogs		Pork[1]		Total[1]		Pork[2]		Total[2]	
	Excess	Deficit	Excess	Deficit	Excess	Deficit	Excess	Deficit	Excess	Deficit
	- 1000 Pounds Live Weight Equivalent -									
1		1,005,085		3,541,409		4,546,494		4,409,637		5,414,722
2	2,450,081		3,625		2,453,706			231,116	2,218,965	
3		378,313		231,226		609,539		341,833		720,146
4		198,924	1,001,693		802,769		970,610		771,686	
5		266,159	5,014,429		4,748,270		4,992,075		4,725,916	
6	974,968		488,639		1,463,607		423,262		1,398,230	
7	209,966		853,248		1,063,214		839,738		1,049,704	
8	279,607		508,519		788,126		495,427		775,034	
9		699,463		403,057		1,102,520		526,531		1,225,894
10	193,797			439,495		245,698		472,866		379,069
11		29,439		657,782		687,221		724,417		753,856
12		143,106		149,663		292,769		204,987		348,093
13		482,043	503,554		21,511		436,973			45,070
14		67,357		515,545		582,902		568,479		635,836
15		53,083		116,884		169,967		139,076		192,159
16		213,183		715,801		928,984		822,369		1,035,552
17		34,966		210,858		245,824		235,136		270,102
18		72,712		51,178		123,890		69,186		141,898
19		21,086		34,563		55,649		48,033		69,119
20		17,214		122,924		140,138		135,422		152,636
21		142,017		259,179		401,196		299,611		441,628
22		284,269		1,719,222		2,003,491		1,901,790		2,186,059
TOTAL	4,108,419	4,108,419	8,373,707	9,168,786	11,341,203	12,136,282	8,158,085	11,230,389	10,939,535	14,011,839

[1] Based on per capita consumption of 63.7 pounds of pork or 99.15 pounds live weight equivalent.

[2] Based on per capita consumption of 70.6 pounds of pork or 109.89 pounds live weight equivalent.

Interregional Shipments and Costs, 1970

In the 1970 solution, approximately 4,032 million pounds of slaughter hogs entered into interregional trade. This represented approximately 19% of the total live weight of production and 33% of total interregional shipments of live hogs and pork.

The optimum distribution of live hogs is shown in Figure 3 and Table 5. A total of six regions (regions 2, 6, 7, 8, 10 and 19) produced more hogs than they slaughtered and therefore exported live hogs. Regions 10 and 19 exported live hogs, but then had to import pork to meet their consumption requirements. Regions 2, 6, 7 and 8 exported both live hogs and pork. In the optimum solution, over one-half of all live hog shipments originated from regions 2 and 6.

Of the sixteen regions that slaughtered more hogs than they produced, and, therefore, imported live hogs, Texas (region 16) ranked eighth. Based on the optimum solution, Texas received its entire requirement from Kansas and Missouri (region 6) as did all other regions of the Southern United States (regions 11-17). Kansas and Missouri also supplied part of the requirements of regions 5, 9 and 22 and still produced an excess of 70,041 thousand pounds of live hogs which were not slaughtered and did not enter into interregional trade, according to the optimum solution.

The total transportation cost of live hog shipments which was consistent with the optimum solution was approximately $31.7 million for the 48 states. The $31.7 million represents about 21% of the total cost of shipping both live hogs and pork. The average cost of all live hog shipments was $0.79 per hundred pounds. Since all live hogs received in Texas originated in region 6, the average cost was $0.80 per hundred pounds which

