Diversity of Sources for Fresh Produce: Implications for Local Markets

Luanne Lohr and Steven D. Hanson*

Abstract

Number of suppliers, approximation of equal-shares market condition and market share held by in-state sources were calculated to determine diversity of sources for 10 fresh fruits and vegetables in eight U.S. wholesale markets. Specificity of growing conditions is associated with few supply sources, unequal market shares and limited purchases from in-state suppliers. For crops with few sources, lower perishability and greater transportability are correlated with greater balance in market shares. For crops with many supply sources, greater perishability and greater transportability are consistent with large market share from imports. Diversity across all commodities can increase market share for local producers.

Key Words: concentration index, fruits and vegetables, source diversity

The U.S. food supply is considered one of the most diverse in the world. An amazing variety of food products is available in the typical grocery store. On average, 280 different fresh fruit and vegetable items are stocked year-round, with 310 different items in summer months (Litwak and Maline). Many of these commodities travel long distances across country, or even internationally, between production and consumption regions. There is an entire infrastructure of production, transportation and marketing that supports this system.

Yet, the apparent abundance may mask a lack of diversity in supply sources. Much of this produce comes from four or fewer states, with some items available only from a single source. Reliance on limited numbers of production regions at great distance from consumers reduces market share for local producers and increases risk of consumer and retailer impacts from supply disruptions. Expenditures by state departments of agriculture on advertising to encourage demand for locally grown fresh produce demonstrate support for greater source diversity.

Little research has been directed toward evaluating diversity in fresh produce markets and explicitly linking it to effects on local producers, consumers and retailers. Previous research has focussed on production diversity, ignoring the interaction of supply and demand factors in the market as well as the influence of marketing factors and consumer preferences on measures of diversity (Tauer; Bacon and Gempesaw). Using data on wholesale shipments collected at demand centers is a simple way of representing the equilibria in markets. Thus, in our approach, consideration may be given to changes beyond the farm-gate that can enhance diversity and self-sufficiency goals.

We describe the relationship between supply diversity and local markets, develop an index of diversity and apply it to data on wholesale shipments to describe eight major U.S. markets for 10 fresh fruits and vegetables in terms of relative

*Luanne Lohr is assistant professor, Department of Agricultural and Applied Economics, University of Georgia. Steven D. Hanson is associate professor, Department of Agricultural Economics, Michigan State University. The authors thank two anonymous reviewers for their comments.

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supply source diversity. The index accounts for number of sources and evenness in market power, as well as market share for local producers. Five fruits (apples, grapes, strawberries, oranges, and cantaloupes) and five vegetables (iceberg lettuce, carrots, tomatoes, celery, and cucumbers) were selected for this study, based on consumer preference rankings in 1990 (*The Packer*). The preference criterion for selection is consistent with the importance of evaluating consumer effects of inadequate diversity.

The objectives of this study are to measure supply source diversity for selected fresh fruits and vegetables, and to discuss the implications of existing diversity conditions for local self-sufficiency. In addition, this research seeks to describe the association between commodity characteristics and differing degrees of source diversity, and to make recommendations for enhancing self-sufficiency.

Source Diversity and Local Markets

There are two competing concerns for local markets - diversity of sources and share supplied by local producers. Diversity can be assessed by balance in market share among suppliers. Fresh fruits and vegetables are packed and shipped from near the production site with minimal processing. Thus, production regions may be considered the source units. The most diverse systems have relatively many supply regions with nearly equal market shares. Greater diversity (number of and balance among sources) reduces risk of supply interruption due to transportation system and geographically specific production problems. Greater demand for local products improves the economic situation for farmers, provides fresher produce for consumers, and reduces dependence on distribution systems. Interest in increasing the market share held by local producers has led state departments of agriculture to encourage demand for locally grown commodities through advertising (McClure).

The conflict between these two objectives is one of balance. Becoming self-sufficient implies the same susceptibility to geographically specific problems (weather and pest infestations) that can result from concentrating production in limited numbers of distant regions. Failure to develop local production possibilities leads to dependence on long distance transportation and distribution systems to coordinate delivery of fresh produce. These systems have become highly concentrated, with a handful of firms controlling global distribution patterns of fresh fruits and vegetables (Friedland). Disruptions in transportation (fuel cost increases, worker strikes) or distribution (contract failures, quarantines) are more significant when the market relies on long distance suppliers. Both total self-sufficiency and concentration of market share increase the risk to the local food system. Food system diversity should be evaluated on the basis of number of sources, balance in market power and share held by local producers.

