Quality Changes and Limited Marketing Season Effects on the Demand for Fresh Blueberries

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This study examines the notion that fresh-fruit prices follow a time trend separate from the effect of seasonal supply changes over the marketing season. In particular, quality changes and a limited marketing season are hypothesized to contribute to the seasonal changes in demand. The empirical results support these hypotheses for the Boston fresh-blueberry market.

The notion that the characteristic components or attributes of a traded good can affect the price consumers are willing to pay for it was first investigated by Waugh in the 1920s. Since then, this line of research has been pursued both theoretically (Rosen; Lancaster; Ladd and Martin; Leffler) and empirically (Cropper, Deck, and McConnell; Palmquist; Jordan, Shewfelt, Prussia, and Hurst; Goodwin, Fuller, Capps, and Asgill; Parker and Zilberman). Most of the empirical work in hedonic pricing has focused on goods with measurable and known characteristics.

It is often difficult to obtain information on some characteristics of market-traded goods without significant research costs. However, there are a series of characteristics related to the "age" of a good that may affect its price in a significant way. Consider fresh fruit, as an example. The quality characteristics valued by the market (ripeness, color, firmness, etc.) change systematically from the beginning of ripening to the point of consumption. For fresh fruit that is not storable for long periods of time, changes in characteristics should be reflected in seasonal price trends.

The fresh-blueberry market is an excellent illustrative example. During the fresh-blueberry season, wholesale buyers routinely substitute purchases of blueberries from a region currently supplying the market to other regions with more recently ripened blueberries as they become available. The indication from buyers is that the quality available in any year from any particular region declines during the season (Woods, Marra, and Leiby). This is supported by evidence that blueberry decay begins just after ripening, whether harvested or not, and the rate of decay quickens after harvest in response to hormonal changes (Ismail and Kender). At the same time, the total seasonal supply of fresh blueberries is limited in a particular market, regardless of region of origin. This, too, may affect willingness of consumers to pay as the season progresses.

This study examines intraseasonal changes in the demand for fresh blueberries from the three largest growing regions marketing in Boston. Knowledge of these seasonal changes in demand is useful for the optimal timing and promotion of perishable products from various regions. Knowledge of how seasonal demand changes for current marketers also is important to potential new entrants into the market.

Quality Changes and Product Unavailability

Thurman provides one way to measure empirically the influence of changes in perceived quality embodied in each quantity unit (PERQS) on the price per quantity unit or on the quantity demanded if the changes are a monotonic function of time. The

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This research was funded by a cooperative agreement, no. 58-3J31-7-0047, between the U.S. Department of Agriculture/ Agricultural Cooperative Service and the University of Maine, and by the Maine Agricultural Experiment Station. The authors wish to thank Wally Thurman and Hartwig Schaefer for the original inspiration for the study; Greg Adams and Jim Leiby, respectively, for various other forms of inspiration; Jim Calnan and Donna Lupo from the Boston/USDA Market News Service for help with the data; two anonymous reviewers for very constructive suggestions; and Tim Woods and Florence Bubar for technical help. MAES Publication no. 1585.

assumption underlying Thurman's method is that consumers care about total consumption of quality units (PERQS) when purchasing these types of goods, making their demand function homogeneous of degree -1 in price per quantity unit and PERQS. Specifically, if PERQS decreases monotonically over time relative to PERQS in some earlier purchase, consumers will want more quantity units but will be willing to pay less for each, ceteris paribus, to equate expenditures on present PERQS with expenditures on PERQS available at earlier dates. As quality changes, this constant expenditure on PERQS results in a shift in the observed price-quantity demand relationship. If the change over time can be represented by a log-linear function, the quantity-unit conversion can be expressed as

$$(1) \qquad Q_1^D = t^{-\Theta} Q_t^D,$$

where Q_1^D is the quantity demanded in the first week of the marketing season, t is a week during the marketing season, Θ is the seasonal-demand parameter, and Q_t^D is the observed quantity demanded at time t. For example, the consumer would have to purchase one pound of the good in week t (> 1) to achieve the same total PERQS contained in t^Θ pounds of the good available in week 1.

