tists use this model, establish its validity for their specific locations, and tailor it to their own use.

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Interregional Analysis of Fresh Dry Onion Production: An Examination of Texas in the Spring and Summer

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Abstract. A national trade model of the fresh onion (*Allium cepa* L.) market is used to identify the capability of Texas to compete with other production areas in dry onion sales throughout the United States. The analysis shows Texas and western U.S. producers to be major competitors in the spring and summer seasons. While Texas producers' proximity to major eastern markets yields a cost advantage, their market share is vulnerable to cost reductions by western U.S. shippers. Thus, both cost-reducing innovations (production) and quality improvements are important in maintaining the competitiveness of Texas producers.

The declining market share of the spring and summer fresh dry onion market supplied by onion producers in the subtropical portion of the Rio Grande Valley (Texas) and South Plains (Fig. 1) has created uncertainty about the producers' ability to remain competitive. A national interregional trade model was used to identify the ability of the Rio Grande Valley of Texas and the South Plains to compete for dry onion sales in various geographic regions of the United States.

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Dry onion production in the United States is identified as 1) spring, 2) summer non-storage, or 3) summer storage crop. The spring crop comprises 15% to 18% of U.S. onion production and is produced primarily in California, Arizona, and the lower Rio Grande Valley of Texas. Spring onions are the first-harvested of the calendar year and typically move directly to the fresh market. Summer nonstorage onions, $\approx 10\%$ of national production, are produced primarily in the upper Rio Grande Valley (Texas and New Mexico). Summer storage onions, 70% to 75% of U.S. onion production, are harvested in northern states from August through October, with shipments continuing through early spring (April). Storage onions do not compete with new onion production until spring harvest commences in March; however, imports from Mexico offer competition during

the winter and early spring.

Per-capita consumption of fresh onions has increased 33% during the past decade, from 6.1 kg in the mid-1970s to nearly 8.2 kg per capita by 1987. The increase is attributed in part to health-conscious consumers increasing consumption of fresh vegetables and away-from-home consumption, which often includes both fresh and processed onion products. Per-capita consumption of onions has also benefited from increased consumption of ethnic foods, particularly Mexican.

While the U.S. production and consumption of dry onions was increasing during 1977-1987, shipments from Texas decreased modestly. Thus, market share for Texas producers declined. Monthly market-share trends calculated for the April-August window showed the lower Rio Grande Valley's national share in April remained relatively constant at $\approx 70\%$. In contrast, market share in May and June declined $\approx 40\%$ over the 1977-1987 period, with the current monthly shares averaging $\approx 40\%$ and 15%, respectively. Similar declines in onion market share were observed for the summer months, a period when shipments originate in the South Plains. Much of Texas producers' declining market share was claimed by California producers. Competing regions other than California showed no definite trend in market share. Whether onion producers in Texas found alternative enterprises that were more profitable or experienced resource constraints that fixed upper bounds on onion production was not determined.

Framework for analysis

Efficient resource use implies a production and geographic distribution that satisfies market requirements at the lowest possible cost (Bressler and King, 1970). King (1969) suggested that a transportation model, in combination with production and processing costs, offers insight into the cost-competitiveness of producing regions. Several studies have used this framework successfully (Bates and Schmitz, 1969; Ben-David and Forker, 1970; O'Rourke, 1977).

Our study uses an interregional transportation model to address the competitiveness issue. The model uses each region's monthly

Fig. 1. Location of study regions in Texas.

producer price as a proxy for cost and monthly transportation charges, linking surplus producing regions with deficit regions to determine the most efficient regional trade patterns. To the extent the estimated flows approximate actual historic flows, changes in shipping patterns resulting from induced stimuli (e.g., transportation rates or producer costs) can be measured.

Economic model. The trade model includes each onion-producing region's monthly supply of fresh onions and each demand region's per-month demand or consumption. In addition, the model includes onion production costs (price) for each production region and transportation costs linking all supply and demand regions. Given supply and demand region constraints and production and transportation costs, the model identifies flows between supply and demand regions that minimize total production and transportation costs.