Market Share for Local Sources

Bacon and Gempesaw found that production of fruits and vegetables is geographically concentrated, with net surpluses in the ratio of farm production to retail demand only for the Pacific, Mountain, and South Atlantic regions. The supply regions that can bring produce to markets at the lowest cost can capture the majority of market share. Farm production in these regions is dominated by California, Oregon, Washington, Arizona, Colorado, and Florida. Since most of these areas grow a variety of crops, rather than specializing in a single commodity, impacts of geographically specific problems may affect a large share of fresh fruit and vegetable production. This risk is not calculated in the marginal cost of production, but suggests aspects other than price are important in market analysis.

While most states cannot achieve self-sufficiency in supply of fresh produce due to climatic and edaphic conditions, it is possible to grow a variety of crops for immediate sale or storage. Apples, tomatoes, potatoes, lettuce, onions, celery, carrots, mushrooms, and corn accounted for 38 percent of supermarket produce sales in 1991 (Litwak and Maline). Weimer and Hallam calculated that production of 11 vegetables and two types of melons in Iowa would generate a net gain of $17 million in new revenues to farmers, and displace more distant competitors in local markets. Higher marginal costs for production factors, cooling systems and distribution channels reduce

competitiveness of local producers, but risk reduction may offset these costs. Supermarkets are willing to purchase locally grown produce when quality is comparable to more distant suppliers (Coupe). Currently, foreign sources are increasing market share, reducing local competition while increasing reliance on long distance transportation and limited distribution channels (Litwak and Maline).

From the farmer's perspective, failure to develop local sources of fresh fruits and vegetables limits choices in diversifying enterprise mix to reduce farm-level risk. Sales of fresh fruits and vegetables may be relatively lucrative, with average farm gate price at $185 per ton in 1983 (Bacon and Gempesaw). If fruit and vegetable farming requires different factors of production, local input suppliers may also benefit by diversifying. By not maintaining local sources, consumers may also lose. If proximity equates with freshness, then longer travel distances result in lower product quality. Coupe cited retailer experience that consumers perceive this difference whether or not physical indicators support this conclusion. To the extent that information about farm practices is important to consumers, obtaining details from local suppliers is probably easier than with distant producers.

Diversity of Sources

Consumer effects from imbalance in market share and limited numbers of supply sources depend on the susceptibility of the consumption region to stochastic disruptions in supply. Besides geographically specific factors, transportation and distribution, involuntary cancellations of as many as 35 pesticide/commodity registrations under the Delaney Clause could result in abrupt decline in productivity in important fruit and vegetable regions (Stimmann and Melnicoe). The more concentrated production is in a limited number of regions, the greater the probability of noticeable market effects. Flexibility of consumption regions in adjusting to stochastic effects is limited. Since crop decisions are made prior to the start of the growing season, the total quantity of produce available at harvest in a given year is fixed. Since product will flow to the demand regions with the greatest ability to absorb price increases, quantity that remains will be distributed according to ability and willingness to pay. Some consumption regions may be unable to obtain a share of desired commodities, as supply is shipped to areas where demand and price are highest.

The potential impacts - price increase, quality deterioration and restricted selection - would be experienced most intensely by marginal consumers of fresh produce. Those with the least disposable income may experience a disproportionate effect through inability to increase spending to compensate for price increases or to search out alternative supply outlets to offset quality deterioration and restricted selection. The size of a price increase determines how many people will be priced out of the market for fresh fruits and vegetables. Those unable to afford fresh produce may be forced to accept substandard quality or to substitute other commodity choices. The distributional impacts on these consumers may be drastic, since substitutes for fresh produce - frozen and canned fruits and vegetables and vitamin pills - are even more costly per unit of nutrient. Further, as Gussow noted, constituent products of foods will not necessarily provide the same nutritional value as the food from which they are derived; an example is catsup compared with fresh tomatoes.

