INTERREGIONAL PRICE FLEXIBILITIES: AN APPLICATION TO THE FED BEEF INDUSTRY

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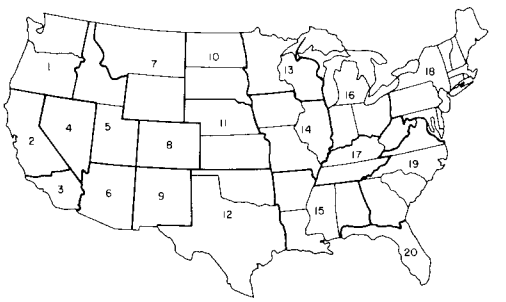
Within spatially complex economic systems, it is given that change in a commodity's production in one region engaged in interregional competition will influence the price of that commodity in all trading regions. Mathematical programming models provide useful tools to predict such price alterations for specified production changes. Unfortunately, only running and analyzing many alternative formulations of such a model can generate an understanding of the relationships among regions involved in interregional competition. Specifically, this paper addresses itself to formalizing this process and providing quantitative measures summarizing the impact of regional changes in production upon prices in all regions. This paper is concerned with quantitatively estimating the influence of a change in fed beef production for given regions upon prices of fed beef for all regions of the United States. From estimates of these relationships, economic measures of isolation of regions and the impact of changes in import levels upon regional prices will be developed. Thus, unlike much previous research in the area of interregional competition in the beef industry (1, 2, 4, 6), focused upon finding an "optimum" solution to a mathematical programming model, this research examines the basic economic relationships among regional production and regional prices implied by an interregional competition model.

METHOD

To illustrate the economic relationships implied by interregional competition models, a simplification of King and Schrader's (4) model was used as the base for the analysis. The simplified model had the same regional structure as King and Schrader's (see Figure 1). It included components of linear demand functions for each region, fixed production of fed beef at actual levels, and transportation costs of shipping beef among regions (3). As a starting point for research, total transportation costs were minimized, subject to the restraint that the solution be a spatial equilibrium one utilizing Tramel's (5) formulation of reactive programming.

Figure 1. GEOGRAPHICAL DEMARCATION



REGION	AREA INCLUDED
1	WASHINGTON - OREGON
2	NORTHERN CALIFORNIA
3	SOUTHERN CALIFORNIA
4	NEVADA
5	IDAHO - UTAH
6	ARIZONA
7	MONTANA - WYOMING
8	COLORADO
9	NEW MEXICO
10	NORTH DAKOTA - SOUTH DAKOTA
11	NEBRASKA - KANSAS
12	OKLAHOMA - TEXAS
13	MINNESOTA - WISCONSIN
14	IOWA - ILLINOIS - MISSOURI
15	ARKANSAS - LOUISIANA - MISSISSIPPI - ALABAMA
16	MICHIGAN - INDIANA - OHIO
17	KENTUCKY - TENNESSEE - WEST VIRGINIA
18	MAINE - NEW HAMPSHIRE - VERMONT - NEW YORK - CONNECTICUT MASSACHUSETTS - RHODE ISLAND - PENNSYLVANIA - NEW JERSEY MARYLAND - DELAWARE - DISTRICT OF COLUMBIA
19	VIRGINIA - NORTH CAROLINA - GEORGIA - SOUTH CAROLINA
20	FLORIDA

Source: King and Schrader (1963, p. 345).

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As a basis for developing a summary of regional price impacts of production changes, a region's production levels were systematically changed, to develop a data base of regional price estimates as related to production changes in a specific region. For example, the production of Region 1 was varied by units equivalent to 10 percent of actual production, from 10 to 200 percent of actual production. The production of all other regions was held constant at actual levels. For each level of production assumed for Region 1, a solution of the reactive programming model was generated. Information obtained from these solutions included prices in each region resulting from each level of production. This involved one set of prices for each of the 20 regions.

A regression was run for each set of prices, relating price in each region to the production in Region 1. The specific form was:

$$\log P = a + b \log Q \quad (1)$$

Where P was price in a specific region and Q was level of production in Region 1. Alternative formultions of equation 1 were also estimated. The linear form was judged to be equally as good from a statistical point of view as the log form; it could have been used to develop summary measures similar to those developed in the remainder of this paper. The log form seemed more useful because results in terms of price flexibility were more easily interpreted. Specifically, the resulting set of 20 estimates of b can be interpreted as interregional price flexibilities, relating production in Region 1 to prices in all other regions. The above process was repeated by systematically varying production sequentially in each region, resulting in 20 sets of estimated price flexibilities (Table 1). The R^2 values, for all 400 regressions, were all above 0.85.