Total real expenditures on the good in the reference week are $P_1^D Q_1^D$, where P_1^D is the real per unit price the consumer is willing to pay for the week 1 quality. If the price per unit quantity the consumer is willing to pay in week t is denoted by P_t^d, it follows from (1) that in the first week of availability ($t = 1$),

$$(2) \qquad P_1^D t^{-\Theta} Q_t^D = P_t^D Q_t^D.$$

This yields the relationship between the price the consumer is willing to pay in week t relative to week 1 (Thurman):

$$(3) \qquad P_1^D = t^\Theta P_t^D.$$

If $\Theta > 0$, the price per unit quantity in week t ($t > 1$) will be less than the price per unit quantity in the first week, ceteris paribus. If $\Theta < 0$, then consumers observe more PERQS per unit quantity and are, therefore, willing to pay more per unit quantity at time t relative to the reference week. This can result if there is an increase in quality over time or if demand increases as consumers are constrained by the length of time left in which they can make their purchases.

To illustrate the latter, consider the seasonal demand for fresh apples relative to fresh blueberries. Quality of either fresh product can be expected to decrease over time as the fruit ripens. Fresh apples are storable for long periods of time and are available at the retail level year-round. The effect of quality deterioration on the demand for apples should be unambiguous, and Θ should be greater than zero. Blueberry quality from a particular growing region also diminishes over the season, but the effect on price can be confounded by the short duration of market availability. Some consumers purchase fresh blueberries for immediate use, while others may purchase them to freeze for later use. Throughout the season, point-of-purchase materials and other forms of advertising promote demand for blueberries and encourage consumers to make their seasonal purchases of berries. Near the end of the season, consumers may perceive the imminent unavailability of fresh blueberries, and the demand for all consumption past the marketing season is brought to bear most heavily on the last marketed blueberries. This phenomenon was discussed by Jordan et al. in their study of the seasonal pricing of fresh tomatoes. They found the firmness characteristic to be higher-valued at the end of the marketing season. They argued that firmness is a proxy for shelf life, which is more valuable to consumers at the end of the season.

Changes in price due to these perceptions of unavailability are, of course, separate from the effect of changes in the quantity available in any time period. That is, the seasonal-demand parameter for blueberries may be reflecting both quality deterioration and the seasonal increase in demand from the imminent unavailability of the product. Therefore, Θ could be greater than, equal to, or less than zero depending on the relative magnitudes of the effects. One would expect the increase in demand due to imminent unavailability to affect a measure of Θ more in those regions marketing closer to the end of the fresh-blueberry marketing season.

Application to the Boston Blueberry Market

This study examines the demand for fresh blueberries at the wholesale level in Boston, Massachusetts over the 1979–88 period. Wholesale buyers are assumed to be a single consumer who represents the demands of many consumers. By making this assumption, it is implied that consumer preferences are reflected in the purchase decisions of wholesalers. The major producing regions supplying this market and their average market shares over the study period are New Jersey (64%), Michigan (13%), and Canada (5%). After surveying wholesale buyers in the Boston market, it was hypothesized that the demand relationships might differ across regions of origin as well as depend upon the timing during the season. Demand is, therefore, modeled separately for each region. The real price of fresh blueberries from a marketing region in week t during the season (P_t^B) is assumed to be a function of the quantity of fresh blueberries available from that region (Q_t^B), the week during the marketing season (t), the quantity of strawberries (a proxy for goods related in demand) in week t (Q_t^S), real disposable personal income (I_t), and the total quantity of blueberries available from all other regions (J) during week t (Q_t^J). Although the average quality of the composite of the berries from other regions probably changes over the season and affects demand, the change is not expected to be monotonic, as is the case of the berries from the region in question. Therefore, a quality adjustment for this variable was not included in the estimating equation presented below.

Using the relationships in equations (1) and (3), we derive the following homogeneous demand function for each region, beginning with the demand relationship in week 1 and moving to the demand relationship in the tth period:

$$(4) \quad P_1^B = \alpha_0 (Q_1^B)^{\alpha 1} (Q_1^S)^{\alpha 3} (I_1)^{\alpha 4} (Q_1^J)^{\alpha 5}$$

$$(5) \quad P_t^B t^{\Theta} = \alpha_0 [(Q_t^B)^{\alpha 1} t^{-\Theta \alpha 1}] (Q_t^S)^{\alpha 3} (I_t)^{\alpha 4} (Q_t^J)^{\alpha 5}$$

$$(6) \quad P_t^B = \alpha_0 (Q_t^B)^{\alpha 1} t^{-\Theta(\alpha 1 + 1)} (Q_t^S)^{\alpha 3} (I_t)^{\alpha 4} (Q_t^J)^{\alpha 5}.$$

In log-linear form, the estimating equation becomes

$$(7) \quad \ln P_t^B = \alpha_0 + \alpha_1 \ln Q_t^B + \alpha_2 \ln t + \alpha_3 \ln Q_t^S + \alpha_4 \ln I_t + \alpha_5 \ln Q_t^J.$$

Since $\alpha_2 = -\Theta(\alpha_1 + 1)$, the empirical measure of $\Theta = -\alpha_2 / (\alpha_1 + 1)$.

