The Development of a Quality Scale to Measure the Impact of Quality on Supermarket Fruit Demand

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This research examines how fluctuations in quality affect consumer expenditures for fresh fruit at the retail level. This paper examines how consumers' purchasing behaviors react to changes in fresh fruit quality by quantifying quality characteristics based on weekly observations. A four-point scale was created and used to quantify four different quality characteristics: bruising, markings, brilliance, and maturity. A non-linear Almost Ideal Demand System was used to model the share equations for Gala apples, Fuji apples, Red Delicious apples, other sweet apples, tart apples, pears, bananas, and oranges. Seventy-nine weeks of data on weekly store sales were collected from two grocery stores in the Portland, Oregon metropolitan area. Results from the quality measures are provided and discussed. Suggestions are made for modifications to the quality measures to improve the modeling results of future fruit-demand studies.

Fruit sales are important to overall grocery store profitability (Schaffner 2002; Gentry 2001; Perosio et al. 2001), so it is important to understand the factors influencing consumer purchasing-behaviors. Classic demand models for fresh fruit typically examine how aggregated sales are influenced by own and substitute prices, seasonality, advertising, and income levels. Surveys conducted by the Vance Research Service (2003), The Perishables Group (2001), and Claxton and Ritchie (1979) state that quality impacts consumers' purchasing behaviors of fresh fruit. Supporting the results from these surveys, a bulletin by Putnam and Allshouse (1999) states that better-quality fresh fruits have lead to an increase in consumption levels.

Despite the importance of quality, pervious research has not quantified quality information in the analysis of consumer demand for fresh fruit. This study develops fresh fruit quality measures for retail sales to quantify how the appearance of fresh fruit impacts consumers' purchasing behaviors. This paper covers the development of the quality measures for and results from a demand analysis.

Development of Quality Measures

The quality scale was developed in an attempt to evaluate quality of fruit in a retail setting, and was based on earlier research focused on rating individual fruit, store manager interviews, and practical considerations. Quality data was collected on bruising, marking (includes russet, waxy build-up, etc), damage (dents and breaks in skin), brilliance (shine), and maturity/color.

Previous studies examining fruit quality were based on panels judging individual fruits (Williams and Carter 1977), so the scales used in those studies would not accurately quantify fluctuations of quality for fresh fruit displays. These previous studies do provide information on quality measures and examples of point-scales to assess the different levels of quality. Literature indicates that the quality measures that influence consumer's purchasing behaviors for fresh fruit are bruising (Brumfield, Adelaja, and Lininger 1993; Ricks, Sterns, and Woods 2002), brilliance (Williams and Carter 1977), and color (Kappel, Fisher-Fleming, and Hogue 1995; Ricks, Sterns, and Woods 2002).

Interviews with produce managers and personal observations of fresh fruit in grocery stores also reveal quality factors have not been evaluated individually (Williams and Carter identify blemishes, which included bruising and other damage). Fruit damage, other than bruising, is also likely to have a negative impact on consumer purchases of fresh fruit. Also, fruit markings such as dirt or a build-up of wax on fresh fruit may create a negative impression of fruit quality.

Once the quality characteristics to be examined were identified, an assessment process was developed. The objective of the assessment process was to create a scale that measured the overall quality of an entire fruit display; this was measured by assessing the proportion of fruit within a display that are high quality for a characteristic. A decision was made to use a four-point scale because it had the benefit of enabling quick in-store assessment and it reduced the variation between different data collectors.

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The values of the quality scale were based on examination of the fresh fruit at the retail level in four stores over a number of weeks. For bruising, markings, and damage the same evaluation technique and scale values were used. Table 1 provides the levels of the four-point scale.

The assessment for maturity/color used the same percentage cut-off values, but the description of these values is more detailed than those for bruising, marking, and damage. The maturity/color quality measure took into account the amount of immature and over-ripe fruit within a display. Fruit maturity/color was based on the ground color of each variety of apple, banana, or pear. The ground color is referred to the base color of the specific fruit variety; depending on the variety, a green ground color could reflect immaturity, as in bananas, or the expected color, as in Granny Smith apples.

The quality scale characterization for brilliance differed from the assessment used for bruising, markings, damage, and maturity. Fruit is generally uniform in shine level, which is the same across all the fruit in a display, so each display was assessed. Table 2 displays descriptions for the brilliance measure.