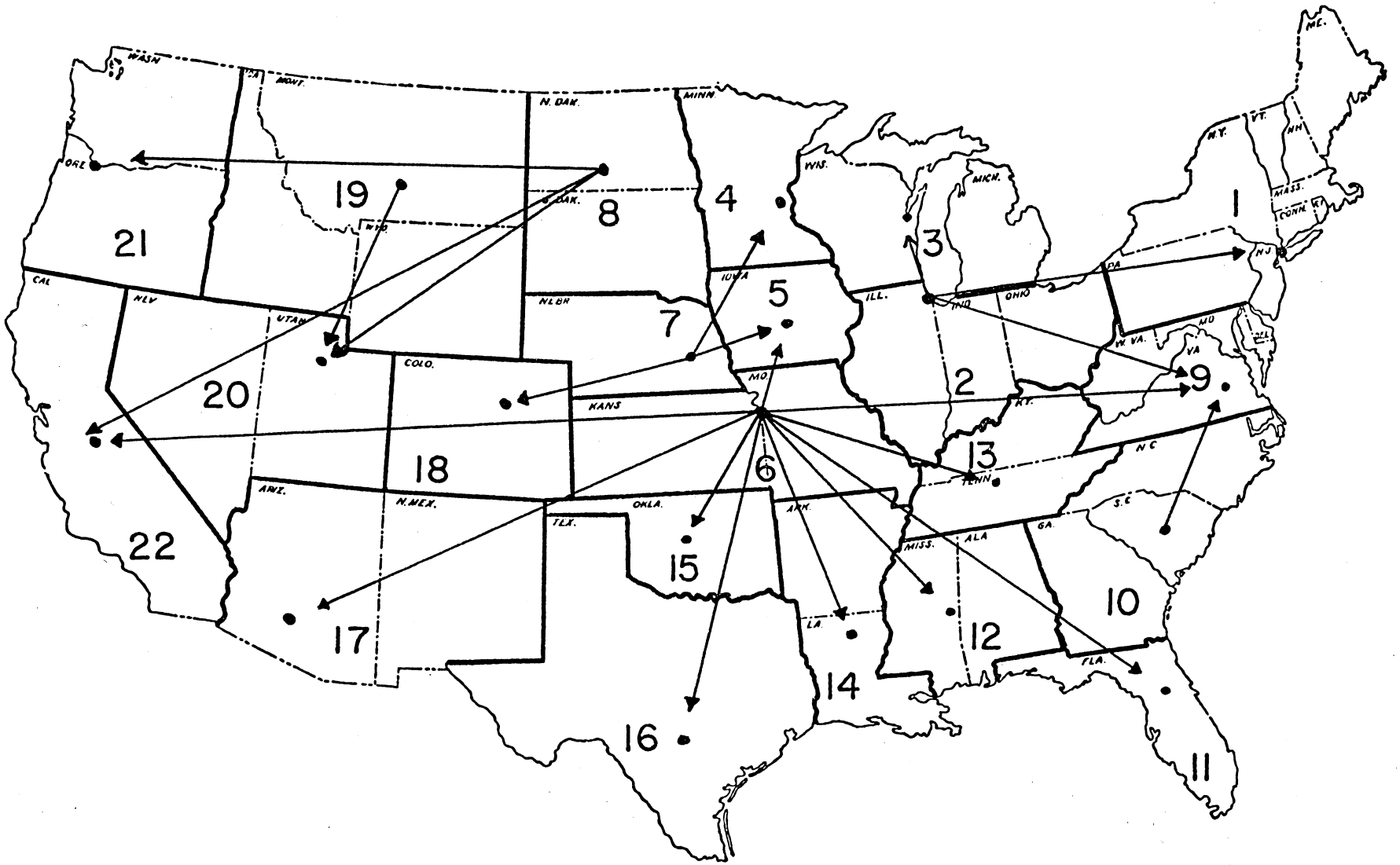

Figure 3. Optimum Shipment Pattern of Live Hogs, 1970.

TABLE 5

OPTIMUM SHIPMENTS OF LIVE HOGS AND PRICE DIFFERENTIALS, 48 STATES, 1970

From: / To:	REGION 2	6	7	8	10	19	TOTAL	d_j [a]
	- 1000 Pounds Live Weight Equivalent -							
1	953,979						953,979	10.99
3	579,979						579,979	6.43
4			75,434				75,434	6.59
5		66,282	465,208				531,490	4.55
9	159,620	94,278			360,783		614,681	10.74
11		38,532					38,532	11.37
12		14,597					14,597	8.63
13		384,940					384,940	7.57
14		9,506					9,506	7.88
15		77,484					77,484	5.99
16		123,922					123,922	8.89
17		24,323					24,323	11.30
18			110,041				110,041	7.09
20				8,469		683	9,152	10.07
21				148,619			148,619	11.55
22		301,706		33,386			335,092	13.35
TOTAL	1,693,578	1,135,570	650,683	190,474	360,783	683	4,031,771	
d_j [a]	1.65	0	.01	.08	4.63	2.29		

[a] Price differentials in dollars per 1000 pounds live weight equivalent.

is the estimated cost of shipping live hogs from Kansas City to San Antonio.

Approximately 8,067 million pounds of pork (live weight equivalent) entered into interregional trade in 1970. This represented approximately 39% of the live weight of total slaughter and 67% of total interregional shipments of both live hogs and pork.

Figure 4 and Table 6 show the optimum distribution patterns of pork. Eight regions (regions 2, 4, 5, 6, 7, 8, 13 and 18) slaughtered more hogs than they consumed and therefore exported pork. Four of these regions (regions 4, 5, 13 and 18) imported live hogs, performed the slaughter service, and exported pork while the other four (regions 2, 6, 7 and 8) exported both live hogs and pork. Iowa (region 5) alone accounted for more than one-half of the total exports of pork.

Texas was the third largest importer of pork. In the optimum solution, approximately 56% of the pork received by Texas was supplied by Iowa (region 5) with Nebraska (region 7) furnishing the other 44%. Southern regions east of Texas (regions 10, 11, 12 and 14) received all or part of their pork requirements from Iowa, while Oklahoma (region 15), New Mexico and Arizona (region 17) received all of their pork requirements from Nebraska (region 7). California (region 22) had the second largest requirement for pork and was located the farthest from the regions with excess pork. California's pork requirement was supplied by regions 5, 6, 8 and 18, according to the optimum solution.

Total slaughter exceeded total consumption by 70,041 thousand pounds live weight in 1970. The optimum solution shows Minnesota (region 4) to be the region with the excess slaughter capacity in 1970.

Based on the assumptions of the model and the estimated transportation cost, the total cost of all interregional shipments of pork was

