Market Quality of Pacific Northwest Pears

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This study uses data collected from retail grocery chains during marketing season 2003-2004 to examine the external quality and price variations of Pacific Northwest pears. Quality refers to overall fruit appearance and presence of external disorders. Results from a bivariate probit model show that fruit weight and firmness had a positive effect on overall appearance. Results from a hedonic price model show that the recurrence of external disorders is not necessarily negatively correlated with price variations. Overall, this study shows the need to investigate methods of storage, packing, and transportation to achieve the ideal fruit characteristics that appeal to consumers, wholesalers, and retailers.

The largest volume of pears produced in the United States is grown in the Pacific Northwest (PNW) (Washington and Oregon). For years 2009-2010, 71 percent of the total pear production was concentrated in the PNW (USDA 2010). For the same years, total PNW pear production for the fresh market reached 522 million pounds. About 52 percent of this volume was sold through domestic retail grocery chains, 33 percent was exported, and 15 percent was sold through other channels (e.g., foodservice) (Washington Growers Clearing House Association 2010; Yakima Valley Growers-Shippers Association 2009; and Producer Market Guide 2011). Typically, fresh pears sold to retail grocery chains are transported from the PNW to population centers in the western, mid-western, and eastern regions of the country. One major problem the industry faces is that it is possible for pears to be damaged during shipping, storage, and display. Kupferman et al. (1992) reported that various types of damages to pears appear during harvest, packing, after storage, during transport, or in the marketplace. These damages represented losses to the industry totaling $1.5 million for Anjou pears, in 1991. Given the importance of retailers (52 percent of all fresh production is sold through this channel), PNW pear growers would like to mitigate potential fruit damage during transit to retail stores by optimizing methods to ensure delivery of pears with visual and edible quality to consumers. One step towards this goal is to determine which damages are most important by assessing the quality of fresh pears in grocery stores across the nation and identifying external quality differences across states, season during the year, and cultivars.

Few studies have focused on fresh fruit quality variability through the marketing chain; most previous research related to pear quality assess consumers' preferences; for example, Kappel et al. (1995), Predieri et al. (2002), Turner et al. (2005), Combris et al. (2007), Zhang et al. (2010), and Gallardo et al. (2011). Overall, these studies provide useful insights on consumers' preferred fresh pear size, color, shape, flavor, texture, and overall quality. Very few studies have evaluated the appearance of fresh fruit at the grocery store level. Durham et al. (2005) measured the effect of quality on the purchase of fresh fruit (i.e., pears; Gala, Fuji, and Red Delicious apples; other sweet apples; tart apples; bananas; and oranges) at a grocery store. They found that fruit shine had a positive effect on the quantities sold, while bruising and marking reduced fruit sales.

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While previous research on fresh pear quality has increased awareness on the quality characteristics of pear fruit on consumers' preferences, this study presents findings of a unique experiment analyzing quality variability in grocery stores in five states across the U.S. This manuscript presents a case for analysis during specific months of one marketing year, with the goal of providing cues on quality variability and explanations for price variations. This, we hope, will add to the overall purpose of providing consistent and acceptable fruit quality being delivered through retail grocery chains. Specific objectives are threefold. First, determine if weight and firmness of pears affect overall external appearance and recurrence of external disorders. Second, investigate if factors such as grocery chain type, location, and season have an effect on external appearance of pears. Third, analyze potential correlations between prices and pear characteristics (i.e., weight, firmness, external appearance, and presence of external disorders).

Methods

During the 2003-2004 marketing season, PNW pears were purchased, when available, from retail grocery stores across five U.S. states on four sampling dates (October 2003; January, April, June, and July 2004). Retail locations included: Wenatchee and East Wenatchee, WA; Ithaca, NY; Raleigh and Cary, NC; East Lansing, MI; and Davis, CA.