Data components of model. Once the production and consumption regions were defined, available supplies in each producing region and consumption in each demand region by month were estimated. Further, estimated regional production costs and transportation charges linking production and demand regions were determined.

Demand and supply regions. The trade model includes 33 regions; 13 are supply regions and 20 are consumption or demand regions (Fig. 2). Monthly onion production per supply region was based on the average of 1983-1985 shipments (Table 1) (USDA, 1983-1985b).

The consumption of fresh onions was based on the Nationwide Food Consumption Survey (NFCS) (USDA, 1983) and the Census of Housing (U.S. Dept. Commerce, 1983). The NFCS shows per-household consumption of dry onions to be highest in the northeast (0.24 kg-week⁻¹), followed by the west and south (0.20 kg-week⁻¹, each). The northcentral region had the smallest per-household consumption of onions (0.17 kg-week⁻¹), ≈22% less than the national average (0.20 kg-week⁻¹). Consumption in each demand region was estimated by multiplying the per-household consumption data for each region by the estimated number of households per region.

Regional production costs. Monthly average prices received by farmers at the point of first sale, for all grades and quality of dry onions for the period 1983-1985 were used as a proxy for cost of production (USDA, 1986). Competing regions' relative prices mirrored relative costs; thus, we judged it

appropriate to use prices as a proxy for costs (Fuller et al., 1989b).

Transportation costs. Transportation costs between supply and demand regions may have an important bearing on the ability of a supply region to compete in a national market. Linear regression equations based on truck rate information from the Fruit and Vegetable Truck Rate and Cost Summary (USDA, 1983-1985a) were estimated to calculate the charges for shipping dry onions over various transportation corridors. Distance of haul was, as expected, the most important factor determining rates.

Validation of model

The model's capability to project actual trade flows was evaluated by comparing city terminal market share data with projected flows (shares). The validity of this comparison is based on the assumption that a producing region's share of a city terminal market is similar to the share it supplies to the region where the city is located.

Texas producers' historical market share in the various terminal markets was determined from the Fresh Fruit and Vegetable Unload Totals (USDA, 1983-1985 c). The model-projected flows show Texas' princi-

Fig. 2. Demand regions included in spatial model.

Fig. 3. Potential annual shipments from Texas in view of reduced costs in California.

pal markets to be in the East and Southeast, followed by the Midwest and southcentral regions. This finding parallels an earlier one by Fuller et al. (1989a). In addition, the model's projected market share for a particular region approximated Texas' historical share for that region. For example, historical unload data show Columbia, S. C., New Orleans, La., Louisville, Ky., and Cincinnati, Ohio, received about one-third of their annual onion unloads from Texas, a market share that closely corresponds to the model-estimated share of 32% to 38%. The model-projected share in the northeastern United States was also similar to the historical share. However, the model tended to underestimate the flow of Texas onions to the northcentral and western regions of the United States. Historical shares at northcentral terminal locations (Chicago and St. Louis) ranged from 19% to 30%, while the flows from Texas

were projected to be generally < 20% of a terminal's onion unloads. Even though Texas' market share in the western United States is small, e.g., only 3% in Los Angeles, the model tended to underestimate this flow.

Factors that contribute to differences between the model-projected shares and historical shares for terminal cities located within a particular demand region include: a) the model's sometimes-erroneous assumption that Texas' historical share of a terminal market should parallel the projected share of the demand region where the terminal city is located; b) the model's assumption that fresh onions are a homogeneous commodity rather than a heterogeneous product satisfying a variety of demands; and c) the difficulty in estimating representative transportation charges because of the unregulated nature of these hauls. Since the transcontinental flow of commodities and products from west to

east exceeds the east to west flow, very low transportation charges often exist for back-hauls to west coast locations. These low transportation rates may be the principal reason for the observed flow of onions from Texas to western U.S. locations. Nevertheless, the model correctly projected all major flows, and, accordingly, was judged appropriate to test hypotheses regarding the competitiveness of Texas in the national fresh onion market.

