Price Incentives for Commercial Fresh Tomatoes

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Abstract

Hedonic price models are estimated to determine if there are incentives to supply higher quality tomatoes. Price premiums are associated with extra-large tomatoes originating from shipping points located closer to consumption points. Price differences between mature-green and vine-ripe tomatoes are not significant. Vine-ripe tomatoes are favored by consumers in the summer while mature-green tomatoes are favored the rest of the year. The U.S. Department of Agriculture should consider changing the present tomato grading system, which is based on shape and smoothness, to include a flavor indicator based on harvest maturity.

Key Words: tomato quality, hedonic prices

The perception U.S. consumers have that commercial fresh tomatoes lack flavor and firmness is a major roadblock to increasing per capita consumption (How; Nevins). The perceived low quality of commercial fresh tomatoes stems largely from the unique problems associated with their production and marketing. First, tomatoes are very temperature sensitive. At temperatures lower than 50 degrees Fahrenheit, the fruit loses color and softens. At temperatures higher than 86 degrees, tomatoes turn orange or yellow rather than red (Ryall and Lipton). Second, tomatoes need to be well packaged and carefully handled because they are highly susceptible to physical damage that leads to spoilage. Third, when tomatoes have fully ripened, they have a short shelf-life of only 2 to 4 days. Fourth, the long distance between warm temperature production points in Florida, California, and northwest Mexico and consumption points exacerbates the problem of fragility and short shelf-life.

To address these problems, breeders developed the mature-green tomato, which is physiologically mature but green in color when picked. The mature-green is cheaper to produce, is more durable, has an extended shelf-life, and can be exposed to ethylene to speed up the ripening process. However, mature-green tomatoes are less pleasing in taste and color, have thicker walls, and contain fewer vitamins than vine-ripened tomatoes. Most of the flavor problems are due to harvesting at an early stage of maturity (Ryall and Lipton). Nevertheless, the industry has moved toward marketing mature-green tomatoes and away from marketing vine-ripes (How).

Vine-ripened tomatoes, which show some pinkish or reddish color when picked, provide the best flavor, but consumers have not been willing to pay the higher retail price resulting from the increased costs of growing and marketing vine-ripes (How). Nevertheless, some industry observers believe that vine-ripes are still the industry's best hope. Stevens notes that "improved quality will probably result in increased consumption of fresh tomatoes in the future, even if the price is higher, because the perceived value will be greater" (pg.

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560). Brumfield, Adelaja, and Lininger found that New Jersey consumers exhibited brand loyalty to New Jersey grown vine-ripened tomatoes when they were identified by brand name. Broker et al. found that consumers were willing to pay a premium for locally grown tomatoes that were considered to be fresher than tomatoes from distant markets.

Relying heavily on work by Lancaster, Rosen, and Griliches, hedonic pricing models have been used to assign implicit prices to physical characteristics of heterogeneous agricultural commodities. Among these applications have been 31 retail food products (Ladd and Suvannunt), wheat (Espinosa and Goodwin), malting barley (Wilson), green peppers (Estes), rough rice (Brorsen, Grant, and Rister), cotton (Ethridge and Davis), and potatoes (Goodwin et al.). With an emphasis on post-harvest losses, Jordan et al. have estimated separate hedonic price functions for Florida (April), Georgia (August), and North Carolina (September) vine-ripened tomatoes. Quality characteristics included weight, percent with scorable defects, color, and firmness. The authors generally found discounts/premiums associated with the four quality characteristics as anticipated a priori; however, the importance of these results were unknown until studies could be conducted to estimate the marginal costs of improving these characteristics.

This paper estimates a hedonic pricing model for U.S. fresh tomatoes using seasonal dummy variables. Unlike Jordan et al., who emphasized post-harvest losses, we concentrate on quality issues from a consumer's perspective. Specifically, we want to determine if price premiums are given to vine-ripe over mature-green tomatoes. Furthermore, we do not assume homogeneity across shipment points, but rather theorize that since tomatoes grown closer to final consumption points can be harvested at later stages of maturity and have less physical damage, they should command a price premium because they are of higher quality. The inclusion of shipment point variables follows the Goodwin et al. terminal market hedonic pricing models for Texas potatoes, including 18 shipment point dummy variables.