Fruit purchased was conveyed to a laboratory in each state, and evaluated following a detailed protocol. The protocol included photographs of appearance and external disorders to ensure the same ratings were used across laboratories. In each location, fruit were kept at room temperature and tested for color, weight, overall appearance, external disorders (e.g., bruising, decay, marking, punctures, and shrivel) and internal quality (e.g., firmness). Evaluations were conducted on the first and fourth day after the fruit was purchased. Because the purpose of this study was to evaluate quality as consumers perceive it at the grocery store, we considered evaluation results only on the first day. Color was evaluated visually using a standard 0.5-5 color chart, where 0.5 was green and 5 was yellow. This characteristic was measured for Anjou and Bartlett only, given the complexity of having a uniform criterion to measure color on Bosc and Red Anjou. Appearance and external disorders were also evaluated visually, following the protocol and photographs distributed to each laboratory. The first step of this procedure was to determine the presence or absence of an external disorder. Then, based on the comprehensive evaluation of external disorders, overall appearance was examined.

The external cosmetic disorders (e.g., bruising, skin marking, shrivel, and skin punctures) included in this study are the most prevalent cosmetic disorders for PNW pears. Cosmetic refers to defects that negatively affect the appearance of the fruit, but, unlike decay, does not render the fruit inedible. For this study, bruises were defined as dark brown spots affecting the skin and the tissues immediately beneath, that could be consumed without risk of compromised food safety. This defect is known to result from either one or a combination of friction, impact, or pressure and imply rough handling procedures. Bruising was recorded as presence or absence only; severity was not estimated. Skin marking was defined as browning apparently caused by scuffing or superficial scald. Scuffing is typically caused by friction on the brush or belt when packing or by handling by consumers on retail display (Kupferman et al. 1985). Superficial scald in Anjou pears is due to immaturity at harvest, high temperatures, and high relative humidity in storage (Chen et al. 1996). Shrivel is defined as wrinkles in the fruit surface resulting from water loss. Skin punctures were determined as any break in the surface of the skin that might be caused by an impact with the stems of other fruit. The presence of decay symptoms on the skin surface was the only non-cosmetic surface disorder assessed. Because decay often accompanies wounding of the fruit, (Kupferman et al. 1985) we were careful to inspect decay sites for puncture wounds, which might otherwise be obscured.

Flesh firmness was measured on two sides per fruit. The instruments used were standard, destructive firmness testers, such as a Fruit Texture Analyzer (Güss Manufacturing, Strand

South Africa) or a handheld penetrometer (Effegi) fitted with an 8-mm tip. Other internal quality factors (e.g., juiciness and soluble solids) were measured but not included in this study since consumers would not be able to assess them before purchase.

Price per pound data was also collected, as was the type of grocery store chain where the fruit was purchased. Here, a distinction was made between grocery store chains with fewer than 100 and more than 100 stores nationwide. To account for the effect of seasonality on price, as might be affected, for instance, by the potential presence of pears' substitutes, we use month as an indicator variable. Note that not all fruit were available in all months when the analysis took place. For example, Bartlett pears were only available in October 2003 and January 2004. Finally, indicator variables for states were included in the model. Overall, 810 pear samples were purchased and analyzed for this study.

Data Analysis

Variables for appearance and external disorders are correlated given that the recurrent presence of external disorders in the fruit will lead to an unacceptable appearance. However, the presence of each external disorder is not necessarily correlated with each other. For example, pears with bruises will not necessarily exhibit shrivel or punctures. However all bruises, shrivel, and punctures will affect the overall appearance of the fruit. In view of this situation, we used a bivariate probit model. This specification allows having two regressions to be estimated simultaneously, assuming that both have correlated disturbances (Greene 2008). Moreover, we conducted likelihood ratio tests and results favored the bivariate rather than the univariate specification (likelihood ratio statistics for all five models ranged between 17.7 and 118.1; leading one to reject the null hypothesis that the univariate specification yielded better estimates). The general specification for the two-equation model is:

$$\begin{aligned} Appearance &= \beta_{10} + \beta_{11}\ln weight \\ &+ \beta_{12}\ln firmness + \beta_{13} grocerystore \\ &+ \beta_{1k} cultivar_k + \beta_{1l} state_l + \beta_{1m} month_m + \varepsilon_1 \end{aligned} \quad (1)$$

