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An analysis of structural and geographic shifts in U.S. pork and feeder beef production

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ABSTRACT

Changes in the size distribution and regional location of pork and feeder beef production in the United States could have substantial impacts on the production of those livestock commodities by the year 2000. Historical data indicate that shifting size distributions and regional production proportions have had tremendous impacts on regional pork and feeder beef farm numbers and costs of production. Similar shifts will continue to occur in the future.

This study analyzes possible pork and feeder beef cattle farm-size distributions in the year 2000. Specifically, five scenarios involving farm-size distributions and regional production percentages are developed in an attempt to ascertain regional and national farm numbers, costs of production, and comparative efficiencies for the year 2000.

CHAPTER I. INTRODUCTION

The Problem

Over the past 20 years, many changes have taken place in the structure of livestock production in the United States. As a result, the composition of inputs required in the livestock production process has also undergone significant change. This has led to many unanticipated problems for the infrastructures that support the various livestock industries in specific areas, as livestock farms have increased in average size and concentrated in fewer areas of the United States. This fact has also been the cause for increasing concern by policy makers in rural areas concerned with preserving the "family farm" in their political territories.

As early as the late 1960s, many agricultural economists were becoming aware of just how significant the changes in United States livestock production could be. As profit margins in livestock farming dwindled, costs of farm labor soared, and capital requirements multiplied, it became obvious that major shifts in many aspects of agricultural production were forthcoming (Ball and Heady, 1972).

Probably the most obvious change in livestock production over the last 20 years has occurred in the production of grain-fed beef. Today, industrialized commercial beef feedlot operations dominate in the production of grain-fed beef, with less than 450 of these "farms" accounting for more than one-half of the national production of grain-fed beef (Schertz, 1979).

Regional production

As pointed out in a recent assessment of future agricultural resources, however, the changes that have been occurring, and will continue to occur in the future within other types of livestock production, are not as obvious. This is because such changes, especially regional shifts in the production of such land-based livestock production activities as cow-calf operations and (to a lesser extent) farrow-to-finish pork operations, do not come in the form of major or rapid shifts, but only as gradual adjustments over time (Fontenot, 1984).

An analysis of past U.S. Agricultural Census data tends to support this observation. Tables 1 and 2 show how the national production of feeder beef cattle and pork have been distributed between the nine U.S. Agricultural Census Divisions (Figure 1) over the last four Census reports. Interestingly, proportional production of feeder cattle has remained fairly constant between census divisions since 1969, with only small relative decreases in the proportions of total United States production occurring in the West South Central Division and small relative increases in the proportionate production in the Pacific Division. Other dimensions have had small fluctuating changes in proportion between census reports or relatively minor changes in proportion since 1969.

By contrast, Table 2 shows that the changes in proportionate production of pork by census division have been more consistent since 1969, with the West North Central Division's share of national production

Table 1. U.S. Department of Agriculture Census Division percentages of national feeder beef cattle production for 1969-1982

Region	Percentage of national production (1969)	(1974)	(1978)	(1982)
New England	0.97	0.85	0.93	0.95
Middle Atlantic	4.11	3.68	4.05	4.15
East North Central	11.08	10.26	10.50	10.51
West North Central	27.18	27.32	26.92	26.46
South Atlantic	8.30	8.92	8.95	9.10
East South Central	9.60	10.44	9.25	8.94
West South Central	20.61	20.01	20.36	19.94
Mountain	12.11	12.25	12.43	12.81
Pacific[a]	6.05	6.27	6.61	7.12
U.S. production[b]	45,511,356	51,912,414	44,445,284	44,985,290

[a]Excluding Alaska and Hawaii.

[b]Based on census data on the number of cows and heifers that have calved.

Table 2. U.S. Department of Agriculture Census Division percentages of national pork production for 1969-1982

Region	Percentage of national production			
	(1969)[a]	(1974)	(1978)	(1982)
New England	0.12	0.10	0.10	0.08
Middle Atlantic	0.98	0.18	1.58	1.82
East North Central	30.60	27.57	26.42	27.13
West North Central	50.76	52.97	52.82	53.68
South Atlantic	7.86	8.39	9.33	8.97
East South Central	5.27	4.66	4.81	4.02
West South Central	2.47	2.71	2.63	2.11
Mountain	1.32	1.72	1.69	1.61
Pacific[b]	0.62	0.70	0.63	0.60
U.S. production[c]	N/A	66,730,709	71,204,875	74,675,363

[a]Assumes same percentage of total numbers are feeder pigs as reported in the 1974 Census, since no disaggregation occurred in the 1968 Census data.

[b]Excluding Alaska and Hawaii.

[c]Based on census data or number of hogs sold, excluding feeder pigs.

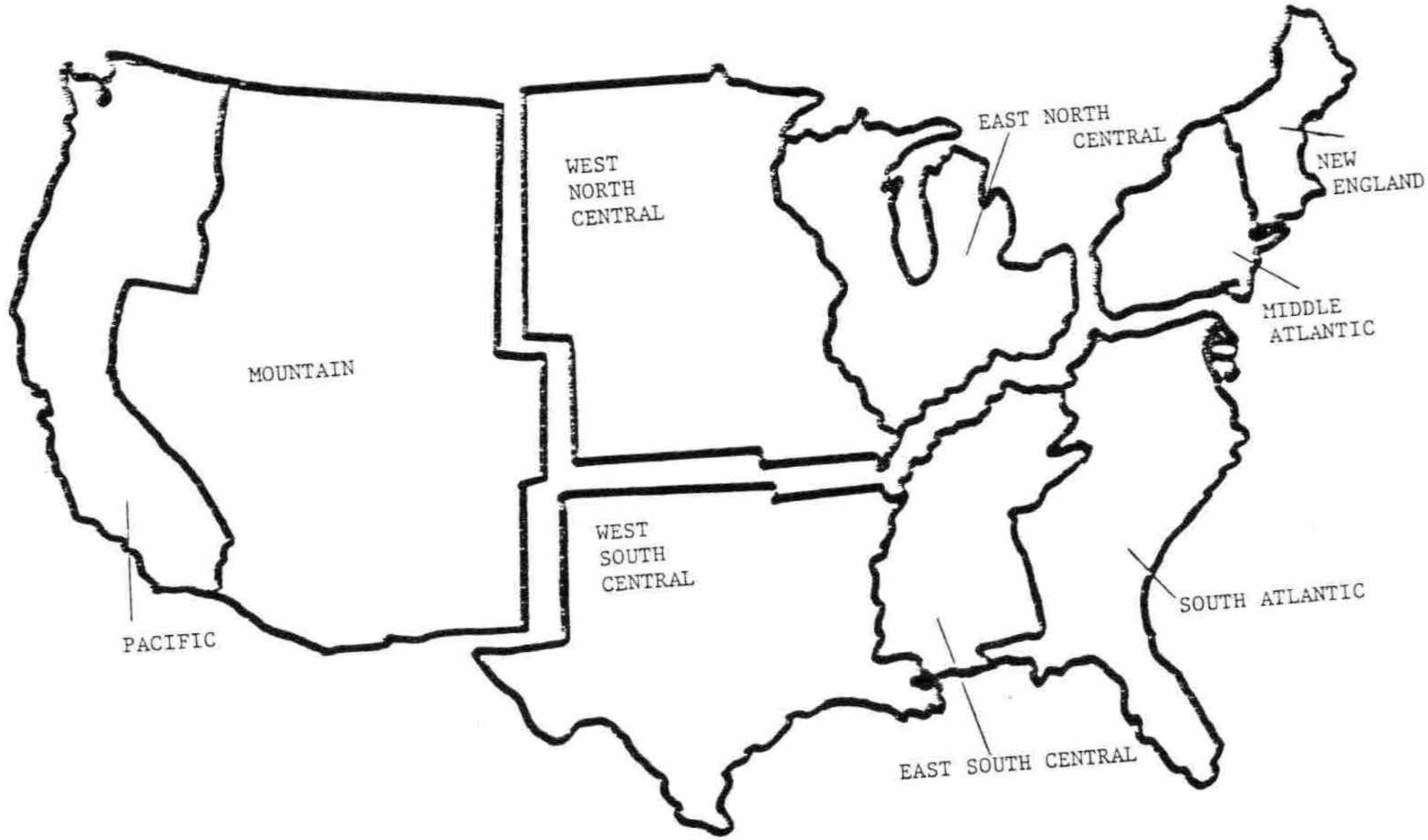

Figure 1. The nine U.S. agricultural census divisions

increasing by 3 percent at the expense of the East North Central Division. Other divisions seem to be experiencing decreasing proportionate shares of national pork production, with the exception of the South Atlantic Division, which has shown minimal increases.

Farm numbers

In contrast to the slow, but gradual, shifts in the regional production distribution of feeder beef cattle and pork, is the rate at which regional farm size distributions have been changing over the past 20 years. Trends towards larger and more cost efficient feeder beef and pork producing farms in almost all census divisions have led to substantial decreases in farm numbers. Tables 3a and 3b show how farm numbers in each of the census divisions producing significant quantities of feeder beef cattle (3a) and pork (3b) have changed since 1969.

Overall farm numbers among the seven significant feeder beef producing divisions were down 17 percent below 1969 farm numbers in 1982, with the East North Central Division showing the largest drop (27 percent below 1969 numbers). It should be noted, that feeder beef farm numbers in 1982 were slightly higher than the respective numbers in 1969 for the South Atlantic Division. But, the 1982 farm numbers in the South Atlantic Division still show a decreasing trend in farm numbers when compared to 1974 and 1979 census data.

Table 3b shows that the number of farms producing pork has declined even more rapidly. Total farm numbers reported in the 1982 Census of Agriculture for the six significant pork producing divisions were less

Table 3a. Changes in total number[a] of feeder beef producing farms between 1969 and 1982 census reports

Aggregated region	Number of farms by census report year (1969)	(1974)	(1978)	(1982)
East North Central	157,637	149,753	124,958	115,499
West North Central	297,834	286,389	243,236	223,855
South Atlantic	73,823	88,120	78,274	74,506
East South Central	117,498	133,347	110,933	103,221
West South Central	180,613	177,292	176,052	162,673
Mountain	53,491	54,567	49,974	47,729
Pacific	28,256	29,837	27,742	26,612

[a]Excluding those farms producing less than 10 feeders per year.

Table 3b. Changes in total number[a] of pork producing farms between 1969 and 1982 census reports

Aggregate region	Number of farms by census report year (1969)	(1974)	(1978)	(1982)
East North Central	142,285	96,526	87,442	66,278
West North Central	243,334	180,436	168,492	127,290
South Atlantic	66,508	44,070	51,352	27,277
East South Central	64,674	37,780	45,895	23,547
West South Central	28,438	15,343	21,502	10,059
Mountain	10,496	7,379	8,618	5,123

[a]Excluding those farms producing less than 10 hogs per year.

than one-half the total number reported in the 1969 census. The two census divisions responsible for the majority of pork production in this country (Table 2) experienced declines in farm numbers of 53.4 percent (East North Central) and 47.7 percent (West North Central) between 1969 and 1982.

Regional size distributions

As mentioned above, a major reason for the decline in farm numbers has been the trend towards larger farm units. Tables 4a-4g show how the distribution of feeder beef producing farms by size has changed over the last five census reports for each of the census divisions with significant feeder beef cattle production. Tables 4a-4d show that there are relatively few feeder beef farms producing more than 200 feeder cattle per year in the East North Central, West North Central, South Atlantic, and East South Central divisions. It is also clear that the relative number of farms producing 200 or more feeder cattle per year in those divisions has not changed substantially over the last 20 years. The more revealing results from Tables 4a-4d, however, are the substantial shifts in the relative percentages of small farms (10-49 head) and medium farms (49-199 head) over the last 20 years. This shift is most pronounced in the East North Central Division, where a 20 percentage point decline in small feeder beef farms has been accommodated by a similar increase in percentage points by medium-sized feeder beef producing farms. Similar shifts from small to medium-sized feeder beef farms have occurred in the West North Central Division and, to a lesser extent, in the South Atlantic and East South Central divisions.

Table 4a. Historical feeder beef farm number percentages by size in the East North Central Division

Number of feeder cattle produced	Percentage of total feeder cattle farms in the region				
	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	94.036	88.026	82.298	79.241	74.866
49-199	5.703	11.809	17.307	20.276	24.506
200-500	0.239	0.152	0.369	0.441	0.5706
> 500	0.0224	0.0133	0.0267	0.0424	0.05714
	100	100	100	100	100

Table 4b. Historical feeder beef farm number percentages by size in the West North Central Division

Number of feeder cattle produced	Percentages of total feeder cattle farms in the region				
	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	82.444	78.294	69.562	70.386	67.117
49-199	16.271	20.253	28.057	27.140	29.895
200-500	1.108	1.276	2.103	2.140	2.595
> 500	0.177	0.178	0.278	0.333	0.394
	100	100	100	100	100

Table 4c. Historical feeder beef farm number percentages by size in the South Atlantic Division

Number of feeder cattle produced	Percentage of total feeder cattle farms in the region				
	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	84.733	78.581	76.306	77.677	76.350
50-199	13.236	18.883	20.698	19.272	20.398
200-500	1.456	1.878	2.267	2.277	2.468
> 500	0.574	0.658	0.729	0.774	0.784
	100	100	100	100	100

Table 4d. Historical feeder beef farm number percentages by size in the East South Central Division

Number of feeder cattle produced	Percentage of total feeder cattle farms in the region				
	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	87.226	84.238	79.199	82.233	81.274
50-199	11.627	14.599	19.186	16.393	17.339
200-500	1.021	1.045	1.426	1.204	1.250
> 500	0.126	0.117	0.190	0.170	0.142
	100	100	100	100	100

Table 4e. Historical feeder beef farm number percentages by size in the West South Central Division

Number of feeder cattle produced	Percentages of total feeder cattle farms in the region				
	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	79.784	74.592	69.327	74.472	72.726
50-199	17.264	34.019	26.400	21.824	23.387
200-500	2.322	4.086	3.391	2.938	3.088
> 500	0.629	0.952	0.882	0.765	0.799
	100	100	100	100	100

Table 4f. Historical feeder beef farm number percentages by size in the Mountain Division

Number of feeder cattle produced	Percentages of total feeder cattle farms in the region				
	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	52.871	50.322	45.691	48.425	46.358
50-199	36.904	38.014	39.779	37.351	37.870
20-500	7.988	9.149	11.064	10.878	11.854
> 500	2.237	2.514	3.467	3.346	3.918
	100	100	100	100	100

Table 4g. Historical feeder beef farm number percentages by size in the Pacific Division

Number of feeder cattle produced	Percentage of total feeder cattle farms in the region				
	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	65.731	51.397	56.618	56.755	55.402
50-199	26.334	31.275	30.154	28.963	28.708
200-500	6.000	8.802	9.498	10.262	11.088
> 500	1.935	2.527	3.730	4.019	4.809
	100	100	100	100	100

A further look at Tables 4e-4g shows that the percentage of feeder beef farms in the small-sized category has decreased, although not as significantly as above, in the three western-most census divisions over the last 20 years. However, one should note that in the West South Central, Mountain, and Pacific divisions, these decreases in relative small numbers have been offset by shared increases in relative farm numbers by medium-sized and large-sized (200-500 head) feeder beef farms. In the Mountain and Pacific divisions, there have also been substantial increases in the relative percentage of feeder beef farms in the extra large ($>$ 500 head) size classifications.

As suggested by the sharper declines in pork farm numbers, the trend towards larger farm size has been much more pronounced in the production of pork. Tables 5a-5f show how the distribution of pork farms, by size, has changed since 1959 for each of the six census divisions with significant pork production. Tables 5a and 5b show that small (10-59 head) and medium (50-199 head) sized pork farms in the two census divisions, that account for approximately 80 percent of the national production of pork, have been replaced in large quantities by pork farms of the medium-large (200-500 head), large (500-999 head), and extra large ($>$ 1,000 head) size classifications. Unfortunately, consistent data on the number of pork farms producing more than 1,000 hogs per year are not separately available for census data prior to 1982. Table 6, however, shows how significant farms in the extra-large size classification were in 1982, with those farms composing almost

Table 5a. Historical pork farm number percentages by size in the East North Central Division

Number of hogs sold	Percentage of total pork farms in the region (1959)	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	45.103	32.981	30.744	29.762	28.955	25.067
50-199	41.504	45.212	40.577	38.850	36.660	32.705
200-499	11.439	16.765	20.568	20.236	20.196	21.321
> 500	1.955	5.042	8.111	11.152	14.189	20.907
	100	100	100	100	100	100

Table 5b. Historical pork farm number percentages by size in the West North Central Division

Number of hogs sold	Percentage of total pork farms in the region (1959)	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	38.733	27.933	24.521	21.298	20.764	16.697
50-199	48.854	51.226	44.375	41.363	37.710	32.961
200-499	11.366	17.774	24.327	26.044	26.074	26.399
> 500	1.047	3.068	6.778	11.295	15.453	23.944
	100	100	100	100	100	100

Table 5c. Historical pork farm number percentages by size in the South Atlantic Division

Number of hogs sold	Percentage of total pork farms in the region (1959)	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	78.550	66.617	57.907	52.272	53.092	47.766
50-199	19.113	28.022	30.996	32.878	31.261	29.358
200-499	2.047	4.212	8.170	9.53	9.454	11.328
> 500	0.290	1.500	2.926	5.318	6.193	11.548
	100	100	100	100	100	100

Table 5d. Historical pork farm number percentages by size in the East South Central Division

Number of hogs sold	Percentage of total pork farms in the region (1959)	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	78.590	67.064	59.387	54.635	62.830	49.301
50-199	18.740	28.988	31.340	33.984	24.197	33.164
200-499	2,378	3.009	7.219	7.830	8.975	10.226
> 500	0.293	0.944	2.053	3.552	3.999	7.309
	100	100	100	100	100	100

Table 5e. Historical pork farm number percentages by size in the West South Central Division

Number of hogs sold	Percentage of total pork farms in the region					
	(1959)	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	81.416	67.326	61.059	55.576	69.311	57.601
50-199	16.353	26,.958	28.444	29.864	19.138	27.550
200-499	1.865	4.266	7.831	9.027	7.608	8.429
> 500	0.366	1.450	2.665	5.533	3.943	6.421
	100	100	100	100	100	100

Table 5f. Historical pork farm number percentages by size in the Mountain Division

Number of hogs sold	Percentage of total pork farms in the region					
	(1959)	(1964)	(1969)	(1974)	(1978)	(1982)
10-49	72.033	61.074	55.650	50.291	57.835	48.607
50-199	24.333	30.504	31.869	31.156	23.920	28.424
200-499	2.792	6.436	8.765	11.384	10.794	11.377
> 500	0.843	1.986	3.716	7.169	7.270	11.592
	100	100	100	100	100	100

Table 6. Percentage of pork producing farms by U.S. census division reported as "extra large" (> 1,000 head sold/year) in 1982

Aggregated region	Percentage of total farms[a]
East North Central	9.2097
West North Central	9.2922
South Atlantic	6.4120
East South Central	3.1214
West South Central	3.3336
Mountain	5.7666

[a]Excluding farms selling less than 10 head/year.

10 percent of all pork farms in the East North Central and West North Central divisions.

Tables 5c-5f show that the size distributional trends, in the other four census divisions considered as having significant pork production, have followed similar patterns, with larger farms making up a larger percentage of total farm numbers. It is important to note, however, that the only size classification showing decreasing percentage points in the South Atlantic, East South Central, West South Central, and Mountain divisions is the small-sized farms. This indicates that the size distributional shifts occurring in the less important pork producing areas of the country are following a more gradual course similar to feeder beef producing farms.

Future trends

As Heady, Ball, Fontenot, and other agricultural economists have pointed out, the most significant problem with changes in regional production and size distribution are the effects that these changes have on the infrastructures that support these production activities. Therefore, from an economic standpoint, the biggest challenge is to be able to foresee these changes and to ascertain how current policies can affect these changes to meet economic, political, and social goals.