With the large selection in types of fresh fruits and vegetables, some measure of substitution among items is expected. However, as opposed to seasonal differences in price, quality and availability, which are known in advance, adjustments to sudden changes within the seasonal patterns are more difficult to make. Consumption patterns are set, with over 50 percent of sales in just 11 categories of fresh produce. The factors previously described may limit availability of a class of produce, such as all citrus from a particular region of California. Item replacement is not always possible nor desirable. For example, finding substitutes for fresh tomatoes or potatoes may be difficult. Familiarity with substitutes and household preferences play a major role in willingness to purchase substitute fruits and vegetables, so the effect is not necessarily a dollar-for-dollar replacement. It is not necessary for an entire crop to be lost or all supply sources to be eliminated in order for these effects to occur, since distribution systems reallocate among consumption regions, potentially creating pockets with these conditions. Lack of diversity in both numbers of suppliers and balance among sources intensifies this risk.

Retailers also may be affected by lack of supply diversity. Fresh produce is important in store profitability. In 1991, more than 10 percent of supermarket sales, a weekly average of $21,861, was fresh produce (Litwak and Maline). With an average gross margin of 38.2 percent, fresh fruits and vegetables contributed 18.7 percent of supermarket's total gross profit. Increased wholesale prices due to random shocks reduce the margins on produce items. Obtaining alternate supplies sufficient to meet local demand can be difficult, particularly if suppliers have already contracted their output. Dominance within the supermarket industry is on a regional, rather than a national basis, so there is strong competition at the local level for consumer spending. Consumer perception of stores may be negatively affected if produce selection is limited, quality is poor, or prices are high. Inability to stock sufficient quantity and quality of preferred items in season encourages consumers to shop elsewhere. The greater the dominance by a limited number of sources, the more vulnerable retailers are. A stochastic shock may not affect all retailers equally, since chains, rather than individual stores, negotiate wholesale purchases.

Vulnerability to lack of diversity in fresh produce sources is a matter of degree. With the large number of items in produce departments, some substitution by consumers will occur in the event of a supply shock. Supply recovery depends on the nature of the shock, its effect on productive capacity and the economic incentives for new entry. The main factor in determining susceptibility is the measure of diversity of supply sources.

Measurement of Source Diversity

An appropriate index of diversity should include measures of both the number of supply sources for a market and the distribution of market share among the sources. One such index used in ecological studies (Magurran) and in market concentration studies (Tauer; Hannah and Kay) is

$$I(\alpha) = \left[\sum_{i=1}^{n} S_i^{\alpha} \right]^{\frac{1}{(1-\alpha)}} \quad , \alpha \neq 1 \qquad (1)$$

$$I(\alpha) = \exp\left[-\sum_{i=1}^{n} S_i \ln S_i \right] \quad , \alpha = 1$$

where we define S_i as the share of total market shipments for a given commodity sent from the ith origin to a given terminal. Separate values of $I(\alpha)$ may be calculated for terminals representing different markets.

The parameter α may be set over a range of nonnegative values to compare the number and distribution of items in a unit sampled. Hannah and Kay defined α as an elasticity parameter, whose role is to indicate how much weight to attach to the upper portion of the distribution relative to the lower. In this case, the upper portion includes the dominant supply sources, based on quantity, while the lower portion is composed of other sources who make smaller contributions to overall supply. Hannah and Kay noted that in general, high values for α give greater weight to the role of the largest suppliers in the distribution, and lower values of α emphasize the presence or absence of smaller suppliers. If $\alpha = 0$, the index counts the number of supply origins, n, which can be seen by substituting 0 for α. For this value of α, the index makes no distinction between relative dominance of smaller and larger supply sources. Higher values of α accentuate the evenness of the distribution of market shares among the supply origins. As α approaches infinity, the index tends toward the reciprocal of the share of the largest supply source. For $\alpha = 1$, the index is equivalent to the Theil entropy index of concentration, so that a ranking based on the index is the same as that given by entropy (Hannah and Kay). For $\alpha = 2$, this index becomes the Herfindahl index used to measure market concentration (Hannah and Kay).

Both Tauer and Magurran noted that changes in the index value are small for $\alpha > 2$. Hannah and Kay tested values of α in comparing rankings of industry concentration, and found a range of α from 0.6 to 2.5 sufficient to make distinctions in concentration. Thus, α can be altered to reflect the concentration measure deemed most appropriate for the problem. In our case, the problem was to evaluate the dominant supplier relative to the equal shares condition, so we used $\alpha = 0$ and $\alpha = 2$. We calculated indexes for values up to $\alpha = 5$, but found these values did not substantially alter the results.