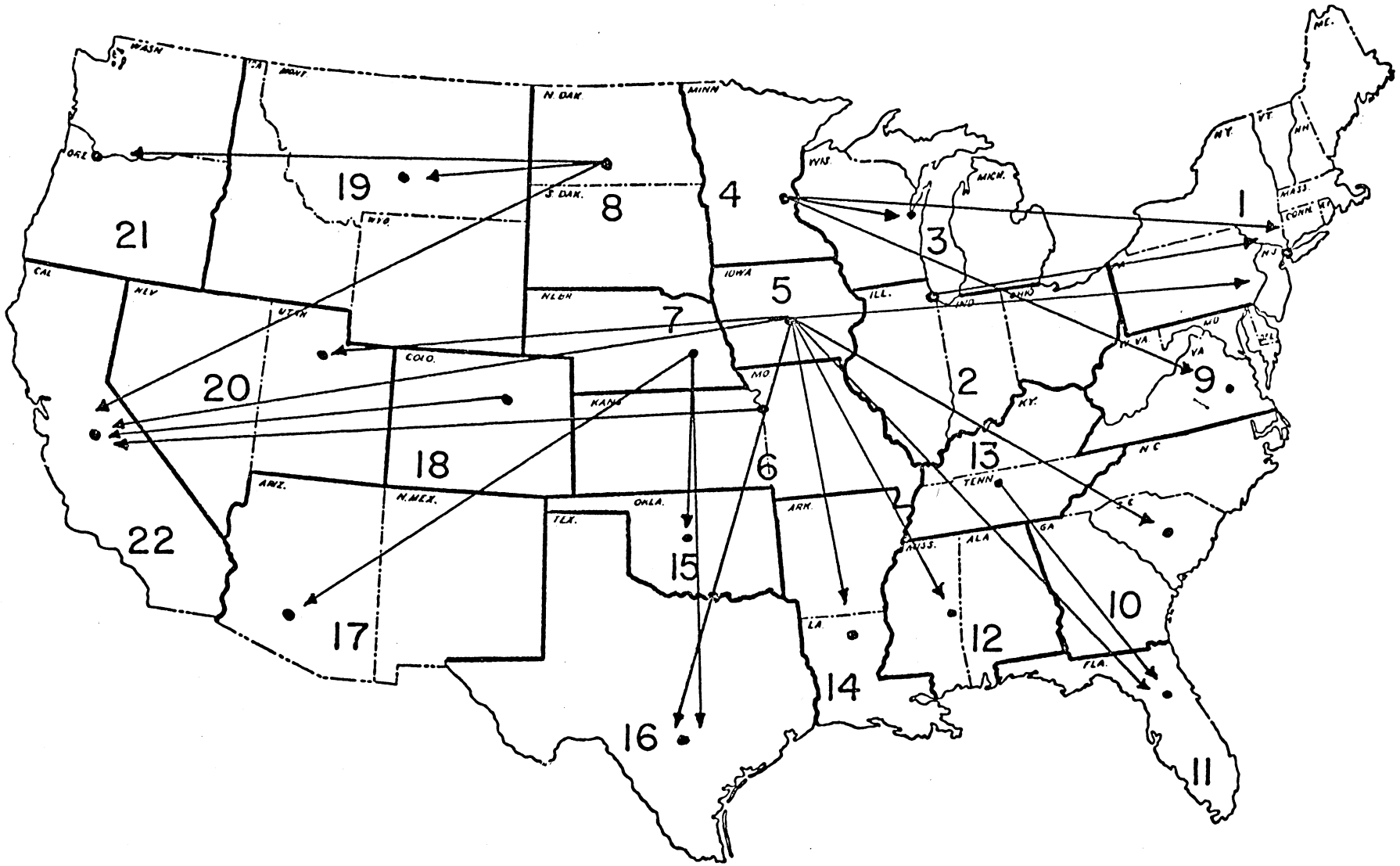

Figure 4. Optimum Shipment Pattern of Pork, 1970

TABLE 6

OPTIMUM SHIPMENTS OF PORK AND PRICE DIFFERENTIALS, 48 STATES, 1970

From: / To:	REGION 2	4	5	6	7	8	13	18	TOTAL	d_j[a]
	-1000 Pounds Live Weight Equivalent-									
1	293,384	513,517	2,645,182						3,452,083	12.60
3		5,318							5,318	1.88
9		375,030							375,030	7.51
10			361,755						361,755	11.48
11			206,991				407,714		614,705	14.51
12			114,991						114,991	8.23
14			447,293						447,293	8.43
15					28,028				28,028	5.29
16			346,112		276,009				622,121	10.42
17					183,472				183,472	14.73
19						38,459			38,459	6.98
20			113,364						113,364	11.79
21						284,795			284,795	15.86
22			836,364	350,610		214,595		23,991	1,425,560	20.05
TOTAL	293,384	893,865	5,072,052	350,610	487,509	537,849	407,714	23,991	8,066,974	
d_i[a]	1.28	-2.97	-2.17	0	-1.12	.19	4.51	4.40		

[a] Price differentials in dollars per 1000 pounds live weight equivalent.

approximately $119.9 million, making the total cost of shipping both live hogs and pork approximately $151.6 million. Pork shipments accounted for 79% of the total cost of shipping both live hogs and pork. The average cost of all pork shipments was $1.59 per hundred pounds of live weight equivalent while the average cost of shipping pork to Texas was approximately $1.21 per hundred pounds of live weight equivalent.

1975 Projections of Interregional Shipments

Two optimum solutions of interregional shipments of live hogs and pork were obtained for 1975. They were based on two projections of 1975 pork consumption. The same regional hog production and slaughter estimates were used in both solutions. The solutions were based on the excess and deficit data given in Table 5 and the estimated transportation rates. It was assumed that the transportation rates between regions will be of the same proportion in 1975 as they were in 1970. As a result, the transport cost functions were not changed for 1975 from those used in the 1970 solution.

In both 1975 solutions, aggregate consumption exceeded aggregate slaughter, therefore, the optimum solutions showed the regions that would not receive pork under such circumstances. In the 1975 optimum solution, approximately 4,108 million pounds of live hogs were involved in interregional trade. Interregional shipments of live hogs represented 20% to the total live weight of production and approximately 33% of total interregional shipments of both live hogs and pork.

The 1975 optimum distribution of live hogs is shown in Table 7. Major differences between the 1970 and 1975 optimum solutions for live hogs were (1) change of region 19 from an excess to a deficit region in live hogs, (2) change in the distribution pattern, and (3) considerable

TABLE 7
ESTIMATED OPTIMUM SHIPMENTS OF LIVE HOGS AND
PRICE DIFFERENTIALS, 48 STATES 1975

From: / To:	REGION 2	6	7	8	10	TOTAL	d_j [a]
	-1000 Pounds Live Weight-						
1	1,005,085					1,005,085	9.42
3	378,313					378,313	4.86
4	49,535		137,254	12,135		198,924	6.74
5		266,159				266,159	4.55
9	535,105				164,358	699,463	9.17
11					29,439	29,439	9.83
12		143,106				143,106	8.62
13	482,043					482,043	6.91
14		67,357				67,357	7.88
15		53,083				53,083	5.98
16		213,183				213,183	8.89
17		34,966				34,966	11.30
18			72,712			72,712	7.24
19				21,086		21,086	6.75
20				17,214		17,214	10.06
21				142,017		142,017	11.54
22		197,114		87,155		284,269	13.35
TOTAL	2,450,081	974,968	209,966	279,607	193,797	4,108,419	
d_i [a]	.08	0	.16	.08	3.06		

[a] Price differentials in dollars per 1000 pounds live weight.

changes in the volume shipped. Figure 5 shows a comparison of the optimum distribution patterns of live hogs for 1970 and 1975.

The 1975 optimum distribution of pork which is consistent with the lower estimate of per capita consumption is shown in Table 8. The use of the lower estimate of per capita consumption resulted in aggregate consumption exceeding aggregate slaughter by 795,079 thousand pounds live weight. To obtain a solution it was necessary to develop a "dummy" origin which was allowed to ship 795,079 thousand pounds to any deficit region at no cost. In the optimum solution, the "dummy" region shipped the entire 795,079 thousand pounds to California (region 22) which means that region 22 would not receive 795,079 thousand pounds live weight of its pork requirement because it is the most costly region to supply.