Several studies have looked at general issues of structural change in agriculture in the past, but very few have tried to separate out livestock farming enterprises from other types of farms, and to this author's knowledge, none have attempted to look at pork and feeder beef production specifically. However, a couple of previous studies have application to the problem as described here.

One of the earliest studies, concerned with future farm structure, was conducted by Rex Daly, J. Dempsy, and C. Cobb in the mid 1960s. This study used census data on dollar sales for all farms to look at changes in the size structure of farms between 1959 and 1964. These data were then used to project regional size distributions for the North, South, and West, employing a transition matrix approach. This study made no attempt to separate farms by type of production and used only data on size distributional changes between the 1959 census report and the 1964 census report.

A second study of related application to this problem was conducted by Anderson and Heady in 1965. This study concentrated on an optimal farm plan for northeastern Iowa, using a number of alternative size and capital intensive activities based on farm surveys for the production of dairy, hogs, and beef. Initially designed to simulate the representative farm situation in northeastern Iowa, farm structural supply responses and optimal farm organizational structures were then obtained in response to changing relative prices of farm products produced in northeastern Iowa.

Objectives of the Study

The main objective of this study is to provide an analytical tool capable of ascertaining the consequences of a variety of general policy environments on the production of pork and feeder cattle by the year 2000. Specifically, an attempt will be made to determine regional production levels, regional and national costs of production, and regional and national farm numbers, under five scenarios of regional production and size distribution by the year 2000. Those five scenarios are:

1. Regional size and regional production distributions in the year 2000 that are equivalent to those reported in 1982.
2. Regional size distributions in the year 2000 that are equivalent to those reported in 1982, with no limitations on the regional production distributions.
3. Regional size and regional production distributions in the year 2000 that are continuations of trends over the last 20 years.
4. National size distribution based on projected trend towards bi-modal national distribution by the year 2000, with no regional production limitations.
5. National size distribution based on projected trend towards bi-modal national distribution by the year 2000, with regional production constraints based on a continuation of trends over the last 20 years.

CHAPTER II: METHODOLOGY

The Mathematical Model

The mathematical representation of the livestock linear programming model, used for this study, can best be viewed as a constrained minimization model with the objective of producing livestock intermediate and final commodities in a national market to meet regional livestock commodity demands. Constraints on the basic model include regional feed-crop production constraints, national feed-crop availability constraints, final regional livestock commodity demands, constraints on roughages as a percentage of total animal ration, and constraints on intermediate livestock production and demand.

Further constraints are placed on the model, under the five alterna tive scenarios, to implement aggregated regional livestock production constraints based on historical production as reported by U.S. census data and projected regional production percentages by the year 2000. In addition, various size distributional constraints are placed on the model, under the five scenarios, to reflect historical regional size distributions, projected regional size distributions, or national projected farm size distributions.

More formally, the functional form of the basic model, before implementing the various additional constraints associated with the individual scenarios, can be expressed as follows:

$$\text{MIN OBJ} = \sum_{h}\sum_{p} XA_{h,p} * CA_{h,p} + \sum_{n}\sum_{h}\sum_{p} XJ_{n,h,p} * CJ_{n,h,p}$$

$$+ \sum_{r}^{7}\sum_{q} XT_{r,q} * CT_{r,q} + \sum_{r=8}^{12} \sum_{q} XT_{r,q} * CT_{r,q}$$

p = 1,....,5 for intermediate and final livestock types

h = 1,....,31 for livestock producing regions

n = 1,....,12 for feed-crops transferred to livestock

q = 1,.... for crop and livestock transportation routes (inter-regional)

r = 1,.... for crop (1-7) and livestock (8-12) transportation (inter-regional)

Subject to:

(1) Feed-crop Availability:

a. $\sum_{p} XJ_{n,h,p} - XT^{E}_{n,q} + XT^{E}_{n,q} \leq C_{n,h}$

for n=1,....,7 [feed crops that are transported inter-regionally in the model]

b. $\sum_{p} XJ_{n,h,p} \leq C_{n,h}$

for n=8,....,12 [feed crops that are not transported interregionally]

(2) Final Livestock Commodity Demands:

$$XA_{h,p} * D_{p} + XT^{I}_{n,q} * D_{p} - XT^{I}_{n,q} * D_{p} \leq RD_{h,p}$$

for p=8,9,11,12 [the interregional transportation of final livestock commodities (milk, pork, and beef)]

(3) Intermediate Demand Constraints:

a. $XA_{h,p} + XT^{E}_{r,q} - XT^{I}_{r,q} \geq ID_{np}$

for p=1,3 [dairy steers, feeder cattle]

b. $XA_{n,p} \geq ID_{h,p}$

for p=2 [feeder pigs]

(4) Roughage Constraints:

a. $\sum_{n=1}^{6} XJ_{n,h,p} * (1-MIN_{p}) - \sum_{n=6}^{12} XJ_{n,h,p} * (MIN_{p}) > 0$

for p=1,....,4,5,6 [minimum roughage restriction]

b. $\sum_{n=1}^{6} XJ_{n,h,p} * (1-MAX_{p}) - \sum_{n=6}^{12} XJ_{n,h,p} * (MAX_{p}) < 0$

for p=1,....,4,5 [maximum roughage restriction]

Where: $XA_{h,p}$ represents solution level of livestock activity type (p) in livestock producing area (h);

$CA_{h,p}$ represents the cost of producing livestock activity type (p) in livestock producing area (h);

$XJ_{n,h,p}$ represents the solution level of crop feedstuff (n) being transferred to livestock activity type (p) in livestock producing region (h);

$CJ_{n,h,p}$ represents costs of producing crop feedstuff (n) for utilization by livestock activity type (p) in livestock producing region (h);

$XT^E_{r,q}$, $XT^I_{r,q}$ represents the solution level of transported crop (E = export, I = import) feedstuffs (r=1,....,7) and livestock commodities (r=8,....,11) along interregional transportation route (q);

$CT_{r,q}$ represents the cost of transporting crop feedstuff (r=1,....,7) or livestock commodity (r=8,....,11) along interregional transportation route (q);

$C_{n,h}$ represents the amount of feed-crop (n) available for use by all endogenous livestock types in livestock producing regions (h);

D_p represents the conversion of livestock production to the final livestock commodities (i.e., for pork D_p represents dressing %)

$RD_{h,p}$ represents final commodity demands for livestock commodity (p) in region (h);

$ID_{n,p}$ represents intermediate demands for intermediate livestock product (p) in livestock producing area (h);

MAX_p represents the maximum percentage of the ration of livestock activity type (p) that can be roughage crop (n=6,....,12);

MIN_p represents the minimum percentage of the ration of livestock activity type (p) that can be roughage crop (n=6,....,12).

Description of the Model

The linear programming model, used as the basis for this study, can be viewed as a set of equations placed in a matrix with each coefficient in that matrix representing the interaction between a production activity and the available resources. The model used in this study features a variety of production processes available to produce beef, pork, and milk. Using these production processes, and subject to the various constraints placed upon the model under a particular scenario, the model determines the regional location of livestock production, the size distributions of production activities used, and the least-cost livestock rations, in order to minimize the overall costs of production.

Regional delineation

The basic model used in this study is a national multi-regional linear programming model, consisting of 31 livestock producing areas (LPAs). Figure 2 shows the 31 LPAs and the designated transportation center for each area. A separate transportation sector, developed by English and Roel (1985), allows for the transportation of all final livestock commodities, some livestock feedstuffs, and some intermediate livestock commodities to meet the demands of a given LPA.

Production activities for the various livestock commodities are limited to those livestock producing areas located in census divisions with significant amounts of production (see Tables 1 and 2). The model allows those LPAs where production activities are not available, or where model production does not meet demand, to import quantities of final livestock commodities to meet demand. Table 7 shows the final demands for beef, pork, and milk by LPA that are used in this study for the year 2000.

In addition, the model allows for the transportation of feeder cattle, an intermediate livestock commodity, across LPAs as an input into the grain-feed beef production activities. Although feeder pig production and feeder pig finishing activities are available, the model does not allow for the transportation of feeder pigs between LPAs.

Figure 2. The 31 livestock producing areas of the basic livestock linear programming model

Table 7. Right-hand side values for final livestock product demands by 31 livestock producing areas in the year 2000[a]

Livestock producing area	Final grain-fed beef demands	Final pork demands	Final milk demands
	(1,000 cwts.)		
1	26,311.22	14,666.72	78,081.94
2	63,967.18	35,657.37	189,830.85
3	21,196.67	15,160.30	80,709.62
4	22,375.34	12,472.74	66,401.72
5	20,762.45	11,573.66	61,615.26
6	37,066.96	20,662.32	110,000.99
7	24,113.72	13,441.76	7,560.57
8	18,163.00	10,124.64	53,901.04
9	18,581.32	10,357.83	55,142.48
10	9,849.68	5,490.53	29,230.22
11	25,716.68	14,335.30	76,317.56
12	12,696.05	7,077.19	37,677.17
13	11,766.24	6,558.88	34,917.84
14	15,995.23	8,916.23	47,467.93
15	10,203.51	5,687.77	30,280.25
16	2,302.25	1,283.35	6,832.23
17	1,403.70	782.47	4,165.67
18	11,495.53	6,407.98	34,114.48
19	19,447.82	10,840.90	57,714.21
20	7,851.30	4,376.57	23,299.77

[a]Source: (Economic Research Service, 1985).

Table 7 (continued)

Livestock producing area	Final grain-fed beef demands	Final pork demands	Final milk demands
21	2,857.58	1,592.90	8,480.24
22	1,002.19	558.65	2,974.14
23	7,753.29	4,321.93	23,008.90
24	3,816.21	2,127.27	11,325.09
25	2,096.30	1,168.54	6,221.04
26	2,187.30	1,219.27	6,491.11
27	3,289.12	1,833.46	9,760.90
28	7,098.59	3,956.98	21,065.99
29	14,171.67	7,899.74	42,056.26
30	16,703.85	9,311.26	49,570.84
31	36,313.71	20,242.43	107,765.62
Total U.S. demands	484,555.76	270,106.97	1,437,981.93

Therefore, if a feeder pig producing activity comes into the optimal linear programming solution in a given LPA, then a feeder pig finishing activity in that LPA must also be a part of the optimal solution. The model also allows for the transport of all feed grains utilized by livestock between LPAs to meet the demands of livestock in deficit areas. The model does not allow for the transport of roughage feeds across LPAs.

Model development

The livestock model is composed of two major types of activities. These activities are designated as either "production activities" or "feed transfer activities." The production activities model the actual production functions for producing the various types of livestock included in the model, while the feed transfer activities model the transfer of crops to meet livestock nutritional requirements.

A unique feature of this livestock model is the degree of substitution that can occur as feedstuffs fulfill the nutrient requirements of the various livestock activities. This integral part of the model, thus, allows the choice of the least cost ration for the livestock activities. The choice of feedstuffs is constrained only by nutrient production. However, it is possible to further constrain the selection of feedstuffs to meet any *a priori* expectations.

Production activities

There are four basic types of livestock production activities which require various inputs from the model and provide intermediate and final outputs to meet demands. Dairy activities produce milk as the primary output and also steer calves and roughage-fed beef as intermediate and joint-product final outputs, respectively.

There are three distinct activities available for the production of pork. Farrow-to-finish activities produce pork as the primary output and include the maintenance and management of a breeding herd. Feeder pig production activities produce feeder pigs as the primary output. Since the production of feeder pigs also requires the management of a breeding herd, the culls from this herd provide a joint-product output of pork. The final activity available for pork production is the feeder pig finishing activity. This activity requires feeder pigs as inputs (therefore, no breeding herd here) and produces pork as the primary output. If feeder pig finishing activities come into solution in a particular region, then feeder pig production activities must also come into solution, because feeder pig finishing activities require feeder pigs as an input and feeder pigs are not transported between the livestock producing areas in this model.

Feeder cattle production activities produce feeder cattle, an intermediate product, as either calves, yearlings, or a combination of the two. These activities also produce roughage fed beef through breeding herd culling. Finally, grain-fed beef activities produce beef as the primary product and require feeder cattle as the primary input in the production process.

Budgets behind activities All pork and beef production activities are based upon budget data contained in the Firm Enterprise Data System livestock budgets developed by the U.S. Department of Agriculture (Economic Research Service, 1980). These budgets are based on data collected by the Economic Research Service through national farm surveys between 1978 and 1980 and reflect average management, practices, and performance. It should be noted that costs of production, presented in these budgets, do not reflect actual costs for any given livestock producing unit, but average costs of production for similar sized production units in that specific area in 1978.

In this model, dairy production activities are based on budgets presented in a paper prepared for the Congressional Office of Technology Assessment by Boyd M. Buxton (1984). These budgets were developed based upon federal milk marketing order data for medium, large, and extra-large dairy operations, using "state of the art technologies." Costs for these budgets were then converted to 1978 dollars, using a series of farm price indexes.

Activity sizes An important feature of this livestock sector is the incorporation of activities representing different sizes. For pork production, farrow-to-finish activities are built from budgets ranging in size from 40 to 5,000 head; feeder pig production activities are built from budgets ranging in size from 140 to 1,600 head; and finally, feeder pig finishing activities are built from budgets ranging in size from 140 to 5,000 head. Grain-fed beef finishing activities are built from budgets ranging in size from 35 up to 51,000 head. Feeder cattle production activities are built from budgets ranging in size from 45 to 1,500 head. Finally, dairy production activities are built from budgets ranging in size from 52 to 1,436 milk cows.

For each livestock type, the complete activity size range is not necessarily present in each LPA. The size range for any given livestock producing area depends on the size distribution of farms actually present in that area.

Unit of production All livestock production activities are designed to produce in units of 100 pounds of the primary output.[1] Thus, a dairy activity produces units of 100 pounds of milk; a feeder cattle production activity produces units of 100 pounds of feeder cattle, and a feeder cattle finishing activity produces units of 100 pounds of beef. The farrow-to-finish and the feeder pig finishing activities each produce units of 100 pounds of pork, while feeder pig production activities produce units of 100 pounds of feeder pigs. All technical coefficients and the objective function for each livestock activity are defined in terms of 100 pounds of the primary output.

Feeding mechanism The feeding mechanism has a rather unique design with nutrient requirements calculated from the National Research Council recommendations for the production of the primary product and the maintenance of any breeding stock, young, or replacement stock [National Academy of Sciences, 1976, 1978, 1979].

For dairy, nutrient requirements are defined in terms of net energy, crude protein, calcium, and phosphorus [National Academy of

[1] Primary output is measured in terms of liveweight.

Sciences, 1978]. Feeder cattle finishing and feeder cattle production activities also have nutrient requirements defined in terms of net energy, crude protein, calcium, and phosphorus [National Academy of Sciences, 1976]. All pork activities have nutrient requirements defined in terms of metabolizable energy, crude protein, calcium, phosphorus, and lysine [National Academy of Sciences, 1979]. An example of the calculation of nutrient requirements for activities based upon FEDS Budget number 102 is presented in Table 8.

The upper and lower roughage constraints are constructed based upon information provided in Schraufnagel and English [1982]. These roughage restrictions constrain the dry matter content of the ration so that the biological needs of ruminants are met and so that the assumed production levels can be achieved. The levels of constraints are shown in Table 9 with assumed levels of dry matter presented in Table 10. The maximum roughage restriction is then effectively implemented using the following steps:

1.) Let g = grain, r = roughage and MAXC as the value of the maximum roughage constraint,

2.) such that; $\frac{g}{r+g} < MAXC$

3.) combining terms; $g < MAXC * (r+g)$

4.) rewriting; $g - (MAXC * r) - (MAXC * g) < 0$

5.) and finally; $g * (1-MAXC) - MAXC * r < 0$

Table 8. Example of the calculation of nutrient requirements for representative feeder beef budget #102

Activity[b] components	Requirements[a] Crude protein (kg)	NE maintenance (Mcal)	NE gains (Mcal)	Calcium (gr)	Phosphorus (gr)
Steer calves (51)	5,425.4	32,553.3	19,772.7	248,115	187,221
Heifer calves sold (26)	2,665.5	15,358.2	10,597.6	120,926	89,648
Heifer calves retained (24)	4,294.6	28,070.4	15,324	154,320	123,648
Cows after cull (105.59)	14,539.7	250,100.5	0	443,953.2	443,953.2
Cows before cull (126)	7,660.8	93,555	0	236,250	236,250
Yearling heifers (20.41) after cull	3,858.5	36,729.8	6,792.4	86,701.7	86,701.7
Yearling heifers (24) before cull	1,207.2	9,991.2	4,051.2	25,200	25,200
Bulls (5)	1,807	21,170	0	38,325	38,325
Totals:	41,458.7	487,528.4	56,537.9	1,353,790.7	1,230,946.9
Totals ÷ PUD[c] = Activity coeff's	107.5	1,264.3	146.6	3,510.9	3,192.3

[a]Details on calculation for all activity coefficients, cull rates, and death losses were obtained from FEDS budget information.

[b]This budget is for a 78 head cow-calf operation.

[c]PUD = Production unit division = Total lbs. of beef sold ÷ 100 (= 385.6 for #102).

Table 9. Roughage consumption restrictions

Livestock category	Restriction type	
	Maximum	Minimum
Dairy	60	35
Feeder cattle production	NA[a]	35
Feeder cattle finishing, grain-fed	50	10

[a]NA indicates no constraint.

Table 10. Dry matter content by crop[a]

Crop	Dry matter[b]	Crop	Dry matter[a]
	(pounds)		(pounds)
Barley	42.74	Sorghum	49.28
Corn	49.84	Sorghum silage[c]	290.00
Corn silage[c]	350.00	Soybeans	53.40
Legume hay[c]	1,720.00	Wheat	53.40
Nonlegume hay[c]	1,720.00	Private pasture[c]	560.00
Oats	28.48	Public pasture	560.00

[a]Source: (Schraufnagel and English, 1982).

[b]Grains are assumed to contain 12.35 percent moisture.

[c]Considered as roughage crops.

The minimum roughage restriction is similarly implemented as follows;

1.) Let g = grain, r = roughage, and let MINC be the value of the minimum roughage constraints,

2.) such that; $\frac{g}{r+g} > MINC$

3.) combining terms; $g > MINC * (r+g)$

4.) rewriting; $g - (MINC * r) - (MINC * g) > 0$

5.) and finally; $g * (1 - MINC) - r * MINC > 0$

Additionally, changes in feeding efficiency are built into the model over time to reflect increased efficiency in the conversion rate by the year 2000. Table 11 shows the assumed increases in feed and protein efficiency in the year 2000.

Cost calculation All livestock production costs are derived from the Firm Enterprise Data System [Economic Research Service, 1980]. The objective function value includes all pertinent costs of production other than the costs of feed. There are five cost categories:

1) Labor

2) Machinery and equipment

3) Transportation and marketing

4) Miscellaneous

5) Ownership

Table 12 lists the costs included in the objective function of various activities by category. Notice that the costs listed under Category 5, ownership costs, are also included in the machinery and equipment

Table 11. Feed and protein conversion efficiency increase assumptions by the year 2000[a]

Livestock category	Conversion efficiency increase by 2000	
	Feed	Protein
	--------percentages-------	
Beef	15.5	22.0
Pork	15.5	17.0
Dairy	10.3	13.0

[a]Source: (Fontenot, 1984).