$$\begin{aligned} &Externaldisorder_i = \beta_{20} + \beta_{21} \\ &\ln weight + \beta_{22}\ln firmness + \beta_{23} \\ &grocerystore + \beta_{2k} cultivar_k + \beta_{2l} state_l \\ &+ \beta_{2m} month_m + \varepsilon_2 \end{aligned} \quad (2)$$

where Appearance is a binary variable that equals 1 if appearance is found acceptable and 0, otherwise. External disorder is a binary variable that equals 1 if the i^{th} external disorder is present and 0, otherwise (*i*=bruise, decay, marking, puncture, and shrivel) (a total of five bivariate equation systems were conducted). The set of independent variables for both equations in the system was the same and included weight, firmness, grocery store, cultivar, state, and month. The variables weight and firmness were nonlinearly transformed into a logarithmic form to achieve a regression curve. This approach was chosen on the assumption that the effects of these characteristics on appearance were not linear (Gutman et al. 2002). The variable grocery store was equal to 1 if the grocery retail chain had less than 100 stores, and 0, otherwise. The variable cultivar was equal to 1 if the cultivar corresponded to any of the *k* pear cultivars in the study (*k*=Anjou, Bartlett, Bosc, and Red Anjou) and 0 otherwise. The variable state was equal to 1 if pears were purchased in the state corresponding to any of the *l* states in the study (*l*=New York, Michigan, North Carolina, and California). The variable month was equal to 1 if pears were bought in any of the *m* months when the study took place (*m*=January, April, June, July, and October). β_{10} to β_{13} , β_{1k} to β_{1m} , β_{20} to β_{23} , and β_{2k} to β_{2m} were the parameters to be estimated.

To avoid having perfect multicollinearity when including the whole set of indicator variables (i.e., four indicator variables for cultivar, five for state, five for month, and an intercept term), one variable for each group was dropped. The dropped variable serves as the basis for comparison for the rest of the variables in the group. For example, variable Red Anjou was dropped, and the parameter estimates for Anjou, Bartlett, and Bosc indicate the effect of each variable on appearance compared to Red Anjou, with all of the other variables unchanged. State and month variables were treated similarly; for state the base variable was Washington and for month, the base variable was October. Parameters were estimated by maximum likelihood.

Hedonic Price Regression

We were interested in analyzing variations in prices across fruit purchased. For this, a set of eight hedonic price regressions were used. A separate equation was estimated for each pear cultivar in the study, and the first four, out of the eight equations, had appearance among the set of explanatory variables and the last four have each external disorder, as the explanatory variables. This section of the study follows Rosen (1974) who postulated that hedonic prices are the implicit prices of each quality attribute of the good in analysis. These implicit prices are revealed from observed prices and varying amounts of the good's quality characteristics. Hence this approach assumes that the price for pears can be expressed as a function of its quality attributes, controlling for factors such as aggregate supply, location, and month.

We used a fixed effects model to control for heterogeneity known to be stable across observations. In our specific case, variable state was the classification variable and it is assumed to be the equivalent of a treatment. As noted by Allison (2005) classifying observations' variability across treatments helps reducing error variance.

As explained previously, a total of eight regressions were conducted. The first four regressions modeled each cultivar including "appearance" as explanatory variable, and follows:

$$\begin{aligned}(3)\quad Price_k &= \alpha_0 + \alpha_1 indexmo \times appearance_k \\ &+ \alpha_2 indexmo \times color_k + \alpha_3 indexmo \times firmness_k \\ &+ \alpha_4 indexmo \times weight_k + \alpha_5 indexmo \times volumeship_k \\ &+ \alpha_6 grocerystore_k + \alpha_{7l} state_{lk} + \alpha_{8m} month_{mk}\end{aligned}$$

where Price is the price for the k^{th} cultivar and is used in its logarithmic form. Indexmo represents an index variable for months when the experiment took place. We included interaction effects of indexed month with appearance, color, firmness, weight, and volume shipped to account for potential substitution effects from other fruits that were available in specific months. Volume ship is a proxy variable for aggregated pear supply. This variable depicts the total volume of all pear cultivars in millions of pounds that were shipped from PNW packing houses to both domestic and export markets. These data were obtained from the Washington Growers Clearing House Association (2010) monthly summary reports. Here, α_0 to α_8 are the parameters to be estimated.

