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INTRASEASON TRANSPORTATION MODELS: AN APPLICATION TO FRESH GRAPEFRUIT

by

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Applications of spatial equilibrium models in solving allocation problems for agricultural products have tended to focus on one production season or on a specific period within the season.[1] For perishable commodities where the harvest and shipping season in all producing areas is the same, such an approach would seem appropriate. However, there are many fruit and vegetable products for which the harvest and shipping seasons vary between the major producing regions. Fresh grapefruit is an example of this type of commodity. For this category of products, the application of a spatial equilibrium model representing the entire season would appear to be misleading if not altogether inappropriate.

This paper summarizes the authors' experiences and results in applying transportation models to four specific periods within the 1964-65 grapefruit marketing season. Comparisons are made between the period analyses and a model representing the full season. As might be expected, results from the period models differ substantially from those of the full season analysis.

The original purpose of the study was to determine in what areas of the continental United States would promotion of fresh Arizona grapefruit be most effective [6, p. 3]. It was felt that a partial answer to this question could be obtained by studying the competitive advantage and the relative disadvantage of Arizona grapefruit in various consumption areas of the United States. The minimum cost transportation model is well-suited for this type of analysis [4]. However, in studying the monthly shipment patterns for grapefruit, it became obvious that Arizona's competitive advantage changed considerably during one marketing season. The need for shorter, period analyses was evident.[2]

MODELS[3]

The models that evolved contained four producing regions (Florida, Texas, California Summer and California-Arizona Desert) and 19 consumption areas (Figure 1). The 12-month production season was divided into four periods as follows:

Period 1 - August through October
Period 2 - November through February
Period 3 - March through May
Period 4 - June and July

The periods were selected in order to emphasize peak shipping times in the various producing regions.[4] For example, during Period 3 production in the California-Arizona Desert region reaches its peak; production and shipment from the other areas is either declining (Florida and Texas) or just beginning (California Summer).

Estimates of the quantities supplied in the producing regions and quantities demanded in the consuming areas were established for the entire season and for each of the four periods. Deriving these estimates, particularly the quantities demanded, proved to be the major obstacle in completing the study [6, pp. 38-46]. A number of simplifying assumptions were required. For example, in order to estimate the quantities demanded in each region and period, total supply for a particular period, net of exports and imports, was allocated on the assumption of equal per capita consumption in all consuming areas.[5] Thus, per capita consumption varied between periods but not between regions for a particular period.

Transportation costs were based on actual railway rates between the producing regions and selected central cities in the consuming areas. Although trucks are used extensively for shorter hauls, the unavailability of reliable truck rates prevented their inclusion in this study. Transportation costs were assumed to remain constant for each of the four periods.

RESULTS

A major protion of the results is reflected in Figure 1 and Table 1.[6] The changing competitive advantage of the various producing regions is evident (Figure 1). The optimum flows for Period 2 and Period 4 differ greatly from each other and from the full season analysis. The results of the Period 2 analysis indicate that Florida grapefruit can be competitively marketed as far west as Washington, Oregon, and California during the months of November through February. During June and July (Period 4) the flows are reversed with Arizona and California grapefruit having a competitive advantage as far east as the New England States. The full season analyses fails to indicate these seasonal changes in competitive advantage.

Comparison of the optimum volumes shipped further illustrates the differences between the full season analysis and the period analyses. It was discovered that the optimum volume shipped from any producing region to any specific market area for the full season model was **not** equal to the sum of the optimum shipments for the same region and area derived from the period analyses. Optimum shipments from the Desert region to the 11 Western States serve as an example. In the model representing the entire 1964-65 season the total supply of the Desert region (1,811,000 hundredweight) was allocated to the 11 Western States. However, the sum of optimum shipments from the Desert region to the 11 Western States calculated from the period models revealed that only 1,226,200 hundredweight were optimally allocated to these markets.

Table 1 contains the relative disadvantage estimates derived from the full season model and the model for Period 2. These estimates clearly illustrate the changing competitive conditions that are revealed by the use of intraseason analysis. A careful evaluation of the relative disadvantage estimates and the changing pattern and volume of optimal flows will result in numerous interpretations and conclusions. For example, in terms of the original purpose of the study, the authors' general conclusion was that the concentration of promotional activities during March, April, and May in the 11 Western States would return the greatest benefits to the Desert grapefruit industry.

In conclusion, it is obvious that a great deal of additional useful information can be obtained from the solution of intraseason transportation models. However, further application of this technique is contingent upon the availability of reliable seasonal and regional estimates of demand, thereby overcoming a major limitation of this study.