Table 12. List of livestock cost items incorporated into each major category

Major category	Cost item
Labor	Hired labor
	Family labor
	Equipment labor
	Livestock labor
	Yard crew
	Managers
	Accountants
	Consultants
	Mechanic
	Truck drivers
Machinery and equipment	Machinery fuel and lube
	Machinery repair
	Equipment fuel and lube
	Equipment repair
	Ownership cost-machinery
	Ownership cost-equipment
	Machine hire
Other	Vet and medical
	Interest on operating capital
	Ownership cost-livestock
	Ownership cost-land taxes
	Miscellaneous
	Grinding and mixing
	Antibiotics
	Vet service
	Vet supplies
	Growth stimulant
	Utilities
	Legal fees
Transportation and marketing	Trucking
	Marketing
	Hauling and marketing
	Livestock hauling
	Sales commission
	Hauling
Ownership	Machinery
	Equipment
	Livestock
	Land taxes

and miscellaneous categories. Thus, the objective function for each activity is actually an aggregation of cost categories 1 through 4. It should be noted that each of the cost items listed does not appear in every activity. For example, smaller farms would not employ yard crews or consultants. Finally, livestock ownership costs are only included for those activities that include breeding stock.

Feed transfer activities

The nutrient requirements of the livestock produced are met through the transfer of nutrients from 13 alternative suppliers represented by 10 crops, 2 pastures, and a calcium and phosphorus purchasing activity. These 13 alternative suppliers, listed in Table 13, provide the following nutrients:

1) Crude protein (kilograms/transfer unit)

2) Net energy (mili-calories/transfer unit)

3) Calcium (grams/transfer unit)

4) Phosphorus (grams/transfer unit)

5) Metabolizable energy (mili-calories/transfer unit)

6) Lysine (grams/transfer unit)

Only the pasture transfer activities are allowed to vary in nutrient value content among livestock producing areas. The other feed transfer activities provide fixed amounts of the aforementioned nutrients to the production of livestock (metabolizable energy and lysine to pork activities only) based on calculations using feed stuff values contained in the National Academy of Sciences' Guide to Nutrient Requirements. The fixed

Table 13. The feed transfer activity types

Activity code	Feed name	Transfer unit
JBRL	Barley	bushel
JCRN	Corn	bushel
JCSL	Corn silage	ton
JHLH	Legume hay	ton
JNLH	Nonlegume hay	ton
JOTS	Oats	bushel
JSRG	Sorghum	bushel
JSSL	Sorghum silage	ton
JSBN	Soybeans	bushel
JWHT	Wheat	bushel
JPRP	Private pasture	ton
JPUP	Public pasture	ton
JCBY	Calcium and phosphorus buying	grams

transfer activity coefficients for pork and feeder beef production are listed in Table 14. The following formula is used to convert the nutrient values found in the National Academy of Sciences' Guide to Nutrient Requirements into coefficient values:

$$\text{coef value} = (U_j) * (DM_j) * (V_{ijk}) * (C_k)$$

Where:

U_j represents the pounds per unit of feedstuff j (i.e., 56 lbs./bu. for corn).

DM_i represents the dry matter percentage of feetstuff j.

V_{ijk} represents the NAC value of feedstuff j to livestock type i for nutrient k.

C_k represents the conversion of units to find units for coefficients.

The values of the coefficients for the pasture transfer activities, however, are dependent upon the region where the pasture is being utilized. This distinction in the pasture transfer activities was made because it was felt that the nutrient values supplied by grazed forages varied considerably from one region to another. This could have important implications from the standpoint of minimizing the costs of production since costs of producing a ton of pasture varies considerably across LPAs and the nutrients available should reflect those different costs. Table 15 lists the objective function values for the private pasture transfer activities. The limited amount of public pasture available is assumed to be only available to the feeder beef

Table 14. Nutrient values available (per unit) from fixed feed transfer activities

Activity type	Feed type	Crude protein	ME	NE	Calcium	Phosphorus	Lysine
		(kilograms)	(MCALs)	(MCALs)	(grams)	(grams)	(grams)
Pork	Barley	2.422	62.880	N/A	15.502	91.000	80.559
	Corn	2.261	84.460	N/A	6.782	79.125	60.964
	Oats	1.602	38.756	N/A	14.210	62.006	58.061
	Sorghum	2.615	82.022	N/A	6.706	73.765	55.884
	Soybeans	9.858	66.072	N/A	68.967	142.729	626.509
	Wheat	3.488	87.636	N/A	14.549	138.219	108.864
Feeder beef	Barley	2.422	N/A	66.912	15.502	91.000	N/A
	Corn	2.261		85.004	4.521	79.125	
	Corn silage	25.402		809.676	857.304	635.040	
	Legume hay	119.750		1213.140	10218.701	1596.672	
	Nonlegume hay	78.319		1238.000	2957.546	1678.604	
	Oats	1.602		37.076	14.210	62.006	
	Sorghum	2.615		69.294	6.706	73.765	
	Sorghum silage	19.470		477.420	841.882	480.090	
	Soybeans	9.858		61.279	68.967	142.729	
	Wheat	3.488		86.813	14.549	108.999	

Table 15. Objective function values, by LPA, assigned to the transfer of of private pasture and silage to feeder beef producing activities

Livestock producing area	Cost of private pasture	Cost of silage
	------------(\$/ton)------------	
1	N/A	N/A
2	N/A	N/A
3	14.43	5.59
4	15.16	5.59
5	5.50	5.83
6	16.95	5.59
7	15.37	8.86
8	20.30	7.38
9	12.49	4.10
10	14.47	5.59
11	15.37	5.30
12	21.07	7.08
13	16.40	6.41
14	8.76	6.19
15	15.86	6.64
16	8.48	5.30
17	9.27	5.59
18	8.13	6.11
19	3.72	5.79
20	3.60	4.73
21	5.52	5.30
22	24.62	4.94
23	21.52	4.53
24	13.99	4.94
25	25.01	5.74
26	18.86	3.62
27	17.28	4.85
28	10.26	4.40
29	13.76	4.40
30	24.99	4.40
31	27.75	4.40

producing activities and the cost of public pasture is assumed constant at \$7.20 per ton.[1]

Table 16 shows the calculated nutrient coefficients for the variable pasture transfer activities available for feeder beef production. The assumption has been made that the nutrient values calculated for private pasture fed to beef can be used for the public pasture. More information on how the variable pasture transfer activity coefficients were developed can be found in Disney and English [1984].

Table 15 also shows the additional costs associated with storing silage on the feeder beef producing farms. These costs, based on FEDS Budget data, prevent the model from substituting silage for corn without accounting for the costs of silage storing facilities.

Other crop prices are entered exogenously into the model for the purposes of this study. A calcium and phosphorus buying activity is included to prevent the model from using excess feed grains just to meet the calcium and phosphorus requirements. Table 17 shows the base prices that were used in the model for the purposes of this study. It should be explained that these prices represent only base national projected prices for the year 2000. These prices are adjusted to reflect historical regional differences; the model then determines the "on farm" prices, in 1978 dollars, for each feedstuff at the point of production.

[1]This is based on the assumption that public grazing costs are a constant \$3.20 per A.U.M. and an A.U.M. requires an average of 800 pounds of forage.

Table 16. Variable coefficients for the nutrient values available[a] per ton to beef pasture transfer activities

Livestock producing area	Nutrient			
	Protein	NE	Calcium	Phosphorus
	(kilograms)	(mcals)	(grams)	(grams)
1	43.324	283.727	1980.743	980.233
2	42.477	272.719	2040.232	931.486
3	42.946	275.959	1725.157	933.917
4	43.833	277.942	1575.146	900.850
5	32.878	240.258	1508.780	615.530
6	42.749	281.006	1999.443	989.135
7	46.941	287.613	2455.234	978.814
8	43.893	274.953	1965.420	950.684
9	40.643	267.613	1696.358	779.533
10	42.641	306.740	2084.165	1022.260
11	42.641	306.740	2084.165	1022.260
12	47.069	290.016	2464.269	1014.062
13	42.721	273.063	1830.680	883.226
14	40.683	272.116	1691.760	782.898
15	46.091	297.133	2174.458	999.642
16	42.641	306.740	2084.165	1022.260
17	40.970	433.577	2729.810	825.953
18	41.901	339.181	1803.308	839.948
19	39.159	275.635	1877.860	668.486
20	35.525	298.327	1862.590	642.810
21	44.074	375.239	2259.630	746.840
22	41.673	435.640	3645.140	895.650
23	38.553	458.479	2939.550	852.350
24	49.935	444.371	3211.901	899.703
25	40.802	391.360	2978.000	1047.390
26	48.339	314.026	2657.490	1078.190
27	27.081	203.446	1168.945	630.087
28	37.838	310.164	3687.470	786.725
29	40.722	352.097	2079.951	953.002
30	43.426	289.955	2494.797	780.253
31	44.833	312.243	3469.450	834.160

[a]Source: Disney and English [1984].

Table 17. Base national feed crop prices for the year 2000 used in the model

Feed	$/unit
Barley	3.61
Corn	3.61
Corn silage	20.00
Legume hay	80.00
Nonlegume hay	65.00
Oats	2.19
Sorghum	3.60
Sorghum silage	20.00
Soybeans	9.20
Wheat	3.91
Private pasture	N/A[a]
Public pasture	7.20
Calcium and phosphorus	0.26

[a]See Table 15 for cost by LPA.

The Analysis

In order to facilitate the analysis of size and geographic distributions of future pork and feeder beef production, it was necessary to aggregate the 31 livestock producing areas that comprise the model described in the previous section of this chapter into larger and more definable units. The most effective means of accomplishing this was to assign each of the 31 livestock producing areas to an aggregate region consistant with one of the nine U.S. Census Divisions. Table 18 shows each census division by the area of the country where it is found, and the livestock producing areas assigned to that aggregate region.

Not only does the aggregation of livestock producing areas into aggregate regions allow for ease of presentation of results and reader comparison with other studies, but it also allows for the direct use of census data on production and size distributions. It is important to note that this simulation is limited in its ability to simulate actual farm size distributions by the number of activities of a given size present in the model and in any given aggregate region. Tables 19a and 19b show the number of production activities that are available within the model by size and aggregate region for feeder beef and pork production, respectively. Obviously, the majority of the activities available within the model for the production of both pork and feeder beef are located in areas of high relative production. The fact that certain size activity classifications within certain aggregate regions (i.e., pork, Mountain - small and medium) have only one activity indicates that production by those sized farms is realistically quite insignificant.

Table 18. Assignment of the 31 livestock production areas to aggregate regions consistent with Census Divisions

Census of Agriculture Divisions	Livestock production areas assigned to each Census Division
Northeast	
New England	1
Middle Atlantic	2
North Central	
East North Central	6,7,11
West North Central	10,12,13,15,16,17
South	
South Atlantic	3,4,5
East South Central	8,9
West South Central	14,18,19,20,21
West	
Mountain	22,23,24,25,26,27,28
Pacific	29,30,31

Table 19a. Number of feeder beef activities by aggregated region and size included in the linear programming model

Aggregate region	Size[a] (10-49)	(50-199)	(200-500)	(> 500)
	------------number of activities------------			
East North Central	5	2	1	1
West North Central	12	13	6	1
South Atlantic	6	5	7	1
East South Central	8	5	5	3
West South Central	16	17	14	4
Mountain	12	18	16	8
Pacific	5	10	9	8
Totals	64	70	58	26

[a]Based on number of sales reported in the representative FEDS budget for that activity.

Table 19b. Number of pork activities by aggregated region and size included in the linear programming model

Aggregate region	Size[a] (10-49)	(50-199)	(200-499)	(500-1000)	(> 1000)
	----------------number of activities-------------				
East North Central	4	7	10	13	11
West North Central	11	23	29	26	34
South Atlantic	4	7	10	10	13
East South Central	4	7	7	8	10
West South Central	6	11	18	15	27
Mountain	1	1	2	2	6
Total	30	56	76	74	101

[a]Based on budget size of the representative FEDS Budget.

In Chapter I, it was found that only seven of the nine census divisions produce significant amounts of feeder beef cattle and only six produce significant amounts of pork. Therefore, only 7 aggregate regions are considered in the analysis of feeder beef production and only six aggregate regions are considered in the analysis of pork production.

Three general types of scenario-specific restrictions are used in the analysis in an attempt to acertain the effects of various farm-size distributions on the production of pork and feeder cattle by aggregate region in the year 2000. Those types of general scenario-specific restrictions include regional farm-size distributional restrictions, national farm-size distributional restriction, and regional production restrictions. In the following pages, the methods used for imposing these restrictions is explained and examples are presented. Actual data used for each of the scenarios involved in the study are presented in the next section of this chapter.

Regional farm-size distributional restrictions

Regional farm-size distributional constraints are placed upon the model under all scenarios except those where only national size distributions are used. These constraints restrict the size distributions of pork and feeder beef farms in a given aggregate region to meet some *a priori* assumption about what the distribution of those farms will be in the year 2000. Imposition of these constraints follows the following theoretical formula:

Let $C^{L}_{k,i,j}$ be production (total cwts) by activity (i) in size category (j) for aggregate region (k) of livestock type (l); and let $PUD_{k,i,j}$ be the production unit divisor defined as the number of cwts that can be produced using 1 unit (1 farm) of activity (i).

Where:

i=1,....,n for activities within each size category (j);

j=1,....,m for size categories within each aggregate region (k);

k=1,....,9 for aggregate regions;

l=1,2, for livestock types (pork, feeder cattle only).

So that:

$$\sum_{i=1}^{n} (C_{k,i,j}/PUD_{k,i,j}) = F_{j,k}$$ = number of times whole budgets (farms) of size (j) in region (k) come into the optimal solution.

And therefore:

$$\sum_{j=1}^{m} \sum_{i=1}^{b} (C_{k,i,j}/PUD_{k,i,j}) = TF_{k}$$ = number of total whole budgets (farms) in each region (k).

$$= \sum_{j=1}^{m} F_{j,k}$$

Then, assuming an *a priori* size distribution as follows:

Farm size	Percentage of total farms in region (k)
F_1	40
F_2	30
F_3	20
F_4	10

A distributional constraint can be implemented through the use of a numerare size classification using the following steps:

Step 1: $F_{1,k} = .4TF_k$ $\quad F_{3,k} = .2TF_k$

$F_{2,k} = .3TF_k$ $\quad F_{4,k} = .1TFk$

Step 2: $2.5F_{1,k} = TF_k$ $\quad 5F_{3,k} = TF_k$

$3.33F_{2,k} = TF_k$ $\quad 10F_{4,k} = TF_k$

Step 3:

$$3.33F_{2,k} = 2.5F_{1,k}$$

$$5F_{3,k} = 2.5F_{1,k}$$

$$10F_{4,k} = 2.5F_{1,k}$$

Step 4:

$$F_{2,k} = 0.75\ F_{1,k}$$

$$F_{3,k} = 0.50\ F_{1,k}$$

$$F_{4,k} = 0.25F_{1,k}$$

So that, using the example, the regional distribution restriction is implemented by requiring three F_2-sized activities, two F_3-sized activities, and one F_4-sized activity to come into solution in aggregate region k every time four F_1-sized activities come into solution.

In practice, however, implementation of the theory is complicated by the fact that, in a linear programming model, the production activities do not come into solution at discrete production levels equivalent to single farms, but as continuous units of production. Therefore, a method of identifying single farm units within the model was a prerequisite for implementing any farm size distributional constraints. The production unit divisor (PUD), defined as the number of cwts. produced by one production activity (or farm), proved to be essential in developing this constraint. Figure 3, a scaled-down version of the linear programming matrix described later in this chapter, shows how the PUD was used in actually implementing the size distributional constraints using the example outline above.

As can be seen in Figure 3, implementing the size distributional constraints involves the addition of one activity ("Z" activities) for each size classification in each aggregate region for both pork and feeder cattle. Two sets of matrix rows are then added to the model. The first serving the function of defining single farms from the production activities ("V" rows) and the second to constrain the farm size distributions ("Q" rows). It should be noted that in Figure 3 only four size classifications are represented for pork and four for feeder beef (assumes same distribution for both, same as example). Under the various scenarios, up to five and few as three size classifications are in place.

National farm-size distributional restrictions

National farm-size distributional constraints are placed upon the model under two scenarios (4 and 5) when regional size constraints are not in place. These constraints simply restrict the total number of U.S. pork and feeder beef farms to some predetermined distribution similar

	A21BUDPA	A22BUDPA	A23BUDPA	A24BUDPA	A51BUDPA	A52BUDPA	A53BUDPA	A54BUDPA	ZPKSMLAR	ZPKMEDAR	ZPKMLGAR	ZPKLRGAR	ZBFSMLAR	ZBFMEDAR	ZBFLRGAR	ZBFEXLAR
VPKSMLAR	L/PUD								-1							
VPKMEDAR		1/PUD								-1						
VPKMLGAR			1/PUD								-1					
VPKLRGAR				1/PUD								-1				
VBFSMLAR					1/PUD								-1			
VBFMEDAR						1/PUD								-1		
VBFLRGAR							1/PUD								-1	
VBFEXLAR								1/PUD								-1
QPKMEDAR									0.75	-1						
QPKMLGAR									0.50		-1					
QPKLRGAR									0.25			-1				
QBFMEDAR													0.75	-1		
QBFLRGAR													0.50		-1	
QBFEXLAR													0.25			-1

Figure 3. Implementing size distributional restrictions

to the restrictions placed on an individual aggregate region with regional size distributional restrictions. Theoretically, and in application, the imposition of these restrictions is identical to the imposition of the regional size distributional restrictions except that here there is only one set of restrictions for the entire United States, instead of one set of restrictions for each aggregate region.

Regional production restrictions

Regional pork and feeder beef production restrictions are placed upon the model under three scenarios (Scenarios 1, 3, and 5) to more realistically simulate actual production distributions between aggregate regions. These restrictions are simply achieved by setting minimum right-hand-side values for the production of pork in six aggregate regions and for the production of feeder beef in seven aggregate regions. In addition, the production of milk is restricted in a similar way among all nine aggregate regions.

The Scenarios

Five scenarios concerning the regional size and production distribution of pork and feeder beef cattle farms in the year 2000 are involved in this study. These scenarios were designed to reflect the effects of general farm policies on the regional production and size distribution of pork and feeder beef cattle production by the year 2000. In the following pages, the scenarios are described and the intuitive reasoning behind their inclusion is explained.

Scenario 1

Regional size distribution   Scenario 1 attempts to simulate the regional production and size distributions of pork and feeder beef cattle production as it exists at the present time. To do this, information on size distributions by aggregate region (census division) is calculated directly from the 1982 Census of Agriculture. Table 20a shows the size distributions by aggregate region that were used for feeder beef cattle farms and Table 20b shows the size distributions by aggregate region that were used for pork farms in Scenario 1.[1]

Regional production percentages   In Scenario 1, production constraints based on 1982 census data are also imposed. Table 21 shows the minimum right-hand-side values that were used to allocate the regional production percentages of pork and feeder beef cattle based on the 1982 regional production percentages presented in Tables 1 and 2 of Chapter I (excluding insignificant census divisions).

It should be explained that the total production numbers (194,738,000 cwts. of feeder cattle and 270,106,000 cwts. of pork) used in developing these regional minimum production levels fall slightly short of optimal model demands. Therefore, any excess production required by the model will be produced in the most efficient aggregate region. However, this does not significantly change the regional percentages and may, in fact, provide additional information on the most efficient areas of pork and feeder beef production at the margin.

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[1]Note that these are the same distributions as those shown for 1982 in tables 4a-4g and 5a-5f of Chapter 1.