The only major difference in the first 1975 optimum pork distribution pattern and the 1970 pattern was that Colorado (region 18) changed from an excess pork region in 1970 to a deficit pork region in 1975. The new deficit region (region 18) was supplied by Nebraska (region 7). The region previously supplied by region 18, California (region 22), was not supplied completely in the 1975 solution based on the lower consumption estimate. All other routes remained the same as the 1970 routes with the only changes being in the volume of shipments. A total of approximately 8,374 million pounds live weight of pork was involved in the interregional shipment for the 1975 optimum solution when the lower estimate of per capita consumption was used. This represented 41% of the total projected slaughter of 1975.

Table 9 shows the optimum flows of pork obtained by using the higher estimate of per capita consumption for 1975. Due to the fact

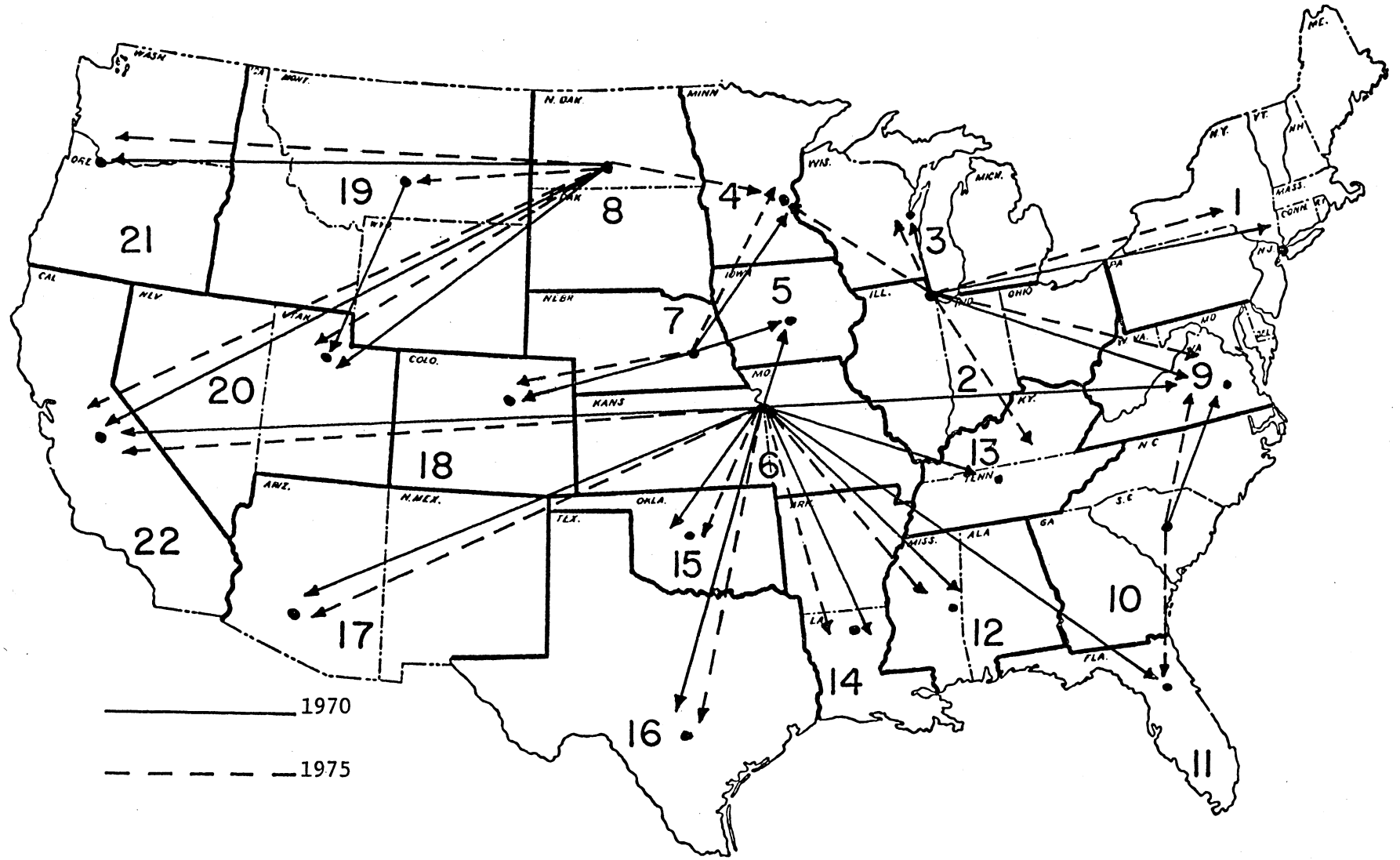

Figure 5. Comparison of Optimum Flows of Live Hogs in 1970 and 1975

TABLE 8

ESTIMATED OPTIMUM SHIPMENTS OF PORK, BASED ON LOW CONSUMPTION ESTIMATE[a], AND PRICE DIFFERENTIALS, 48 STATES, 1975

From: / To:	REGION 2	4	5	6	7	8	13	Dummy	TOTAL	d_j[b]
	- 1000 Pounds Live Weight Equivalent -									
1	3,625	367,410	3,170,374						3,541,409	22.31
3		231,226							231,226	11.59
9		403,057							403,057	17.22
10			439,495						439,495	
11			154,228				503,554		657,782	24.23
12			149,663						149,663	17.95
14			515,545						515,545	18.15
15					116,884				116,884	15.00
16			214,473		174,328				715,801	20.14
17					110,858				110,858	24.45
18					51,178				51,178	16.01
19						34,563			34,563	16.69
20			122,924						122,924	21.51
21						259,179			259,179	25.57
22			220,727	488,639		214,777		795,079	1,719,222	29.77
TOTAL	3,625	1,001,693	5,014,429	488,639	853,248	508,519	503,554	795,079	9,168,786	
d_i[b]	10.92	0	3.00	9.72	8.44	9.83	7.32	29.77		