Hedonic Pricing Model

Both utility and profit maximization will yield a hedonic price function that expresses the commodity's market price as a function of the quality and quantity of physical attributes associated with the commodity. In this paper, we use the profit maximization approach to develop the hedonic price model as described by Espinosa and Goodwin and by Ladd and Suvannunt. Assume that a firm buys and sells in perfectly competitive markets and maximizes a profit function subject to a well-behaved production function, $F(X_1,X_2,...,X_n)$, in which output is a function of input characteristics. First-order conditions of the profit function

$$\pi = PF(X_1,X_2,...,X_n) - R_1Q_1 - R_2Q_2 - ... - R_mQ_m, \quad (1)$$

yield hedonic price functions. The characteristic levels are in turn functions of the input levels, i.e.,

$$X_i = X_i(Q_{i1},Q_{i2},...,Q_{im}), \quad (2)$$

where X_i is the quantity of the ith characteristic and Q_{ij} is the quantity of the jth input in the ith characteristic. R_j is the unit value of the jth input. Taking the first-order condition of the profit function yields

$$\partial\pi/\partial Q_j = P(\partial F/\partial X_1)(\partial X_1/\partial Q_{1j}) + P(\partial F/\partial X_2)(\partial x_2/\partial Q_{2j}) + ... + P(\partial F/\partial X_n)(\partial X_n/\partial Q_{nj}) = R_j. \quad (3)$$

The first-order condition can be simplified by assuming that $P(\partial F/\partial X_i)$, the marginal implicit value of the ith characteristic, is equal to a constant A_i and $(\partial X_i/\partial Q_{ij})$ is equal to δ_{ij}, the quantity of characteristic i, so that the equation can be rewritten as

$$\Sigma A_i \delta_{ij} = R_j, \quad (4)$$

i.e., the value of the jth input is equal to the sum of the marginal products of its characteristics. This simplification means that each additional unit of input Q contributes the same amount of the kth characteristic to the production function F, and that the marginal implicit price for characteristic k is constant, which is consistent with the reality of marginal inputs (Ladd and Martin). Empirically, R_j and δ_{ij} are known, so that only A_i, the marginal implicit value of the characteristic, has to be calculated.

Data

The data, consisting of 823 observations, are taken from issues of the U.S. Department of Agriculture's *Fresh Fruit and Vegetable Prices: Wholesale Chicago and New York City, F.O.B. Leading Shipping Points* and Marketing News Services state office reports released between 1985 and 1991. The variables used in the hedonic pricing model are described in table 1. The dependent variable (price) is the monthly nominal shipment-point price divided by the monthly Consumer Price Index for tomatoes. The monthly shipment-point tomato price is the simple average of each Wednesday's prices. Because the consumer-level price index reflects shifting supply-demand factors, the resulting indexed price is free of supply-demand effects. Tomato quality is depicted by combining different sizes of tomatoes (medium, large, and extra-large) with the mature-green and vine-ripe designations. Smoothness and shape are used to grade fresh tomatoes; however, all tomatoes sold in the fresh tomato market receive the U.S. Department of Agriculture's top-quality grade. Consequently, tomato grades are not a factor in determining fresh tomato prices.

The model includes three seasonal dummy variables--spring (January through May), summer (June through September), and fall (October through December)--to capture the effects that different tomato marketing seasons have on tomato prices. Tomato shipments are included to adjust for the impact that available supplies have on tomato prices. Because there is no disaggregation available by type, trailers shipped includes both mature-green and vine-ripe tomatoes in some months. This only affects shipments from the San Joaquin Valley, North Carolina, and Mexico, however.

Production location is expected to impact tomato price because more distant producers, whose tomatoes have higher transportation costs, more physical damage, and decreased shelf-life, will have to lower their price to be competitive with producers closer to consumption points. Consequently, production points close to consumption points, such as East Shore, Michigan, New Jersey, North Carolina, and South Carolina, should carry premiums, while the more distant shipment points of Salinas, San Joaquin Valley, Southern California, Florida, and Mexico would be expected to be discounted. Table 2 illustrates monthly shipment-point activity for each location.