Table 20a. Distributions used in implementing size distributional constraints for feeder cattle production activities based on 1982 census data

Aggregate region	Percentage of total farms by size (cows and heifers having calved)			
	(10-49)	(50-199)	(200-500)	(> 500)
East North Central	74.87	24.51	0.57	0.057
West North Central	67.12	29.89	2.59	0.39
South Atlantic	76.35	20.40	2.47	0.78
East South Central	81.27	17.34	1.25	0.14
West South Central	72.72	23.39	3.09	0.80
Mountain	46.36	37.87	11.85	3.92
Pacific	55.40	28.71	11.08	4.81

Table 20b. Distributions used in implementing size distributional constraints for pork production activities based on 1982 census data

Aggregate region	Percentage of total farms by size (sales per year)				
	(10-49)	(50-199)	(200-499)	(500-999)	(> 1000)
East North Central	25.07	32.71	21.32	11.70	9.21
West North Central	16.70	32.96	26.40	14.65	9.29
South Atlantic	47.77	29.36	11.33	5.14	6.41
East South Central	49.30	33.16	10.23	4.19	3.12
West South Central	57.60	27.55	8.43	3.09	3.33
Mountain	48.61	28.42	11.38	5.83	5.77

Table 21. Regional feeder cattle and pork production[a] lower bounds used in right-hand sides for Scenario 1

Aggregated region	Quantity of feeder cattle	Quantity of pork
	--------------(1,000 cwts)---------	
East North Central	21,575.0	75,149.0
West North Central	54,300.0	148,701.0
South Atlantic	18,681.0	24,849.0
East South Central	18,348.0	11,128.0
West South Central	40,928.0	5,831.0
Mountain	26,291.0	4,448.0
Pacific	14,615.0	N/A

[a]Based on regional production percentages reported in the 1982 Census of Agriculture and displayed in tables 1 and 2

Regional milk production constraints In all scenarios, the regional production of milk is constrained among the nine aggregate regions. Table 22 shows the minimum right-hand-side values for milk production by aggregate region. These right-hand-side values are based on regional production distributions for milk calculated from 1978 Census data and prevent the production of milk from shifting to one or two aggregate regions of the United States where dairy activities in the model are most efficient, thus, causing unrealistic competition for inputs in those regions.

Intuition behind Scenario 1 The intuition behind Scenario 1 is based upon two things. First, it is desirable under any analysis using various scenarios to have a means of comparing results with some tangible base. Scenario 1, closely reflecting the currently existing situation in the pork and feeder beef cattle producing sectors, provides this base. Secondly, the distributional assumptions under Scenario 1 could likely be similar to the distributions that would exist in the year 2000 if policies were implemented, over the concern to "save the family farm," to preserve the regional pork and feeder beef cattle farm-size distributions that are in existence today.

Scenario 2

Scenario 2 uses regional size distributions for pork and feeder beef cattle based on 1982 Census data (tables 20a and 20b) similar to those in Scenario 1. In Scenario 2, however, all regional restrictions on pork

Table 22. Regional dairy production[a] lower bounds used in right-hand-sides for all scenarios

Aggregate region	Quantity of milk produced
	(1,000 cwts)
New England	52,900.0
Middle Atlantic	217,810.0
East North Central	397,785.0
West North Central	256,815.0
South Atlantic	115,680.0
East South Central	88,500.0
West South Central	86,390.0
Mountain	63,134.0
Pacific	158,940.0
Total U.S. Production	1,437,981.93

[a]Based on regional production percentages reported in the 1978 Census of Agriculture.

and feeder beef cattle production are deleted. Thus, Scenario 2 allows unrestricted shifts in the regional production of pork and feeder beef cattle by the year 2000, but only as long as the size distributional restrictions are met within those regions where production occurs.

Intuition behind Scenario 2 The intuition behind Scenario 2 is based upon the fact that, in the absence of any size or production restrictions, a majority of the production of pork and feeder beef cattle would concentrate on the most efficient farm size in the most efficient regions of production (excluding any consideration of input depletion). However, if regional production restrictions were released but regional size distributions remained in place, then the production of pork and feeder beef would tend to concentrate, not in regions with the most efficient farm size, but in the regions with the most efficient farm size distributions. This scenario, therefore, gives policy makers concerned with the size distributions of pork and feeder beef cattle farms in the future, a suggestion as to which aggregate regions have comparatively efficient farm size distributions and which aggregate regions have comparatively inefficient farm size distributions.

Scenario 3

Scenario 3, like Scenario 1, involves restrictions on both the regional production and regional farm-size distributions of pork and feeder beef cattle production. However, in Scenario 3, the restrictions are based upon projected distributions in the year 2000. The projected regional size distributions and regional production percentages are both based upon observed trends in past census reports.

Regional production percentages Tables 23a and 23b show how the regional production distributions, among those aggregate regions defined in the model, have changed for pork and feeder beef cattle between past census reports. This is the information used to project regional production percentages in the year 2000 for Scenario 3.

A simple average differences approach is used to develop the projected regional production percentages. For example, as shown in Table 23b, the percentage of national production of pork produced from aggregate regions included in the model by the West South Central aggregate region, declined from 2.76 percent in 1974 to 2.69 percent in 1978 and to 2.16 percent in 1982. Thus, the average difference between census reports was -0.3. Assuming a continuation of past trends in shifting regional production, this average difference can be used to conclude that the West South Central region's share of natural pork production will decline by 12 percentage points by the year 2000, thus, leaving the West South Central Region with slightly less than 1 percent of pork production in the year 2000. Tables 24a and 24b show the regional production distributions that are used in Scenario 3. Table 25 illustrates the minimum right-hand-side values that constrain the model based on those projected regional production percentages.

Table 23a. Historical percentages of national feeder beef production by aggregated region represented through activities in the linear programming model

Region	Percentage of national production as represented through available modeling activities			
	(1969)	(1974)	(1978)	(1982)
East North Central	11.676	10.746	11.047	11.079
West North Central	28.634	28.616	28.334	27.884
South Atlantic	8.745	9.343	9.417	9.593
East South Central	10.109	10.933	9.732	9.422
West South Central	21.708	20.962	21.433	21.017
Mountain	12.756	12.833	13.082	13.501
Pacific	6.372	6.568	6.955	7.505
Percentage of national production represented by modeling activities	94.9	95.5	95.0	94.9

Table 23b. Historical percentages of national pork production by aggregated region represented through activities in the linear programming model

Aggregate region	Percentage of national production represented through available modeling activities		
	(1974)	(1978)	(1982)
East North Central	28.127	27.041	27.822
West North Central	54.038	54.065	55.053
South Atlantic	8.560	9.554	9.200
East South Central	4.755	4.922	4.120
West South Central	2.761	2.688	2.159
Mountain	1.759	1.729	1.647
Percentage of national production represented by modeling activities	98.0	97.7	97.5

Table 24a. Projected regional production distribution of feeder beef in the year 2000 based on historical percentages

Aggregate region	Percentage of total model production
East North Central	10.88
West North Central	27.63
South Atlantic	9.90
East South Central	9.19
West South Central	20.78
Mountain	13.74
Pacific	7.88

Table 24b. Projected regional production distribution of pork in the year 2000 based on historical percentages

Aggregate region	Percentage of total model production
East North Central	27.211
West North Central	57.081
South Atlantic	10.478
East South Central	2.851
West South Central	0.956
Mountain	1.423

Table 25. Regional feeder cattle and pork production[a] lower bounds used in right-hand sides for scenarios 3 and 5

Aggregate region	Quantity of feeder cattle	Quantity of pork
	---------------(1,000 cwts.)----------	
East North Central	21,185.0	73,400.0
West North Central	53,805.0	154,100.0
South Atlantic	19,279.0	28,300.0
East South Central	17,895.0	7,700.0
West South Central	40,465.0	2,500.0
Mountain	26,757.0	3,800.0
Pacific	15,345.0	N/A

[a]Based on projected regional production percentages for the year 2000 reported in tables 24a and 24b.

Regional size distributions   Regional size distributions for Scenario 3 are developed by the same average differences method and are used to project production percentages. The data discussed in Chapter I (Tables 4a- 4g and 5a-5f) were used to develop an average difference for each size category within each aggregate region. These average differences were then expanded out from the distributions reported for 1982 to the year 2000. The resulting projected distributions are shown in Table 26a (feeder beef cattle) and Table 26b (pork).

Intuition behind Scenario 3   Scenario 3 simply extends past trends in pork and feeder cattle regional size distributions and production percentages out to the year 2000. To the extent that these trend extensions capture changes in regional production and regional size distributions caused by unique external factors occurring over the years covered by the census data used, these projected distributions are not very realistic. However, these trend extensions do capture the directions in which trends in size distribution and regional production are moving and, therefore, serve to indicate, in a general sense, what the regional production percentages and size distributions of the pork and feeder beef cattle sectors will be in the year 2000 if current agricultural policies affecting these sectors are not modified.

Scenario 4

In Scenario 4 all regional constaints on the production and farm-size distributions of pork and feeder beef cattle are lifted and the only restriction placed upon these activities is a national farm size

Table 26a. Projected size distribution of feeder cattle production by the year 2000, based on historical trend by aggregate region

Aggregate region	Percentage of total farms by size (cows and heifers having calved)			
	(10-49)	(50-199)	(200-500)	(> 500)
East North Central	55.7	43.3	0.9	0.1
West North Central	51.8	43.5	4.1	0.6
South Atlantic	68.0	27.5	3.5	1.0
East South Central	75.3	23.0	1.5	0.2
West South Central	65.0	30.0	4.0	1.0
Mountain	40.0	39.0	15.5	5.5
Pacific	45.0	31.0	16.0	8.0

Table 26b. Projected size distribution of pork production by the year 2000, based on historical trend by aggregate region

Aggregate region	Percentage of total farms by size (sales per farm			
	(10-49)	(50-199)	(200-500)	(> 500)
East North Central	9	33	22	36
West North Central	0	20	38	42
South Atlantic	23.25	37.5	18.75	20.5
East South Central	26	44.5	16.5	13
West South Central	38.5	36.5	13.5	11.5
Mountain	30	36.75	18.25	20

distributional restriction. Table 27 shows the national farm-size distributions for pork and feeder beef cattle production implemented under scenarios 4 and 5. As noted, these national distributions assume that, by the year 2000, the trends in the size of pork and feeder beef farms will be in the direction of a "bi-modal" distribution. Under this assumption, the relative proportion of small farms remains fairly constant, while the relative proportion of medium-sized farms decreases and the relative proportion of large farms increases.

Intuition behind Scenario 4 Scenario 4 was included in the analysis for two reasons. First, Scenario 4 was included in an attempt to show how concerns over national pork and feeder beef farm size distributions, without regard for regional differences in farm structure, could affect the overall production of pork and feeder cattle. Secondly, the bi-modal national distributions for pork and feeder beef cattle farms shown in Table 27 are very realistic projections of what the national pork and feeder beef farm-size distributions might look like in the year 2000 as the medium-sized farms find it harder and harder to survive the increasing outside capital needs (as compared to small farms) and lower economies of scale (as compared to large farms) associated with the production of pork and feeder beef cattle.

Table 27. Projected national size distributions of pork and feeder cattle farms by the year 2000, under the assumption of an increased trend towards a bi-modal distribution of livestock production[a]

Farm type	Size (head sold)	Percentage of national distribution
Pork	10-199	37.3
	200-1,000	21.8
	> 1,000	40.9
Feeder Cattle	10-199	66.7
	200-499	9.8
	> 500	23.5

[a]Source: (Personal communications with Yao Chi-Lu, Office of Technology Assessment, January 1985).

Scenario 5

Scenario 5, like scenario 4, employs the national farm-size distributions for pork and feeder beef cattle shown in Table 27. However, unlike Scenario 4, Scenario 5 also employs regional production restrictions on pork and feeder beef cattle production. Those regional production restrictions are the same projected regional production right-hand-side values shown in Table 25 and based on the average differences between past census reports expanded out to the year 2000.

Intuition behind Scenario 5   Scenario 5 is included in an attempt to account for the regional differences in farm structure under the implementation of national pork and feeder beef cattle farm-size distributions. Results from this scenario could prove very useful to policy makers concerned with implementing policies designed to encourage trends towards a bi-modal national distribution of pork and feeder beef cattle farms with as little disruption to the infrastructure surrounding these sectors as possible.

The Linear Programming Matrix

The livestock production activities, feed transfer activities, model constraints, and scenario restrictions are combined to form a large linear programming matrix that, unfortunately, cannot be effectively reproduced in this text. However, the essential details of the model can be represented with a partial matrix using a single livestock producing area and the respective aggregate region for that LPA. Figure 4 represents a matrix schematic for a representative LPA which includes

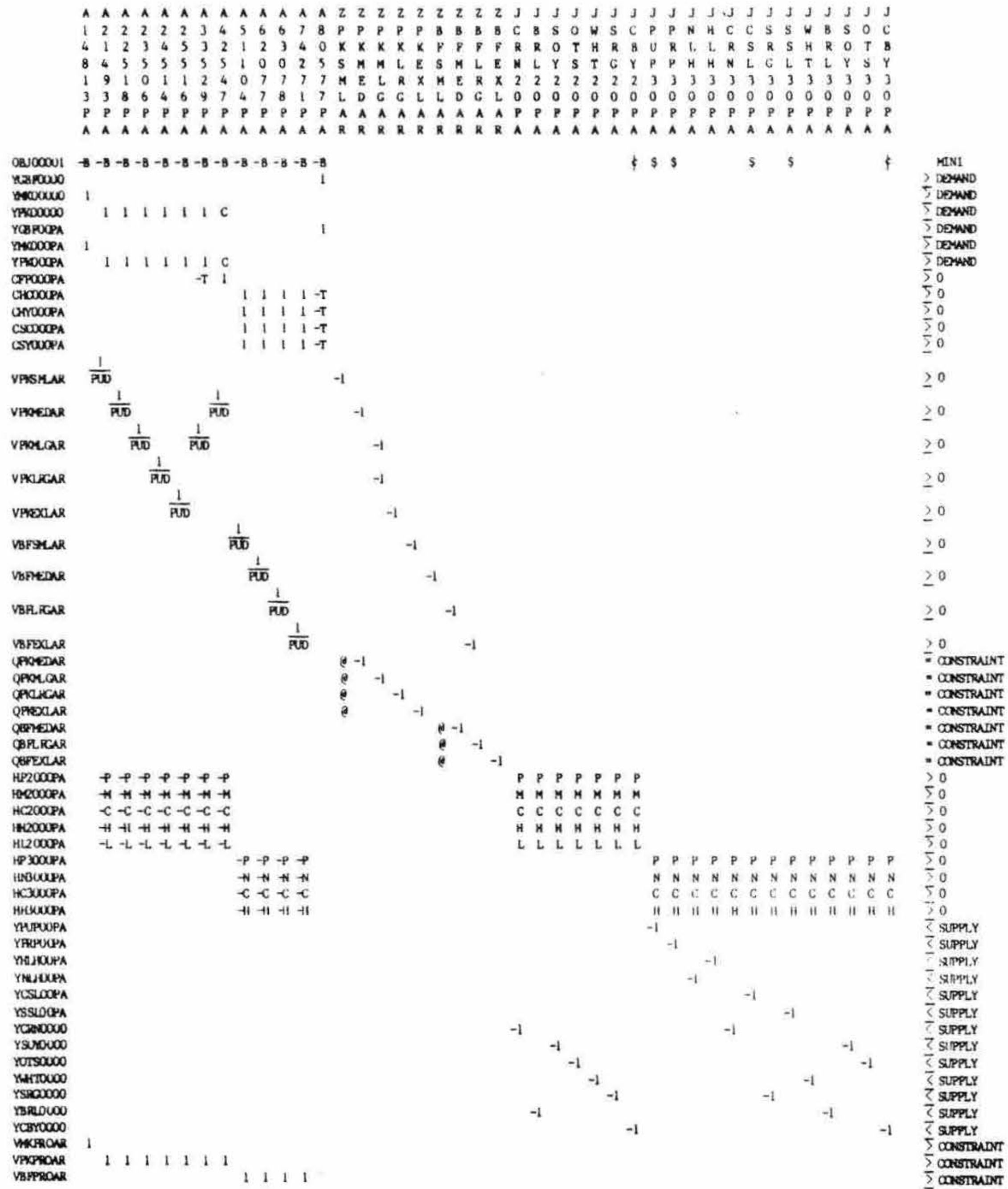

Figure 4. A matrix schematic for a representative LPA

only representative examples of the total number of activities available in the model.

The activities that are shown in Figure 4 can be defined as follows:

A14813PA: Dairy production activity based on budget #813 in representative PA

A21493PA: Small pork production activity (farrow-to-finish) based on budget #493

A22518PA: Medium pork production activity (farrow-to-finish) based on budget #518

A23506PA: Medium-large pork production activity (farrow-to-finish) based on budget #506

A24514PA Large pork production activity (farrow-to-finish) based on budget #514

A25516PA: Extra-large pork production activity (farrow-to-finish) based on budget #516

A33529PA: Medium-large pork production activity (feeder pig finish) based on budget #529

A42547PA: Medium pork production activity (feeder pig producing) based on budget #547

A51104PA: Small feeder beef activity (feeder calves) based on budget #104

A62077PA: Medium feeder beef activity (feeder yearlings) based on budget #077

A63078PA: Large feeder beef activity (feeder yearlings) based on budget #078

A74271PA: Extra large feeder beef activity (calves and yearlings) based on budget #271

A80577PA: Grain-fed beef producing activity based on budget #577

ZPKSMLAR: Activity for small pork farms used in implementing size restrictions

ZPKMEDAR: Activity for medium pork farms used in implementing size restrictions

APKMLGAR: Activity for medium-large pork farms used in implementing size restrictions

ZPKLRGAR: Activity for large pork farms used in implementing size restrictions

ZPKEXLAR:	Activity for extra-large pork farms used in implementing size restrictions
ZBFSMLAR:	Activity in small feeder beef farms used in implementing size restrictions
ZBFMEDAR:	Activity for medium feeder beef farms used in implementing size restrictions
ZBFLRGAR:	Activity for large feeder beef farms used in implementing size restrictions
ZBFEXLAR:	Activity for extra-large feeder beef farms used in implementing size restrictions
JCRN20PA:	Corn transfer activity to pork production
JBRL20PA:	Barley transfer activity to pork production
JSOY20PA:	Soybean transfer activity to pork production
JOTS20PA:	Oats transfer activity to pork production
JWHT20PA:	Wheat transfer activity to pork production
JSRG20PA:	Sorghum transfer activity to pork production
JCBY20PA:	Calcium and phosphorus buying activity for pork
JPUP30PA:	Public pasture transfer activity to feeder beef
JPRP30PA:	Private pasture transfer activity to feeder beef
JNLH30PA:	Nonlegume hay transfer activity to feeder beef
JHLH30PA:	Legume hay transfer activity to feeder beef
JCRN30PA:	Corn transfer activity to feeder beef
JCSL30PA:	Corn silage transfer activity to feeder beef
JSRG30PA	Sorghum transfer activity to feeder beef
JSSL30PA:	Sorghum silage transfer activity to feeder beef
JWHT30PA	Wheat transfer activity to feeder beef
JBRL30PA:	Barley transfer activity to feeder beef
JSOY30PA:	Soybean transfer activity to feeder beef
JOTS30PA:	Oats transfer activity to feeder beef
JCBY30PA:	Calcium and phosphorus buying activity for feeder beef

In addition, representative examples of the constraints (rows) for a given livestock producing area (PA) within a given aggregate region (AR) are matched to those activities.