The other four regressions included each external disorder in the set of explanatory variables, following:

$$\begin{aligned}(4)\quad Price_k &= \lambda_0 + \lambda_1 indexmo \times bruise_k \\ &+ \lambda_2 indexmo \times marking_k + \lambda_3 indexmo \times shrivel_k \\ &+ \lambda_4 indexmo \times decay_k + \lambda_5 indexmo \times puncture_k \\ &+ \lambda_6 indexmo \times color_k + \lambda_7 indexmo \times firmness_k \\ &+ \lambda_8 indexmo \times weight_k + \lambda_9 indexmo \times volumeship_k \\ &+ \lambda_{10} grocerystore_k + \lambda_{11l} state_{lk} + \lambda_{12m} month_{mk}\end{aligned}$$

Similar to previous regressions, when using indicator variables, one variable was dropped from each group, to avoid perfect multicollinearity (e.g., Washington for state, and October for month). In both equations (3) and (4) dependent variable price is in log form, given that this specification leads to a well-fitting model with statistically significant coefficients. Also in an attempt to establish a regression curve with 13 independent variables, color, firmness, and weight were transformed to their logarithmic form to achieve the regression curve (Gutman et al. 2002).

Results

Appearance and External Disorders

Results from the bivariate probit model are listed in Table 1 (see Appendix). Only parameter estimates that were significantly different from zero, at the 5% and 10% level, are discussed.

Holding all other factors constant; an estimate with a positive sign indicates that the variable contributes to an acceptable appearance, while a negative sign indicates a detriment for appearance. Parameter estimates for the appearance equation were consistently similar across all five models. In general, pears' firmness had a positive effect on the probability that appearance was acceptable. Bartlett cultivars were less acceptable than Red Anjou pears. Overall appearance of pears sampled in Michigan, North Carolina, and California was more acceptable than in Washington. Pear appearance in January, April, June, and July was rated less acceptable than in October.

With respect to external disorders, holding all other factors constant, a positive sign in the parameter estimate indicates a positive effect for the presence of each disorder. Pears' firmness had a negative effect on all external disorders listed in this study. As expected, the more firm the pear, the less prone it would be to exhibit bruises, marking, shrivel, decay, and punctures. This proves that firmer pears are easier to handle since they arrive with less cosmetic damages to the grocery stores shelves. However, excessive firmness could be a detriment for consumers' preferences. Previous studies (Kappel et al. 1995; Gallardo et al. 2011) have shown pears that are too firm are not preferred by consumers. Industry programs, like the conditioning program managed by the Pear Bureau Northwest attempt to minimize the delivery of underripe, excessively firm fruit to the consumer by inducing ripening at warehouses. The overall goal of this and similar programs is to supply fruit with optimal quality characteristics (including firmness) while minimizing potential losses due to handling less firm fruit (Moffitt 2011).

In relation to cultivars, Anjou pears exhibited more marking and shrivel, but less decay and punctures than Red Anjou. Given that marking is a skin discoloration disorder, it is reasonable that such defects are less evident in dark-colored Red Anjou pears. Bartlett had more marking, but fewer punctures; and Bosc more marking and shrivel, but less decay than Red Anjou.

In general, the type of grocery retail chain (based on the number of stores) had no effect on acceptable appearance or presence of external disorders, with the exception of punctures. Pears in grocery chains with less than 100 stores exhibited more punctures when compared to large chains. As for the effects of states, when compared to Washington, pears in New York had more bruises, but less marking. Pears in Michigan had more bruises, marking, and punctures; whereas in North Carolina, more bruises, marking, and decay, but less shrivel; and in California, more bruises, marking, decay but less shrivel. When considering months, in general, pears in October exhibited less disorders than in January, April, June, or July. Marginal effects are listed in Table 2 (see Appendix).