Data and Methodology

The data used for this study used weekly purchases from two retail grocery stores within the same chain. The stores had different management styles and were located in different demographic areas in the Portland, Oregon metropolitan area. Weekly store visits entailed data collection on apples, bananas, pears, oranges, and other hand fruit.[1] Information was collected on prices, origin of production, eco-labeling, fruit sizes, display sizes (each product could be displayed in multiple locations), point-of-purchase material size, and corresponding sensory wording. Quality measures were also collected for each variety of apples, bananas, and pears as well. Detailed maps of the produce area were taken each week. The maps provided information on display locations for each fresh fruit variety. Pictures were taken of each display and the point-of-purchase signage corresponding to a given display. The pictures were used to help create new variables based on point-of-purchase sensory wording and to double check any abnormalities or errors that appeared in the data set. Quantity sold was collected from printouts provided by the produce managers or other produce personnel within each store. The printouts provided data on total revenue and aggregated weekly quantity sold that were organized by PLU numbers, codes used by almost all stores to track produce sales.

[1] "Other hand fruit" is the type of fruit people can eat with little preparation, similar to apples; e.g. oranges and kiwis.

Table 1: Quality Scales.

Scale value	Standard
4	Less then 10 % of the fruit on display has the negative quality characteristic present
3	10 to 30 % of the fruit on display has the negative quality characteristic present
2	30 to 50 % of the fruit on display has the negative quality characteristic present
1	Greater than 50 % of the fruit on display has the negative quality characteristic

Table 2. Brilliance Scale for Level of Fruit Shine.

Scale value	Fruit appearance
4	Very shiny looking
3	Shiny looking
2	Glossy looking (halfway between shiny and dull)
1	Dull looking

Hard copies of the data collected were cataloged and sorted by week. The information was manually entered into an Excel spreadsheet. Checking the accuracy of ten entries each week guarded against entry errors. If errors were found the entire weekly entry was double-checked with pictures and the information collected during the store visits.

This study follows from classical demand models, using own and substitute prices as well as expenditures. Analysis at the store level allows for other variables to be incorporated. These variables include price promotions, product branding, seasonality, display location, display sizes, point-of-purchase sizes, and quality measures.

To estimate demand for apples, bananas, pears, oranges, and other hand fruit, the Almost Ideal Demand System (AIDS) was used (Deaton and Muelbauer 1980). The linear approximation of the AIDS model was used as a starting point for selecting the combination of variables useful in determining fresh fruit demand. Once the specific variables were selected the non-linear AIDS model was used to model the data because of its better properties, and the non-linear model had a stronger relationships between the cross prices across share equations than did the linear approximation of the AIDS model.

Weekly availability of Gala, large Fuji, and large Red Delicious apples permitted them to be to be analyzed in individual share equations. However, other varieties of apples and pears only appear for part of the year and needed to be aggregated to produce a continuous data series for share equations. The other apple varieties that appeared from week to week were aggregated based on industry descriptions into either an "other sweet apples"[2] share equation or a "tart apples"[3] share equation. Pears, regular bananas, oranges, and other hand fruits[4] also had share equations. The price is a weighted average price for each of the aggregated share equations.

[2] Other sweet apples included Golden Delicious, Cameo, Jonagold, Small Red Delicious, Small Fuji, Pacific Rose, Honey Crisp, Sonata, and Queen apples.

[3] Tart apples included Braeburn, Pink Lady, McIntosh, Southern Rose, Pippin, and Granny Smith apples.

[4] Other hand fruit included: kiwis, peaches, plums, bagged fruit, organic fruit, etc. This equation was excluded from the model to ensure that the data matrix would be non-singular.

Results

This study examined how different variables impact consumers' purchasing behaviors for fresh fruit at the retail level. Model results were very good overall, with the adjusted R^2 for all of the share equations over 0.65 except the banana-share and the tart apple-share equations. The tart apple-share equations had an adjusted R^2 of 0.51, which maybe due to additional levels of seasonality or possibly to the mix of apples not matching consumer perceptions (all may not be considered tart). The banana share equation was the most problematical, and only after a variable for a sale in the proceeding week was added did the own-price coefficient became negative. Beyond the quality variable results, which will be provided in detail, it was found that prices, total display size, end displays, total point-of-purchase size, advertisements, the availability of a bagged-apple substitute, sensory wording, origin/labeling, seasonality, total number of products available, and an expenditure index are all significant variables. In addition, the assumptions of a demand system are met: negativity is satisfied, and restrictions for symmetry and homogeneity were tested not rejected.