PRICE FLEXIBILITY COEFFICIENTS

Price flexibility coefficients for all regions provide a picture of distribution of price effects due to changes in regional production. Coefficients estimated for 1968 are presented in Table 1. The coefficient for the impact of a one percent change in a region's production upon the price of other regions has been established in columns, while rows indicate effect on some given region's price due to a one percent change in production in other regions. For example, in Southern California in 1968, the impact of production changes upon price of fed beef on all other regions is presented in column 3, Table 1. The coefficients show that Southern California had its greatest impact on the Western Regions, coefficients ranging from 0.096 to 0.080. Southern California had its highest impact on itself (.096), its lowest impact being on the price in Region 18 — the New England states (.067). Thus, estimates indicate that a 10 percent increase in Southern California's production would have decreased fed beef prices in that region by 0.96 percent. The same 10 percent increase would have caused an 0.07 percent decline in the price of fed beef in region 18. Differences among the set of coefficients, reflecting the impact of changes in Southern California production, are largely a function or expression of the degree of isolation of various areas from Southern California.

Table 1. PRICE FLEXIBILITY COEFFICIENTS*, 1968

Regional Price Impact	Region with Production Change																			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	.0602	.0637	.0827	.0050	.0275	.0246	.0236	.0536	.0151	.0469	.1755	.1271	.0678	.2323	.0384	.0557	.0268	.0572	.0289	.0118
2	.0465	.0716	.0811	.0040	.0269	.0241	.0231	.0525	.0148	.0460	.1719	.1245	.0664	.2285	.0376	.0546	.0263	.0561	.0283	.0116
3	.0374	.0566	.0958	.0041	.0239	.0330	.0232	.0520	.0155	.0454	.1711	.1347	.0677	.2272	.0400	.0541	.0261	.0560	.0295	.0117
4	.0468	.0668	.0818	.0051	.0271	.0243	.0233	.0529	.0149	.0463	.1732	.1255	.0696	.2303	.0379	.0550	.0265	.0565	.0285	.0117
5	.0452	.0576	.0801	.0042	.0340	.0246	.0236	.0536	.0151	.0469	.1804	.1320	.0708	.2392	.0304	.0558	.0278	.0577	.0289	.0118
6	.0377	.0544	.0905	.0041	.0241	.0361	.0234	.0524	.0156	.0457	.1738	.1356	.0602	.2321	.0402	.0545	.0263	.0564	.0297	.0118
7	.0376	.0463	.0710	.0041	.0240	.0244	.0257	.0531	.0150	.0465	.1835	.1308	.0702	.2463	.0581	.0553	.0265	.0572	.0286	.0117
8	.0373	.0451	.0700	.0041	.0239	.0242	.0232	.0540	.0140	.0461	.1821	.1298	.0696	.2443	.0378	.0548	.0263	.0567	.0284	.0116
9	.0374	.0471	.0776	.0041	.0239	.0250	.0232	.0519	.0178	.0453	.1799	.1356	.0678	.2418	.0397	.0540	.0260	.0559	.0293	.0117
10	.0371	.0457	.0696	.0041	.0237	.0240	.0230	.0524	.0148	.0463	.1809	.1290	.0692	.2427	.0375	.0545	.0262	.0564	.0282	.0116
11	.0369	.0455	.0693	.0041	.0236	.0230	.0229	.0522	.0147	.0451	.1808	.1286	.0690	.2418	.0374	.0543	.0261	.0562	.0281	.0115
12	.0368	.0461	.0720	.0040	.0235	.0246	.0229	.0511	.0152	.0446	.1751	.1370	.0665	.2355	.0393	.0532	.0256	.0550	.0290	.0115
13	.0368	.0453	.0691	.0041	.0235	.0239	.0229	.0520	.0147	.0455	.1796	.1281	.0690	.2411	.0373	.0541	.0260	.0560	.0280	.0115
14	.0366	.0451	.0687	.0040	.0234	.0237	.0228	.0517	.0146	.0453	.1783	.1272	.0684	.2401	.0371	.0542	.0250	.0557	.0279	.0114
15	.0363	.0455	.0712	.0040	.0232	.0243	.0226	.0505	.0150	.0440	.1727	.1342	.0657	.2322	.0393	.0525	.0253	.0543	.0286	.0113
16	.0363	.0447	.0681	.0040	.0232	.0235	.0226	.0513	.0145	.0449	.1767	.1261	.0677	.2379	.0367	.0537	.0256	.0552	.0276	.0113
17	.0361	.0446	.0695	.0040	.0231	.0234	.0225	.0511	.0144	.0447	.1732	.1298	.0664	.2331	.0374	.0531	.0260	.0550	.0275	.0113
18	.0357	.0439	.0669	.0039	.0228	.0231	.0222	.0504	.0142	.0441	.1740	.1241	.0666	.2333	.0361	.0524	.0252	.0543	.0271	.0111
19	.0357	.0447	.0699	.0039	.0228	.0239	.0222	.0406	.0148	.0433	.1699	.1298	.0646	.2291	.0381	.0516	.0240	.0534	.0281	.0111
20	.0357	.0447	.0699	.0039	.0228	.0239	.0222	.0405	.0148	.0432	.1697	.1316	.0645	.2282	.0381	.0516	.0240	.0533	.0281	.0111