There is no absolute indicator of ideal number of suppliers in a market, nor of distribution of market shares that eliminates susceptibility to stochastic supply disruption. Hannah and Kay defined the process of market concentration as an increase in the extent to which economic activity is controlled by large firms, or in the present case, large quantity suppliers. Differing market conditions for terminal locations and commodities make determination of single threshold values impossible. Instead, relative diversity across markets may be compared using weighted market shares and numbers of sources. Since weighted market shares depend on the number of supply sources, a common basis of comparison that is independent of number of supply origins must be established.

We frame this index in terms of a perfectly balanced market in which each source contributes an equal share of the market supply. This is not necessarily the cost-minimizing market condition, since this situation may be costly to establish and maintain. However, if the preceding analysis is correct, it is more likely to result in risk reduction than a condition with imbalance of market share. Without reference to the equal-shares market condition, the values generated by the index in equation 1 with $\alpha = 2$ can be used only for determining balance within a specific market. To determine how closely the actual market approximates an equal-shares condition, and to compare balance across markets, the index must account for equal-shares conditions that are specific to each market.

Markets are defined by commodity of interest and terminal location. Depending on the number of supply sources, each market has its own idealized equal-shares condition. Since the requirements for an equal-shares condition are the same for all markets, a basis of comparison is established that shows how well each market approximates its idealized condition. In combination with numbers of supply sources, this information provides a perspective on relative diversity across markets.

The opposite of an equal-shares situation is a monopoly, where one origin supplies the entire market. Under this condition $S_i = 1$ in equation 1 for the ith origin, the monopolist, and $I(\alpha) = 1$, regardless of the value of α. The farther from the monopoly situation a market is, the closer it is to an equal-shares condition. When this difference is maximized, market shares are balanced among all n supply origins. However, to avoid specifying this difference as a function of the number of origins in a market, so that markets are not perceived to be better balanced simply by virtue of having more origins, we normalize the monopoly and equal-shares conditions by the number of supply origins. Then we may compare how closely the actual market approximates the equal-shares condition by using the monopoly situation as a point of reference.

We propose the index

$$\lambda(\alpha) = \left[\frac{I(\alpha)}{n} - \frac{I^*(\alpha)}{n}\right] \Big/ \left[1 - \frac{I^*(\alpha)}{n}\right] \qquad (2)$$

where $\alpha > 0$, and $I(\alpha)$ is the index of market diversity from equation 1, calculated for the actual market. The total number of supply origins in the market is n, which is the same as $I(0)$ in equation 1. The specific value of n for a given market is determined by the data. $I^*(\alpha)$ is the diversity index for a monopoly situation, which is divided by n to normalize the index. $I^*(\alpha)$ reduces to 1, since the one source supplies 100 percent of the market.

The denominator in equation 2 is the market specific equal-shares condition, given by the difference between the normalized indices for the perfectly balanced and the monopoly situations. The normalized diversity index for the perfect balance situation has a value equal to 1. Since S_i is the same for each source, the diversity index from equation 1 is equal to n, and is divided by the number of sources in the market, normalized to an equal-shares index equal to 1. The numerator describes how close to a monopoly the actual market is, given as the difference between the normalized indices for the actual and monopoly conditions. Substituting the parameter $\alpha = 2$ and simplifying equation 2 gives

$$\lambda(2) = \frac{I(2) - 1}{n - 1} \quad , n > 1 \qquad (3)$$

$$\lambda(2) = 0 \quad , n = 1$$

The resulting diversity index, $\lambda(2)$, measures actual market concentration as a proportion of the equal-shares condition for a given market. Since this index is a proportion, $\lambda(2)$ is bounded by zero and one. If $\lambda(2) = 0$, the actual market is controlled by a single supply source. If $\lambda(2) = 1$, market shares are evenly distributed among sources. Values of $\lambda(2)$ between zero and one tend toward either single source dominance if near zero or the equal-shares condition if near one.

