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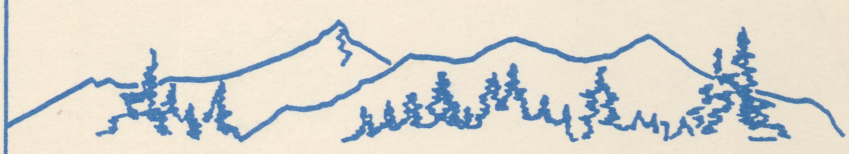

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Market Windows for Characteristics: A Hedonic Price Analysis of the Apple Industry

A hedonic price function that included crop year, seasonality, region, variety, size, grade, storage method, and a variable to measure the effect of the Alar scare was estimated. Results suggest that size, grade, seasonal, and storage factors are the most important elements for influencing the price of apples.

In a market economy, value is not only attributed to quality characteristics, but also to spatial factors, and timeliness of product sale. Many studies have utilized hedonic price analysis to determine the market value attributed to quality characteristics for agricultural goods (e.g., Ethridge and Neeper; Brorsen et al.; and Veeman). Also, timeliness of product sale in conjunction with quality characteristics was found by Jordan et al. and Wilson to be important for tomato, and malting barley prices, respectively. But, no studies known to exist have attempted to utilize hedonic price analysis to sort out the market value associated with spatial, seasonal, and quality factors.[1]

The purpose of this study was to utilize hedonic price analysis to sort out the implicit value of spatial, seasonal, and quality characteristics of the U.S. apple market. Because growers from almost every state are trying to distinguish their apples as superior to other states, spatial price information on apple origin is very important for the direction that cooperative advertising campaign efforts should take. Seasonal characteristics are very important for analyzing the returns to current and/or future storage facilities. Also, seasonal characteristics are important for determining the viability and/or potential of new producing regions by the premium or discount that their fresh pickings will obtain. Apples that are relatively large in size, low in defects, and possess good color are expected to receive a premium price.

Theoretical and empirical models are presented in the following section. Data sources and estimation procedures are outlined in the third section and followed by a section of empirical results. Then, the last section of concluding comments discusses implications for apple growers and future research efforts.

Theoretical and Empirical Considerations

Lancaster was one of the first to suggest that utility is derived from the characteristics or attributes of the good rather than the goods themselves. He states that, "Utility or preference orderings are assumed to rank collections of

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[1] In part, this is because most previous hedonic price analyses of agricultural products have considered goods that are transported with relative ease and their origin is not differentiated for consumers.

characteristics and only to rank collections of goods indirectly through the characteristics they possess." Hedonic price analysis assumes that buyers not only have a demand for just the good, but also for the bundle of quality characteristics each good possesses.

Ladd and Savannunt derive a hedonic price function where utility is a function of n products and m+i product characteristics. Each good possess m product characteristics that all other goods have in common and a unique product characteristic (i) provided by no other products. The hedonic price function they obtain is:

$$(1) \qquad P_i = \sum_J (\partial x_{oJ} / \partial q_i)(\partial E / \partial x_{oJ}) + \partial E / \partial x_{om+i}$$

where P_i is the price of the ith good, x_{oJ} is the total amount of the jth product characteristic provided by all products, $\partial x_{oJ} / \partial q_i$ is the marginal "yield" of the jth product characteristic by the ith good, E is total expenditure on all goods, and $\partial E / \partial x_{oJ}$ is the marginal rate of substitution between expenditure and the jth product characteristic. Equation (1) states that the price paid by the consumer for each good equals the sum of the quantity of characteristic obtained from each marginal unit of product ($\partial x_{om+i} / \partial q_i$) multiplied by the marginal implicit price of the characteristic ($\partial E / \partial x_{oJ}$). Note that $\partial x_{om+i} / \partial q_i$ equals 1 since each good is assumed to have one unique product characteristic.