Empirical Analysis

The empirical work assumes that (1) each individual characteristic is an input in a production process, (2) buyers demand tomatoes because of the characteristics they possess, and (3) the relationship between tomatoes and their marginal implicit values is linear. Thus, the price for a carton of tomatoes is the linear sum of the marginal implicit values multiplied by the level of the characteristics. The coefficients on the characteristic variables can be interpreted as premiums and discounts over a base, in this case, a medium size, mature-green tomato produced in Florida. The basic model is

$$R_{ijt} = \beta_0 + \sum A_k \, \delta_{ikt} \, . \qquad (5)$$

In this model, R_{ijt} is the indexed 25-pound-carton price at the ith shipment point with the jth set of characteristics in month t, β_0 is the base price, A_k is the marginal implicit price for the kth characteristic, and δ_{ijk} is the quantity of the kth characteristic in the ith shipment point at time t.

Before estimating the model, multicollinearity among the independent variables was diagnosed using the Belsey, Kuh, and Welsch regression-coefficient variance-decomposition procedure. Multicollinearity was not judged a problem because no condition index was greater than 30. Heteroskedasticity was detected and corrected using a heteroskedasticity-consistent covariance estimation procedure (White). This procedure allows for the estimation of a covariance matrix that is consistent but does not rely on a specific model of the structure of heteroskedasticity.

Table 1. Definitions and Means of Hedonic Tomato Price Model

Variable	Description	Mean
Price	25# price indexed by monthly Consumer Price Index for tomatoes	5.87
Vine-Ripe Medium	1 = vine-ripened 2 8/32 - 2 16/32 inch diameter 0 = otherwise	0.10
Vine-Ripe Large	1 = vine-ripened 2 17/32 - 2 24/32 inch diameter 0 = otherwise	0.15
Vine-Ripe Extra Large	1 = vine-ripened 2 25/32 or greater diameter 0 = otherwise	0.14
Mature-Green Medium	1 = mature-green 2 8/32 - 2 16/32 inch diameter 0 = otherwise	0.17
Mature-Green Large	1 = mature-green 2 17/32 - 2 24/32 inch diameter 0 = otherwise	0.23
Mature-Green Extra Large	1 = mature-green 2 25/32 or greater 0 = otherwise	0.21
Spring	1 = January, February, March, April, or May 0 = otherwise	0.28
Summer	1 = June, July, August, or September 0 = otherwise	0.52
Fall	1 = October, November, or December 0 = otherwise	0.20
Spring Shipments	Monthly tomato shipments in thousands of hundredweight from each production point in the spring	1463
Summer Shipments	Monthly tomato shipments in thousands of hundredweight from each production point in the summer	649
Fall Shipments	Monthly tomatoes shipments in thousands of hundredweight from each production point in the fall	997
Salinas	1 = produced in Salinas District, California 0 = otherwise	0.10
San Joaquin Valley	1 = produced in Northern or Central San Joaquin Valley, California 0 = otherwise	0.15
Southern California	1 = produced in San Diego County, California or Baja California Norte, Mexico 0 = otherwise	0.15
North Carolina	1 = produced in Ashville, North Carolina 0 = otherwise	0.07
South Carolina	1 = produced in Charleston or Beaufort, South Carolina 0 = otherwise	0.04
East Shore	1 = produced in Eastern Shore of Virginia and Maryland 0 = otherwise	0.05
Florida	1 = produced in Central or Southern Florida 0 = otherwise	0.10
Mexico	1 = produced in Sinaloa, Mexico and shipped from Nogales, Arizona 0 = otherwise	0.17
Michigan	1 = produced in Benton Harbor, Michigan 0 = otherwise	0.03
New Jersey	1 = produced in Vineland or Swedesboro, New Jersey 0 = otherwise	0.04