*The percentage change in price associated with a 1 percent change in regions production.

The 1968 impact of production changes in other regions upon the price of beef in Southern California are presented in row 3, Table 1. Entries indicate that production of Regions 14 (Iowa, Illinois, and Missouri), 11 (Nebraska - Kansas) and 12 (Oklahoma - Texas), respectively, had the strongest impact on fed beef prices in Region 3. The price flexibility for impacts upon this region ranged from 0.004 to 0.227. More specifically, a 10 percent increase in Region 14 production would reduce the price of fed beef in Region 3 by 2.27 percent, while the same 10 percent increase in Region 4 (Nevada) production would cause a decline of only 0.04 percent in the price in Southern California, all other factors being constant.

The larger a region's production, then, the larger the potential impact on prices of percentage changes in this production. If transportation costs were zero, the only necessary information to predict impacts of production changes, (given regional demand functions) would be their magnitude. However, this is not the case in the real world. In general, the higher transportation costs are, in relation to the total cost of production and marketing, the less important the magnitude of production within a region, in terms of influencing prices in other regions. The fed beef industry represents a case where although transportation costs are such that magnitude of regional production remains highly significant, it is not the sole determinant of regional price flexibilities.

Price flexibility coefficients do quantitatively describe interregional price quantity relationships in the fed beef industry. They confirm the common sense notion that size of production and distance between regions determines the relative magnitude of the impact of changes in one region's production on prices in other regions. Still, other uses of the information are possible. In particular, measures of a region's isolation in an economic sense and impacts of varying import levels can be developed for the basic price flexibility information.

INDEX OF ISOLATION

The degree of regions' economic isolation, in terms of the fed beef sector, can be developed by comparing price response to a give increment of production. Specifically, if a given increment of production in Region A causes the price in A to fall (by more than a similar increment of production in Region B would reduce the price in B), Region A can be said to be more isolated.

An index of isolation was developed to permit comparisons among regions (Table 2). This index represents change in price in a region, given a production increase there by an amount equal to one percent of the national fed beef consumption. Indices were calculated from price flexibility coefficients (Table 1), adjusted to reflect differences in production levels among regions. Western regions were found to have the highest index of isolation. This reflects their inability to effectively moderate price effects of the home region's increased production, by increasing trade with other regions. Regions in the midwest, able to ship either east or west, had lower indices of isolation. The lowest such indices were for eastern seaboard states, all in a relatively large deficit position in fed beef. Florida, due to its proximity to large markets and its large deficit position in fed beef, had the lowest isolation index.

Table 2. INDEX OF ISOLATION

Rank	Region	Index*
1	Washington - Oregon	1.86
2	Northern California	1.75
3	Arizona	1.71
4	Idaho - Utah	1.66
5	Southern California	1.54
6	Nevada	1.46
7	New Mexico	1.40
8	Montana - Wyoming	1.22
9	Oklahoma - Texas	1.22
10	Colorado	1.22
11	Arkansas - Lousiana	1.21
12	Mississippi - Alabama - Nebraska - Kansas	1.20
13	Iowa - Illinois - Missouri	1.20
14	North Dakota - South Dakota	1.19
15	Minesota - Wisconsin	1.19
16	Kentucky - Tennessee - West Virginia	1.17
17	Michigan - Indiana - Ohio	1.16
18	Virginia - North Carolina - Georgia	1.16
19	Maine - New Hampshire - Vermont - New York - Connecticut - Massachusetts - Rhode Island - Pennsylvania - New Jersey - Maryland - Delaware - District of Columbia	1.14
20	Florida	1.13

*Represents the change in price in the specified region associated with a change in production in that region equivalent to 1 percent of the national total. The higher the index, the more isolated a region is.