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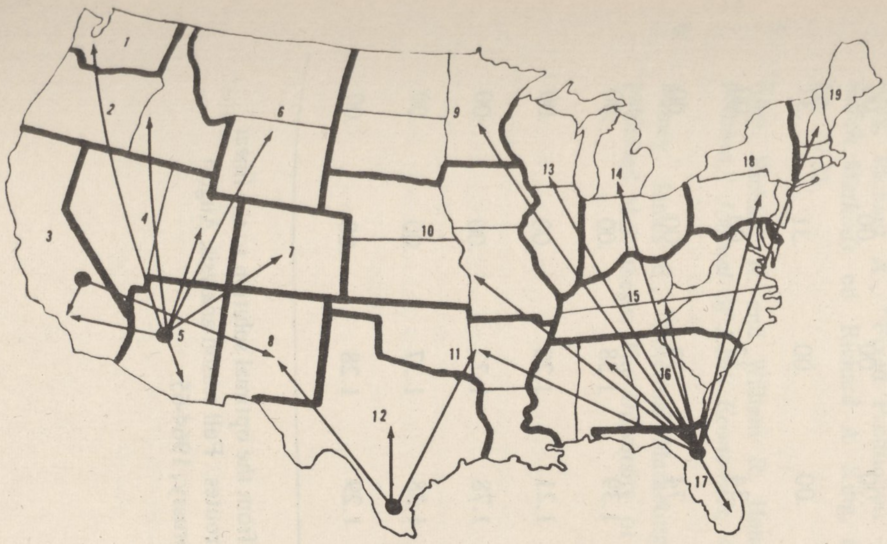
FOOTNOTES

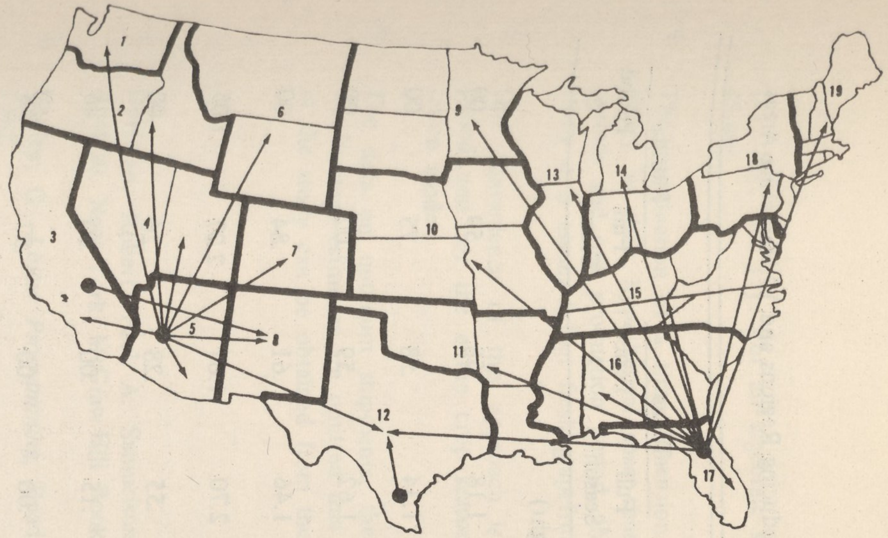
1. The authors reviewed 20 published studies using spatial equilibrium techniques. Eighteen were based on annual or production season data; the remainder used data from one specific period within the season.

2. The lack of time dimension considerations in spatial models was noted by King and Henry in 1959 when they reported their inability to ". . . find any empirical studies in which space-time or space-form-time transportation models have been used" [5, p. 1006].

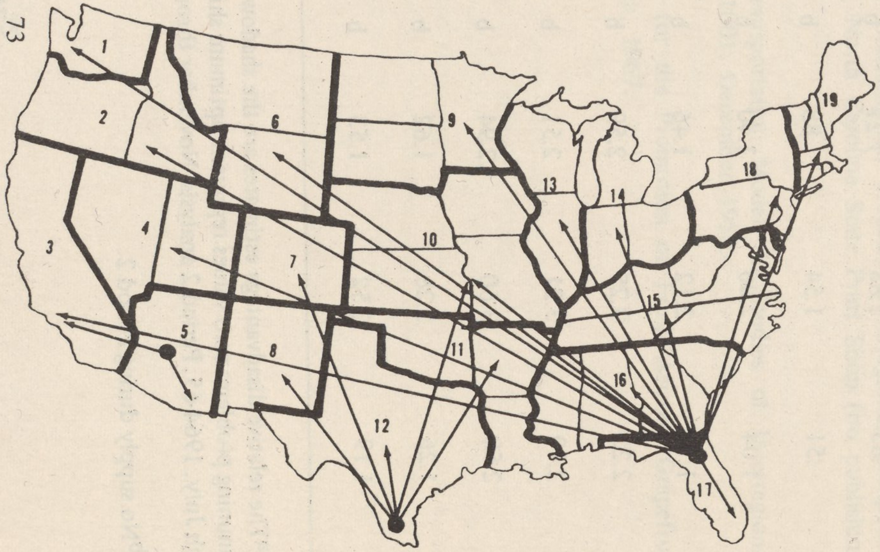
3. Because of space limitations, discussion of the economic and mathematical properties of the transportation model has been omitted. Excellent treatments of these aspects of the model are contained in