Approximation of the equal-shares condition, combined with information about number of supply origins and shares from in-state and foreign sources, provides an indication of vulnerability to disruption. This index is richer than conventional measures of concentration such as market share of the four most dominant sources because it simultaneously accounts for all suppliers in the market. Diversity depends as much on the number and shares of other suppliers in the market as it does on the top four sources. The equal-shares index quantifies the difference between the actual market and a perfectly balanced market.

Data and Results

Arrival data published by the U.S. Department of Agriculture (USDA) quantifying shipments of fresh produce by truck, rail, air and boat are classified by commodity, state or country of origin and wholesale terminal destination. These data represent more than 90 percent of the volume of shipped produce received at U.S. terminals (How). This constitutes on average 94 percent of produce sold through retailers (Litwak and Cepeda).

Data selected for this study were 1990 cumulative annual arrival quantities of fresh fruits and vegetables, measured in hundredweights (cwt), from state or country of origin to eight major wholesale terminals (USDA, 1991a; USDA, 1991b). Regional dominance by the Pacific, Mountain, and South Atlantic states evident in this data implies that 1990 shipments may be taken as representative of domestic supply sources for at least the last 10 years, reflective of similar trends exhibited in self-sufficiency ratios for fruit and vegetables calculated by Bacon and Gempesaw for 1983, 1970, 1960, and 1949 data. Cumulative data account for storage and sales from inventory and the foreign supplies that alternate seasons with domestic sources. The eight terminals chosen represent four locations on the Atlantic Seaboard (Baltimore-Washington, Boston, New York-Newark, and Philadelphia) and four sites in the Midwest (Chicago, Cincinnati, Detroit, and St. Louis).

Eighty-eight separate fruit and vegetable commodity categories are tracked by the USDA. Selection was based on consumer purchases. These commodities are relevant since consumer reaction to price increases, quality changes and reduced availability depends on preferences, which are reflected in purchase patterns. Though ranked second among fruits, bananas were not included because no origin data were available, so the sixth ranked fruit was added. Fruits selected, by percent of consumers purchasing, were apples (96 percent), grapes (87 percent), strawberries (79 percent), oranges (78 percent), and cantaloupes (77 percent). Vegetables chosen were iceberg lettuce (88 percent), carrots (88 percent), tomatoes (84 percent), celery (81 percent), and cucumbers (78 percent).

The equal-shares index $\lambda(2)$ was calculated for each of the 10 commodities identified and eight wholesale terminals. Proportional market shares for each origin were based on total quantity shipped for each crop and terminal combination. Market shares attributable to the in-state and foreign sources were based on percentage of deliveries from each source. For the New York-Newark market, both New York and New Jersey shipments were considered in-state.

Table 1 shows approximations of the equal-share condition, given by values of $\lambda(2)$, and the numbers of sources for the five fruit commodities and eight terminals. Values of $\lambda(2)$ in tables 1 and 2 may range from 0.000 to 1.000. The closer is $\lambda(2)$ to 0.000, the closer is the market to dominance by a single firm. As $\lambda(2)$ approaches 1.000, the market share is more uniformly divided among the sources. Table 2 provides the same information for the five vegetable commodities and eight terminals. Table 3 gives the percentage of arrivals from in-state and foreign sources for the 40 fruit-terminal

combinations, while table 4 gives this information for vegetable commodities.

The most important factor in supply diversity and self-sufficiency is uniqueness of production requirements. Regions that meet unique growing requirements will dominate all markets for that crop. Among the sources that can produce a given crop, balance may depend on seasonality, perishability and transportation and distribution systems. The shorter the domestic season for a crop, the larger share foreign sources may supply. The more perishable a crop, the higher the marginal cost of transporting it, and the more likely that less distant sources can supply part of the market. The more constrained the transportation and distribution systems for a crop, the less distant the sources tend to be from the demand center. These hypotheses may be examined using the results on tables 1 through 4.

Overall, most markets for fruits and vegetables exhibit relatively imbalanced conditions, regardless of whether there are only a few or many supply sources. Among individual fruit markets, the greatest balance exists in the Detroit market for oranges (0.486) and the St. Louis market for grapes (0.429), yet each of these has few supply sources (two and three, respectively). For both consumption regions, markets for grapes show the greatest balance, averaging 0.296 in the Atlantic Seaboard and 0.321 in the Midwest. The least balance is in the Philadelphia and Chicago apple markets (0.033 and 0.036, respectively), with the apple market displaying the least balance over both regions, with averages of 0.069 in the Atlantic Seaboard and 0.098 in the Midwest.

