Estimation of Implicit Prices For Green Pepper Quality Attributes Using an Hedonic Framework*

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Abstract

Marginal implicit prices for selected green pepper quality attributes were estimated using conventional linear regression techniques within an hedonic framework. Results indicated that cooler product temperatures and larger sized fruit were important physical attributes valued by wholesale buyers operating on Atlanta Farmers' Market during the 1985 summer period. In general, marginal implicit valuations for temperature and fruit size did not change appreciably over the marketing season.

Introduction

A major concern among producers and intermediate handlers of perishable crops is the role that quality plays in the determination of selling and receiving prices. Vegetable quality can be described as a combination of attributes or properties which are embodied in a commodity and can provide one basis for differentiating otherwise homogeneous products. Linkages between quality and price are often obfuscated by shifts in daily, weekly, and seasonal supply levels, by changing demand influences, and by the somewhat subjective nature of quality determination. In circumstances where produce characteristics are evident and measurable but their impacts on price are not obvious, price and quality relationships can be examined through a conventional regression technique using an hedonic modeling approach.

It is hypothesized that quality characteristics are important determinants of an overall price received by a seller for a perishable vegetable commodity. The specific contribution or value of each characteristic toward the overall value of a product is not directly observable since most attributes are not usually traded in the marketplace independent from the product. Therefore, particular study objectives of this project were: (1) to identify important physical quality characteristics considered in the intermediate sale of a high value, perishable product; and (2) estimation of a set of marginal implicit prices for attri-

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value, perishable product; and (2) estimation of a set of marginal implicit prices for attributes embodied in a product bundle. Estimation of hedonic prices for a set of quality attributes can provide information concerning the relative contribution of each characteristic toward the overall market price for a product and can provide some guidance in the determination of an upper cost bound associated with providing a particular attribute or feature. Bell peppers were identified as a major consumption vegetable crop where buyers and sellers were likely to be concerned with variable product quality.

Theoretical Model

The effect of quality variability on prices has been examined in theoretical models by Griliches (1971), Lancaster (1971), Rosen (1974), Palmquist (1984), Hager (1983), and McConnell and Phipps (1984). Agricultural applications of hedonic modeling techniques include Waugh (1929), Ladd and Martin (1976), Perrin (1980), Ethridge and Davis (1982), Carl, Kilmer, and Kenny (1983), Wilson (1984), and Jordan, Shewfelt, Prussia, and Hurst (1985).

Recent investigators of hedonic price estimation procedures (Rosen, Palmquist, Danielson) have noted that earlier hedonic studies typically identified neither demand nor supply schedules and thus information obtained via this technique must be interpreted carefully. In particular, hedonic estimation procedures provided simply a common schedule of observable short-run equilibrium points where buyers and sellers were mutually satisfied with the exchange price and a set of characteristics or services embodied in the product.

Using Rosen's framework, a product can be depicted as a good possessing both various amounts and types of attributes. For a particular good, Q, possessing m different characteristics, the price at which the product sells depends on the amount of each characteristic embodied in the product, or equivalently expressed as:

$$P(Q) = P(q_1, \ldots, q_i, \ldots, q_m) \qquad (1)$$

where:

P(Q) = observed market price of product
Q = a particular good
q_i = amount of characteristic i contained in Q

Equation (1) is often termed an hedonic price schedule in the literature and can be estimated using standard econometric methods. As noted earlier, however, the identification of a series of equilibrium points as recorded by transactions in the market (i.e., price associated with a particular set of attributes) does not necessarily result in the identification of a demand or supply schedule for quality characteristics. If a general demand function for a characteristic is desired, however, Rosen showed that a two-step estimation procedure could achieve this result. In general, estimation of a demand function is preferred to observations of market equilibrium points since these relationships are less dependent on spatial or temporal considerations. The difficulty in coordinating data collection over several time periods and at several market locations, however, precluded the development of a more general characteristic demand function in this study.