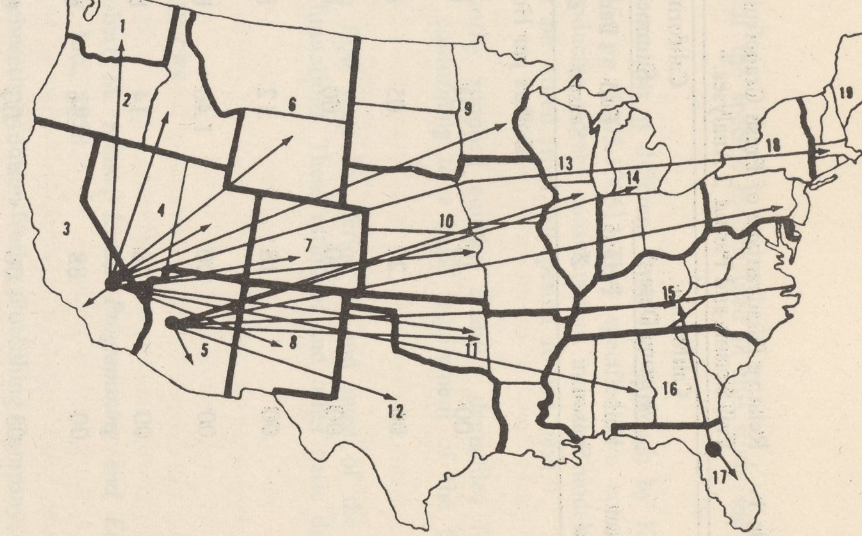
Full Season Analysis, August through July, 1964-65.



Period 3 Analysis, March through May, 1965.



Period 2 Analysis, November through February, 1964-65.



Period 4 Analysis, June and July, 1965.

Figure 1. Optimum Rail Shipment Patterns for Fresh Grapefruit: Full Season and Intraseason Analyses, 1964-65.

Table 1. Relative Disadvantage of Fresh Grapefruit for 4 Producing Regions and 19 Marketing Areas, Full Season and Period 2 Analyses.[a]

Market Area	California-Arizona Desert		California Summer		Texas		Florida	
	Full Season	Period 2	Full Season	Period 2	Full Season	Period 2	Full Season	Period 2
	(Dollars per Hundredweight)							
1	.00	.43	.04	b	1.18	.58	.59	.00
2	.00	.27	.05	b	1.34	.58	.75	.00
3	.00	.00	.00	b	1.62	.59	1.02	.00
4	.00	.18	.12	b	1.46	.61	.84	.00
5	.00	.00	1.46	b	2.70	1.67	2.07	1.05
6	.00	.76	.14	b	.55	.28	.26	.00
7	.00	.88	.36	b	.15	.00	.60	.46
8	.03	1.06	.00	b	.00	.00	.57	.58
9	.61	1.63	.97	b	.17	.16	.00	.00
10	.41	1.43	.77	b	.01	.00	.00	.00
11	.85	1.88	1.21	b	.00	.00	.00	.00
12	.51	1.54	.88	b	.00	.00	.31	.32
13	1.04	2.06	1.40	b	.34	.33	.00	.00
14	1.10	2.12	1.46	b	.74	.73	.00	.00
15	2.23	3.25	2.59	b	1.39	1.38	.00	.00
16	2.19	3.21	2.51	b	1.21	1.20	.00	.00
17	2.58	3.60	2.94	b	1.78	1.77	.00	.00
18	1.26	2.28	1.62	b	1.38	1.37	.00	.00
19	1.19	2.52	1.53	b	1.29	1.28	.00	.00

[a]The relative disadvantage estimates are the shadow prices from the optimal solution to the linear programming problem; zero values represent optimum shipment routes. Full season analysis, August through July, 1964-65; Period 2 analysis, November through February, 1964-65.

[b]No supply during Period 2.

[1], [2], and [3]. For an algebraic statement of the specific models used in this study see [6, pp. 48-49].

4. The introduction of a time dimension into this analysis is different from the approach by King and Henry in their hypothetical space-time model [5, pp. 1005-1006]. They specified two consumption periods and one production period, thereby introducing storage considerations into the model. In our study it is assumed that fresh grapefruit will not be stored from one period to the next.

5. One convenience of this approach is that quantity supplied equaled quantity demanded for each period and for the entire crop season, thereby conforming to a basic requirement of the transportation model.

6. The data on optimum shipments, the optimum flow map for Period 1, and most of the relative disadvantage estimates are omitted due to space limitations. These estimates and other basic data used in the study can be obtained from the authors.

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