Results presented in this section are interesting considering the negative effect of firmness on the recurrence of external disorders. Also interesting is the recurrence of disorders according to the cultivar. Some disorders, like marking, are more evident in light colored pears, thus Red Anjou consistently exhibited less of this defect. It is difficult to infer conclusions about the grocery store type, state and month, due to the short period of analysis (five months of one marketing year 2003-2004). However, results are aligned to one's expectations. First, one would expect that fruit in the state of Washington would exhibit fewer disorders due to the proximity to production sites. Despite not observing this tendency when evaluating overall appearance, one can observe fewer disorders in Washington with only two exceptions: less marking in New York and less shrivel in North Carolina. Second, winter pears in the PNW are typically harvested in September and October. Thus, one would expect that fruit in October show fewer disorders.

Hedonic Price Regression

Results for the first four regression models with appearance in the set of explanatory variables are reported in Table 3 (see Appendix). Holding all other factors constant, acceptable visual appearance was positively correlated with prices for Anjou and Bosc, but not for Red Anjou. Firmness had a positive effect on Red Anjou prices. An increase in weight led to higher Bosc prices. The negative effect of appearance in Red Anjou prices could indicate the lack of substitutes for this variety, in the period of study. In other words, Red Anjou consumers appeared to be loyal to this cultivar, and preferred to purchase it despite its appearance. In relation to the aggregate supply, the volume of PNW pears shipped had a negative effect on Anjou and Bosc. A positive shift in the aggregate supply curve, holding all other factors constant, could have led to a decrease in Anjou and Bosc prices.

In relation to price variations across grocery store type, grocery chains with less than 100 stores had lower prices than chains with more than 100 stores. In general, fruit was less expensive in Washington, with the exception of Bosc pears in New York. Relevant to month, all cultivars were more expensive in October.

Table 4 (see Appendix) lists results for the hedonic model including external disorders in the set of explanatory variables. Contrary to expectations, the presence of bruises in Anjou pears had a positive correlation with prices. This could be explained by the fact that despite presenting this cosmetic defect consumers are loyal in their preference for this fruit. Marking was positively correlated with Anjou, but negatively correlated with Bosc and Red Anjou prices. Shrivel had a negative correlation with Anjou and Bosc prices, but positive with Red Anjou. Puncture was positive for Anjou prices, but negative for Bosc. Unexpectedly, decay was positively correlated with Red Anjou prices. One could infer that the grocery store would adjust their prices according to the movement of the fruit. It is probable that at the moment this fruit with decay was purchased, prices were held at a high level, but this could have changed after store managers notice the recurrence of this defect.

Conclusions

Grocery store chains account for 52 percent of all pears shipped from the PNW. Given the importance of this distribution channel for the industry, this study aims to provide information about potential factors affecting appearance and external disorders of pears displayed at grocery store outlets, the point of purchase for about half of the PNW pear production. We used data collected on specific months during the 2003-2004 marketing season. In general, fruit firmness had a positive effect on appearance, that is, firmer fruit overall had more acceptable appearance compared to less firm fruit. Firmness was negative for presence of external disorders. Also, there were no significant differences between external appearances, in grocery store chains with less than 100 stores, compared to chains with more than 100 stores. As for price variations, cosmetic disorders did not show a consistent negative correlation with prices.

Visual appearance of fruits on the grocery store shelf is often cited as an important factor consumers consider when deciding whether to purchase fruit or not. Equally important for repeated purchases are internal quality characteristics such as firmness. The fact that firmness and the occurrence of external disorders and fruit appearance were negatively correlated indicates the need to investigate methods of storage, packing, and transportation to achieve the ideal fruit firmness that appeal to consumers, wholesalers, and retailers. Current commercial programs such as pear conditioning aimed to supply consumers with fruit with the “right” quality characteristics, emphasizing flesh firmness. Finally, this study demonstrates the additional need to improve handling, shipping, storing, and retail display practices to avoid fruit damage, and potentially increase per capita fresh pears consumption.