Data on weekly blueberry unloads and prices over the study period at the Boston Terminal Market were obtained from the U.S. Department of Agriculture's Market News Service. Figure 1 depicts the average seasonal distribution of marketings by region over the study period. Table 1 contains the average real weekly wholesale prices by region over the study period. During weeks when a range of prices was recorded, the midpoint was used to represent the price in that week. Prices were deflated by the Producer Price Index for Fruits, Juices, and Ades (U.S. Dept. of Agriculture). Monthly personal income data for the six-state New England region were obtained from the Bureau of Economic Analysis (U.S. Dept. of Commerce) and changed into weekly observations by linear interpolation. The Consumer Price Index for all items purchased by urban consumers (CPI-W, 1982 = 100) (U.S. Dept. of Labor) was used as an income deflator.

Table 1. Average Weekly Fresh-Blueberry Prices at the Boston Terminal Market by Region of Origin in 1982 U.S. Dollars, 1979–88

Week	New Jersey	Michigan	Canada
	Dollars per Pint		
1			
2			
3			
4	1.27		
5	1.05		
6	0.99		
7	0.90		
8	0.87		
9	0.83	0.75	
10	0.80	0.93	
11	0.78	0.91	1.14
12	0.85	0.92	1.22
13	0.87	0.95	1.58
14	0.77	1.04	1.67
15	0.90	0.99	1.54
16		1.26	1.69
17		1.25	1.83
18		0.93	1.88
19		1.43	2.04
20			1.95
21			1.96
22			2.16

Source: U.S. Department of Agriculture, Agricultural Marketing Service, Market News Service, Boston, MA.
Note: Week 1 is the first week in each year for which marketings were recorded, generally the third week of May.

Results

Parameter estimates of the model are reported in Table 2. In the case of New Jersey, coefficients of own-quantity, time, and quantity of strawberries are all significant and are all of the expected signs except for quantity of strawberries. In this model, fresh strawberries are estimated to have a complementary relationship to fresh blueberries. This result is plausible if one thinks of the two fruits as inputs into fresh-fruit salads. The estimate of Θ (0.2648) vis-à-vis its standard error[1] (0.0124) indicates that New Jersey blueberries are subject to a structural decrease in demand over the season consistent with quality deterioration. It is not expected that New Jersey berries would be subject to the imminent-unavailability effect since they are marketed toward the beginning of the season, so

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[1] $$\mathrm{Var}(\Theta) = \frac{\alpha_2^2 \sigma_{11}}{(\alpha_1 + 1)^4} - \frac{2\alpha_2 \sigma_{12}}{(\alpha_1 + 1)^3} + \frac{\sigma_{22}}{(\alpha_1 + 1)^2},$$

where σ_{ii} is the appropriate element of the covariance matrix of the parameter estimates.