The rows that are shown in Figure 4 can be defined as follows:

OBJ00001: Overall objective function

YGBF0000: National grain-fed beef accounting row

YMK00000: National milk accounting row

YPK00000: National pork accounting row

YGBF00PA: LPA demand for grain-fed beef

YMK000PA: LPA demand for milk

YPK000PA: LPA demand for pork

CFP000PA: Constraint on intermediate demand in LPA for feeder pigs

CHC000PA: Constraint on intermediate demand in LPA for heifer calves

CHY000PA: Constraint on intermediate demand in LPA for heifer yearlings

OSC000PA: Constraint on intermediate demand in LPA for steer calves

CSY000PA: Constraint on intermediate demand in LPA for steer yearlings

VPKSMLAR: Rows used for identifying farm units - small pork

VPKMEDAR: Rows used for identifying farm units - medium pork

VPKMLGAR: Rows used for identifying farm units - medium-large pork

VPKLRGAR: Rows used for identifying farm units - large pork

VPKEXLAR: Rows used for identifying farm units - extra large pork

VBFSMLAR: Rows used for identifying farm units - small beef

BFMEDAR: Rows used for identifying farm units - medium beef

VBFLRGAR: Rows used for identifying farm units - large beef

VBFEXLAR: Rows used for identifying farm units - extra large beef

OPKMEDAR: Rows used for implementing size distributions - medium pork

QPKMLGAR: Rows used for implementing size distributions - medium-large pork

OPKLRGAR: Rows used for implementing size distributions - large pork

QPKEXLAR: Rows used for implementing size distributions - extra-large pork

QPFMEDAR: Rows used for implementing size distributions - medium beef

OBFLRGAR: Rows used for implementing size distributions - large beef

OBFEXLAR: Rows used for implementing size distributions - extra-large beef

HP2000PA: LPA crude protein constraint for pork

HM2000PA	LPA metabolizable energy constraint for pork
HC2000PA:	LPA calcium energy constraint for pork
HH2000PA:	LPA phosphorus constraint for pork
HL2000PA:	LPA lysine constraint for pork
HP3000PA:	LPA crude protein constraint for feeder beef
HN3000PA:	LPA net energy constraint for feeder beef
HC3000PA:	LPA calcium constraint for feeder beef
HH3000PA:	LPA phosphorous constraint for feeder beef
YPUP00PA:	LPA public pasture constraint
YPRP00PA:	LPA private pasture constraint
YHLH00PA:	LPA legume hay constraint
YNLH00PA:	LPA nonlegume hay constraint
YCSL00PA:	LPA corn silage constraint
YSSL00PA:	LPA sorghum silage constraint
YCRN0000:	National corn used by livestock, accounting row
Y5040000:	National soybeans used by livestock accounting row
YOTS0000:	National oats used by livestock accounting row
YWHT0000:	National wheat used by livestock accounting row
YSRG0000:	National sorghum used by livestock accounting row
YBRL0000:	National barley used by livestock accounting row
YCBY0000:	National calcium and phosphorus bought, accounting row
VMKPROAR:	Rows used for aggregate region production constraints - milk
VPKPROAR:	Rows used for aggregate region production constraints - pork
VBFPROAR:	Rows used for aggregate region production constraints - feeder beef

Limitations of the Model

It should be noted that linear programming models have limitations which restrict the scope of their use and limit the analysis of results. Linear programming uses linear apprcximations to develop relationships between inputs and outputs, and their associated costs. Therefore, by construction, the objective function assumes constant costs over the relevant range of production possibilities. This implies that the model does not have the capability to reflect pecuniary economies and, more importantly, diseconomies as the production of pork and feeder beef cattle shifts from one aggregate region to another.

An additional, characteristic of this particular model that limits its ability to provide irrefutable results is the degree of dependence that the production of feeder beef cattle has on the grain-fed beef sector. Because of budget inconsistencies that are not easily correctable due to lack of reliable data, the grain-fed beef sector employed by this model is not highly accurate in reflecting the current or projected structure of U.S. grain-fed beef production (Disney and English, 1985). To the extent that this inaccuracy impacts the production of feeder cattle under the various scenarios, this study has the potential for repudiation.

Finally, very little attention was paid to crop costs in this model. These costs could be of considerable importance under any of the scenarios which are a part of this study. However, as long as relative costs remain the same, the results under the various scenarios should not change substantially.

CHAPTER III: RESULTS

In this chapter, resulting regional production levels, regional and national farm numbers, and regional and national costs of production are presented for the five scenarios that were a part of this study. Comparisons are made between scenarios with similar base assumptions and, finally, general comparisons among all scenarios are presented.

Scenario 1

Figures 5 and 6 show the optimal regional production levels, farm numbers, and average total costs of production for feeder beef cattle and pork in Scenario 1. Scenario 1 most closely resembles the present farm structure of pork and feeder beef cattle production with farm size distributions and regional production percentages based on 1982 census data.

Regional production

As can be seen in Figure 5, optimal regional production of feeder cattle is at the minimum constraint levels in all aggregate regions except the West South Central Region. Therefore, the model is clearly indicating that, under Scenario 1, the West South Central Region is the most efficient aggregate region in the production of feeder cattle.

Similarly, Figure 6 reveals that, in Scenario 1, the optimal regional production of pork is at the minimum constraint levels (adjusted for feeder pig production) in all aggregate regions except the East North Central Region. Note that, under Scenario 1, the production (1,470,000

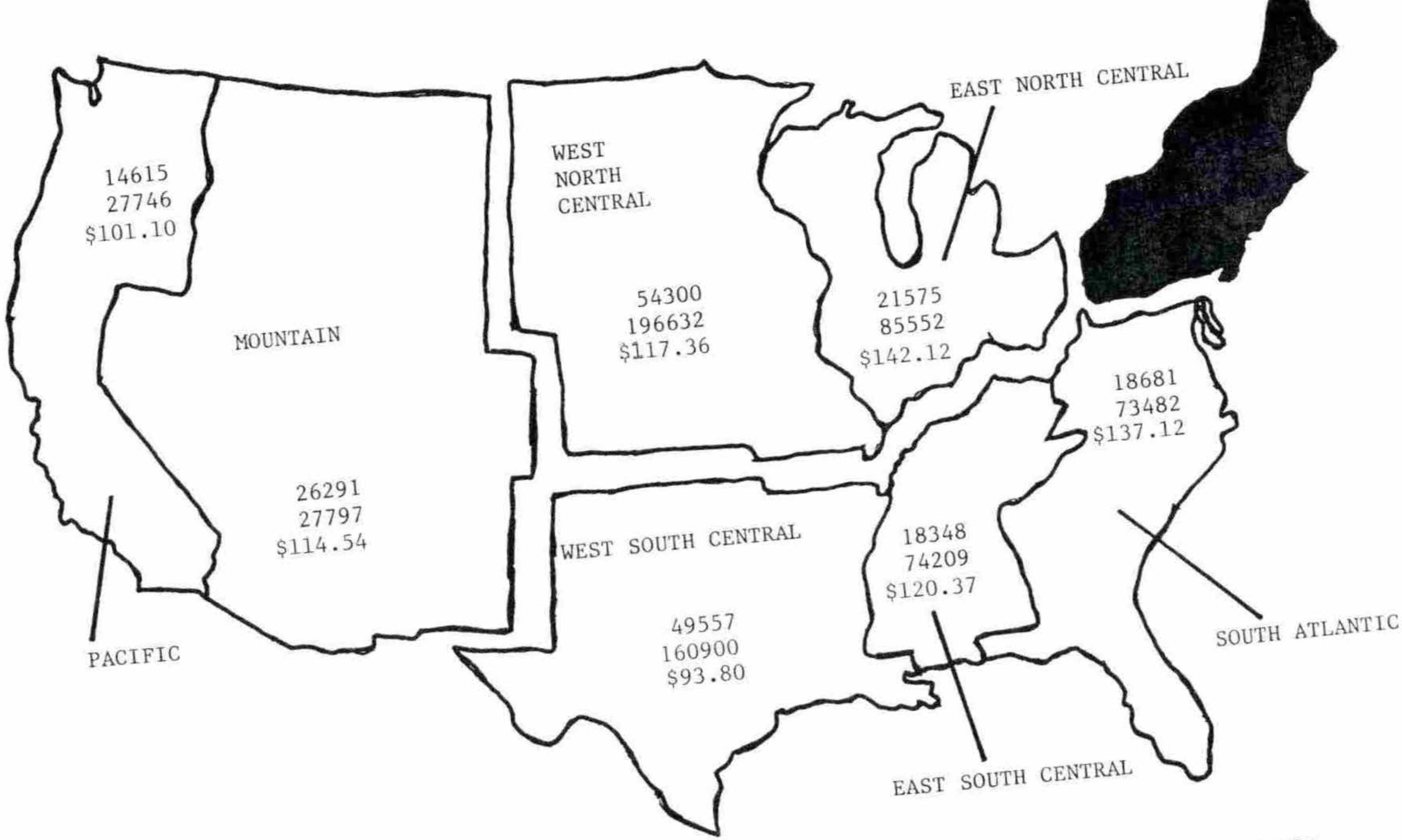

Figure 5. Feeder beef regional production (1,000 cwts.), farm numbers, and average costs ($/cwt.) under Scenario 1

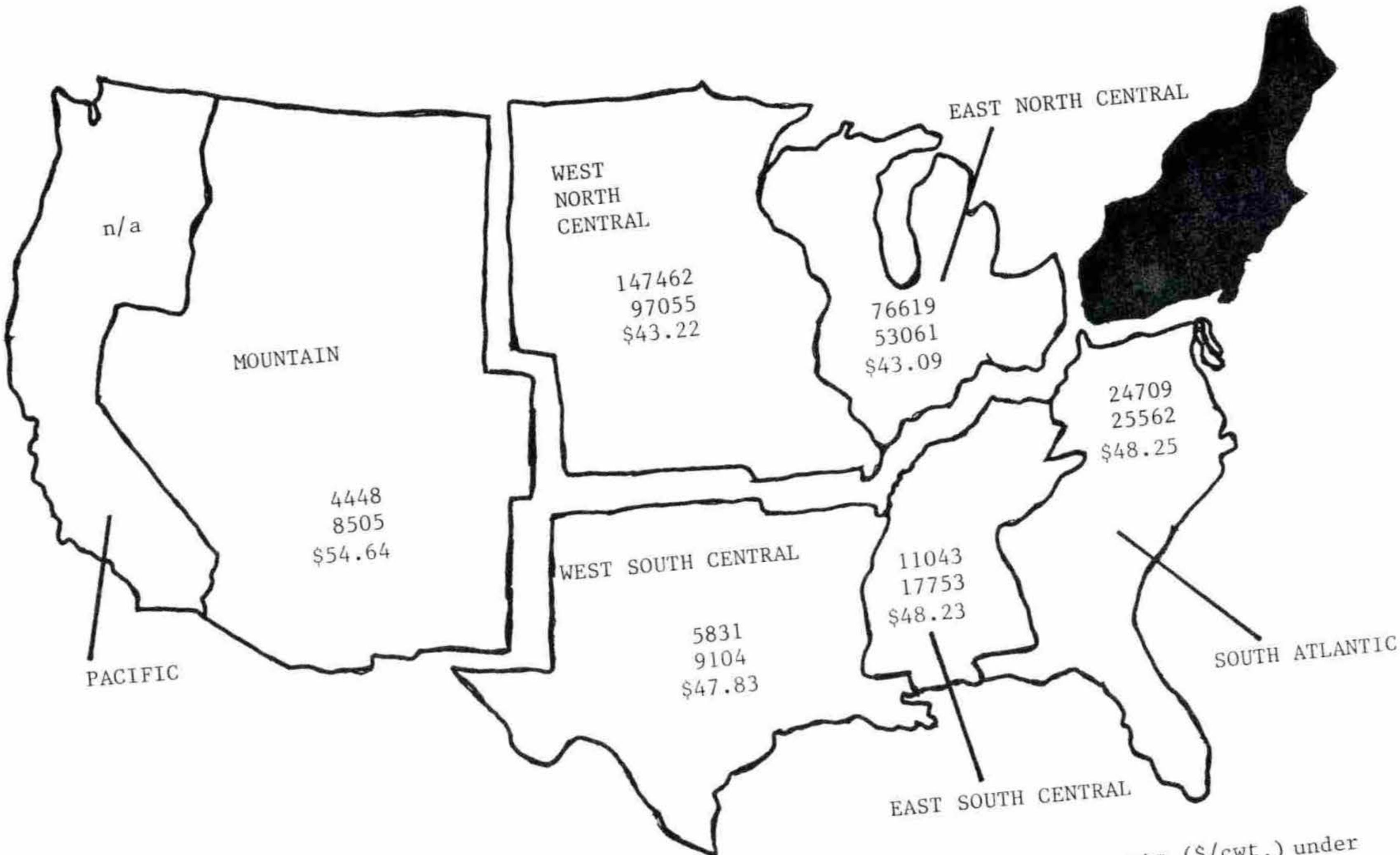

Figure 6. Pork regional production (1,000 cwts.), farm numbers, and average costs ($/cwt.) under Scenario 1

cwts) demanded in excess of regional minimum constraints is produced in the East North Central Region because of a slight cost advantage over the West North Central Region.

Farm numbers

A good test of the model's ability, under Scenario 1, to simulate the present structure of the pork and feeder beef cattle sectors is to compare optimal farm numbers generated under Scenario 1 with actual farm numbers as reported in the 1982 Census of Agriculture. A summation of the regional farm numbers reported in Figure 5 shows that, under Scenario 1, 646,317 farms are required to meet the national production demands for feeder beef cattle. According to the 1982 Census of Agriculture, there were 754,095 feeder beef cattle farms in 1982. The 14 percent difference between optimal feeder beef farm numbers can be attributed to more efficient production by the model activities of each size classification and to the discrete nature of activities available for model production.

Similarly, a summation of farm numbers reported in Figure 6 shows that 211,040 pork farms were required by the model to meet the demands for pork under the assumptions used in Scenario 1. This, when compared with 1982 census data, shows an 18 percent difference in farm numbers over actual 1982 reported pork farms (259,274). Again, this difference can be attributed to better efficiency (i.e., use of facility capacity) by the modeling activities.

Costs of production

Average total costs of production per cwt. of feeder beef cattle production in Scenario 1 are also shown in Figure 5 by aggregate region. These costs seem extremely high, but there are a couple of reasons for these high costs. First, the costs included in the modeling activities represent all costs associated with starting out in the feeder beef cattle producing business and, therefore, allow for depreciation charges on equipment and facilities as though they were acquired during the current year. In reality, many feeder beef producing farms are using buildings and equipment that are already fully depreciated. Therefore, very few costs are attached to their use. The second reason for high average total costs is because the implementation of farm size distributions causes small, less efficient, feeder beef producing activities to come into solution. Not only do these smaller activities fail to achieve the cost economies of scale associated with larger feeder beef operations, but these activities may not be producing feeder beef cattle at the capacity of their fixed charges for buildings and equipment, thus, causing average costs per cwt. to rise even further.

As Figure 5 shows, the West South Central Region has a significant cost advantage over the other 6 aggregate regions in the production of feeder cattle, with total costs averaging $93.80 per cwt of feeder beef cattle produced. Surprisingly, the Pacific Region is the closest competitor in terms of cost. However, due to milder winter calving conditions in these regions, the use of buildings is less intensive and, therefore, the problem of over-costing described above is less frequent.

This may mislead one into concluding that the cost advantages are greater than they are in reality.

On the other hand, Figure 6 shows that the average total costs per cwt of pork production, under Scenario 1, are very similar to what the actual costs of producing pork were in 1982. This figure clearly shows a slight cost advantage (13¢ per cwt) for the East North Central Region over the West North Central Region in the production of pork. Other aggregate regions have significant cost disadvantages when compared to the two major producing areas.

Scenario 2

Scenario 2, like Scenario 1, involves the use of size distribution for pork and feeder beef cattle farms based on 1982 Census data. However, in Scenario 2, all production constraints on the regional location of pork and feeder beef production are lifted and the results are quite interesting. Figures 7 and 8 show the optimal regional production levels, farm numbers, and average total costs of production for feeder beef cattle and pork in Scenario 2.

Regional production

As shown in Figure 7, the regional production of feeder beef cattle, under Scenario 2, is concentrated in two aggregate regions. In fact, 72 percent of the nation's feeder beef cattle are produced in the West South Central Region and 20 percent in the West North Central Region. The remaining 8 percent of national production is split among four

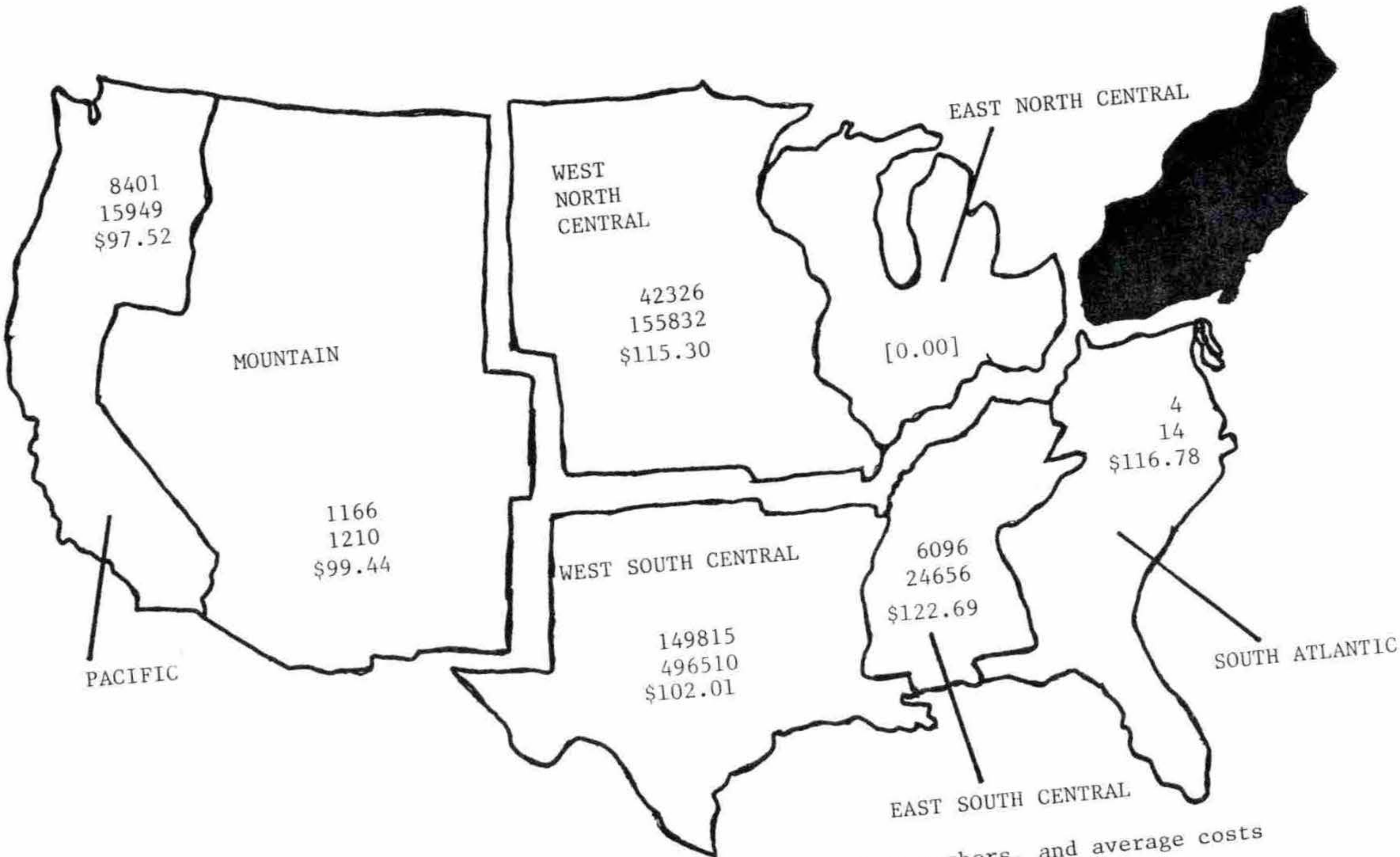

Figure 7. Feeder beef regional production (1,000 cwts.), farm numbers, and average costs ($/cwt.) under Scenario 2