A number of variations of the quality measures were tested in the demand model. A quality measure was calculated by summing together the values for bruising, marking, and damage. All the quality-measure values were summed together to create a total quality value. Binary variables for when the quality values were 2 or less were created. Also, logged values of the quality measures were tried in the model, but including the non-logged values from the four-point scale for brilliance, bruising, markings, and maturity in the final model provided the best results. The damage variable was excluded from the final model because the coefficients were insignificant across all share equations.

To interpret the bruising, marking, and maturity scales as linear, the 4-to-1 scale is considered, with range midpoints of 0, 20, 40, and 60% levels of negative characteristic. While the value 1 represents displays in which more than 50% of the fruit with the characteristic, fruit of lower quality (70–100% of the fruit in the display with had the low quality characteristic) were not observed in the data used for the analysis. Table 3 presents the coefficients and scale values observed for each of the quality measures.

Table 3. Results and Statistics for Quality Measures.

Quality	Coefficient estimates	Percentage of occurrence			
Share equation		Low (1)	Low medium (2)	High medium (3)	High (4)
Brilliance					
Gala	0.0017	3.2	7.1	61.9	27.7
Fuji	0.0014	0.0	8.9	60.8	30.4
Red Delicious	0.0015**	0.0	3.8	27.9	68.9
Sweet	-0.0079	0.0	5.1	79.8	15.2
Tart	-0.0003	0.0	16.5	74.7	8.9
Pear	0.0085*	1.9	27.4	61.8	8.9
Banana	-0.0006	1.3	25.3	60.8	12.7
Bruising					
Gala	-0.0048**	0.0	1.3	29.0	69.7
Fuji	-0.0131*	0.0	1.3	50.6	48.1
Red Delicious	0.0030*	0.0	3.2	13.9	82.9
Sweet	0.0024	0.0	0.0	41.8	58.2
Tart	-0.0092*	0.0	0.0	60.1	39.9
Pear	0.0058**	0.0	13.4	49.7	36.9
Banana	-0.0055	0.0	2.5	63.9	33.5
Marking					
Gala	-0.0029	1.3	2.6	38.1	58.1
Fuji	-0.0014	1.9	4.4	44.9	48.7
Red Delicious	-0.0002	0.0	1.3	25.3	73.4
Sweet	0.0028	0.0	0.0	32.3	67.7
Tart	0.0054**	0.0	0.0	57.0	43.0
Pear	-0.0089**	0.0	6.4	83.4	10.2
Banana	0.0030	0.0	2.5	48.7	48.7
Maturity					
Gala	0.0044	0.7	1.9	19.4	78.1
Fuji	0.0012	0.0	4.4	30.4	65.2
Red Delicious	0.0021*	0.0	4.4	20.9	74.7
Sweet	0.0044	0.0	0.6	20.3	79.1
Tart	-0.0005	0.0	0.0	38.0	62.0
Pear	0.0019	0.0	0.0	50.3	49.7
Banana	-0.0030	2.5	8.2	43.7	45.6

** 0.01% significance, * 0.05% significance

Brilliance

Though it is not the case for other quality variables, as will be discussed below, Table 3 shows that all of the fruits had a number of observations in the low-medium range for brilliance and some fruits had observations in the lowest range as well. However, greater brilliance appears to increase only demand for Red Delicious apples and pears.

The importance for Red Delicious apples as opposed to other apples may come from a number of sources. One is that, as seen above, Red Delicious apples often display a high degree of shine—both naturally and/or from waxing treatment—and this high level of shine is associated with Red Delicious apples in the minds of buyers. It may also be that Red Delicious apples solid red color makes the level of shine more noticeable, compared to Fuji

and Gala, which have a more variegated appearance. It may also be that consumers who prefer Red Delicious apples prefer or expect more shine while those who select other apples associate shine with waxing and they dislike waxing. In any case the results from this analysis indicate that of the apple varieties only Red Delicious apples are impacted by brilliance. For pears the range of shine is mostly in the lower end and may have different associations for pear buyers. Bananas also show very good variation in brilliance but do not seem to be affected by its level.