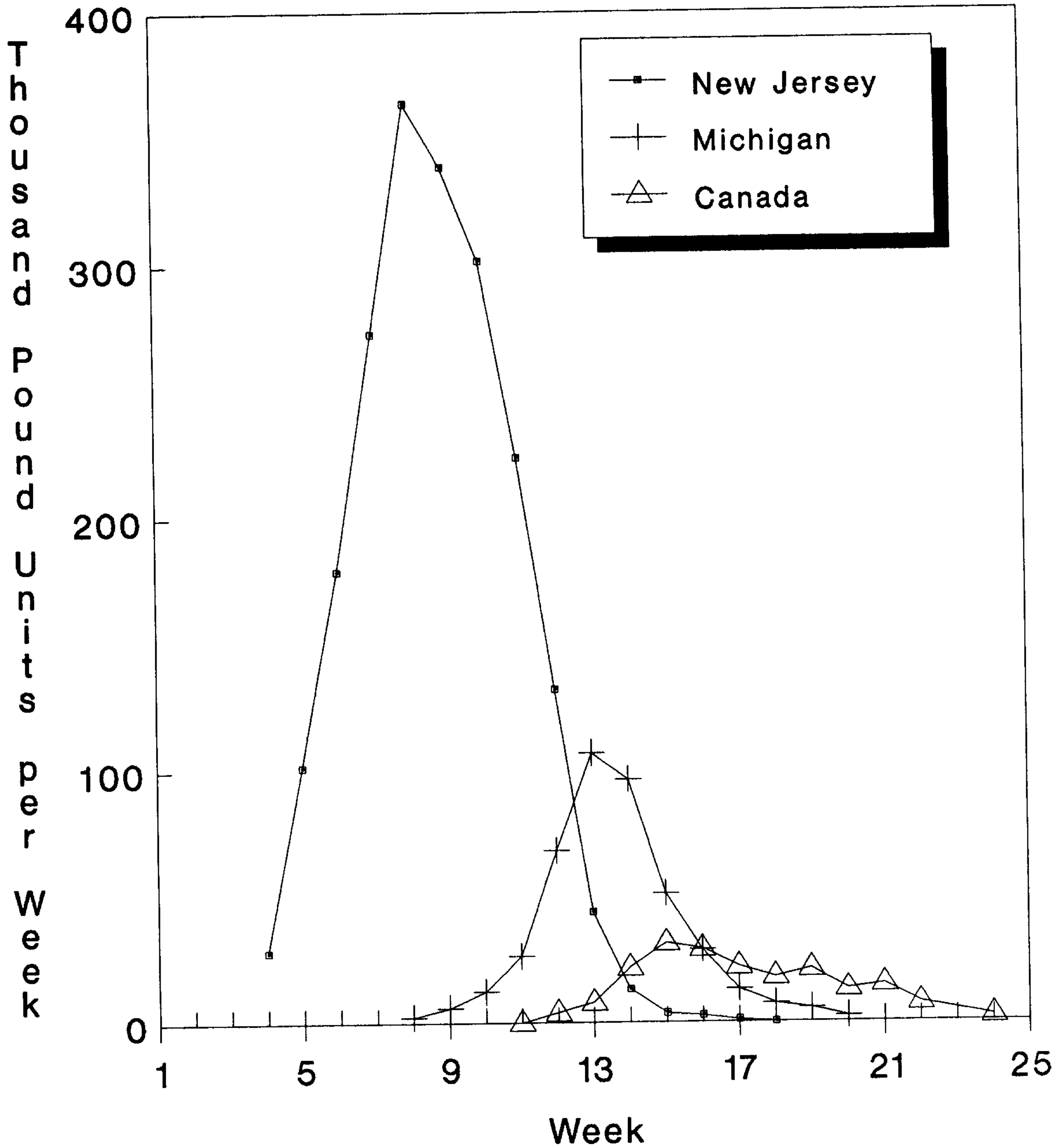

Figure 1. Average Seasonal Fresh-Blueberry Unloads by Region of Origin at the Boston Terminal Market, 1979–88

the quality-deterioration effect should be unambiguous.

In the case of Michigan, coefficients of own-quantity, time, and income also are significant and of the expected signs. The estimate of Θ (-0.7275) vis-à-vis its standard error (0.0269) indicates price appreciation separate from the own-quantity effect. This is consistent with the notion that as the fresh-blueberry season progresses, the imminent unavailability of fresh blueberries results in an increase in demand and that this effect is dominant.

In the case of Canada, the parameter estimates indicate statistically insignificant changes in demand over time, own-quantity, and cross-quantity effects, although these coefficients, as well as the estimate of Θ, have the expected signs. The quan-

Table 2. Estimated Logarithmic Decay Function Demand Models

Independent Variables	Dependent Variables $\ln p^{NJ}$	$\ln p^{MI}$	$\ln p^{CA}$
	Estimate (Standard Error)		
Intercept[a]	6.6101**	−11.2989**	−15.6614**
	(3.0609)	(2.8839)	(2.9161)
$\ln Q^B$	−0.0675**	−0.0536**	−0.0084
	(0.0188)	(0.0256)	(0.0380)
$\ln t$	−0.2469**	0.6886**	0.0904
	(0.0834)	(0.2061)	(0.3091)
$\ln Q^S$	0.1236*	0.0152	0.1311
	(0.0726)	(0.0871)	(0.0824)
$\ln I$	−0.1588	1.1780**	1.6632**
	(0.2838)	(0.2495)	(0.2593)
$\ln Q^J$	−0.0211	−0.0121	−0.0954**
	(0.0227)	(0.0295)	(0.0396)
R^2	0.4789	0.5982	0.6648
θ	0.2648**	−0.7275**	−0.0912
	(0.0124)	(0.0269)	(0.0472)
N	54	60	44

[a]Double and single asterisks indicate significance at the 95% and 90% levels, respectively. N is the number of observations.