Among individual vegetable markets, the greatest balance exists in the New York-Newark and Cincinnati markets for cucumbers (0.360 and 0.370, respectively). The cucumber markets average the greatest balance, with averages of 0.293 in the Atlantic Seaboard and 0.307 in the Midwest. For the five vegetable commodities, the Atlantic Seaboard region overall tends to experience less

Table 1. Equal-shares Approximation and Number of Sources for Five Fruit Commodities and Eight U.S. Wholesale Terminals in 1990[a]

		Apples	Grapes	Strawberries	Oranges	Cantaloups	Average λ(2)
ATLANTIC SEABOARD							
Baltimore-Washington	λ(2)	0.070	0.364	0.339	0.276	0.204	0.251
	n	12	3	2	3	15	
Boston	λ(2)	0.105	0.225	0.077	0.073	0.170	0.130
	n	14	5	3	4	10	
New York-Newark	λ(2)	0.068	0.304	0.056	0.228	0.129	0.157
	n	14	2	3	3	8	
Philadelphia	λ(2)	0.033	0.292	0.217	0.140	0.121	0.159
	n	15	4	2	4	13	
Average λ(2)		0.069	0.296	0.172	0.179	0.156	
MIDWEST							
Chicago	λ(2)	0.036	0.197	0.124	0.086	0.084	0.105
	n	14	4	3	4	14	
Cincinnati	λ(2)	0.084	0.328	0.168	0.250	0.192	0.204
	n	11	4	3	2	9	
Detroit	λ(2)	0.186	0.330	0.143	0.486	0.177	0.264
	n	10	4	3	2	7	
St. Louis	λ(2)	0.087	0.429	0.058	0.163	0.178	0.182
	n	6	3	2	2	11	
Average λ(2)		0.098	0.321	0.123	0.246	0.158	

[a] Equal-shares approximation is λ(2). Number of sources is n.

Table 2. Equal-shares Approximation and Number of Sources for Five Vegetable Commodities and Eight U.S. Wholesale Terminals in 1990[a]

		Lettuce	Carrots	Tomatoes	Celery	Cucumbers	Average λ(2)
ATLANTIC SEABOARD							
Baltimore-Washington	λ(2)	0.038	0.230	0.200	0.139	0.292	0.180
	n	11	9	14	7	14	
Boston	λ(2)	0.068	0.062	0.075	0.157	0.234	0.119
	n	8	10	25	6	19	
New York-Newark	λ(2)	0.209	0.023	0.166	0.097	0.360	0.171
	n	5	6	15	4	13	
Philadelphia	λ(2)	0.073	0.077	0.153	0.176	0.287	0.153
	n	9	7	16	5	14	
Average λ(2)		0.097	0.098	0.148	0.142	0.293	
MIDWEST							
Chicago	λ(2)	0.061	0.051	0.167	0.030	0.229	0.108
	n	5	6	15	6	16	
Cincinnati	λ(2)	0.212	0.161	0.213	0.105	0.370	0.212
	n	3	4	14	4	9	
Detroit	λ(2)	0.130	0.316	0.227	0.115	0.336	0.225
	n	3	3	12	5	10	
St. Louis	λ(2)	0.252	0.100	0.234	0.153	0.292	0.206
	n	3	3	13	3	11	
Average λ(2)		0.164	0.157	0.210	0.101	0.307	

[a] Equal-shares approximation is λ(2). Number of sources is n.

Table 3. Percentage of Arrivals from In-state and Foreign Sources for Five Fruit Commodities and Eight U.S. Wholesale Terminals in 1990