[a] 99.15 pounds of live weight or 63.7 pounds of pork per capita

[b] Price differentials in dollars per 1000 pounds live weight equivalent

TABLE 9

ESTIMATED OPTIMUM SHIPMENTS OF PORK, BASED ON HIGH CONSUMPTION ESTIMATE [a], AND PRICE DIFFERENTIALS, 48 STATES, 1975

From: / To:	REGION 4	5	6	7	8	13	Dummy	TOTAL	d_j [b]
	-1000 Pounds Live Weight Equivalent-								
1	102,346	4,096,330					210,961	4,409,637	22.31
2		231,116						231,116	13.22
3	341,833							341,833	11.59
9	526,431							526,431	17.22
10		135,893				436,973		572,866	21.20
11							724,417	724,417	22.31
12		204,987						204,987	17.95
14		323,749	244,730					568,479	18.15
15				139,076				139,076	14.79
16			178,532	643,837				822,369	19.92
17							235,136	235,136	22.31
18				56,825	12,361			69,186	15.80
19					48,033			48,033	12.93
20					135,422			135,422	13.72
21					299.611			299.611	21.81
22							1,901.790	1,901,790	22.31
TOTAL	970,610	4,992,075	423,262	839,738	495,427	436,973	3,072,304	11,230,389	
d_i [b]	0	3.00	9.44	8.22	6.07	8.05			

[a] 109.89 pounds of live weight or 70.6 pounds of pork per capita

[b] Price differentials in dollars per 1000 pounds live weight equivalent

that the estimates of live hog production and slaughter and pork consumption for 1975 were obtained independent of each other by extending the 1950-69 linear trend, the use of the higher per capita consumption estimate of pork - 70.6 pounds of pork - resulted in a deficit in production of 3,072 million pounds live weight for the 48 states. Due to this large estimated deficit in pork production, region 1 would receive only part of its total pork consumption requirement, and regions 11, 17 and 22 would receive none of their pork consumption requirements, based on the optimum solution. Such an outcome is however, not expected to occur in reality due to adjustment of prices which will alter projected flow of pork among regions. Use of the higher estimate of 1975 pork consumption involved an estimated 8,158 million pounds live weight equivalent of pork in interregional shipments.

The major change in the 1975 optimum solution based on the higher pork consumption estimate was that region 2 changed from an excess pork region to a deficit pork region. As a deficit pork region, region 2 would receive pork from region 5 (Iowa). The higher consumption estimate resulted in several route changes in pork shipments and in changes in the volume of pork shipped as shown in Figure 6.

The optimum solution based on the lower pork consumption estimate indicated that Texas (region 16) should receive pork from regions 5 and 7 while the optimum solution based on the higher pork consumption estimate indicated Texas should receive pork from regions 6 and 7.

REGIONAL COMPETITIVE POSITION

A region's competitive position was determined by its location relative to hog production, slaughter, and consumption centers and by its relative cost of production.

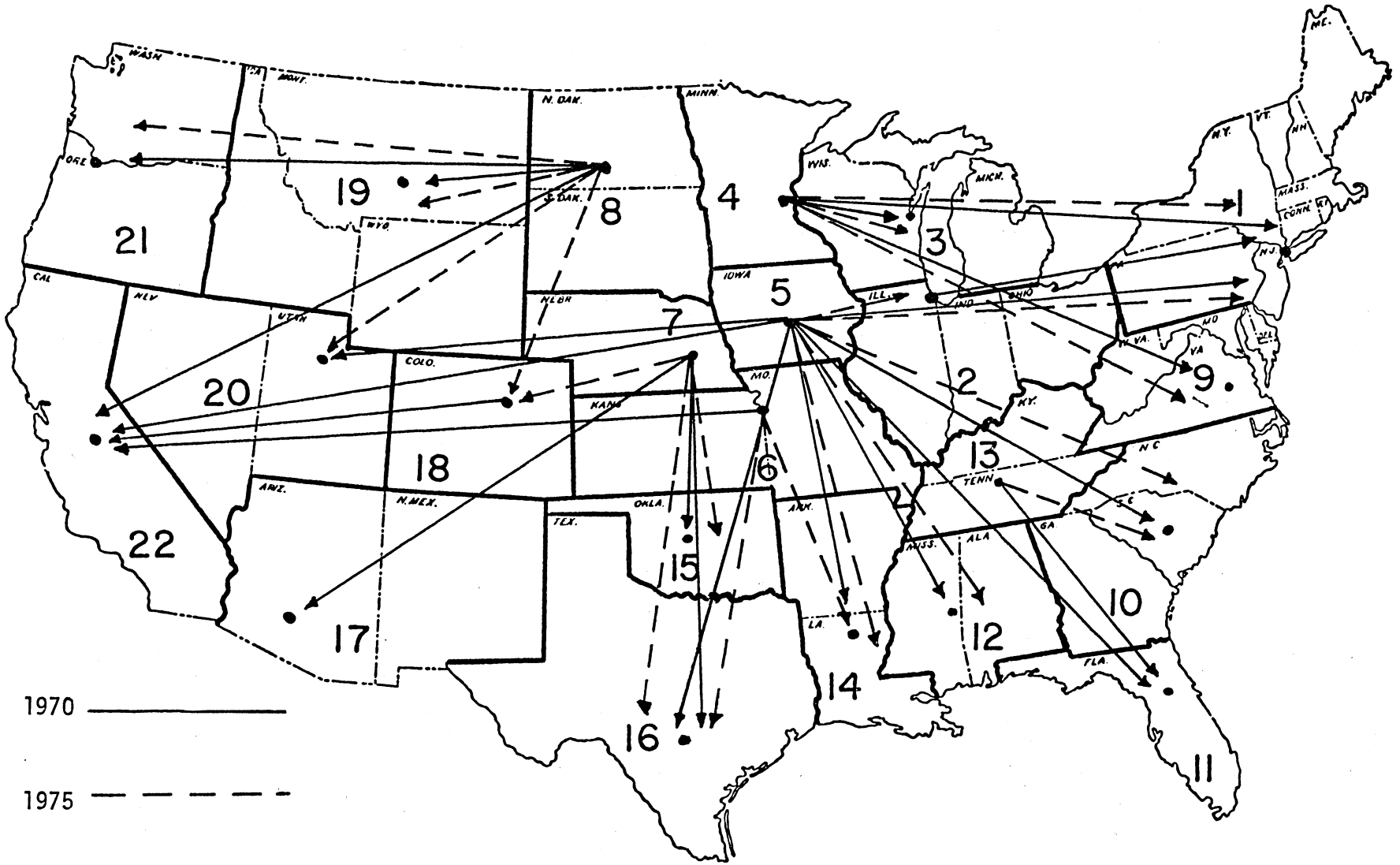

Figure 6. Comparison of Optimum Flows of Pork in 1970 and 1975

Regional Cost of Production

In estimating relative regional cost of hog production it was assumed that all regions used similar technology of production and incurred some costs of production except for the costs of feed grains which showed wide variation between regions. Feed grains account for an estimated one-third of the total cost of hog production; therefore, one-third of regional weighted average price of corn and sorghum was used to measure the relative regional costs of hog production and the regional production cost differentials using region 6 (Kansas and Missouri) as the base region. Region 6 was selected as the base region because of its central location and a large volume of surplus live hogs. The regional production cost differentials are shown in Table 10.