A priori economic reasoning does not provide much guidance concerning specification of a functional form relationship among observed market prices and amounts of characteristics provided in a good (Halvorsen and Pollakowski; Jordan, Shewfelt, Prussia, and Hurst). Jordan et al., suggest utilization of Box-Cox power transformation parameters in order to allow the data to select the appropriate functional relationship. A general hedonic model utilizing Box-Cox transformations can be written as:

$$\frac{Y^{\lambda_o} - 1}{\lambda_o} = \beta_o + \sum_{i=1}^{k} \beta_i \left(\frac{X_i^{\lambda_i} - 1}{\lambda_i} \right) + e_i \qquad (2)$$

$$Y = \left(\lambda_o \left(\beta_o + \sum_{i=1}^{k} \beta_i \left(\frac{X_i^{\lambda_i} - 1}{\lambda_i} \right) \right) + 1 \right)^{1/\lambda_o} + e_i \qquad (3)$$

where:

Y = dependent variable

X_i = i^{th} independent variable

$\lambda_o, \lambda_1, \ldots, \lambda_k$ are transformation parameters

β_o = intercept term

β_i = i^{th} coefficient term associated with the ith independent variable

e_i = random error term

Results from Jordan, et al., and convenience considerations suggest that evaluation of equations of the general form of (3) can be simplified by assuming equal λ values for all independent variables. Thus, estimation of $\lambda_o, \ldots, \lambda_k$ parameters is reduced to estimation of only two λ values; one associated with the dependent variable (λ_o) and the other associated with all independent variables (λ_1). A nonlinear grid search algorithm (PROCNLIN) can be utilized to evaluate alternative sets of parameter estimates ($\lambda_o, \lambda_1, \beta_i$) which result in the smallest mean square error for the model. This procedure indicated that a nonlinear functional form for the hedonic model was appropriate.

Pepper Characteristics and Empirical Model

At the wholesale market level, intermediate buyers often purchase loads of peppers based on physical and condition quality factors. Physical factors can be described as features which usually do not change over time such as size, fruit shape, mechanical injuries, and selected physiological disorders. Condition components of quality involve factors which can change over time and include color, ripeness, texture (firmness), environmental factors, and pathological breakdowns. For suppliers, the management and control of physical and condition factors often increase total and per unit costs since additional specialized equipment and labor is often necessary to ensure proper post harvest techniques are employed. Suppliers must consider and compare positive marginal costs for quality control with possible added benefits such as receiving price premiums or improved marketability of their peppers. From an economic perspective, supplier decisions to include or exclude selected quality characteristics should be evaluated on the basis of comparing positive marginal costs with marginal implicit prices for each physical and/or condition feature demanded by buyers. Thus, for characteristics to have a positive implicit value in an hedonic formulation, it is necessary that buyers are willing to bid slightly higher prices for products which include desired features *and* the characteristic is also more costly for sellers to produce; that is, the marginal cost function is not perfectly elastic.

Desirable consumer attributes for green peppers include large fruit size with dark green color, extreme firmness, and a skin surface that is free from disease, insect damage and scars. An evaluation of physical and condition factors results in an overall grade designation which reflects the proportion of fruit scoring satisfactorily on this criteria. Four U.S. grade designations are recognized in pepper markets ranging from the top classification of U.S. Fancy to the lowest grade designation of U.S. No. 3 quality.

A cursory examination of federal grade standards for peppers suggests that size, color, firmness, and external defects are major elements in quality determination and should be included as explanatory factors in a preliminary specification of an hedonic model. Size can be measured most directly by counting the number of peppers in a container. For

can be measured most directly by counting the number of peppers in a container. For convenience, count per bushel was utilized as the size proxy variable. Therefore, price and count would be expected to be related inversely. Bell peppers can be harvested at three different stages of ripeness or maturity: (1) dark green; (2) partly green and partly red, which is identified as a mixed color; and (3) fully red. In general, buyers prefer a general color uniformity within a single container. Since this investigation targeted green peppers for study, the proportion of dark green peppers in a particular container was used to construct a color measurement index. Using this measurement scheme, color and price are positively related. Another important quality feature is the incidence of physiological and pathological breakdowns on pepper fruit surfaces. The combined effect of these disorders can be identified as scorable defects. As the proportion of defects increased in a load, the price offered will likely decline. Therefore, price and defects are expected to be inversely related.