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Appendix

Table 1. Parameter Estimates for the Bivariate Logit Model, PNW Pears' Appearance and External Disorders

	Parameter Estimate									
	Appearance	Bruise	Appearance	Marking	Appearance	Shrivel	Appearance	Decay	Appearance	Puncture
Intercept	-1.955	0.895	-1.606	-0.135	-2.042	-0.910	-1.971	-3.898	-1.884	-1.774
	(2.165)	(1.985)	(2.179)	(1.893)	(2.175)	(2.534)	(2.250)	(4.168)	(2.205)	(1.903)
Weight	0.260	-0.088	0.191	-0.008	0.278	0.134	0.262	0.174	0.244	0.361
	(0.401)	(0.367)	(0.404)	(0.351)	(0.403)	(0.470)	(0.417)	(0.755)	(0.408)	(0.353)
Firmness	0.936**	-0.958**	0.931**	-0.499**	0.956**	-0.936**	0.962**	-0.149	0.934**	-0.439**
	(0.110)	(0.106)	(0.109)	(0.094)	(0.111)	(0.132)	(0.111)	(0.199)	(0.109)	(0.095)
Anjou	0.057	-0.045	0.075	0.751**	0.049	0.700**	0.054	-0.544**	0.072	-0.435**
	(0.159)	(0.142)	(0.161)	(0.138)	(0.161)	(0.226)	(0.165)	(0.258)	(0.159)	(0.133)
Bartlett	-0.489**	-0.145	-0.471**	1.271**	-0.493**	-3.761	-0.497**	0.371	-0.455**	-0.401**
	(0.205)	(0.190)	(0.206)	(0.182)	(0.206)	(56.666)	(0.205)	(0.265)	(0.207)	(0.176)
Bosc	-0.158	0.051	-0.128	0.425**	-0.137	1.626**	-0.188	-1.610**	-0.112	-0.217
	(0.167)	(0.150)	(0.167)	(0.144)	(0.167)	(0.224)	(0.168)	(0.440)	(0.167)	(0.141)
Grocery store	-0.152	-0.105	-0.114	0.061	-0.103	-0.049	-0.117	0.021	-0.137	0.412**
	(0.156)	(0.147)	(0.158)	(0.134)	(0.160)	(0.192)	(0.158)	(0.250)	(0.158)	(0.132)
New York	0.269	0.517**	0.326	-0.556**	0.258	0.111	0.265	0.396	0.274	0.109
	(0.213)	(0.209)	(0.213)	(0.176)	(0.214)	(0.246)	(0.216)	(0.534)	(0.213)	(0.186)
Michigan	0.489**	0.972**	0.508**	1.134**	0.461**	0.005	0.460**	0.475	0.499**	0.821**
	(0.196)	(0.185)	(0.197)	(0.168)	(0.196)	(0.228)	(0.199)	(0.467)	(0.196)	(0.164)
North Carolina	0.337**	0.579**	0.388**	0.408**	0.348*	-0.412*	0.383**	1.707**	0.349*	-0.082
	(0.191)	(0.188)	(0.191)	(0.169)	(0.190)	(0.228)	(0.193)	(0.373)	(0.191)	(0.181)
California	0.570**	-0.031	0.607**	0.571**	0.593**	-0.252	0.603**	0.617*	0.580**	-0.114
	(0.169)	(0.173)	(0.171)	(0.153)	(0.173)	(0.205)	(0.173)	(0.363)	(0.170)	(0.155)
January	-0.443**	0.305**	-0.453**	0.568**	-0.526**	0.037	-0.479**	0.400	-0.440**	0.090
	(0.164)	(0.145)	(0.166)	(0.132)	(0.167)	(0.181)	(0.169)	(0.458)	(0.165)	(0.133)
April	-0.572**	0.282*	-0.602**	0.706**	-0.634**	-0.008	-0.615**	1.070**	-0.589**	-0.037
	(0.184)	(0.160)	(0.186)	(0.150)	(0.189)	(0.187)	(0.190)	(0.504)	(0.186)	(0.150)
June	-0.751**	0.684**	-0.700**	0.719**	-0.773**	-0.202	-0.752**	1.718**	-0.758**	0.356**
	(0.218)	(0.195)	(0.225)	(0.188)	(0.225)	(0.263)	(0.227)	(0.500)	(0.221)	(0.183)
July	-1.074**	0.044	-1.083**	0.442**	-1.099**	-5.633	-1.038**	2.484**	-1.072**	-0.432
	(0.395)	(0.399)	(0.390)	(0.398)	(0.388)	(0.000)	(0.396)	(0.706)	(0.390)	(0.440)
Rho	-0.587**		-0.341**		-0.525**		-1.000**		-0.460**	