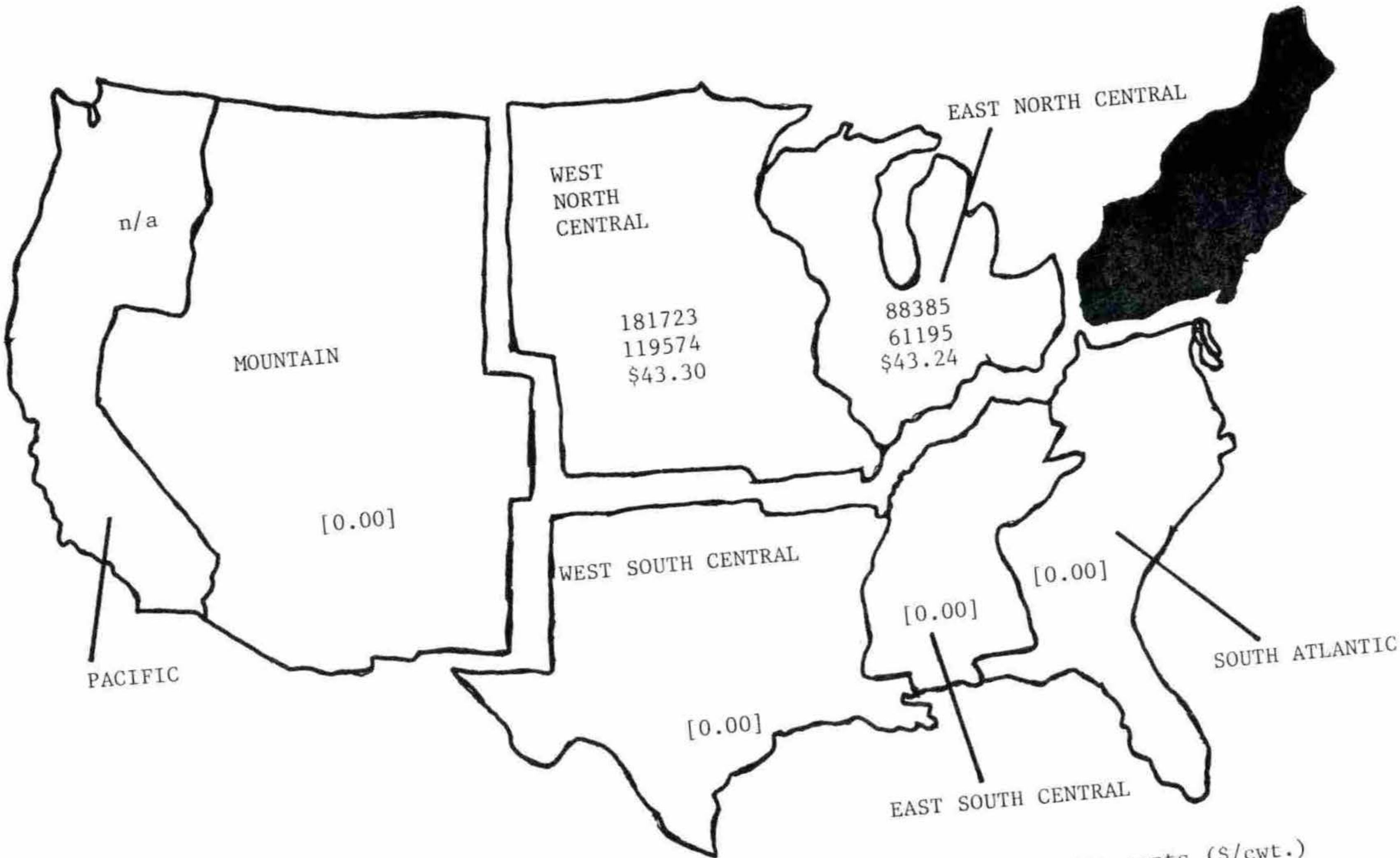

Figure 8. Pork regional production (1,000 cwts.), farm numbers, and average costs ($/cwt.) under Scenario 2

aggregate regions with the East North Central Region being entirely eliminated as a producer of feeder cattle.

Similarly, Figure 8 shows that, in the absence of any regional restrictions on the production of pork, all pork production shifts to two regions of the United States. In Scenario 2, the West North Central Region accounts for 67.3 percent of national pork production and the East North Central Region accounts for 32.7 percent of the national pork production. All other aggregate regions are eliminated as producers of pork in the absence of regional production constraints.

Farm numbers

A summation of farm numbers from Figure 7 indicates that, in Scenario 2, 694,171 farms are required by the model to produce feeder beef cattle. This number is actually higher than the number of farms required under Scenario 1 for the production of feeder beef. The reason for this, however, is quite intuitive. Since 72 percent of the production of feeder beef cattle is occurring in the West South Central Region, the model must meet the size distributional restriction within that region. Thus, large numbers of smaller farms in the West South Central Region cause total farm numbers to increase. Seemingly, this means that the cost savings associated with feeder beef farms in the West South Central Region offsets the diseconomies of small farm size. Clearly, the size distribution of feeder beef farms in the West South Central Region is comparatively more efficient that size distributions of other feeder beef producing regions, all other things held constant.

An aggregation of farm numbers from Figure 8 shows that, in Scenario 2, optimal farm numbers for the production of pork drop to 180,769 in the absence of regional production constraints. This indicates that the pork farm size distributions, currently existing in the West North Central and East North Central regions, are comparatively more efficient than farm size distributions existing in other aggregate regions of the United States.

Costs of production

Figure 7 shows that average costs per cwt. of feeder beef production, in Scenario 2, are very much like those in Scenario 1 for similar reasons. It should be noted that average costs increase substantially in the West South Central Region in Scenario 2, as more feedstuffs are imported into that region to meet the high production levels.

Figure 8 shows that total costs per cwt. of pork production in the West North Central and East North Central regions, in Scenario 2, are almost the same as costs in those two aggregate regions under Scenario 1.

Scenario 3

Figures 9 and 10 show the optimal regional production levels, farm numbers, and average total costs of production for feeder beef cattle and pork in Scenario 3. Recall that Scenario 3, like Scenario 1, includes both regional size distributions and regional production percentages. However, in Scenario 3, these distributions and production percentages are based on projected trends to the year 2000.

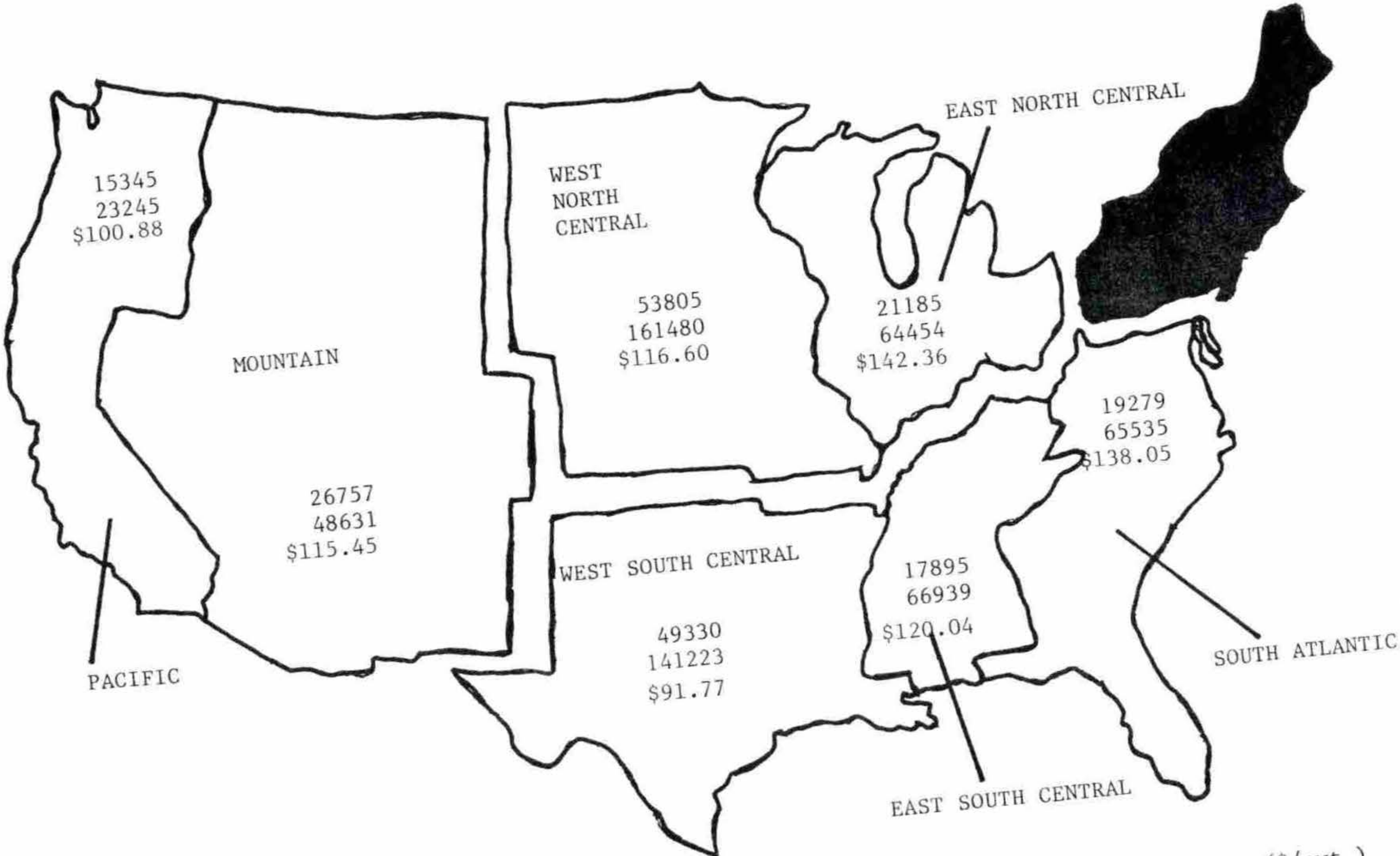

Figure 9. Feeder beef regional production (1,000 cwts.), farm numbers, and average costs ($/cwt.) under Scenario 3

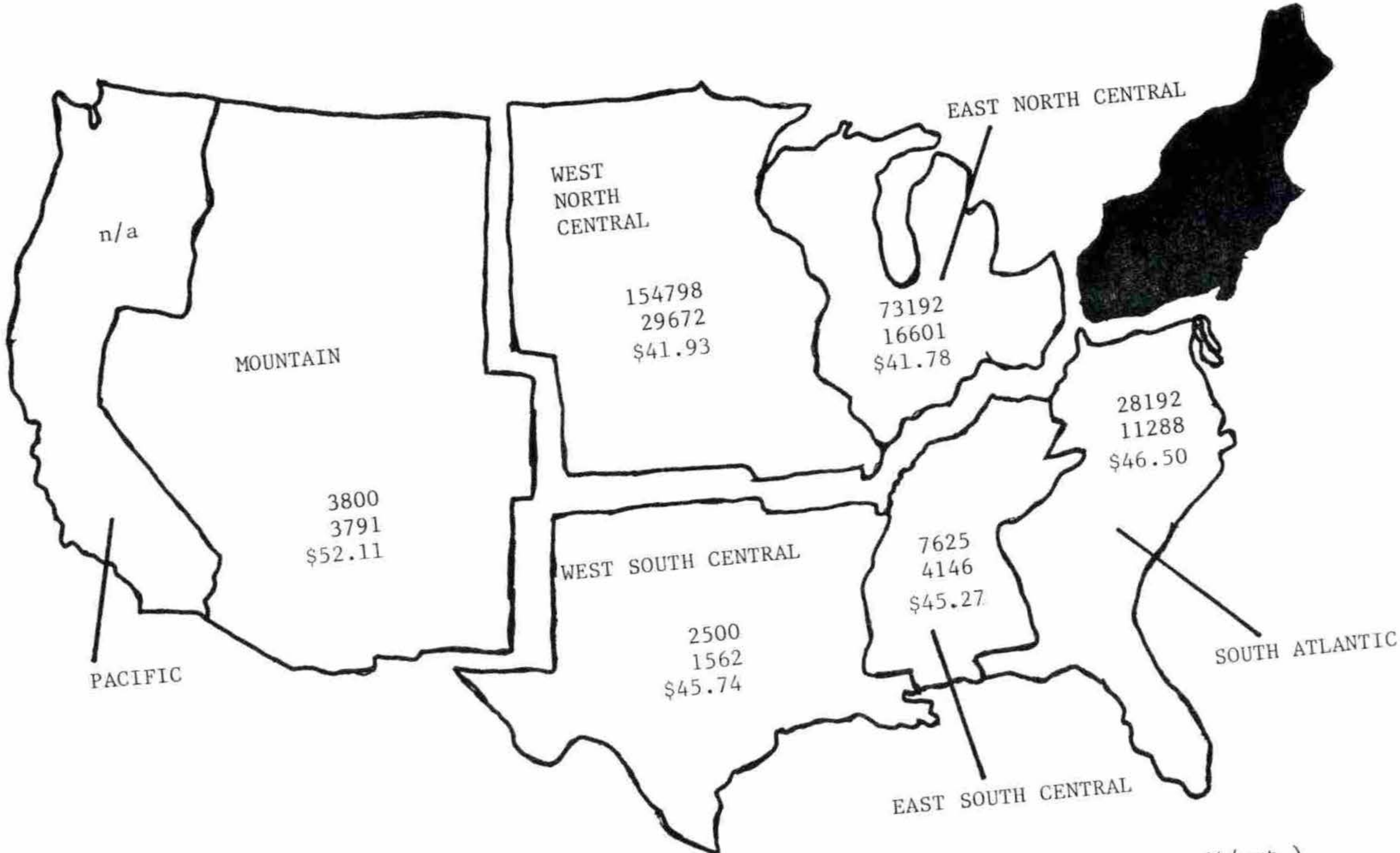

Figure 10. Pork regional production (1,000 cwts.), farm numbers, and average costs ($/cwt.) under Scenario 3

Regional production

As can be seen in Figure 9, optimal regional production of feeder beef cattle is, just as in Scenario 1, at the minimum constraint levels in all aggregate regions except the West South Central Region. The unconstrained production of approximately 9,000,000 cwts. of feeder beef cattle in the West South Central Region above minimum regional production levels is consistent with results from Scenario 1 and the same implications are implied.

The regional production of pork, in Scenario 3, is also proportionately similar to that under Scenario 1, given the new minimum regional production constraints used in Scenario 3. The only noticeable differences in the regional production of pork between Scenario 3 and Scenario 1 are the slight changes in regional production percentages that are the result of different regional production percentages assumed in Scenario 3.

Farm numbers

An aggregation of the regional farm numbers shown in Figure 9 reveals that 571,507 feeder beef farms are required in the optimal solution for Scenario 3. This is down 11.5 percent from the total number of feeder beef farms required in Scenario 1. This seems logical since, as size distributions shift away from smaller farms and towards larger farms, fewer total farms are needed to produce to meet a fixed demand.

Similar aggregation of the regional farm numbers shown in Figure 10 reveals that 67,060 pork farms are required in the optimal solution for Scenario 3. This is down very significantly from the 211,040 pork farms that were required to produce the same output in Scenario 1. This is simply a reflection of the strong downward trends in pork farm numbers over past census reports, but, assuming these strong downward trends were to continue, Scenario 3 indicates a 68 percent decline in the number of pork farms by the year 2000, compared to the number of pork farms required in Scenario 1.

Costs of production

Average total costs of production per cwt. of feeder beef production in Scenario 3 are also shown in Figure 9 by aggregate region. As shown, similar comparative average costs per aggregate region exist for feeder beef cattle production as in Scenario 1. In fact, there is very little difference in the average cost of production of feeder cattle between Scenario 3 and Scenario 1.

Figure 10 shows the average costs per cwt. of pork production by aggregate region. A comparison with Figure 6 shows that average costs for pork production are approximately $2 per cwt. less in Scenario 3 than in Scenario 1. This, again, is due to the sharp increases in relative numbers of larger pork farms, and their associated cost economies of scale, under the assumptions in Scenario 3.

Scenario 4

Results for Scenario 4 provide for interesting policy discussion. Recall that, in Scenario 4, all regional size distributions and regional production percentage restrictions are lifted and the model is only restricted by national farm size distributions. Figures 11 and 12 show the optimal regional production levels, farm numbers, and average total costs of production for feeder beef cattle and pork under the assumptions of Scenario 4.

Regional production

The regional production of feeder beef cattle in Scenario 4 is, as shown in Figure 11, greatest in the West South Central and West North Central regions. However, when compared with Scenario 2 (the other scenario with no regional restrictions), the percentage of national feeder beef production produced by the West South Central Region declines from 72 percent to 57 percent. This is made up, in Scenario 4, by an increase in the share of national feeder beef production by the Mountain (8 percent) and East South Central (6 percent) regions.

As shown in Figure 12, the production of pork again occurs only in the West North Central (66.8 percent) and East North Central (33.2 percent) regions in Scenario 4. Therefore, regional production of pork under Scenario 4 is almost identical to Scenario 2.

Farm numbers

A summation of farm numbers from Figure 11 indicates that 170,634 farms are required to produce the optimal quantity of feeder beef cattle in Scenario 4. Therefore, although regional production in Scenario 4 is very comparable with regional production in Scenario 2, farm numbers are not. When national size distributions are substituted for regional

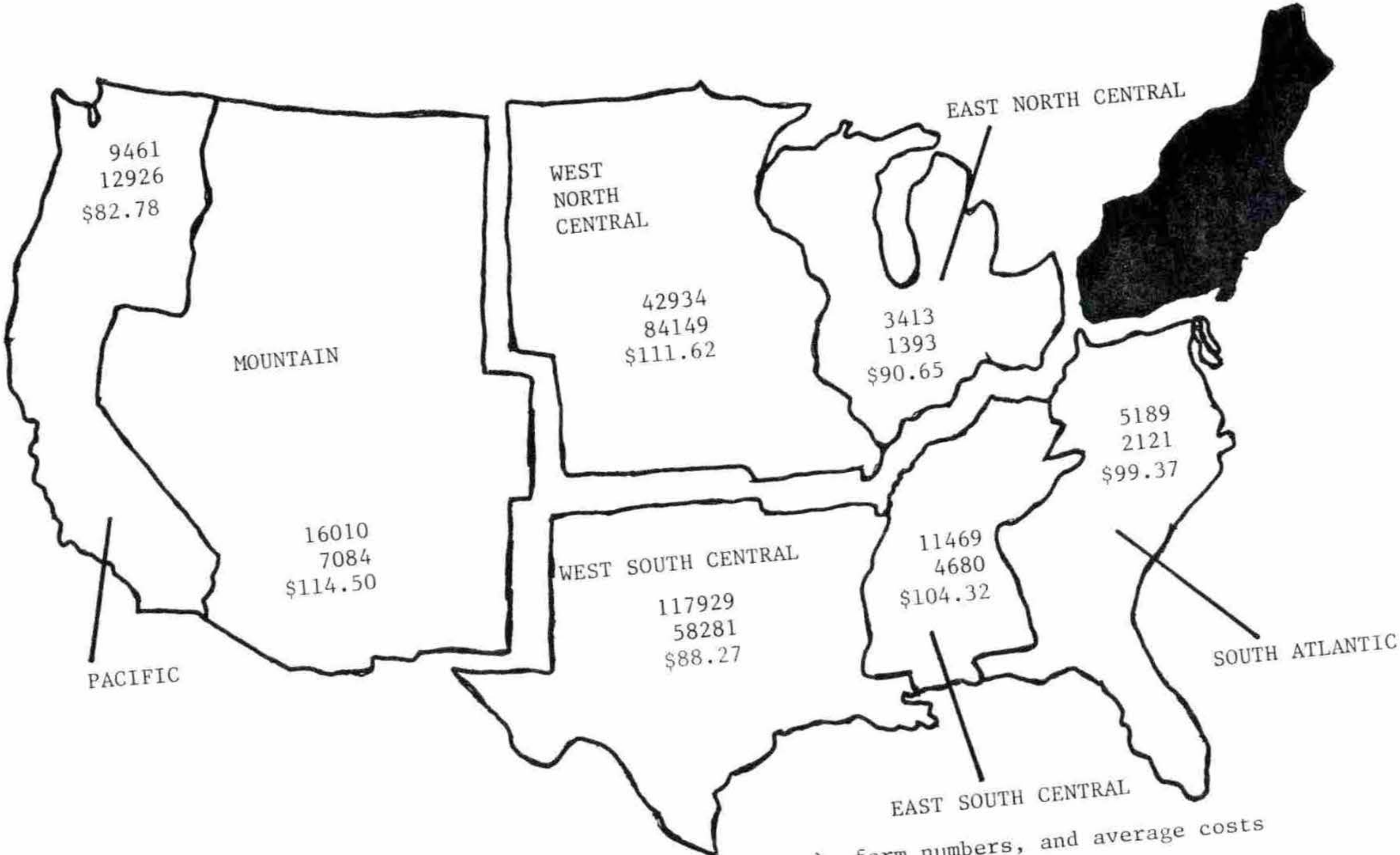

Figure 11. Feeder beef regional production (1,000 cwts.), farm numbers, and average costs ($/cwt.) under Scenario 4