All vegetables begin to deteriorate after they are harvested, but the rate of deterioration is most directly a function of temperature. The notion that high product temperatures over extended periods of time reduce shelf life and induce rapid senescence is well established in economic literature (Pierson, Allen and McLaughlin, 1982). However, peppers are sensitive also to chilling injury if they are stored at temperatures below 40°F. Therefore, as long as the peppers are stored above the minimum chill injury temperature, price and temperature are expected to be inversely related with higher prices associated with lower temperatures. The final attribute of importance to intermediate handlers is the textural property of the fruit. Firm fruit has a higher tolerance for rough handling than does soft fruit and therefore firmness is an attractive attribute for intermediate handlers. Price and firmness would be directly related with firm fruit commanding higher prices than soft fruit.

From the above discussion and excluding the influence of market forces which can affect general price levels, a general empirical model for peppers can be specified as:

$$\text{Price}_i = \beta_o + \beta_1 CT_i + \beta_2 CL_i + \beta_3 F_i + \beta_4 D_i + \beta_5 T_i + e_i \quad (4)$$

where:

Price_i = observable market price per bushel of peppers for sample i

CT_i = number of peppers counted in sample bushel i

CL_i = decimal proportion of dark green pepper contained in sample bushel i

F_i = decimal proportion of firm peppers contained in sample bushel i

D_i = decimal proportion of scorable defects for peppers in sample bushel i

T_i = average temperature of peppers in degrees Fahrenheit of sample bushel i

e_i = random disturbance term

For estimation purposes, equation (4) was transformed into a Box-Cox format equivalent to equation (3). Therefore, the estimated empirical model can be written as:

Price per bushel =

$$\left(\lambda_o\left[\beta_o + \beta_1\left(\frac{CT_i^{\lambda_1} - 1}{\lambda_1}\right) + \beta_2\left(\frac{CL_i^{\lambda_1} - 1}{\lambda_1}\right) + B_3\left(\frac{F_i^{\lambda_1} - 1}{\lambda_1}\right) + \beta_4\left(\frac{D_i^{\lambda_1} - 1}{\lambda_1}\right) + \beta_5\left(\frac{T_i^{\lambda_1} - 1}{\lambda_1}\right)\right] + 1\right)^{1/\lambda_o} \quad (5)$$

Data

As noted previously, hedonic price relationships reflect short run equilibrium observations and are necessarily time and location specific. The Atlanta Farmers' Market was chosen as a study location because of the willingness of wholesale operators to cooperate in this study and the Atlanta Market is one of the largest volume facilities in the Southeastern United States. Large amounts of peppers handled on a daily basis was a desirable feature because of the need to collect cross-sectional data during a short time period. Data collection was restricted to a single 8-hour shift in order to provide *reasonable* assurances that the market price and the implicit prices of embodied attributes did not change due to non-attribute related market factors. In post-data collection conversations with buyers operating on the market, there was no evidence to suggest that supply related factors contributed to possible price changes in peppers during periods when sample data were collected.

As arriving shipments of peppers were identified at wholesale dealer facilities, random samples per pallet were selected and inspected for quality attributes. Each sample container of peppers was visually evaluated for color and firmness by horticultural specialists with the total number of scorable defects noted. Arrival product temperatures were recorded using a Comark digital thermometer probe. The total number of peppers in each container was recorded along with the price paid by the receiver, the shipping point origin, the total number of containers in the load, and the type of shipping container used (fiber or wood). Dealers were recontacted one week later to ensure that any price adjustments agreed on by both the shipper and receiver for sampled loads were incorporated into the data.

Hedonic data were collected on three different occasions in mid-June and July, 1985. Each date represented a different set of market equilibrium conditions and, therefore would result in different implicit valuations for attributes. While aggregation of data is of little value, possible changes in attribute valuations over time may be of interest. The three dates were selected to correspond with early, middle, and late season harvested peppers. For each date, a total of 24,000 pounds of peppers (800 containers) was received by dealers on the market during the 8-hour observation period and an average of 600 pounds of peppers (20 containers) were inspected per visit.