Regional Price Differentials

The optimum solution for the interregional flow of live hogs and pork provided regional price differentials - a measure of competitive position of regions in live hog production, slaughter or both. The first set of price differentials were obtained using only transportation costs of shipping live hogs or pork between regions ignoring the regional hog production cost differentials. The second set of price differentials were obtained using both transportation costs and regional production cost differentials.

The price differentials for the regions with excess live hogs represent the magnitudes of the competitive advantages which these regions have over the base region, region 6, in supplying live hogs to deficit regions. The price differentials for the regions with live hog deficit represent the delivered price of live hogs to these regions relative to the base region, region 6. For example, the live hog price

TABLE 10

WEIGHTED AVERAGE PRICE RECEIVED BY FARMERS FOR CORN AND GRAIN SORGHUM AND LIVE HOG PRODUCTION COST DIFFERENTIALS BY REGIONS, 1970

Region	Price Received			Production Cost[1]	Production Cost Differential[2]	Live Hog Price Differential	Combined Price Differential
	Corn	Sorghum	Average				
1	2.72	NA[3]	2.72	.90	1.50	10.99	9.49
2	2.52	1.94	2.52	.83	.80	1.65	.85
3	2.44	NA	2.44	.81	.60	6.44	5.84
4	2.18	NA	2.18	.72	-.30	6.59	6.89
5	2.34	1.86	2.34	.77	.20	4.55	4.35
6	2.45	1.97	2.26	.75	0	0	0
7	2.29	1.89	2.22	.73	-.20	.01	.21
8	2.19	1.82	2.16	.73	-.40	.08	.48
9	2.65	2.05	2.65	.87	1.20	10.74	9.54
10	2.81	2.44	2.80	.92	1.70	4.63	2.93
11	2.77	NA	2.77	.91	1.60	11.37	9.77
12	2.81	2.26	2.67	.88	1.30	8.62	7.32
13	2.78	2.14	2.77	.91	1.60	7.57	5.97
14	2.62	2.00	2.22	.73	-.20	7.88	8.08
15	2.36	2.02	2.08	.69	-.60	5.99	6.59
16	2.52	2.02	2.06	.68	-.70	8.89	9.59
17	2.71	2.24	2.26	.75	0	11.30	11.30
18	2.32	1.98	2.23	.74	-.10	7.09	7.19
19	2.53	NA	2.53[4]	.83	.80	2.29	1.49
20	NA	NA	2.41[4]	.80	.50	10.06	9.56
21	2.86	NA	2.86	.94	1.90	11.54	9.64
22	2.84	2.59	2.69	.89	1.40	13.35	11.95
48 States	2.43	2.04	2.37	.78	.30		

[1] Price of feed grains account for an estimated 33% of the production cost of live hogs

[2] Region 6 was selected as the base region

[3] Not Available

[4] Calculated by using region 22 (California) price ratio.

differential of $5.99 per thousand pounds for region 15 (Oklahoma), which is a live hog deficit region, shows that the delivered price of live hogs to the region was $5.99 higher than the price of hogs in the base region.

Region 10 had the highest competitive advantage of all regions with excess live hogs in 1970 due to its proximity to the regions with live hog deficits on the East. Region 19 (Idaho, Montana, and Wyoming) had the highest competitive locational advantage in providing live hogs to the regions in the West.

The delivered price of hogs relative to region 6 ranged from a low of $4.55 in region 5 to a high of $13.35 in region 22. In general, the deficit regions on the West and East coasts had the highest price differentials while the deficit regions adjoining surplus regions had the lowest delivered prices relative to region 6. Of the sixteen deficit regions, Texas (region 16) ranked eighth with a price differential of $8.89.

The pork price differentials of the excess pork regions consistent with the 1970 optimal solution ranged from $2.97 in region 4 to $4.51 in region 13. Region 4 (Minnesota) with the lowest pork price differential had the greatest locational disadvantage. Region 13 (Kentucky and Tennessee) had the highest locational advantage for shipping pork to deficit regions. The high pork price differential of region 13 was due to its proximity to the deficit pork regions of the East coast while region 18 (Colorado) has a high pork price differential due to its locational advantage for shipping pork to the West coast. The relative delivered prices of pork in the deficit pork regions varied from a low of $1.88 in region 3 (Wisconsin and Michigan), which is surrounded by excess pork regions, to a high of $20.05 in region 22 (California) which

is located the farthest from the excess pork regions of the Midwest.

Texas (region 16) had the eighth highest pork price differential of the fourteen deficit pork regions in 1970. The pork price differential for Texas is $10.42 per thousand pounds live weight.

The optimum shipment pattern of live hogs for 1970 based on the combined transportation costs and production costs was the same as the optimum shipment pattern of live hogs shown in Table 5 which was based on transportation costs only indicating that the production cost differentials were too small to alter the optimum shipment pattern of live hogs. However, inclusion of the regional production cost differentials with transportation costs increased the competitive position of regions with relatively low production costs and made the regions with relatively high production costs less competitive. Texas (region 16) had the lowest production cost differential and therefore became more competitive. As shown in Table 10, Texas had a production cost differential of -$0.70 per 1000 pounds live weight meaning that Texas could produce 1000 pounds of live hogs for $0.70 less than region 6 (Kansas and Missouri), the base region. Regions 4, 7, 8, 14, 15, 16 and 18 had production cost differentials less than the base region (region 6). All other regions had production costs greater than or equal to the production costs in region 6.

Marginal Values

The marginal values were computed by utilizing a cost-minimizing linear-programming model to analyze the changes in aggregate transport cost resulting from a change in regional levels of production, slaughter, and/or production. Marginal values of any two regions can be compared to obtain an indication of the relative profitability of shifting a marginal unit -- 1,000 pounds live weight or equivalent -- of an activity

from one region to another. Regions with existing excess live hogs have zero marginal values for increased production because an increase in production would only add to the region's existing excess live hogs.