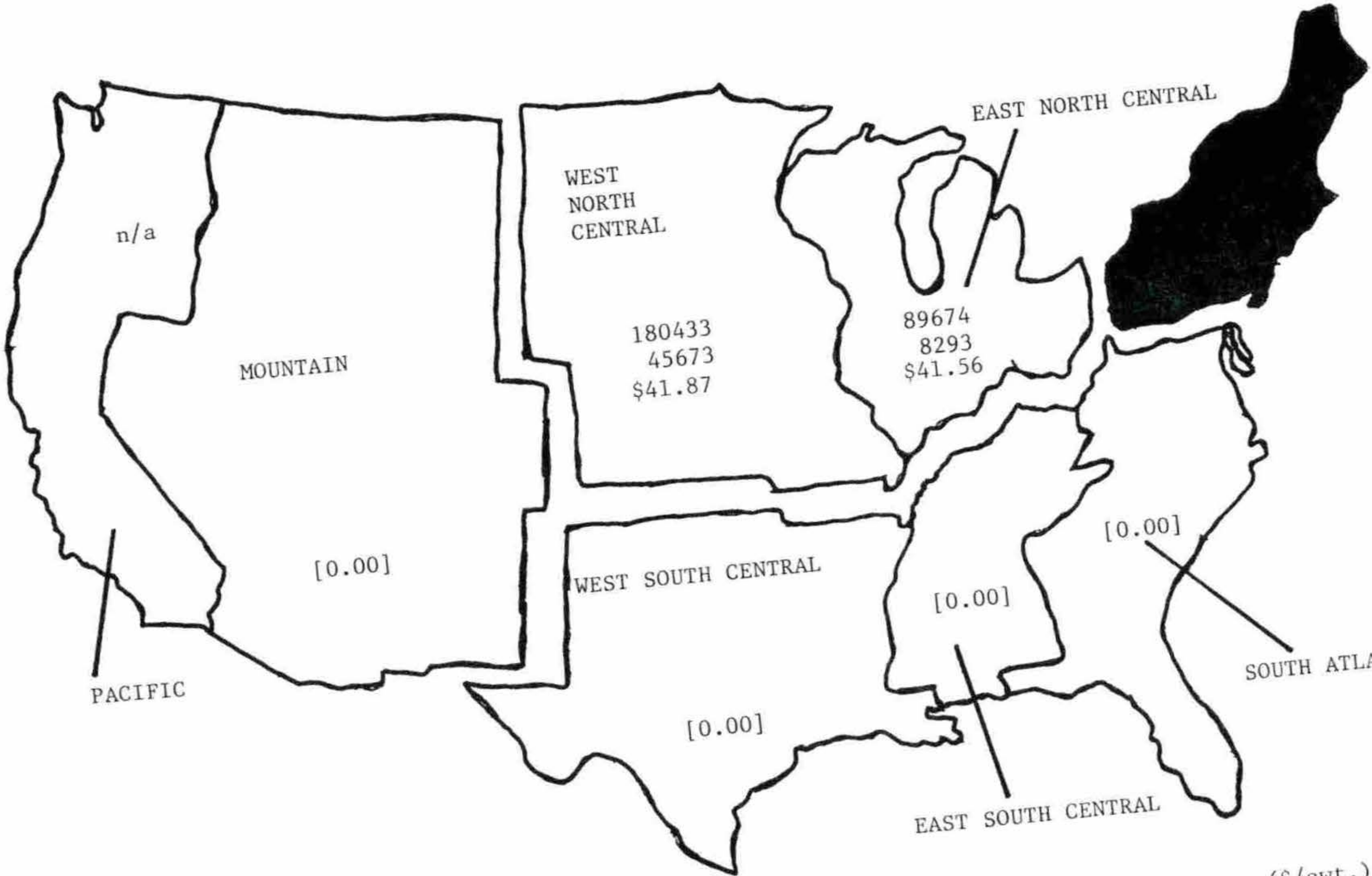

Figure 12. Pork regional production (1,000 cwts.), farm numbers, and average costs ($/cwt.) under Scenario 4

size distributions, optimal feeder beef farm numbers declined from 694,171 to 170,634.

Figure 12 shows that, in Scenario 4, the optimal model solution requires 53,966 pork farms to meet national pork demands. Just as with feeder beef in Scenario 4, therefore, substantial reductions in pork farm numbers occur when national pork farm size distributions are substituted for regional pork farm size distributions.

Costs of production

Figures 11 and 12 also show average regional total costs of production per cwt. of feeder beef cattle and pork production in Scenario 4. Note that, compared to Scenario 2, costs of production are down by 13.5 percent in the West South Central Region for the production of feeder beef cattle. This seems quite intuitive, since in the absence of regional size distributional constraints, the model does not require, as it did in Scenario 2, that the high-cost small farms come into solution in the West South Central Region.

From Figure 12, it is also interesting to note that average total costs per cwt. of pork produced in the West North Central and East North Central regions are approximately $2 cheaper in Scenario 4 than in Scenario 2. Although production between the two regions remains fairly constant between the two scenarios, the cost economies of scale achieved in Scenario 4 have significant effects on average costs.

Scenario 5

Figures 13 and 14 show the optimal regional production levels, farm numbers, and average total costs of production for feeder beef cattle and pork in Scenario 5. As in Scenario 4, national farm size distributions are imposed on the model in Scenario 5. However, unlike Scenario 4, in Scenario 5 region production percentage restrictions are placed on the model as well.

Regional production

As Figure 13 shows, optimal regional production of feeder beef cattle in Scenario 5 is at the minimum constraint levels in all aggregate regions except the West South Central Region. Again, as in scenarios 1 and 3, all feeder beef required by the model in excess of minimum regional constraint levels is supplied by the West South Central Region.

However, Figure 14 shows that, in Scenario 5, the regional production of pork is not limited to the minimum constraint levels in the South Atlantic and East South Central regions. When Scenario 5 is compared with Scenario 3 (the other scenario with the same regional production percentage restrictions), it is seen that the production of pork is down slightly in the West North Central, up slightly in the East North Central, and up in both the South Atlantic and East South Central regions.

Farm numbers

An aggregation of the regional feeder beef farm numbers shown in Figure 13 shows that 199,851 feeder beef farms are required in the optimal

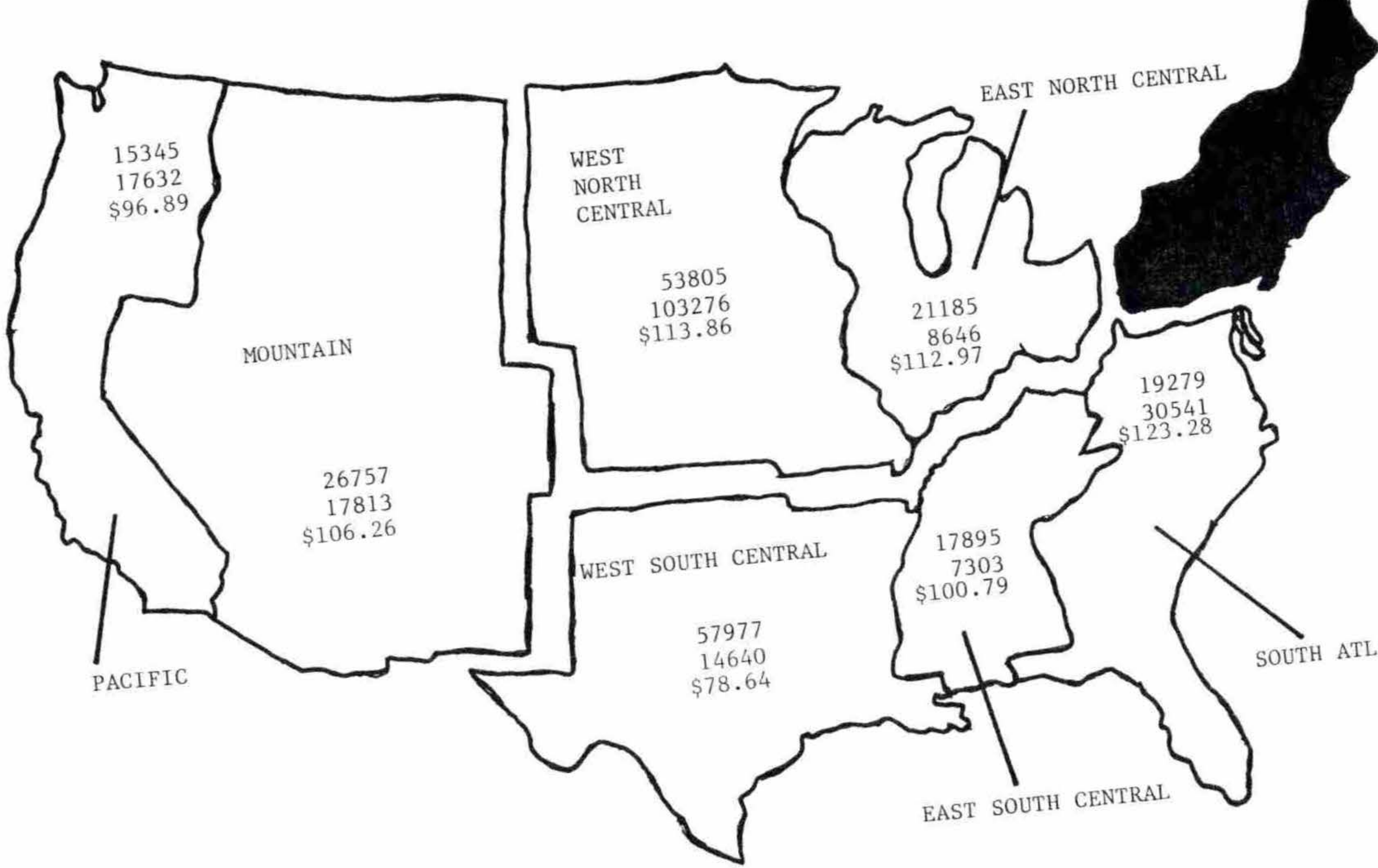

Figure 13. Feeder beef regional production (1,000 cwts.), farm numbers, and average costs ($/cwt.) under Scenario 5

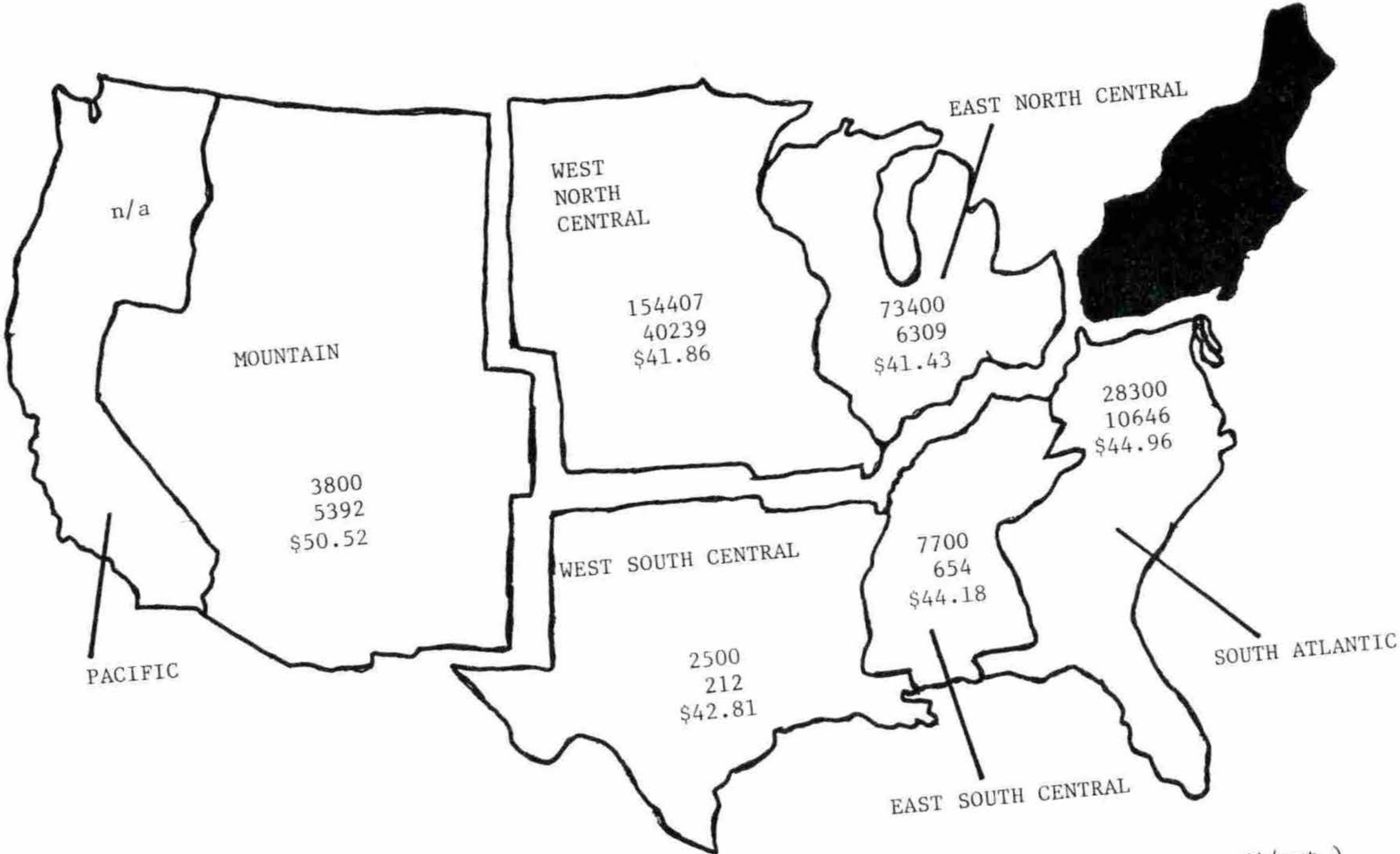

Figure 14. Pork regional production (1,000 cwts.), farm numbers, and average costs ($/cwt.) under Scenario 5

solution for Scenario 5. This number is 30,000 higher than the optimal number of feeder beef farms required in Scenario 4 (without regional production restrictions) but 370,000 lower than the optimal number of feeder beef farms required in Scenario 3 (projected regional size distribution restrictions).

An aggregation of the regional pork farm numbers shown in Figure 14 shows that 63,452 pork farms are required in the optimal solution for Scenario 5. This number is 10,000 higher than the number of pork farms required in Scenario 4, but interestingly, only 4,000 lower than the number of pork farms required in Scenario 3.

Costs of production

As Figure 14 shows, costs of producing feeder beef cattle change quite significantly in Scenario 5. Costs are lowered by $10 per cwt. (as compared by Scenario 4) in the West South Central Region because of the limited amount of production under regional production restrictions. For the same reasons, costs in the East North Central and South Atlantic regions rise considerably as the minimum regional production levels force additional production into those regions.

Average costs of producing pork, as shown in Figure 14, are very similar to average costs under Scenario 3 for all six pork-producing aggregate regions. Also, note that average costs in the West North Central and East North Central regions in Scenario 5 are almost identical to average costs in those regions in Scenario 4.

General Comparisons

In the following pages, some general comparisons among all five scenarios are presented. These general comparisons include tables for regional production, regional farm numbers, average feed costs, and total costs of production. In addition, a brief discussion of the transportation of feeder beef cattle and pork is presented.

Regional production

Tables 28 and 29 show how the regional production of feeder beef cattle and pork change between scenarios. Most noticeable in Table 28 is the sharp increases in the production of feeder cattle in the West South Central Region when regional production constraints are lifted. This, however, is more a reflection on the budgets underlying modeling activities than on any economic shifts that would realistically occur by the year 2000. Also, note that total cwts. of feeder beef cattle change significantly between scenarios. This is explained by a changing input demand for feeder cattle, an intermediate product, by the beef feeding activities of the model. Thus, as the total cwts. of feeder cattle increases, beef feeding activities are requiring feeder beef cattle inputs at higher weights.

Table 29 shows that, as discussed earlier in the chapter, in absence of regional production percentage restrictions, all pork production concentrates in two regions. Unlike feeder beef production, however, this is probably a fair representation of pork production by the year 2000. All scenarios show that, by the year 2000, the majority of

Table 28. A comparison of feeder beef production by region under the five scenarios

Aggregate region	Production under:				
	Scenario 1[a]	Scenario 2	Scenario 3[a]	Scenatio 4	Scenario 5[a]
	(1,000 cwts)				
East North Central	21,575	-0-	21,185	3,412	21,185
West North Central	54,300	42,326	53,805	42,935	53,805
South Atlantic	18,681	3.5	19,279	5,189	19,279
East South Central	18,348	6,096	17,895	11,469	17,895
West South Central	49,556	149,814	49,330	117,929	57,977
Mountain	26,291	1,166	26,757	16,009	26,757
Pacific	14,615	8,401	15,345	9,461	15,345
Total U.S. production of feeder beef (intermediate product)	203,366	207,806	203,576	206,404	212,243

[a]Region production constraints were in place under these scenarios.

Table 29. A comparison of pork production by region under the five scenarios

Aggregate region	Production under:				
	Scenario 1[a,b]	Scenario 2[a]	Scenario 3[a,b]	Scenario 4	Scenario 5[b]
	(1,000 cwts)				
East North Central	76,619	88,385	73,192	89,674	73,400
West North Central	147,461	181,723	154,798	180,432	154,407
South Atlantic	24,709	-0-	28,192	-0-	28,300
East South Central	11,042	-0-	7,625	-0-	7,700
West South Central	5,831	-0-	2,500	-0-	2,500
Mountain	4,448	-0-	3,800	-0-	3,800

[a]Numbers have been adjusted downward for feeder pig production to avoid double-counting.

[b]Regional production constraints were in place under these scenarios.

pork production will be occurring in the West North Central and East North Central regions.

Farm numbers

Table 30 shows how optimal feeder beef cattle farm numbers fluctuate between scenarios. Note, however, how closely the optimal number of feeder beef farms by aggregate region in Scenario 1 is to the actual regional farm numbers reported in the 1982 Census of Agriculture. Differences between the two numbers can be attributed to a more efficient use of facility capacity by modeling activities and to the discrete sizes of modeling activities available in a given aggregate region.

Comparisons between regional feeder beef farm numbers reported in Scenario 1 and Senario 3 probably give policy makers a good idea of what will happen to feeder beef farm numbers by the year 2000 if past trends in regional size distributional changes continue at the same rate until then. Declines of approximately 20,000 feeder beef farms in the East North Central Region and 35,000 feeder beef farms in the West North Central Region are projected by optimal modeling solutions. Note that optimal feeder beef farms actually increase by 20,000 in the Mountain Region between senarios 1 and 3.

Comparisons between regional feeder beef farm numbers reported in Scenario 3 and Scenario 5 show the effects of substituting national size distributional restrictions for regional size distributional restrictions. These results could provide useful information to policy makers concerned with implementing policies to effect feeder beef cattle farm distributions.