Texas' capability to compete with other producing regions in the national dry onion market was evaluated in three aspects. First, the competitiveness of Texas' production was determined; second, the vulnerability of Texas' market share to incremental cost reductions by competing regions was examined; and third, each region's historical supply constraint was relaxed to identify those regions that would produce if total production and transportation costs were minimized.

Cost-competitiveness of Texas. Evaluating Texas' competitiveness based on possible cost advantages (production and transportation costs) during its market window (March through September) was accomplished by relaxing its supply constraints and then determining whether it would be cost-minimizing to ship additional supplies from Texas. The solution suggests shipments would increase from 1919 to 3553 t, an 85% increase, when Texas supplies are unconstrained. This implies competing regions are now supplying onions during the March-September window that could be supplied at lower cost by producers in Texas. The projected increase in shipments is large and somewhat overstated in view of biological constraints faced by Texas producers in certain periods. For example, shipments from Texas in March are projected to increase from 5.8 to 27.8 t, an unrealistic assumption in view of the difficulty Texas producers have in producing high quality onions in large volume during this early period. However, the large projected increase in volume relative to Texas' historic onion shipments implies Texas producers are not at a cost disadvantage relative to many regions that ship during Texas' window.

The solution to the interregional trade model offered two additional findings regarding the competitiveness issue. First, most of the projected increase in onion shipments by Texas producers was at the expense of California shipments, which were reduced significantly when Texas supplies were unconstrained. This finding implies Texas producers have an unexploited cost advantage relative to California. Second, the projected increase in shipments differed by month. Texas' cost advantage yielded modest increases in shipments during April and June ($\leq 10\%$) but more substantial increases in May (41%), July (112%), August (106%), and September (1105%).

The sensitivity of Texas' expanded trade share to increases in production and transportation costs will indicate whether the cost advantage is meaningful. If the higher costs have little effect on Texas shipments, the

Table 1. Estimated supplies of fresh dry onions, by months, 1983-85 averages (1000 tons) (from USDA 1983-1985 b).

Shipping state or country	January	February	March	April	May	June	July	August	September	October	November	December	Total
Arizona ^z	---	---	---	---	13.9	16.3	---	---	---	---	---	---	30.
California ^{z,y,x}	4.72	2.54	1.77	3.35	41.3	49.4	41.3	19.1	9.03	8.85	8.43	6.94	197
Colorado ^x	13.7	12.9	8.76	2.27	---	---	---	13.0	26.4	20.0	19.6	16.4	133
Georgia ^z	---	---	---	---	7.12	4.04	---	---	---	---	---	---	11.
Idaho ^x	16.6	13.1	7.53	0.50	0.05	---	---	4.67	12.0	19.2	17.7	17.8	109
Michigan ^x	11.9	9.4	8.08	1.68	---	---	---	0.91	9.85	11.7	12.2	11.1	76.
New Mexico ^y	---	---	---	---	---	21.5	19.7	14.7	2.63	---	---	---	58.
New York ^y	19.6	16.0	16.3	10.8	---	---	---	3.81	17.7	18.5	17.7	16.6	137
Oregon ^{y,x}	22.1	18.9	16.1	3.90	0.73	---	0.32	7.03	16.3	23.2	20.4	20.6	150
Texas ^{z,y}	---	---	5.76	59.3	60.8	15.9	27.0	21.1	1.95	---	---	---	192
Utah ^x	1.95	---	---	---	---	---	---	---	1.91	3.54	3.68	2.59	13.
Washington ^{y,x}	5.54	5.26	5.31	2.22	0.05	---	12.7	5.76	5.44	6.53	6.49	6.44	61.
Mexico	6.17	6.72	22.0	12.4	3.81	1.54	---	---	---	---	0.73	3.40	56.