For apples, explanatory price variables included in the model consist of seven "quality-related" characteristics. Crop year, region, variety, size, grade, seasonality, storage method, and a variable intended to measure the effect of the Alar scare on Red Delicious apple prices were included in the hedonic price function. Although all these are not "quality characteristics" in a purist hedonic sense, as O'Connell notes, "At a given point in time, it can identify not just what factors are important in determining the price of a commodity but also how important each factor is and the consistency of its relationship with price."

The hedonic price function used in this analysis of apples is expressed as follows:

$$(2)\ P_t = \alpha_o + \sum^{6} \beta_a \mathbf{Y}_{at} + \sum^{11} \Lambda_a \mathbf{M}_{at} + \sum^{3} \delta_a \mathbf{R}_{at} + \sum^{6} \phi_a \mathbf{V}_{at} + \sum^{3} \Gamma_a \mathbf{S}_{at} + \sum^{2} \vartheta_a \mathbf{G}_{at} + \Pi_a \mathbf{Z}_{at} + \sum^{3} \Theta_a \mathbf{A}_{at} + \varepsilon_t$$

where P_t is the real f.o.b. price of apples in period t ($/40 lb. box), α_o is a constant, all "$_a$" summations go from 1 to the number above Σ, **Y** equals crop year, **M** signifies month, region equals **R**, **V** is variety, **S** equals size, **G** stands for grade, **Z** denotes storage type, **A** (Alar) is a variable representing a 1988 Red Delicious price quote, and ε is the disturbance term. Equation (2) represents seven "quality characteristics" and a variable to measure the effects of the Alar scare on prices (i.e., **A**). All independent variables are expressed as dummy variables. Because most of the quality factors noted above are only quantifiable in discrete form, this approach was utilized. Also, Pretzel and Monke argue for the validity of dummy variables in their hedonic analysis of rice price differentials.

The model was estimated with seven years of crop prices, beginning in 1982

and ending in 1988. The 1986 crop year was selected as the base year for equation (2) so that all results for crop year are in reference to 1986 price levels. October was selected as the reference month in equation (2), since virtually all varieties are sold in some quantity during October. Hudson Valley, NY, Western/Central, NY, Washington State, and Michigan were the four regions of production selected for this analysis. These regions account for about two-thirds of the nation's total commercial apple production. Washington was selected as the base region since they are the largest producer.

Seven varieties were considered in this analysis. Red Delicious, Golden Delicious, McIntosh, IdaRed, Empire, Red Rome, and Granny Smith were investigated. These varieties account for over two-thirds of all the apples grown in the U.S. (Bultitude). Other varieties such as Winesap, Jonathan, and some of the newer varieties would have been interesting to consider but limited price quotes for these varieties from several regions posed some serious potential multicollinearity problems. Red Delicious was selected as the base since it is the most widely grown and commercially sold variety.

The fifth variable of size (S) represents the number of apples that will fit into one standard box which weighs between 40 and 42 pounds. Four group sizes were classified; 72 and below, large; sizes 72 to 120 as medium; 125 and above, small; and bag prices considered as extra small. The size of medium was chosen as the base size since this size is by far the most popular and widely sold. Grade is the next variable considered. Three grades considered were Extra Fancy, Fancy, and a combination grade consisting of Fancy and Extra Fancy. U.S. one was precluded since it was only reported in one region and this grade is considered to be slightly better than apples sold for processing. Extra Fancy was chosen as the standard grade since it is clearly the premium grade. Because the sale of cold storage often overlaps the period of apples sold from CA storage, a storage variable was constructed. Apples under cold storage were selected as the standard. Because CA stored apples endure better and keep into the spring and summer months when the demand for fruit tends to be stronger, CA stored apples were expected to receive a premium relative to cold storage apples.

The final variable was constructed to measure the impact of Alar on the apple industry. Since Red Delicious apples received all the media focus from the "Alar scare", only these apples were considered to be impacted by the scare, even though other varieties were treated with Alar too. Thus, the Alar variable represents Red Delicious apple sales between February, 1989 and July, 1989 for all regions. Western/Central, NY was selected as the base region. Because Washington is the region most well known for it's Red Delicious apple, it is expected to show the most significant price effect.