Table 3. Estimated Exponential Decay Function Demand Models

Independent Variables	Dependent Variables $\ln p^{NJ}$	$\ln p^{MI}$	$\ln p^{CA}$
	Estimate (Standard Error)		
Intercept[a]	7.4003**	−9.8594**	−15.5258**
	(3.0511)	(2.8761)	(2.9481)
$\ln Q^B$	−0.0727**	−0.0498*	−0.0077
	(0.0201)	(0.0275)	(0.0373)
t	−0.0258**	0.0448**	0.0057
	(0.0099)	(0.0151)	(0.0202)
$\ln Q^S$	0.1486**	0.0097	0.1319
	(0.0713)	(0.0894)	(0.0837)
$\ln I$	−0.2590	1.1606**	1.6647**
	(0.2779)	(0.2548)	(0.2587)
$\ln Q^J$	−0.0197	−0.0210	−0.0956**
	(0.0230)	(0.0294)	(0.0400)
R^2	0.4608	0.5833	0.6647
θ	0.0278**	−0.0471**	−0.0057
	(0.0015)	(0.0020)	(0.0031)
N	54	60	44

[a]Double and single asterisks indicate significance at the 95% and 90% levels, respectively. N is the number of observations.

tity of blueberries from other regions has a relatively large effect on the price of Canadian blueberries. This may explain the lack of significance of the other variables. Canada is the smallest player in this market and, therefore, would be expected to be a price-taker and be relatively more subject to price changes in response to the availability of other blueberries.

As an alternative to the logarithmic decay function, an exponential time trend ($e^{\Theta t}$) can be assumed. In this case, the equation to be estimated becomes

$$(8) \qquad \ln P_t^B = \beta_0 + \beta_1 \ln Q_t^B + \beta_2 t + \beta_3 \ln Q_t^S + \beta_4 \ln I_t + \beta_5 \ln Q_t^J.$$

The empirical measure of Θ and its standard error are calculated using the same method as for the logarithmic decay function (equation 7).

The estimated coefficients of this model are presented in Table 3. Notice the similarity of these results to those in Table 2. The empirical measure of Θ is smaller in absolute value but is of the same sign and significance in each of the three regions, indicating price deterioration over the New Jersey season, price appreciation over the Michigan season, and a dominant effect of blueberries from other regions during the Canadian season. All other variables have the same qualitative results, as well.

A third way to model the time trend is a two-step process. In the first step, a series of dummy variables for each week is used in a regression including the own-quantity, substitute quantity, and income variables. In the second step, to establish the time trend, the predicted weekly natural logs of prices generated by the dummy-variable model are regressed on time (t) in a linear regression. The coefficient on t from this regression $(\partial \ln P)/\partial t$ is a summary measure of how price changes over the marketing season. This coefficient also is a component of Θ and determines its sign. That is, assuming the decay function of equation (8),

$$\Theta = \left(-\frac{\partial \ln P}{\partial t}\right) \Big/ \left(\frac{\partial \ln P}{\partial \ln Q} + 1\right).$$

Therefore, the coefficient on t and the comparable Θ should have opposite signs to show the same qualitative result. These results are reported in Tables 4 and 5.

Table 4 shows the initial regression results from the model containing the weekly dummy variables. Table 5 shows the regression results using the price changes over time implied by the dummy-variable coefficients as the dependent variables and time (t) as the regressor. Again, the qualitative results are similar to those from the first two approaches. The summary measure of price change over time in each region is equivalent in sign and significance and similar in magnitude to the measure of Θ derived

Table 4. Estimated Demand for Fresh Blueberries from Three Regions Using Linear Dummies for Weeks during the Season