The regional marginal values consistent with the 1970 optimum solution are shown in Table 11. Region 22 (California) showed the highest level of Marginal value ($13.35 per 1,000 pounds of live weight) for increased production indicating that an increase of live hog production in California, assuming that the necessary resources for increased production are available, would reduce the aggregate total transfer cost of live hogs among regions by $13.35 per marginal unit up to a point. Region 10 (N. Carolina, S. Carolina, and Georgia), on the other hand, showed marginal value of $21.05 for increased slaughter activity. Such a high marginal value for Region 10 is due to the fact that the region had an excess live hogs, in relation to existing slaughter activity in the region, but insufficient pork production to meet consumption requirements. Thus, increased slaughter activity of the region would eliminate the necessity of shipping out excess live hogs to other regions for slaughter then import pork to satisfy the region's consumption.

COMPETITIVE POSITION OF TEXAS

According to the model and the optimum solution using the 1970 data, Texas (Region 16) ranked third in combined price differentials with $9.59 per 1,000 pounds live weight -- $0.70 in production cost differential and $8.89 in live hog price differential, (Table 10). Region 22 (California) and region 17 (Arizona and New Mexico) showed higher price differentials with $11.95 and $11.30 respectively than Texas. The production cost differential of $0.70 per 1,000 pounds for Texas was the highest of all regions reflecting the advantage which Texas has over all other regions

TABLE 11

MARGINAL VALUES RESULTING FROM INCREASES IN REGIONAL PRODUCTION, SLAUGHTER, AND PRODUCTION AND SLAUGHTER, 1970

Region	Production Only	Slaughter Only	Production and Slaughter
	- Dollars Per 1000 Pounds Live Weight or Equivalent -		
1	10.99	11.17	22.16
2	1.65	9.20	10.85
3	6.44	5.00	11.44
4	6.59	0	6.59
5	4.55	2.85	7.40
6	0	9.56	9.56
7	.01	8.43	8.44
8	.08	9.67	9.75
9	10.74	6.33	17.07
10	4.63	21.05	25.68
11	11.37	12.71	24.08
12	8.62	9.18	17.80
13	7.57	6.51	14.08
14	7.88	10.12	18.00
15	5.99	8.87	14.86
16	8.89	11.10	19.99
17	11.30	13.00	24.30
18	7.09	6.88	13.97
19	2.29	14.25	16.54
20	10.06	11.30	21.36
21	11.54	13.88	25.42
22	13.35	16.27	29.62

in production of live hogs. The production cost differential for Texas was due primarily to low feed grain prices.

Marginal values for Texas were found to be $8.89 and $11.10 per 1,000 pounds for increased live hog production and increased slaughter activities respectively. The combined marginal value of $19.99 was the seventh highest among the 22 regions.

High price differentials and marginal values for Texas indicates that Texas has very strong competitive advantages in both increased hog production and increased slaughter activities. The competitive advantages of Texas were analyzed further by artificially increasing the levels of production, slaughter or both activities above the estimated 1970 level in Texas while holding the production and slaughter activities of all other regions at estimated 1970 levels then studying the resulting marginal values and optimum flow routes of live hogs and pork among the 22 regions.

Increased Live Hog Production

The changes in optimum flows and marginal values resulting from selected increases in Texas hog production are shown in Table 12.

In 1970, Texas hog slaughter exceeded Texas production by an estimated 124 million pounds live weight equivalent. In the optimum solution, the deficit was supplied by region 6 (Kansas and Missouri). Increased hog production of 124 million pounds in 1970 in Texas above the 1970 production level would have made Texas self-sufficient in relation to existing slaughter activity. Such an increase would have reduced the total cost of transportation, consistent with optimum solution, by $8.89 per 1,000 pounds for a total reduction of about $1,102,000.

Further increases of hog production in Texas would have made Texas an excess live hog region in which case the region would compete with other

TABLE 12

MARGINAL VALUES AND ROUTING CHANGES CORRESPONDING TO SELECTED INCREASES IN LIVE HOG PRODUCTION, TEXAS, 1970

Increase in Texas Hog Production	Total Increase In Texas Production	Marginal Value of Texas Production	Routing Changes	
			Old Route	New Route
- 1000 Pounds Live Weight -		- Dollars Per 1000 Pounds -		
123,922	123,922	8.99	6 16	16 16
24,323	148,245	1.25	6 17	16 17
9,506	157,751	.72	6 14	16 14
301,706	459,457	.50	6 22	16 22
33,386	492,843	.43	8 22	16 22
38,532	531,375	.20	6 11	16 11
14,597	545,972	.02	6 12	16 12

excess live hog regions to supply deficit live hog regions. According to the optimum solution, the first 24,323 thousand pounds of excess live hogs produced in Texas should be shipped to region 17 (New Mexico and Arizona) replacing the shipment from region 6 to region 17. Based on the estimated transportation costs and the assumptions of the model, the total cost of transportation would be reduced by $1.25 for each thousand pounds live weight shipped from Texas to region 17 instead of from 6 to region 17. An additional live hog increase of 9,506 thousand pounds in Texas would be shipped to region 14 (Arkansas and Louisiana) with a corresponding reduction in the total cost of transportation of $0.72 per thousand pounds. Live hog shipments from Texas to region 14 would replace shipments from region 6 to region 14. The next 301,706 thousand pounds of hogs produced in Texas would be shipped to region 22 (California) replacing the shipment from region 6 to region 22 at a reduction in the total cost of transportation of $0.50 per thousand pounds live weight. The next 33,386 thousand pounds of hogs produced in Texas would also be shipped to region 22 replacing the shipment from region 8 (North Dakota and South Dakota) to region 22 at a reduction in the total cost of transportation of $0.43 per thousand pounds. Still greater increases in Texas live hog production would result in shipments of 38,532 thousand pounds and 14,597 thousand pounds from Texas to regions 11 (Florida) and 12 (Mississippi and Alabama) respectively with shipments from region 6 to regions 11 and 12 being replaced. The corresponding reductions in the total transport cost would be $0.20 and $0.02 per thousand pounds live weight. On the basis of transportation costs only, additional increases in Texas hog production would accumulate as an excess in Texas which would not be shipped to any other region.