Note: Numbers in parenthesis are standard errors. * Indicates P ≤ 0.05; ** Indicates P ≤ 0.01

Table 2. Marginal Effects for the Bivariate Logit Model, PNW Pears' Appearance and External Disorders

	Appearance	Bruise	Marking	Shrivel	Decay	Puncture
Weight	0.122	0.007	0.184	-0.052	0.005	0.075
	(0.056)	(0.002)	(0.062)	(0.038)	(0.005)	(0.015)
Firmness	0.195	-0.247	-0.143	-0.160	-0.035	-0.107
	(0.088)	(0.082)	(0.048)	(0.116)	(0.034)	(0.021)
Anjou	0.061	-0.030	0.230	0.056	-0.031	-0.147
	(0.028)	(0.010)	(0.077)	(0.041)	(0.029)	(0.030)
Bartlett	-0.081	0.024	0.490	-0.197	-0.002	-0.150
	(0.037)	(0.008)	(0.164)	(0.143)	(0.002)	(0.030)
Bosc	-0.028	0.053	0.150	0.295	-0.022	-0.096
	(0.013)	(0.017)	(0.050)	(0.213)	(0.021)	(0.019)
Grocery store	-0.016	0.002	-0.007	0.018	-0.005	0.103
	(0.007)	(0.001)	(0.002)	(0.013)	(0.005)	(0.021)
New York	0.127	0.118	-0.183	0.024	0.020	0.046
	(0.058)	(0.039)	(0.061)	(0.018)	(0.019)	(0.009)
Michigan	0.076	0.265	0.315	0.035	0.071	0.216
	(0.035)	(0.088)	(0.105)	(0.025)	(0.068)	(0.043)
North Carolina	0.058	0.240	0.151	-0.079	0.111	0.036
	(0.026)	(0.079)	(0.051)	(0.057)	(0.107)	(0.007)
California	0.158	-0.007	0.143	-0.177	0.032	-0.006
	(0.072)	(0.002)	(0.048)	(0.128)	(0.031)	(0.001)
January	-0.072	0.036	0.211	0.013	-0.014	-0.024
	(0.033)	(0.012)	(0.071)	(0.009)	(0.013)	(0.005)
April	-0.114	0.086	0.197	0.008	0.013	-0.064
	(0.052)	(0.028)	(0.066)	(0.006)	(0.013)	(0.013)
June	-0.206	0.185	0.233	-0.056	0.052	0.065
	(0.094)	(0.061)	(0.078)	(0.041)	(0.050)	(0.013)
July	-0.358	0.158	0.157	-1.115	0.096	-0.014
	(0.163)	(0.052)	(0.053)	(0.807)	(0.092)	(0.003)

Note: Numbers in parenthesis are standard deviations.