Table 2. Average Shipment Point Activity by Season, 1985-1991

	Spring					Summer				Fall		
Shipment Point	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Salinas						G791*	G1260	G1171	G1418	G1573	G284	
San Joaquin Valley						GV501	GV1256	GV1144	G1387	G1556	G419	
Southern California						V457	V493	V516	V524	V699	V578	V403
East Shore							G735	G186				
North Carolina							GV16	GV66	GV47			
South Carolina						G709	G193					
Florida	G1463	G889	G1334	G2029	G2946	G1191				G366	G1413	G2004
Mexico	GV1216	GV1514	GV1526	GV1009	GV348							
Michigan							V18	V93	V52			
New Jersey						V87	V220	V220	V116			

* G indicates mature-green tomatoes, V indicates vine-ripe tomatoes, and the number indicates shipments that month for both mature-green and vine-ripe tomatoes in thousands of hundredweight

Table 3 contains the estimated coefficients for the hedonic tomato price model. The coefficients are presented by season to facilitate the discussion of the results. Positive signs represent premiums, and negative signs represent discounts over the base price. Coefficient values are the dollar premium or discount on a 25-pound carton of tomatoes. The price coefficients have the expected sign except for vine-ripe medium tomatoes, whose price coefficient is not significantly different from zero. The remaining price coefficients are significant, with the exception of vine-ripe large tomatoes in the spring and fall models.

Generally, price premiums increase with tomato size. In the spring and fall, larger premiums are given to mature-green than to vine-ripe tomatoes for both large and extra-large sizes. In the summer, vine-ripe tomatoes carry a price premium over mature-green tomatoes. However, a statistical comparison of the price premiums between each tomato size and type indicates that only 13 of 30 pair-wise combinations are significantly different at the 5 percent level (table 4). Notably, extra-large mature-green tomatoes are higher priced than large mature-green tomatoes in the summer and large vine-ripe tomatoes in the spring and fall. Both large and extra-large vine-ripe tomatoes are higher priced than large mature-green tomatoes in the summer.

One of the major reasons for the above results is that hotel and restaurant buyers prefer mature-green tomatoes because of their durability, consistent quality, and reliable supply (Giese). They value these characteristics more than taste. Hotel and restaurant buyers are more consistent purchasers of fresh tomatoes throughout the year than are household consumers, and, therefore, are more important consumers in the off-season. Hotel and restaurant purveyors, who dominate off-season trade, buy from shipping points, i.e. Florida, California, and Mexico, that offer these characteristics. These three large, warm-climate shipping points are also long distances from major consumption centers. Producers in these three areas produce large quantities of the durable, longer shelf-life mature-green tomatoes to reduce losses from handling and transportation.

In contrast, household consumers enjoy fresh tomatoes as a fruit as well as an ingredient in salads and other dishes, and they place more emphasis on taste than on durability and extended shelf-life. Therefore, the results in the relation between summer large and extra-large mature-green and vine-ripe tomatoes is expected because household consumers, who purchase tomatoes primarily in the summer, prefer the taste of vine-ripe to mature-green tomatoes. In fact, household consumer preference for vine-ripe tomatoes results in a larger coefficient for large vine-ripe tomatoes than for mature-green tomatoes in both the large and extra-large sizes. As shown in table 2, tomato quality is more important in the summer than in the other seasons because consumers can select from

Table 3. Parameter Estimates of Hedonic Tomato Price Model

Variable	Spring	Summer	Fall
Vine-Ripe Medium	-0.7265 (0.5954)[a]	-0.6482 (0.6135)	0.2925 (1.4478)
Vine-Ripe Large	0.0396 (0.5870)	2.1236* (0.5502)	0.5627 (0.9880)
Vine-Ripe Extra Large	1.8464*[b] (0.5870)	2.6233* (0.5093)	1.9412* (0.9900)
Mature-Green Large	1.4119* (0.4522)	0.6304* (0.3138)	1.8031* (0.4821)
Mature-Green Extra Large	2.5818* (0.4522)	1.5392* (0.3270)	3.0623* (0.5055)
Spring	7.4200* (0.5279)		
Summer		6.1965* (0.6660)	
Fall			6.0304* (0.6128)
Spring Shipments	-0.0010* (0.0002)		
Summer Shipments		-0.0008* (0.0004)	
Fall Shipments			-0.0008* (0.0003)
Salinas		-1.6769* (0.5316)	-1.1403* (0.5391)
San Joaquin Valley		-1.5579* (0.5160)	-1.4449* (0.4585)
Southern California		-2.7691* (0.7211)	-1.0077* (0.8103)
North Carolina		-0.9602 (0.7430)	
South Carolina		-0.1435 (0.6333)	
East Shore		-0.6243 (0.6220)	
Mexico	-1.4856* (0.3685)		
Michigan		-2.2245* (0.8368)	
New Jersey		3.6673* (0.8330)	

[a] Standard errors in parentheses.