Independent Variables	Dependent Variables		
	$\ln p^{NJ}$	$\ln p^{MI}$	$\ln p^{CA}$
	Estimate (Standard Error)		
Intercept[a]	4.7468 (3.5892)	−9.5614** (3.1285)	−14.8304** (3.2126)
$\ln Q^B$	−0.0632** (0.0235)	−0.0964** (0.0353)	−0.0013 (0.0400)
$\ln Q^S$	0.1105 (0.0806)	−0.0213 (0.1029)	0.1551 (0.1054)
$\ln I$	−0.0495 (0.3229)	1.2143** (0.2797)	1.6095** (0.2745)
$\ln Q^J$	−0.0421 (0.0276)	0.0009 (0.0329)	−0.1013** (0.0403)
D^1	0.3781** (0.1320)	−0.5505** (0.1994)	—[b]
D^2	0.2680** (0.1225)	−0.2421 (0.2145)	−0.0860 (0.1946)
D^3	0.3450** (0.1422)	−0.1853 (0.2655)	−0.1281 (0.1815)
D^4	0.2144 (0.1418)	−0.1384 (0.1389)	0.0169 (0.1956)
D^5	0.1292 (0.2099)	−0.0492 (0.1436)	−0.1205 (0.1601)
D^6	0.0085 (0.1674)	0.0000 (0.1441)	−0.0691 (0.1535)
D^7	−0.0150 (0.1481)	−0.0250 (0.1354)	0.0005 (0.1382)
D^8	0.0370 (0.1241)	0.0860 (0.1244)	−0.0562 (0.1380)
D^9	0.1107 (0.0995)	0.1554 (0.1321)	−0.1001 (0.1463)
D^{10}	0.0871 (0.0924)	0.0348 (0.1655)	—[b]
R^2	0.5494	0.6478	0.6893
N	54	60	44

[a]A double asterisk indicates significance at the 95% level. N is the number of observations.
[b]Beginning and ending weeks had only one observation each during the time series considered.

from the exponential decay function model reported in Table 3.

Theoretically, a model that combines these two steps would allow separation of the quality and limited marketing season effects in the following manner.[2] Define

$$P_t = P_t^* I_t, \tag{9}$$

where P_t is the observed price at time t, P_t^* is the quality-adjusted price at time t that influences the demand for berries, and I_t is a quality index that adjusts P_t. Then the inverse demand for berries will be given by

$$\ln P_t^* = \gamma_0 + \gamma_1 \ln Q_t + \sum_i \gamma_i \ln S_{it} + \gamma_j D_t, \tag{10}$$

where S_{it} represents the effects of demand-shifters, such as prices of related goods and income, and D_t represents the weekly dummy variable used in the model in Table 4. If the quality index is represented as

$$I_t = e^{\Theta t} \tag{11}$$

so that when $t = \Theta$, $I = 1.0$, equations (10) and (11) can be substituted into (9) to give

$$\ln P_t = \gamma_0 + \gamma_1 \ln Q_t + \sum_i \gamma_i \ln S_{it} + \gamma_j D_t + \gamma_k t. \tag{12}$$

This yields a direct measure of the quality effect, $\Theta = \gamma_k$, separate from the effect of relative time during the season, γ_j. When this specification is estimated empirically, however, collinearity between the two measures of time results in inefficient estimates of both parameters of interest.

[2] We thank an anonymous reviewer for this suggestion.

Table 5. Regressions of Price on Time during the Season Using the Results Reported in Table 4

Independent Variables	Dependent Variables		
	$\ln P^{NJ}$	$\ln P^{MI}$	$\ln P^{CA}$
	Estimate (Standard Error)		
Intercept[a]	0.3500*** (0.0544)	−0.3769*** (0.0863)	−0.0937** (0.0399)
t	−0.0347*** (0.0080)	0.0544*** (0.0139)	0.0067 (0.0070)
R^2	0.6750	0.6569	0.1135
N	11	10	9

[a]Triple and double asterisks indicate significance at the 99% and 95% levels, respectively. N is the number of observations.

Conclusions and Further Work

Results of this research provide some evidence of a shift in intraseasonal demand for a fresh, perishable product. One obvious avenue for future work is to see if there is evidence of these changes in demand in other markets and for other fresh crops. In the case of blueberries in the Boston market, the implied changes in seasonal price seem to be invariant to the functional form or method used to derive them. The results for New Jersey indicate a systematic, unambiguous seasonal price deterioration consistent with a decrease in quality per unit. The evidence suggests also that seasonal increases in demand, possibly as a result of the hypothesized effect of a limited marketing season proposed in this paper, outweigh quality-deterioration effects for Michigan blueberries in Boston. For Canadian berries, where no seasonal-demand shift occurs, it could be that these two effects are offsetting, that neither is present, or that the effects are small relative to other more dominant market forces.

These results imply some changes in optimal marketing behavior for producers of fresh crops where quality is important and the marketing season is limited. For early marketers, improved storage technology and/or some restrictions on marketed quality may be profitable. If the timing of marketings can be controlled, there may be some gains from marketing later. This is particularly important for new entrants assessing potential profitability of a market. If a region's harvest season occurs relatively later, then the gains from entering the market may be greater than for a new entrant that must enter the market early in the season.

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