Bruising

As seen in Table 3, the coefficient for bruising was significant with the correct sign only for pears and Red Delicious apples. Gala, Fuji, and tart apple coefficients were significant with the incorrect sign. These latter results could be an anomaly since there was little variation in the bruising (more than 98% of the observations for non-Red Delicious apples had less than 30% of the fruit unbruised). Pears were the only fruit group that had more than 4% of its observations in the low medium range (13.4%). Because pears, particularly Bartlett, are quite fragile, bruising is more prevalent. Once again, the other significant, correctly signed impact was on Red delicious apples, which had slightly more observations in the low-medium category than did the other apples. As with the brilliance result, the uniform color may make bruising more visible with Red Delicious than on other apples.

Marking

The results and observations for markings are somewhat similar to those for bruising, though fewer are significant. Of those, the tart apple coefficient is positive and as expected, and the pear is not. Of the two, the tart apples result would be more convincing if there were any observations below high medium, while for pears it seems unlikely that this negative is meaningful when all other fruits show no impact from marking. Given the six other insignificant coefficients it seems likely that marking is unimportant to the customer because it is easily avoided by selecting unmarked fruit and represents one type of physical mishandling not associated with taste or ripeness.

Color/Maturity

Only the Red Delicious share was impacted by the maturity variable; this result may also be hypothesized to be due to the uniform color observed in the ripe fruit, which is closely associated with the variety. There are some problems with the maturity scale, which was formulated to measure appropriate ripeness with deviations measured from both over- and under-ripeness, this may be a particular problem for pears. The result for bananas is expected: both over-ripe and under-ripe fruit are often selected by consumers depending on use and preference. For bananas it might not be surprising to have reduced sales when only ripe-for-eating fruit was available. Consumers may view green bananas or over-ripe bananas at the same quality level due to baking needs. Similar circumstances may be occurring for Gala, Fuji, sweet, and tart apples, and pears.

It is also somewhat helpful to look at the results by fruit, rather than by quality characteristic. The Red Delicious apple share had the largest number of significant coefficients for quality—three, including brilliance, bruising, and maturity—all of which had the correct sign and marking was insignificant. Pears had two correct and significant quality characteristics—bruising and brilliance—with maturity positive but insignificant and markings negative and significant. Except for the odd results on bruising with its limited quality variation, only one other apple-equation quality scale—markings for tart apples—was ever significant. No estimate for bananas was significant.

Our interpretation and speculations regarding these differences are as follows. Either quality preferences are firmer for Red Delicious than for other apples, or, possibly, they are easier to evaluate visually because of their uniform color. Bruising matters for pears, though this result could represent something else, such as over-maturity turning customers away from even looking at the bin. Further study might examine whether this effect is more closely associated with the more fragile Bartlett pears and their highly visible bruises. Bananas had no significant quality characteristics observed, despite better variation in quality. This is easy to accept: consumer usage and preferences for bananas allow for both bruised and over-ripe fruit, and consumer confidence that under-ripe bananas will ripen is correctly high.

Conclusions and Future Research

While the quality scales did not entirely yield the expected results, they do provide a good starting point for future research in this area. With little variation occurring in the quality-measure variables, a more detailed scale may need to be developed. There were few observations of low quality, so the lowest quality value of 50% or more may need to be changed. Also, splitting the "low medium" and "high medium" quality-scale values into values that represent 10% changes could add more variation and accuracy to the data, though this will require more time on the part of the data collector.

The quality observations used for analyzing fruit demand were only taken once a week, and this may not accurately reflect how quality fluctuations impact demand for fruit. With each display generally being inspected for poor-quality fruit twice a day by produce-department employees, the quality measurements for this study may not fully reflect the average fruit quality throughout the week. Taking more observations during a given week could help to obtain a better representation of how fluctuations in fruit quality influence demand.

Finally, while this would change how the data is collected, information on how the appearance of mixed-quality fruit in a display bin affects consumer's willingness to select fruit from the bin may be desirable. This information might best be collected using in-store surveys or experimental approaches.

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