In this study, the observation unit was specified to be "boxes of peppers" and the measurement unit for the dependent variable was price per bushel. For U.S. Fancy peppers, a single box contains approximately 70 to 80 peppers while U.S. No. 3 peppers would contain approximately 130 individual peppers per box. Thus, examination of 20 sample containers represented observations on 1400 to 1800 individual peppers.

Results

Preliminary testing of combinations of Box-Cox transformation values via nonlinear regression procedures revealed that model mean square errors (MSE) were lower as λ_o and λ_1 approached zero. An additional iterative grid search procedure employing the false position method (SAS algorithm DUD) around lower MSE estimates indicated that there was

no significant difference between the converged λ_0 and λ_1 values generated by DUD and a log-log functional form. Therefore, the empirical model estimated in this study specified a log-log functional form for equation (5).

Parameter estimates, appropriate equation statistics, and marginal implicit prices obtained via estimation of the log-log specifications are reported in Tables 1, 2, and 3. In general, parameter estimates were consistent with hypothesized signs. However, incorrect signs were obtained for the defect variable in both the early and mid-season pepper sales and the color variable for late season peppers. In addition, variables with incorrect signs were highly insignificant. Adjusted R^2 values and F statistic criteria for all three equations suggest that their overall explanatory powers were good.

A cursory examination of the equation set indicates that size (count) and temperature were important quality attributes considered by Atlanta Market buyers over the season. Indeed, firmness, color, defects were often insignificant factors during the marketing season. In preliminary estimates of the model, several other factors such as the proximity of the seller to the buyer and the number of units purchased per sales transaction from a seller were also tested for possible importance as indicators of quality. These factors were found to be relatively unimportant as measured by statistical significance criterion. For temperature, marginal implicit prices ranged from \$.06 per bushel in midseason ($\bar{P}$ = \$7.90 per bushel) to \$.11 per bushel for early and late season crops ($\bar{P}$ = \$8.70 per bushel). Similarly, marginal implicit prices for larger size peppers (smaller count) ranged between \$.07 per bushel late in the season to \$.16 per bushel in mid-season. Although marginal implicit valuations for size and temperature varied over the entire study period, collectively values seemed to be approximately 2.5 percent of mean price. These findings seem consistent with empirical results obtained by Jordan, et al., in their study of fresh market tomatoes where marginal implicit values ranged between \$.01 and \$.13 per box of tomatoes.

The general lack of significance among firmness, color, and defect influences may be attributable, in part, to the particular market level focus of the study. For example, effective elimination of defective fruit at a packing shed likely results in little variation among loads currently sold to Atlanta buyers and thus would be viewed as statistically unimportant. If this study's focus were redirected to the packing shed level where packers may purchase peppers from a wide group of growers, then the relationship between price offered and number of defects may be of greater importance. To a certain extent, similar arguments can be made concerning the impact of firmness (an indicator of shelf-life) and color (a maturity indicator) on prices at other points in the marketing system.

As a final consideration, it is useful to interpret possible relationships between price and quality attributes as suggested by these empirical findings. The utilization of a log-log estimation form permits direct interpretation of coefficient values. For example, the relationship between price and temperature for early season peppers was such that a 1 percent reduction in temperature would have resulted in a .7 percent increase in price. In terms of specific data, this suggests that a temperature reduction of slightly over 1°F would have increased price offerings by \$.12 per bushel under then existing conditions. If marginal costs of reducing pepper temperatures per box by 1°F were less than \$.12 per bushel, then it would have been beneficial for the supplier to do so. Among the quality attributes measured, however, the greatest marginal gain for pepper sellers (but not necessarily the greatest net gain) may be associated with improved management control of size mix when selling to Atlanta wholesalers. Individual growers must decide if additional losses and costs associated with improved pepper sizes are less than possible additional benefits.