		Apples	Grapes	Strawberries	Oranges	Cantaloups
ATLANTIC SEABOARD						
Baltimore-Washington	In-state	0.6	0.0	0.0	0.0	4.6
	Foreign	0.9	29.3	0.0	0.0	25.6
Boston	In-state	1.1	0.0	0.0	0.0	0.0
	Foreign	3.4	30.9	1.8	1.2	30.6
New York-Newark	In-state	19.0	0.0	0.0	0.0	0.0
	Foreign	1.1	13.5	1.2	0.0	26.4
Philadelphia	In-state	4.5	0.0	0.0	0.0	0.3
	Foreign	2.3	34.8	0.0	0.1	23.8
MIDWEST						
Chicago	In-state	1.3	0.0	0.0	0.0	0.4
	Foreign	0.9	22.9	1.0	0.0[a]	14.5
Cincinnati	In-state	2.5	0.0	0.0	0.0	0.5
	Foreign	1.2	38.9	3.7	0.0	28.8
Detroit	In-state	44.6	0.0	1.8	0.0	3.6
	Foreign	4.9	40.8	0.0	0.0	29.2
St. Louis	In-state	3.3	0.0	0.0	0.0	0.0
	Foreign	0.3	33.6	0.0	0.0	19.6

[a] This value is less than 0.1 but greater than 0.0.

Table 4. Percentage of Arrivals from In-state and Foreign Sources for Five Vegetable Commodities and Eight U.S. Wholesale Terminals in 1990

		Lettuce	Carrots	Tomatoes	Celery	Cucumbers
ATLANTIC SEABOARD						
Baltimore-Washington	In-state	0.0	0.0	6.5	0.0	5.2
	Foreign	0.4	41.5	11.9	2.0	20.4
Boston	In-state	0.0	3.0	0.6	0.0	1.9
	Foreign	0.9	11.3	8.4	0.0	20.1
New York-Newark	In-state	0.2	0.0	0.0	0.0	11.2
	Foreign	0.0	2.9	13.8	0.0	24.0
Philadelphia	In-state	0.0	0.0	4.2	0.0	3.2
	Foreign	0.9	5.8	11.3	0.6	17.2
MIDWEST						
Chicago	In-state	0.0	0.0	1.6	0.0	7.6
	Foreign	0.0	2.2	14.2	0.8	28.3
Cincinnati	In-state	0.0	0.0	3.5	2.8	1.4
	Foreign	0.0	0.6	11.8	0.0	20.0
Detroit	In-state	7.3	24.9	4.2	6.1	10.6
	Foreign	0.0	0.9	24.3	0.0	39.4
St. Louis	In-state	0.0	0.0	1.3	0.0	0.6
	Foreign	0.0	0.0	13.5	0.0	19.6

balance in market share except for celery. Among individual markets, the carrot market in New York-Newark (0.023) and the celery market in Chicago (0.030) exhibit the least uniformity. The lowest average regional values are 0.097 for lettuce and 0.098 for carrots in the Atlantic Seaboard, and 0.101 for celery in the Midwest.

There is greater variability in the average values of $\lambda(2)$ for the commodity categories than for the terminal locations. Across the five fruit crops, Detroit shows the greatest balance (0.264), while Chicago exhibits the least (0.105). For the vegetable commodities, the outcome is the same, with the highest average for Detroit (0.225) and the lowest for Chicago (0.108). These results suggest that, at least among the top five fruits and vegetables, there is relative dominance by a single supply source. This is consistent with the regional production dominance described by Bacon and Gempesaw.

Specificity of growing conditions, perishability and transportation and distribution factors are reflected in the number of supply sources for fruit and vegetable crops. For fruits, markets for grapes, strawberries and oranges use from two to five supply sources, while markets for apples and cantaloupes receive from produce from six to 15 sources. For vegetables, there are greater numbers of suppliers overall. This may be due to greater demand for vegetable commodities. Litwak and Maline noted that vegetables outsell fruit by about 20 percent. Markets for lettuce, carrots, and celery have the fewest sources, from three to 11, while markets for cucumbers and tomatoes are supplied by 9 to 25 sources. For the vegetable crops, there is a positive relationship between number of sources and market balance, so that with more sources, there is greater balance. However, this result does not hold for fruits. The apple market has the most sources, but the least balance in supply sources.

For tomatoes and cucumbers, relatively large market share is attributable to in-state and foreign sources. Table 4 shows that from up to 11.2 percent of supply to cucumber markets is from in-state sources while up to 39.4 percent is imported. For tomatoes, from up to 6.5 percent of supply is produced in-state and up to 24.3 percent is imported. Table 3 shows that grapes and cantaloupes have significant shares from foreign sources, up to 30.6 percent for cantaloupes and up

to 40.8 percent for grapes. Among fruits, apples have the largest shares from in-state production, ranging from 0.6 to 44.6 percent.