Table 3. Parameter Estimates for the Hedonic Price Model for PNW Anjou, Bartlett, Bosc, and Red Anjou Pears, Including Appearance in Set of Explanatory Variables

Variable	Parameter Estimate			
	Anjou	Bartlett	Bosc	Red Anjou
Intercept	0.994**	0.243**	0.859**	0.702**
	(0.196)	(0.026)	(0.129)	(0.101)
Month x Appearance	0.010**	-0.001	0.009**	-0.041**
	(0.004)	(0.006)	(0.004)	(0.008)
Month x Color	-0.007	0.009	--	--
	(0.006)	(0.007)	--	--
Month x Firmness	0.000	0.004	-0.004	0.033**
	(0.003)	(0.003)	(0.003)	(0.006)
Month x Weight	0.004	0.008	0.015*	-0.032
	(0.011)	(0.009)	(0.009)	(0.020)
Month x Volume shipped	-0.017*	-0.012	-0.022**	0.011
	(0.010)	(0.007)	(0.008)	(0.018)
Grocery store	-0.208**	-0.316**	-0.061**	-0.090**
	(0.022)	(0.032)	(0.025)	(0.031)
California	0.092**	0.184**	0.055*	0.459**
	(0.022)	(0.038)	(0.029)	(0.039)
New York	0.029	0.061*	-0.093**	0.063
	(0.025)	(0.032)	(0.029)	(0.045)
Michigan	0.189**	0.076**	-0.018	0.229**
	(0.024)	(0.033)	(0.029)	(0.042)
North Carolina	0.033	0.184**	0.068**	0.385**
	(0.027)	(0.040)	(0.029)	(0.045)
January	-0.642**	--	-0.437**	-0.354**
	(0.177)		(0.115)	(0.090)
April	-0.427**	--	-0.252**	-0.173**
	(0.118)		(0.077)	(0.053)
Jun	-0.220**	--	--	--
	(0.079)			

Note: Numbers in parenthesis are standard errors.
* Indicates P ≤ 0.05
** Indicates P ≤ 0.01

Table 4. Parameter Estimates for Hedonic Price Model: PNW Anjou, Bartlett, Bosc, and Red Anjou Pears

Variable	Estimate			
	Anjou	Bartlett	Bosc	Red Anjou
Intercept	0.893**	0.244**	0.779**	0.747**
	(0.195)	(0.026)	(0.123)	(0.105)
Month x Bruise	0.006*	0.005	-0.003	0.007
	(0.004)	(0.005)	(0.003)	(0.006)
Month x Marking	0.009**	-0.003	-0.007*	-0.011*
	(0.003)	(0.003)	(0.004)	(0.006)
Month x Shrivel	-0.004	--	-0.002	-0.002
	(0.004)	--	(0.004)	(0.016)
Month x Decay	-0.004	-0.003	0.004	0.033**
	(0.010)	(0.012)	(0.031)	(0.010)
Month x Puncture	0.006*	0.002	-0.007**	0.005
	(0.003)	(0.004)	(0.003)	(0.006)
Month x Color	-0.009	0.007	--	--
	(0.006)	(0.007)		
Month x Firmness	0.002	0.004	-0.005**	0.024**
	(0.003)	(0.003)	(0.003)	(0.006)
Month x Weight	-0.002	0.009	0.014	-0.032
	(0.011)	(0.009)	(0.010)	(0.021)
Month x Volume shipped	-0.010	-0.012	-0.017**	0.008
	(0.010)	(0.007)	(0.008)	(0.018)
Grocery store	-0.210**	-0.317**	-0.053**	-0.093**
	(0.021)	(0.032)	(0.025)	(0.032)
California	0.093**	0.185**	0.069**	0.395**
	(0.022)	(0.038)	(0.029)	(0.039)
New York	0.051**	0.060*	-0.096**	-0.012
	(0.026)	(0.032)	(0.029)	(0.048)
Michigan	0.175**	0.072**	0.012	0.169**
	(0.024)	(0.034)	(0.030)	(0.044)
North Carolina	0.040	0.186**	0.064**	0.313**
	(0.027)	(0.041)	(0.029)	(0.049)
January	-0.550**	--	-0.370**	-0.341**
	(0.176)		(0.110)	(0.094)
April	-0.378**	--	-0.205**	-0.142**
	(0.117)		(0.073)	(0.055)
Jun	-0.210**	--	--	--
	(0.079)			

Note: Numbers in parenthesis are standard errors.
* Indicates P ≤ 0.05
** Indicates P ≤ 0.01