INTERNATIONAL TRADE PRICE FLEXIBILITIES

Regions exporting beef to the United States could have been considered as regions within the model and price flexibilities could have been developed as above. Because of the lack of complete data on foreign regions, this was not done. Instead, a new coefficient, "foreign trade price flexibilities," was defined as the price effect upon a region resulting from a one percent change in total net imports. For the purpose of calculation, beef imports were assumed to enter only into regions 1, 2, 3 and 18 (see Figure 1). Further, it was assumed that distribution of imports among these four regions would remain constant for all levels considered. It was also assumed that the cumulative effect of changes in supply in the four importing regions was the sum of individual effects as expressed by estimated price flexibilities.

The magnitude of these coefficients is significant. The easier it is for a region to absorb imports, the smaller the coefficient's magnitude. Regions farthest from centers of consumption are more sensitive to changes in net imports. Of course, the magnitude of net imports, and their contribution to each region's total supply, influences the price flexibility coefficient of a region and subsequently, net import price flexibility coefficients.

Table 3. NET IMPORTS PRICE FLEXIBILITY, 1968

Region	Area Included	Coefficient*
1	Washington - Oregon	.094
2	Northern California	.091
3	Southern California	.088
4	Nevada	.090
5	Idaho - Utah	.086
6	Arizona	.086
7	Montana - Wyoming	.076
8	Colorado	.075
9	New Mexico	.078
10	North Dakota - South Dakota	.071
11	Nebraska - Kansas	.075
12	Oklahoma - Texas	.075
13	Minnesota - Wisconsin	.074
14	Iowa - Illinois - Missouri	.074
15	Arkansas - Louisiana - Mississippi - Alabama	.075
16	Michigan - Indiana - Ohio	.074
17	Kentucky - Tennessee - West Virginia	.074
18	Maine - New Hampshire - Vermont - New York - Connecticut - Massachusetts - Rhode Island - Pennsylvania - New Jersey - Maryland - Delaware - District of Columbia	.072
19	Virginia - North Carolina - Georgia - South Carolina	.073
20	Florida	.073

*Percentage change in price associated with a 1 percent change in imports. The higher the index, the more imports influences the regions price.

Results indicate that, generally, West Coast regions have higher coefficients (Table 3). The West Coast receives about twice the net imports received at the East Coast. This fact, coupled with a relatively large demand associated with proximity of the Eastern seaboard to populated regions, makes the Eastern regions' coefficients relatively low. Therefore, generally, increases in net imports affect Western regions more.

For example, Region 1 (Washington-Oregon), is one of the receiving points of the West Coast. In 1968, this region had a relatively small share of the total national production. More importantly, about one-third of its total supply consisted of net imports. These factors, along with Region 1's location relative to major markets, cause price to be more sensitive to increases in supply (extra-net imports). Specifically, if net imports increased by 20 percent, not an unrealistic assumption, the price of fed beef, assuming all other factors constant, would drop by about 1.8 percent in Region 1. For the same increase in import levels, the price of fed beef in Region 18 (East Coast) would drop by 1.4 percent — approximately 20 percent less than the price change in Region 1.

CONCLUSIONS

The concept of interregional price flexibility adds an important tool to understanding the interconnection of spatially complex economic systems. By summarizing a large number of alternative formulations of an interregional programming model, information is generated describing the basic economic relationships of interregional competition. Such information is valuable in providing a basic description of an industry. It is also useful in predicting the impact on prices of changes in regional production. It would be particularly useful in cases where alternative changes from current production — consumption patterns that have occurred in the U.S. beef industry in the past 20 years — were to be evaluated. If price flexibilities were developed and known for the international beef market, a better understanding of the impacts of changes

in production, consumption and trade policies in various countries would be facilitated. Similarly, knowledge of price flexibilities for the international crude oil market would have permitted an improved understanding by all parties involved of the impacts of changes in policies of exporting countries.

Although the concept as presently developed provides a useful summary of the interaction of a complex system, further development and verification is needed before practical usefulness of the interregional price flexibility concept can be proven. The use of such a system as a price predictor for alternative levels and distributions of production of fed beef would be of particular interest.

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