Data Sources and Estimation Procedures

Weekly price data was obtained from the Market News Branch of the Agricultural Marketing Service, U.S. Department of Agriculture. Prices reported represent f.o.b. quotes for 40 pound boxes. Weekly prices were averaged for each month to reduce the size of the model and avoid problems associated with sparse

data for some locations during off-season time periods. Prices were deflated by the Consumer Price Index for all goods. Because the crop year is different from the marketing year, price quotes begin in mid-1982 and progress through mid-1989. Also, the availability of price quotes in a season vary depending on the crop size. Furthermore, the length of the marketing season differs somewhat across variety since the Red Delicious are typically the first to be harvested and the Granny Smith are much later. In total, 1,771 observations were utilized in the analysis.

For time-series hedonic estimations of marginal implicit prices of quality characteristics, Rosen strongly suggests that supply response functions also be determined. However, the supply of each product characteristic is assumed to be perfectly inelastic in this study since none of the variables considered are quantitative inputs into the production process. This also eliminates the problem of identification posed by McConnell and Phipps.

An initial OLS regression of equation (2) revealed the presence of autocorrelation. To correct for this problem, the Cochrane-Orcutt procedure for autocorrelation was followed. First and second degree autocorrelation was considered, but only first degree autocorrelation correction was found to be present. Equation (2) was also estimated in log-linear form (i.e., natural log of price regressed on the independent variables). However, results from this regression were very similar to those presented. Thus, for ease of interpretation, the linear form of price was preferred.

Empirical Results

Estimated results of equation (2), using Cochrane-Orcutt's procedure for first order autocorrelation, are presented in Table 1. The constant term measures the bundle of characteristics associated with the base of all variables. That is, an Extra Fancy, Red Delicious, cold stored, medium-sized box of apples grown in Washington and appearing on the market in October of 1986. Coefficients associated with the crop year variable indicate that, as suspected, all years received a discounted price relative to the base year of 1986. Demand outpaced supply in 1986, causing prices to surge. In 1987, the U.S. apple crop was the largest on record, a 33 percent increase from 1986. Our results show that the 1987 crop year was discounted almost twice as much as the next most discounted year. Monthly dummy variables suggest some definite seasonal patterns, with the months of July through September offering the highest price premiums. September apples are over a dollar a box higher than in October when the new harvest starts coming online. Heavily discounted prices for the winter and early spring months are believed to reflect a weaker demand for fruit during these months than the summer and fall months.

Region results suggest that the leader in U.S. production, Washington, does not receive any price premium from marketing its apples as "Washington." It could be argued that Washington apples receive a discounted price compared to other regions since they are not as centrally located to the overall U.S. market. However, in 1988, the cities of Los Angeles and San Francisco received 87% of the total fresh apple shipments that the six cities of Baltimore, Boston, New York, Philadelphia, Atlanta, and Chicago received (Agricultural Statistics). This suggests that

Table 1. Estimated Results of Factors Affecting the Real Price of Apples.