If regional production cost differentials are considered in conjunction

with the transportation costs, then Texas becomes more competitive in live hog production. Based on 1970 feed grain prices, Texas had the lowest production costs of all regions which was $0.70 per thousand pounds live weight lower than the production costs of region 6. Therefore, for Texas to produce enough hogs to fulfill its own slaughter requirements in 1970 rather than import hogs from region 6, would have resulted in a savings of $8.89 per thousand pounds in transportation cost plus an additional reduction in production cost of $0.70 per thousand pounds giving Texas a total advantage of $9.59 per thousand pounds live weight over region 6 in supplying its own live hog requirements. Any shipment from Texas which replaces a shipment from region 6 would reduce the cost of production by $0.70 per thousand pounds live weight. When the combined effects of transportation costs and production costs are considered all marginal values in Table 12 would increase by $0.70 except when Texas replaces region 8 in shipments to region 22. In this case the increase in marginal value would be only $0.30.

An additional 33.5% live weight hog production in Texas would have been required for Texas to have fulfilled its own live hog requirements in 1970. An additional 545,972 thousand pounds, or 248% of 1970 Texas hog production would have been required for Texas to have supplied its own live hog requirements plus the requirements of regions 11, 12, 14, 17 and 22 in 1970.

Increased Slaughter Activity

In 1970, Texas pork consumption exceeded Texas slaughter by approximately 622,121 thousand pounds live weight equivalent. Based on the optimum solution for 1970, Texas would import pork from regions 5 and 7 to fulfill the deficit. Selected increases were made in the

volume of Texas slaughter in 1970 to determine what effects these increases would have had on the optimum distribution patterns of live hogs and pork. The volume of slaughter in Texas was the only variable allowed to change; production and consumption in Texas, and production, slaughter, and consumption in all other regions were assumed to remain constant at their 1970 levels.

As Texas slaughter capacity increases and approaches the state's consumption level, less pork imports are required. However, more live hogs are required to supply the increased slaughter capacity of the state. Therefore, assuming no change in Texas live hog production, each one-thousand pound increase in Texas slaughter capacity requires an equal increase in Texas live hog imports.

The larger requirements for live hogs resulting from an increase in slaughter capacity causes an increase in the total cost of transportation; however, the increase in cost is more than offset by the savings resulting from the smaller amount of pork shipped into Texas. Table 13 shows the gross marginal value which is the reduction in the total cost of transportation resulting from each 1000 pound decrease in the amount of pork shipped into Texas. The increased costs column shows the increase in the total cost of transportation resulting from each 1000 pound increase in the amount of live hogs shipped into Texas. The net marginal value is the net reduction in the total cost of transportation incurred by each 1000 pound increase in Texas slaughter capacity when there is no change in the level of production or consumption in Texas and no change in the levels of production, slaughter, or consumption in any other region.

According to the model, each 1000 pound increase in Texas slaughter in 1970 would have caused an equal increase in the excess slaughter capacity of region 4 (Minnesota) until a total excess slaughter capacity

TABLE 13

SELECTED INCREASES IN SLAUGHTER CAPACITY AND RESULTING GROSS MARGINAL VALUE, INCREASED COSTS, AND NET MARGINAL VALUE FOR SLAUGHTER CAPACITY, TEXAS, 1970

Increase in Texas Slaughter (Live Hog Imports)	Total Increase in Texas Slaughter	Marginal Values for Slaughter Capacity at Selected Levels of Slaughter		
		Gross Marginal Value	Increased Costs	Net Marginal Value
66,282	66,282	19.99	8.89	11.10
9,152	75,434	19.97	8.89	11.08
60,889	136,323	17.13	8.89	8.24
8,469	144,792	17.13	9.00	8.13
24,323	169,115	17.13	9.14	7.99
77,484	246,599	17.13	9.32	7.81
99,513	346,112	17.13	9.34	7.79
193,724	539,836	17.12	9.34	7.78
60,164	600,000	17.12	9.46	7.66

of 145,475 thousand pounds is accumulated in region 4. An increase of more than 145,475 thousand pounds in Texas slaughter would have created excess slaughter capacity in region 5 (Iowa). This continued to the total increase considered in Texas slaughter which was 600,000 thousand pounds live weight. The increased live hog requirements of Texas which would be caused by increased slaughter capacity in Texas in 1970 would be supplied by region 6 (Kansas and Missouri) and region 7 (Nebraska) according to the model. Of the 600,000 thousand pounds of hogs needed to supply the increase in Texas slaughter capacity, the first 539,836 thousand pounds should be supplied by region 6 with the remaining 60,164 thousand pounds to be supplied by region 7.

An increase of 126% in Texas slaughter capacity would have been required for Texas to have supplied its own pork consumption requirements in 1970. In the selected increases used in this study, Texas slaughter was not increased enough to make Texas an excess pork region.

A simultaneous and equal increase in Texas production and slaughter would have resulted in relatively large marginal values until Texas was no longer a deficit region. The gross marginal values of Table 13 show the reductions in the total transport cost per 1000 pounds of simultaneous and equal increases in both production and slaughter in Texas. If production was increased simultaneously and equally with slaughter, then there would have been no increased cost because Texas would not have to import more live hogs to meet the increased slaughter capacity.

The marginal values for Texas can be compared with the marginal values in other regions to determine the change in the total transportation cost that would have resulted from shifting a marginal unit of production or slaughter from any region to Texas. For example, a decrease

in production of 1000 pounds in region 5 (Iowa) would have increased the total cost of transportation by $4.55 as shown in Table 11. However, an equal increase in Texas production would have reduced the total cost of transportation by $8.89. Therefore, a shift in production from region 5 to Texas would have resulted in a net reduction in the total cost of transportation of $4.34 per 1000 pounds. Similarly, a decrease in production in region 2, 3, 4, 5, 6, 7, 10, 12, 13, 14, 15, 18 or 19 coupled with an increase in Texas production would have reduced the total cost of transportation. Also, the total transport cost could have been reduced by shifting slaughter facilities from region 2, 3, 4, 5, 6, 7, 8, 9, 12, 13, 14, 15 or 18 to Texas. A shift in slaughter from any other region to Texas would have increased the total cost of transportation.

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