Table 30. A comparison of feeder beef farm numbers by region under the five scenarios

Aggregate region	Actual 1982 census numbers	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
East North Central	115,499	85,522	-0-	64,454	1,393	8,646
West North Central	223,855	196,632	155,832	161,480	84,149	103,276
South Atlantic	74,506	73,482	14	65,535	2,121	30,541
East South Central	103,221	74,209	24,656	66,939	4,680	7,303
West South Central	162,673	160,900	496,510	141,223	58,281	14,640
Mountain	47,729	27,796	1,210	48,631	7,084	17,813
Pacific	26,612	27,746	15,949	23,245	12,926	17,632

Table 31 shows how optimal pork farm numbers fluctuate between scenarios. Again, note how closely the optimal number of regional pork farms in Scenario 1 is to the actual required pork farm numbers reported in the 1982 Census of Agriculture. Differences between the numbers are easily attributed to the same factors aforementioned.

Similar comparisons can be made for pork farm numbers between scenarios as were made for feeder beef cattle farms above. As noted earlier, pork farm numbers fall dramatically between scenarios 1 and 3 because of the strong trends on which the regional size distributions of Scenario 3 are based.

Average feed costs

The average feed costs for the production of feeder beef cattle, as shown in Table 32, fluctuate considerably among the seven feeder beef-producing aggregate regions and among the five scenarios. Particularly noticeable is that the average costs of feed in the West South Central Region is considerably less, under all scenarios, than in any other aggregate region. This explains why, in the absence of regional production restrictions, feeder beef cattle production concentrates in the West South Central Region to the extent that it does. There are two reasons for feeder beef feed costs being relatively lower in the West South Central Region. First, in reality, feedstuffs utilized by feeder cattle producing farms (i.e., hays, other roughages) are readily available at relatively lower costs in the West South Central Region. Secondly, pasture is probably the most important input into the feeder beef producing sector. The West South Central Region has a comparative advantage over the other aggregate regions in providing adequate quantities of pasture to meet nutritional requirements (Disney and English, 1985.

Table 33 indicates that the average feed cost per cwt. of pork production, in contrast, changes very little over the five scenarios. The differences in pork feed costs among the six pork-producing aggregate regions are consistent with expectations concerning regional price differentials. The most obvious change in pork feed prices occurs in the Mountain Region where average feed costs decrease from $27.60 per cwt. in Scenario 3 to $23.00 per cwt. in Scenario 5. This is most likely a reflection of the large-size pork farms, and their more efficient use of feedstuffs, that are employed to meet the Mountain Region's minimum production proportion under the national size distributional structure assumed in Scenario 5. This seems logical, since the total production of feeder beef and pork is unchanged in the Mountain Region between scenarios 3 and 5.

Total feed costs

Tables 34 and 35 show how the total costs (including feed) of feeder beef cattle and pork differ among the five scenatios. From Table 34, it is easily seen that the removal of regional production restrictions

Table 31. A comparison of pork farm numbers by region under the five scenarios

Aggregate region	Actual 1982 census numbers	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
East North Central	66,278	53,061	61,195	16,601	8,293	6,309
West North Central	127,290	97,055	119,574	29,672	45,673	40,239
South Atlantic	27,277	25,562	-0-	11,288	-0-	10,646
East South Central	23,547	17,753	-0-	4,146	-0-	654
West South Central	10,059	9,104	-0-	1,562	-0-	212
Mountain	5,123	8,505	-0-	3,791	-0-	5,392

Table 32. A comparison of average cost of feed ($/cwt. of production) under the five scenarios for feeder beef

Aggregate region	Average cost for feeder beef under:				
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
	($/cwt.)				
East North Central	60.04	-	60.20	48.95	71.27
West North Central	41.97	39.72	42.13	39.56	42.97
South Atlantic	67.47	47.13	69.58	57.66	75.27
East South Central	48.21	50.53	49.52	62.62	59.09
West South Central	28.00	32.67	27.48	34.69	29.24
Mountain	52.10	40.03	48.09	54.38	49.56
Pacific	45.98	42.40	46.34	39.01	50.23

Table 33. A comparison of average cost of feed ($/cwt. of production) under the five scenarios for pork

Aggregate region	Average costs for pork under:				
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
	($/cwt.)				
East North Central	25.56	25.95	25.76	25.95	25.90
West North Central	25.61	25.83	25.84	25.83	25.87
South Atlantic	27.85	-	27.69	-	27.66
East South Central	28.24	-	28.30	-	28.66
West South Central	27.61	-	28.00	-	26.73
Mountain	28.10	-	27.60	-	23.00
Pacific	N/A	N/A		N/A	N/A

Table 34. A comparison of total costs of production[a] of feeder beef under the five scenarios

Aggregate region	Total cost of feeder beef production under:				
	Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
	($1,000)				
East North Central	3,066,172.09	-	3,015,916.90	309,367.29	2,393,312.70
West North Central	6,372,881.96	4,880,064.24	6,274,073.75	4,792,500.25	6,126,592.86
South Atlantic	2,561,649.53	411.63	2,661,536.02	515,706.08	2,376,680.26
East South Atlantic	2,208,371.42	747,881.17	2,148,258.80	1,196,512.66	1,803,638.52
West South Atlantic	4,648,617.45	15,282,528.81	4,527,329.91	10,409,693.33	4,559,407.71
Mountain	3,011,291.42	115,956.57	3,089,241.29	1,833,053.98	2,843,069.73
Pacific	1,477,646.25	819,313.43	1,548,087.48	783,180.43	1,486,757.88
Total U.S. cost[a]	23,346,630.12	21,846,155.88	23,264,444.15	19,840,014.02	21,589,459.65
Total U.S. cost[b]	14,198,181.0	14,559,179.0	14,140,864.0	11,626,328.0	11,467,030.0

[a]Includes cost of feed.

[b]Does not include cost of feed.

Table 35. A comparison of total costs of production[a] of pork under the five scenarios

Aggregate region	Total cost of pork production under: Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5
	($1,000)				
East North Central	3,328,863.57	3,851,508.61	3,066,199.69	3,726,182.95	3,041,026.62
West North Central	6,426,063.99	7,931,567.76	6,498,972.29	7,553,033.46	6,462,337.03
South Atlantic	1,199,069.39	-	1,316,003.65	-	1,272,375.58
East South Atlantic	536,748.15	-	348,556.32	-	340,155.21
West South Central	278,897.15	-	114,346.18	-	107,026.99
Mountain	243,013.28	-	198,019.56	-	191,977.32
Pacific	N/A	N/A	N/A	N/A	N/A
Total U.S. cost[a]	12,012,655.53	11,783,076.37	11,542,097.68	11,279,216.41	11,414,898.76
Total U.S. cost[b]	4,936,659.5	4,782,763.1	4,469,931.0	4,292,556.7	4,362,614.7

[a]Includes cost of feed.

[b]Does not include cost of feed.

(Scenarios 2 and 4) reduces significantly the cost of feed for feeder beef production. Costs under Scenario 4 show that the elimination of regional production constraints, combined with the substitution of a national size distribution for regional size distributions, yields the lowest total cost scenario for the production of feeder beef. Obviously, Scenario 1 yields the highest total cost for the production of feeder beef, at a cost of roughly $23.4 billion.

Table 35 shows that the scenario with the lowest cost for the production of pork is again Scenario 4, with a total cost of roughly $11.3 billion. Interestingly, however, a comparison between scenarios 1 and 3 shows a reduction in total cost of pork production from $12.0 billion to $11.5 billion if trends in regional percentages and size distributions are continued to the year 2000. Other _a priori_ expectations, such as the fact that the imposition of regional production restrictions adds approximately $2 billion to the cost of producing pork, are easily confirmable from Table 35.

Transportation

Surprisingly, the transportation costs associated with the various scenarios are quite consistent. Table 35 shows the total costs of transporting feeder beef cattle to meet grain-fed beef input demands and pork to meet final commodity demands in the five scenarios. Note that there is very little relative difference in the costs of transportation under the scenarios with regional production restrictions in place (Scenarios 1, 3, and 5), but, that costs of transportation

Table 36. Transportation costs of feeder beef cattle and pork under the five scenarios

Scenario	Total costs of transporting: Feeder beef cattle	Pork
	----------(1,000 dollars)----------	
1	258,090.0	454.139.01
2	318,506.35	532,307.28
3	272,886.04	447,337.55
4	341,055.89	551,340,14
5	247,747.06	452,593.93

increase considerably when regional production restrictions are lifted. Figures 15 and 16 show the interregional transportation directions of feeder beef cattle to meet intermediate demands and pork to meet final demands. The directions of transportation flow changes little between the five scenarios. However, in the absence of regional production restrictions, the quantities of feeder beef cattle and pork flowing from major production areas increases substantially.

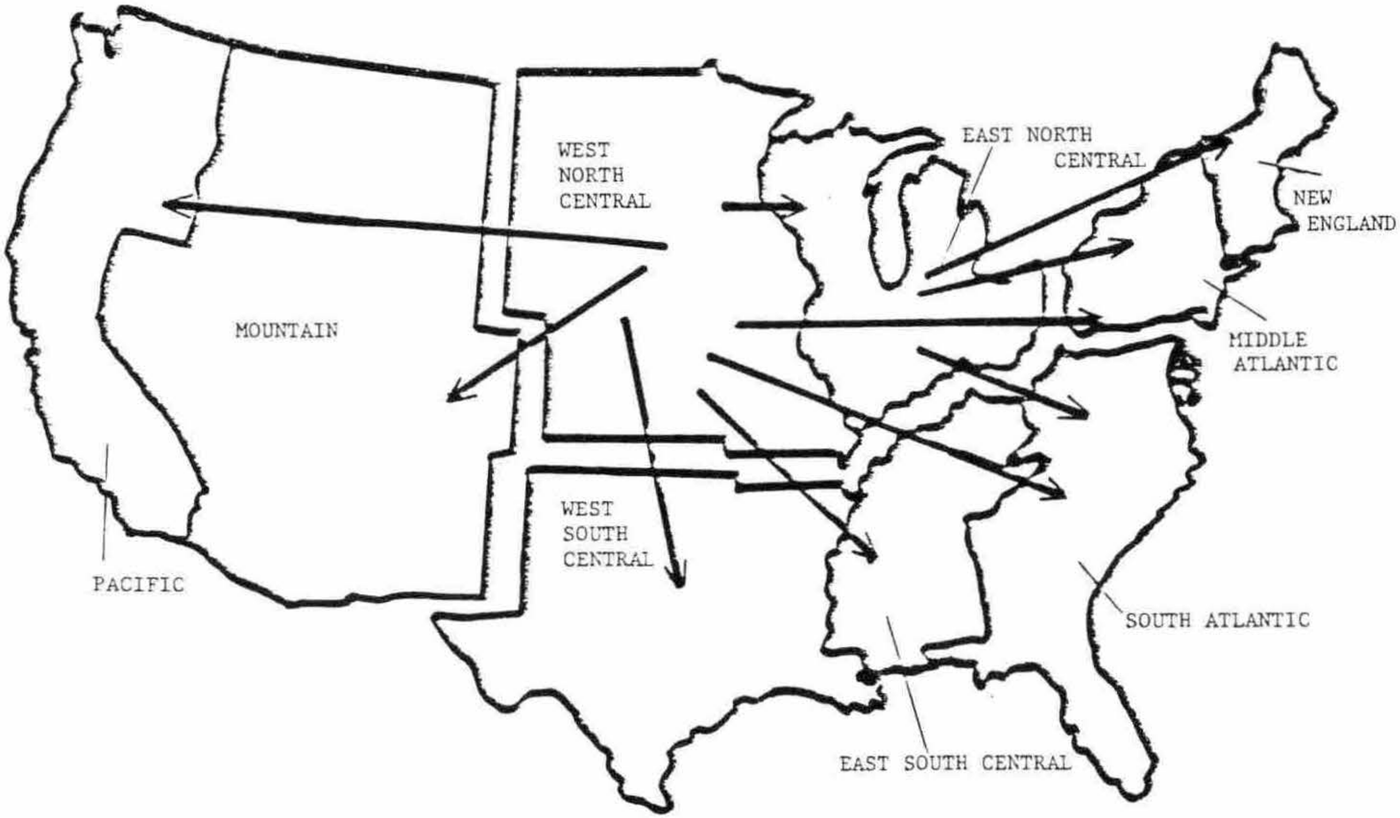

Figure 16. Interregional transportation flows for pork

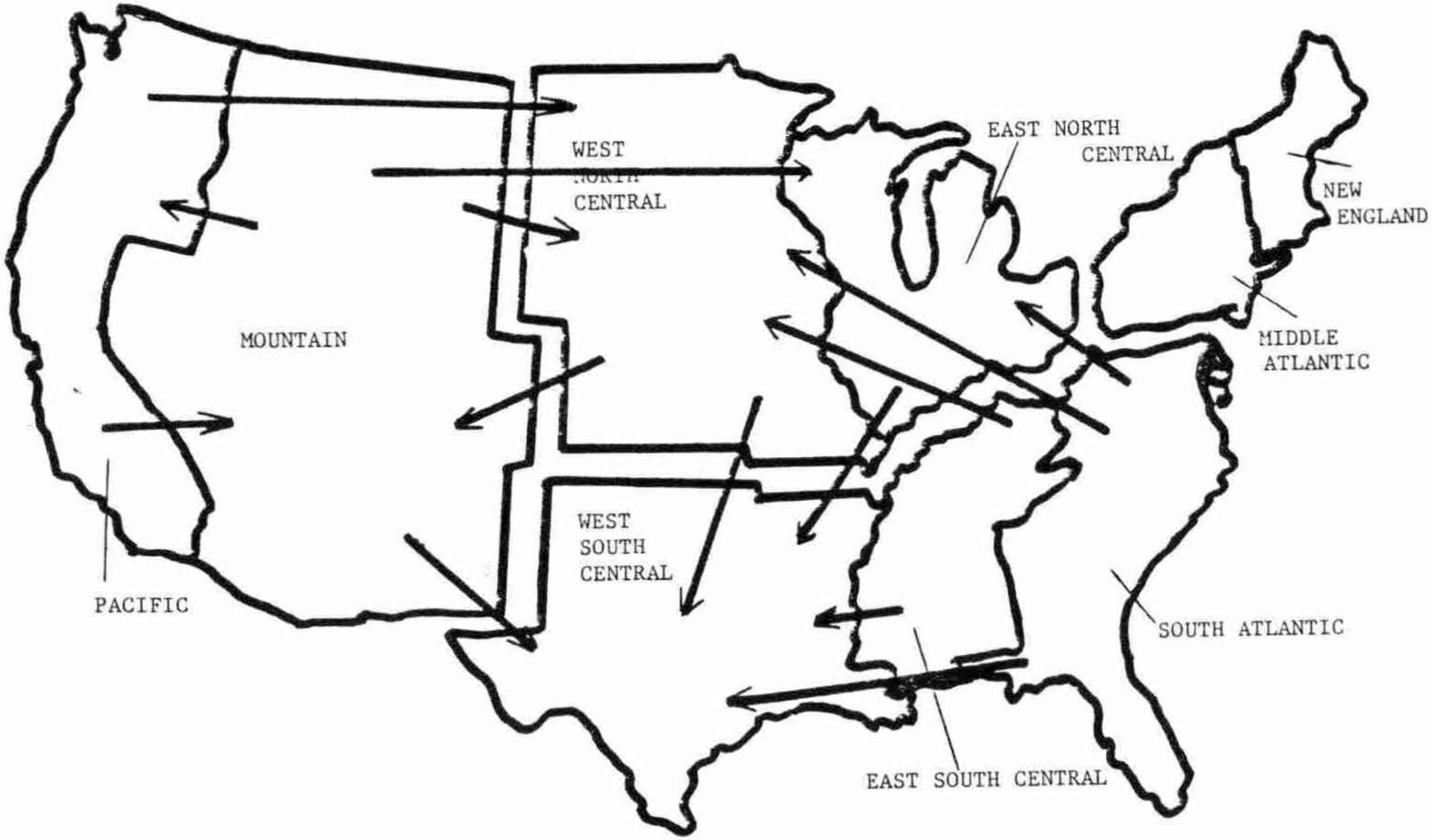

Figure 15. Interregional transportation flows for feeder beef cattle

CHAPTER IV: CONCLUSIONS AND SUGGESTIONS FOR IMPROVEMENT

Shifting regional farm-size distributions and production percentages can have substantial impacts on regional and national farm numbers and costs of production. Historical data have shown that trends towards larger, and more cost efficient pork and feeder beef farms have led to declines in farm numbers in all aggregate regions of the United States. However, it is important to keep in mind that change in farm size distributions occur at different rates in different aggregate regions of the country. It is also important to realize that the size distributional changes that have occurred in the past, and will continue to occur in the future, are quite different among the different livestock sectors.

As referred to in Chapter 1, the pork-producing sector has seen considerable change in size distribution over the last 20 years. The percentage of pork farms producing in excess of 1,000 finished hogs per year has increased substantially. This has led to substantial increases in the concentration of pork production by the East North Central and West North Central regions. This is due to the comparative advantages in cost economies of scale that have been attainable in these aggregate regions.

Assuming that the trends in shifting pork farm-size distributions were to continue at the same rate until the year 2000, this study finds that 68 percent fewer pork farms will be required to meet optimal production levels, in the year 2000, than if current size distributions were sustained. At that time, the East North Central and West North Central Regions would account for 85 percent of the national pork production. Realistically, this is probably a pessimistic projection for pork farm numbers, since it is highly unlikely that the trend towards larger pork farms will continue until the year 2000 at the same rate as in the past.

Changes in the feeder beef-producing sector will occur more slowly. In Chapter I, it was illustrated that changes occurring in the regional size distributions of feeder beef cattle farms are mainly concentrated in the lower size classifications, with small-sized farms being replaced by medium-sized farms. These changes have been minimal, even in certain aggregate regions.

Unlike trends in pork farm-size distributions, these gradual shifts in feeder beef farm-size distributions will continue into the future. This study concludes that, by the year 2000, optimal national feeder beef farm numbers will be down to 57 thousand. This is 11.5 percent fewer total farms than are required under current (1982) feeder beef farm-size distributions. Even more significant here, however, is the fact that optimal farm numbers are down 35,000 in the West North Central Region and 20,000 in the East North Central Region when compared to results using the 1982 feeder beef farm-size distributional assumptions.

An important factor in the production of feeder cattle is always the availability of pastures and hays to meet roughage requirements. In this study, the availability and cost of these feedstuffs has much to do with determining the optimal regional production and costs of feeder cattle. Intuitively, production of feeder cattle occurs where roughages are available and economical. Therefore, one can conclude that, regardless of the farm-size structure imposed, the availability and costs of roughages is important in determining regional production costs and farm numbers in the feeder beef-producing sector. This is a limiting factor in this analysis of the future structure of feeder beef cattle production.

Much useful information on the future structure of feeder beef cattle production could be gained by allowing the availability and costs of pastures and hays to change under similar farm-size distributional assumptions. This would have substantial effects on the regional costs of feeder beef production, and, thus, the optimal solutions. It might also have considerable effect on the feed costs of pork production, since increasing available roughages would free other feedstuffs, currently being used to meet feeder beef nutritional demands, to be used by the pork sector.

Another improvement could be made in this study if the grain-fed beef sector, described in Chapter II, could be improved (Disney and English, 1985). Not only do the grain-fed beef activities demand feeder beef cattle, but they also compete directly with feeder beef cattle and pork for feedstuffs. It is possible that the regional locations of grain-fed beef enterprises could have at least some affect on the regional production of pork and feeder cattle.

Finally, it is quite possible that different results would have been obtained for the various size-distributional assumptions if feed prices had been changed. As the price of corn, relative to the price of wheat, increases, for example, it is highly likely that the concentration on national pork production would shift in westardly direction. These types of intraregional changes could have significant effects on farm numbers and cost of production.

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