Variable	Coefficient	T-Statistic	Significance Levels
Constant	11.866	37.606	.000
Year: (Base Year = 1986)			
1988	-1.362	-3.984	.000
1987	-2.628	-8.175	.000
1985	-0.539	-1.725	.085
1984	-0.502	-1.488	.137
1983	-0.600	-1.745	.081
1982	-1.525	-4.535	.000
Month: (Base Month = October)			
January	-0.983	-8.709	.000
February	-1.081	-8.455	.000
March	-1.082	-7.742	.000
April	-1.058	-7.546	.000
May	-0.701	-4.710	.000
June	-0.352	-1.760	.079
July	0.689	2.813	.005
August	0.656	2.558	.011
September	1.050	9.294	.000
November	-0.031	-3.401	.001
December	-0.451	-4.145	.000
Region: (Base Region = Washington State)			
Hudson Valley, NY	0.361	0.897	.370
Western/Central, NY	0.865	2.354	.019
Michigan	0.356	0.910	.363
Variety: (Base Variety = Red Delicious)			
Golden Delicious	-0.119	-0.638	.523
McIntosh	0.177	1.228	.219
Ida Red	0.098	0.411	.681
Granny Smith	4.512	14.471	.000
Empire	0.455	1.721	.085
Rome	-0.012	-0.053	.958
Size: (Base Size = Medium)			
Extra Small	-3.267	-8.093	.000
Small	-1.421	-10.065	.000
Large	1.661	10.055	.000
Grade: (Base Grade = Extra Fancy)			
Fancy	-1.129	-3.329	.001
Combo	-1.229	-4.325	.000
Storage Method: (Base Storage = Cold Storage)			
Controlled Atmosphere	1.140	11.107	.000
Alar Variable: (Base Alar = West/Central, NY, only Red Delicious Variety)			
Washington	-2.205	5.848	.000
Hudson Valley, NY	-0.921	-1.414	.158
Michigan	-0.560	-1.055	.292
Rho: (first order autocorrelation)	0.719	43.522	.000

Adjusted Coefficient of Determination:	.859
Durbin-Watson Statistic:	1.845

Washington may not have any or a small market location disadvantage. Western/Central, NY is the only region that seems to receive any premium for its location of origin. This region appears to be receiving at least a $.50/box premium above all other regions for its quality associated with region of origin.

The next variable of variety has some pronounced implications for growers. Although "early adopters" of new varieties obviously enjoy a substantial price premium, our results indicate that variety is not a big quality factor for the consumer. Granny Smith is the only variety that showed any substantial price premium, and it is quite large at $4.51/box compared to the base variety of Red Delicious. These results suggest that consumers prefer the tart-crisp taste of the Granny Smith that is usually grown in the Western states. However, growers should take caution in assuming that this high of a price premium will always exist for Granny Smith since the variety was relatively new for the period analyzed and a large increase in Granny Smith acreage is now ready to start full production.

Quality characteristics associated with size, grade, and storage method were all found to be highly significant in affecting apple prices. As expected, larger sizes are greatly preferred to smaller sizes. Similarly, an extra fancy grade is preferred to other grades. But, it is interesting to note that a combo grade (mix between extra fancy and fancy) was found to be discounted more than just a fancy grade. This result suggests that packinghouses should try to pack as homogeneous a product as possible, or pack a fancy and extra fancy grade instead of a combo grade whenever possible. Controlled atmosphere stored apples were also found to bring a significant and substantial premium to cold stored apples (i.e., $1.14/box). In part, this premium reflects a higher cost storage situation but it also implies a higher quality associated with controlled atmosphere stored apples.

Finally, as suspected, the Alar variable indicates that Washington was the region most impacted by the Alar scare. Other regions appear to have suffered much smaller discounts from the Alar scare than Washington, and the level of statistical significance for these regions suggest that they may have not been damaged at all by the Alar scare.

Concluding Comments

Utilizing a hedonic pricing model, this analysis explored the impact that crop year, month, region, variety, size, grade, storage method, and the Alar scare had on the U.S. apple market. Our results suggest that seasonal marketing considerations, apple size and grade, and storage method are the most influential factors for determining the price of apples. Returns for advertising that associate apple quality with place of origin appear to be quite small and limited. Also, variety does not appear to be a major factor for influencing consumers choice of the seven varieties considered, with the possible exception of Granny Smith.

Our results suggest that producers should be reluctant to jump from one variety to another unless they are confident that they can be one of the few that are the very first to enter the market for a new variety that is popular. Size, grade, and storage method linked with seasonal marketing considerations are the areas that our results suggest producers should concentrate most of their efforts. It is quite

possible that higher apple prices associated with late summer marketings could provide a good return to Controlled Atmosphere storage facilities. Because this storage technology is relatively new and most regions have very little Controlled Atmosphere storage, this is an area which needs further research.

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