^zSpring producer.^ySummer nonstorage producer.^xSummer storage producer.

cost advantage is meaningful; conversely, if shipments are substantially reduced, then the cost advantage is modest and possibly insignificant. Cost increases of 5%, 10%, 15%, and 20%, or, of \$18.73, \$37.47, \$56.20, and \$74.94/t, respectively, reduced Texas' expanded shipment volume of 3553 t to 3207, 2268, 2077, and 2052 t, respectively. Shipments in the March, April, May, and June windows were reduced to historic 1983-1985 levels, when costs were increased 10%. July shipments declined to the historic-level with a 15% increase in costs. Only projected August and September shipments (South Plains) exceeded the historic level when costs were increased 20%. We project that the South Plains could increase shipments during August from 211 to 279 t and in September from 20 to 105 t, a potential increase in total annual shipments of ≈8%. The expanded shipments would be to Arkansas, Louisiana, Mississippi, Oklahoma, and Texas markets at the expense of California shipments.

Vulnerability of Texas' market share. The sensitivity of Texas' market share was examined by relaxing competing regions' historic supply constraints and incrementally reducing their costs. California and Arizona are important dry onion shippers during the Texas market window. The removal of California's historic supply constraints had little effect on either California or Texas. This finding is in contrast to the significant expansion of shipments from Texas and the corresponding decline in California shipments when Texas' supply constraints were removed.

While relaxing supply constraints had little effect, the model suggests the national market share held by Texas would drop 4070 if California's costs were reduced 10% (Fig. 3). Texas shipments in June, April, and May were the most vulnerable to California's cost reduction, while March, August, and September shipments were little affected. These findings reinforce the above results regarding Texas' substantial cost advantage in the August and September windows.

Arizona, an important dry onion shipper in May and June, had the capability to dis-

place nearly all competing regions during these months. New Mexico, an exception, would retain its historic shipments in June.

Location of onion production based on least-cost criteria. The trade model projects least-cost dry onion production and shipment patterns in the United States when the supply constraints for all production regions are relaxed. This unlikely situation indicated onion production would be concentrated in six states (Michigan, Oregon, Utah, Washington, Arizona, and New Mexico). Summer onion producers (Michigan, Oregon, Utah, and Washington) would supply 81% of the onion output, while Arizona and New Mexico would generate the remainder. Summer storage onion stocks would be the source of supply in March and April, while May, June, July, and August shipments would originate in Arizona, New Mexico, and Oregon. Clearly, other variables, such as quality characteristics and competing crops, play an important role in explaining the actual geographic location of onion production vs. the purely least-cost pattern suggested by the model.

The analysis indicates Texas was cost competitive during the April–August market window. The decline in Texas' market share was not attributable to unfavorable costs. This outcome is appealing in view of the earlier finding that Texas' production costs are similar to major competitors' during its window and much of its market is located in the eastern half of the United States, while most competing onion production is located in the western United States. It is estimated that Texas' transport cost advantage over California is near \$55/t in the northeastern U.S. markets and in excess of \$66/t in southeastern markets.

Texas' greatest opportunity for increasing shipments and market share would be in periods when its largest cost advantage existed. The analysis showed a small cost advantage during the peak shipment period (April–May) (Rio Grande Valley) and a modest advantage in July, with any increase in shipments coming at the expense of California. The greatest cost advantage was in August and Septem-

ber, when the South Plains' cost advantage was substantial. The increase of 181.5 t represented a 70% increase in shipments for the South Plains during the August–September window.

Although Texas was a cost-competitive producer during its window, it generally had higher costs than many of the regions harvesting storage onions in the late summer. Consequently, if the location of the nation's onion production were based on cost alone, Texas would be an insignificant supplier and onions consumed in the spring and early summer would come from storage stocks. This implies that the lower Rio Grande Valley's current role as a major supplier is based on its ability to offer a product that is preferred to an onion coming from storage in the early spring. Costs, of course, are not irrelevant. Moderately lower production costs in California could significantly reduce Texas' market share. Thus, innovations by horticulturists that enhance production efficiency and quality are important for maintaining the competitiveness of Texas producers.

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