The results on tables 1 through 4 support several hypotheses related to seasonality, perishability and transportation and distribution systems. Greater specificity of growing conditions (oranges, strawberries, grapes, celery, and lettuce) results in fewer sources of supply, with almost no in-state supply outside of the dominant production regions. Within this group, greater seasonality, low perishability, good transportability and well developed international transportation systems promote a large market share for foreign sources (grapes). Market share is most balanced for crops with lower perishability and greater transportability, regardless of share supplied by in-state and foreign sources (grapes and oranges).

For crops with relatively many supply sources, there is less specificity in growing conditions (apples, cantaloupes, carrots, tomatoes, and cucumbers). Large foreign market share is positively related to greater perishability but good transportability (cantaloupes, tomatoes, and cucumbers). Mexico is the primary foreign source for these three crops in all markets. Relatively lower share from imports is correlated with less perishability (apples and carrots). Market balance is greater for crops with high perishability and large foreign market share (cantaloupes, tomatoes, and cucumbers).

For the eight terminals, self-sufficiency is greatest for cucumbers, tomatoes, cantaloupes, and apples, based on market share for in-state sources. The Detroit market has the greatest in-state shares across all crop categories, ranging from 1.8 percent for strawberries to 44.6 percent for apples. Grapes and oranges were the only crops for which the Detroit market did not obtain in-state supplies. Detroit also exhibited the closest approximation of equal-shares across the fruit and vegetable categories. Tauer found that Michigan ranked fifth in the U.S. in 1988 in terms of production diversity, with 44 agricultural commodities of all types produced and a diversification index ($I(2)$ from equation 1) equal to 9.72. By contrast, the Chicago market had the lowest equal-shares indexes for fruits and vegetables, and ranked 34th in production diversity, with 22 commodities produced and a diversification index of 4.62. These correlations between equal-shares index values for the consuming regions and production diversification indexes tend to hold for other markets as well. This suggests that greater diversity in a state's crop mix supports greater diversity and balance in the associated market terminal, beyond the effects of a single additional supply source.

Certain countries dominate the import shares of domestic markets. Mexico is the primary supplier of cantaloupes, tomatoes, and cucumbers from outside the U.S. Canada is the main source for carrots. Chile supplies most of the imported grapes, which constitute mostly out-of-season supply. Increased imports are expected in the wake of the North American Free Trade Agreement (NAFTA) (Litwak and Maline). This might improve market balance as Mexico and Canada increase their share of the U.S. market, but will likely reduce market share for in-state producers.

Conclusions

Diversity of sources for fresh produce may be quantified by approximation of equal-shares condition, number of suppliers, and market share attributable to local (in-state) growers. The equal-shares index values for five fruits and five vegetables in eight market terminals suggest that regional dominance in production creates substantial imbalance in market shares. However, diversity across all commodity groups in a state's crop mix can increase market share for local producers and move markets toward the equal-shares condition.

Balance in market shares is primarily affected by specificity of growing conditions. Certain crops, such as citrus, cannot be grown in most areas of the U.S. Such specificity is associated with few supply sources, highly unequal market shares and almost no purchases from in-state suppliers outside of the dominant production region. For crops with few supply sources, lower perishability and greater transportability are correlated with greater balance in the market. For crops with relatively many supply sources, less specificity is evident in growing conditions. Greater perishability and greater transportability are consistent with large market share from imports.

Transportation and distribution systems for imported crops are critical in increasing foreign market share.

Self-sufficiency may be enhanced by exploiting consumer preferences for local produce, which is generally perceived as fresher. Source labelling requirements and advertising to encourage purchase of locally grown crops would encourage this preference. Use of technologies such as post-harvest cooling systems would reduce producer costs and improve local product quality. Gains from such policies would flow to both producers and consumers.

The relationship between vulnerability to stochastic supply disruption and the equal-shares index has not been determined. Data on transportation and distribution systems are lacking. Future research may determine to what degree less diversity implies greater susceptibility to temporary supply disruptions. While unlikely to threaten the total supply of fresh produce, localized consumer and retailer impacts are likely. Information on demand and supply characteristics is needed to predict the response of producers, consumers and retailers. Diversity studies of other commodity-terminal combinations are needed to assess the validity of these results.

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