Summary and Conclusions

Findings suggested that fruit size and temperature management were relatively important quality features in the sale of green peppers on the Atlanta market last year. In

Table 1

Hedonic Price Estimation Results for Early Season Green Peppers, Atlanta Market, June 1985

Variable	Estimated Coefficient (t-value)	Standard Error	Marginal Implicit Price ($/bushel)[a]	Mean Values
Temperature	-.6896*** 2.395)	.28	.11	55.23
Size (count)	1.1138*** (-5.479)	.20	.13	75.46
Firmness	.3046* (1.471)	.20	.03	.92
Color (consistency)	.6320** (1.790)	.35	.06	.95
Defects	.0116* (.4930)	.02	.01	.20

*** = Significant at 5% level

** = Significant at 10% level

* = Not significant

a = Marginal implicit prices are calculated as the product of the mean of the sample prices times the appropriate coefficient value divided by appropriate explanatory variable mean value.

R^2 = .85 $\bar{P}$ = $8.68

F ratio = 14.91 DW = 1.78

n = 15

Table 2

Hedonic Price Estimation Results for Mid-Season Green Peppers, Atlanta Market, July 1985

Variable	Estimated Coefficient (t-value)	Standard Error	Marginal Implicit Price ($/bushel)[a]	Mean Values
Temperature	-.4012** (-1.500)	.26	.06	49.95
Size (count)	-1.506*** (-9.110)	.16	.16	82.90
Firmness	.0351* (.202)	.17	.003	.92
Color (consistency)	.0155* (.239)	.06	.002	.64
Defects	.0079* (.122)	.06	.003	.24

*** = Significant at 5% level

** = Significant at 10% level

* = Not significant

a = Marginal implicit prices are calculated as the product of the mean of the sample prices times the appropriate coefficient value divided by appropriate explanatory variable mean value.

R^2 = .83

F ratio = 18.71 $\bar{P}$ = 7.90

n = 17 DW = 2.07

Table 3

Hedonic Price Estimation Results for Late Season Green Peppers, Atlanta Market, July 1985

Variable	Estimated Coefficient (t-value)	Standard Error	Marginal Implicit Price ($/bushel)[a]	Mean Values
Temperature	-.6949*** (-3.155)	.22	.10	61.23
Size (count)	-.6255*** (-3.223)	.19	.07	73.35
Firmness	.2955** (1.710)	.17	.03	.89
Color (consistency)	-.0242* (-.719)	.03	.003	.60
Defects	-.0468* (-.971)	.04	.03	.17

*** = Significant at 5% level

** = Significant at 10% level

* = Not significant

a = Marginal implicit prices are calculated as the product of the mean of the sample prices times the appropriate coefficient value divided by appropriate explanatory variable mean value.

R^2 = .85

F ratio = 17.71 $\bar{P}$ = 8.72

n = 17 DW = 1.98

general, the relative importance of these factors did not change appreciably over the pepper marketing season. A corollary of this finding is that other quality features were only irregularly important to wholesale buyers, but their relative contribution to the entire pepper marketing scheme remains unclear because of the focus of this study on wholesale markets only.

Grower-shippers who sell regularly to Atlanta market dealers, or to other terminal market wholesalers, should examine carefully the marginal costs associated with providing cooler green peppers and/or larger sized fruit. Approximate estimations of the direct marginal gains associated with slightly improved product quality are provided by marginal implicit price estimates. Other benefits which may not be captured through enhanced price prospects should also be identified and included in this decision-making process. These benefits may include increased likelihood of sales to dealers, extended time or geographic distribution boundaries because of lower product temperatures, and the development of buyer loyalty.

While these findings do suggest reasonable prospects for utilization of hedonic models to measure marginal implicit price valuations for selected quality attributes, it is important to recognize the limiting features of this approach. First, the relative lack of importance for other attributes such as defects, color, or firmness can be ascertained only through an hedonic investigation of all intermediate marketing points. Secondly, further research needs to be done in order to estimate general demand functions for selected attributes. Growers and intermediate handlers need information which is less dependent on temporal and spatial considerations. Additionally, it would be useful to compare the demand for various attributes among crops, by time of year, and across seasons.

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