[b] Asterisk (*) indicates significance at $\alpha = 0.05$ level.

Table 4. T-Values from Statistical Tests of Equal Price Premiums

		V-Large	V-XLarge	G-Large	G-XLarge
V-Medium	Spring	0.92	3.08*[a]	2.86*	4.42*
	Summer	3.36*	4.10*	1.86	3.15*
	Fall	0.18	1.09	1.22	2.21*
V-Large	Spring		2.18*	1.85	3.43*
	Summer		0.67	2.36*	0.84
	Fall		0.98	1.13	2.25*
V-XLarge	Spring			0.59	1.00
	Summer			3.33*	1.79
	Fall			0.13	1.01
G-Large	Spring				1.83
	Summer				2.01*
	Fall				1.80

[a] Asterisk (*) indicates significance at $\alpha = 0.05$ level.

the largest assortment of tomatoes from the largest number of shipping points.

The coefficients on the seasonal dummy variables are all significant at the 5 percent level (table 3). The shipment point coefficients for Salinas, San Joaquin Valley, Southern California, Mexico, and Michigan, have the expected negative signs, indicating that tomato price discounts exist from these shipment points because they are more distant from major East Coast consumption points than Florida. The East Shore and North and South Carolina shipment points have coefficients that are not significantly different from 0 (at the 5 percent level), while New Jersey tomatoes receive a price premium in comparison to Florida tomatoes. New Jersey's premium can be attributed to its close proximity to the large consumption areas of the Northeast. In general, the more distant shipment points have larger negative coefficients. For example, the three California shipment points and Mexico have larger price discounts than do the East Coast locations.

The ranked means from the table 3 equations are shown in table 5. The estimated mean is the average of the predicted prices for those tomatoes that carry that particular characteristic. With the exception of summer, the results indicate that wholesalers pay more for larger tomatoes and for mature-green tomatoes. In summer the coefficient on vine-ripe extra-large tomatoes is significantly larger than the coefficient on vine-ripe large tomatoes; however, for the ranked mean effects, this relation between the two is reversed. There is an explanation for this phenomenon. New Jersey ships large vine-ripe, but not extra-large vine-ripe, tomatoes. Because of the large premium given to New Jersey tomatoes, the ranked mean effect of vine-ripe large tomatoes is larger than that of vine-ripe extra-large tomatoes. This does not show up in the estimated coefficients in summer because of the presence of the New Jersey dummy shipment variable. When the ranked mean effects are estimated without New Jersey tomatoes, the ranked mean of vine-ripe large tomatoes decreases to 5.43, while that of vine-ripe extra-large tomatoes does not change; thus, the relation reverts to that anticipated a priori. The ranked mean effects of the seasonal dummy variables should be interpreted with caution because they represent the means of the sample and are not representative of actual average seasonal shipment-point prices.

Using the estimated means, we can determine that wholesalers pay on average \$1.18 more for extra-large mature-green tomatoes than for large mature-green tomatoes. They pay 8 cents

Table 5. Ranked Mean Effects of Hedonic Tomato Price Model

Variable	Spring	Summer	Fall
	Ranked by Tomato Quality		
Vine-Ripe Medium	3.94[1]	4.26[1]	4.84[1]
Vine-Ripe Large	4.70[2]	7.62[5]	5.38[2]
Vine-Ripe Extra Large	6.50[3]	6.59[4]	6.76[4]
Mature-Green Large	6.63[4]	5.07[2]	6.15[3]
Mature-Green Extra Large	7.80[5]	6.10[3]	7.51[5]
	Ranked by Season		
Spring	6.15		
Fall			5.93
Summer		5.71	
	Ranked by Shipment Point		
Salinas		4.19	5.05
San Joaquin Valley		4.72	5.29
Southern California		4.46	5.57
Mexico	5.49		
Michigan		5.76	
East Shore		5.92	
South Carolina		6.55	
North Carolina		7.26	
New Jersey		10.88	

more for the extra-large vine-ripe tomatoes than for the large vine-ripes. Wholesalers pay 76 cents more for large vine-ripe tomatoes than for large mature-green tomatoes, but the relationship is reversed for extra-large tomatoes, where mature-green tomatoes have a 34-cent premium over vine-ripes.

In summer, when the household consumer enters the market, the price relationship among different tomato qualities changes, with the vine-ripe tomatoes being preferred. For example, large vine-ripe tomatoes have a $2.55 premium over the large mature-green tomatoes, and the extra-large vine-ripe tomatoes have a 49-cent premium over the extra-large mature-green tomatoes. The ranked mean effects for shipment points give a further illustration of the premiums that wholesalers pay for tomatoes closer to the major consumer markets.

Conclusions

We have estimated hedonic price models to discern if there are incentives to supply higher quality, i.e., better tasting, tomatoes. Increasing price premiums are associated with extra-large tomatoes originating from shipping points located closer to consumption points. Tomato prices are higher for vine-ripe tomatoes in summer when household consumers dominate the market and tomato supplies are close to major East Coast markets.

Household consumers purchase tomatoes primarily during the summer growing season when high-quality, vine-ripe tomatoes are produced close to home. A reasonable marketing strategy could be to build upon consumers' attribute comparisons of local vine-ripe tomatoes versus mature-green tomatoes from distant sources. Emphasis would be given to the improved flavor, freshness, and nutrition of the local vine-ripe tomato. Previous research has indicated that consumers need this information and that branding and promoting local vine-ripe tomatoes could have positive results. The market niche for the mature-green tomato would be the hotel restaurant segment, where uniformity of size, color, better appearance, and lack of blemishes is important.

Tomato prices are higher for mature-green tomatoes in spring and fall as the household consumer drops out of the market and the hotel and restaurant buyers dominate. The hotel and restaurant buyers prefer the mature-green tomato because of its durability. Vine-ripe tomatoes are produced in the spring in Mexico and in the fall in Southern California, but they do command the price premium of the summer-produced vine-ripe tomato because they must be picked before maturity so that they can be shipped over greater distances.

The results indicate that there may be economic incentives to (a) develop cultivars that will mature off the vine with better taste, (b) develop improved packaging and handling so as to reduce physical damage to more mature harvested tomatoes, (c) develop a cultivar that is more resistant to physical damage so as to increase harvest maturity, and (d) develop cultivars that are more suitable to local climatic conditions in areas closer to the point of consumption. As the industry improves vine-ripe tomatoes along these lines we would expect that production areas, such as New Jersey, closer to consumption points would regain market share from the more distant mature-green tomato production areas. However, the development of an improved vine-ripe tomato would have to be linked with effective marketing campaigns aimed at appropriate target markets.

In the future, as hydroponics and other technologies improve, growers of high-quality tomatoes may be able to locate closer to consumption points to maximize quality potential. This would create a high-quality fresh tomato industry in which numerous dispersed growers would supply tomatoes throughout the late spring, summer, and early fall. This paper points out the deficiencies of the current grading system for tomatoes. The current system, based on shape and smoothness, gives no indication of flavor. This may be one reason why tomatoes, except in fruit and vegetable specialty shops, are sold generically. A flavor indicator based on harvest maturity, i.e., color when harvested, should be integrated into the present grading system or used in addition to the current system. Such an innovation, although likely to be resisted by the mature-green industry, would greatly enhance the ability of consumers to make better-informed tomato-purchasing decisions. Previous research has indicated that consumers respond to color in addition to shape and smoothness when purchasing fresh tomatoes. However, additional research would be required to determine whether consumers would be willing to pay the higher price required to grade and sort tomatoes by a color indicator.

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