Combining Consumer Valuation Research with Sensory Science Techniques: A Laboratory Experiment

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1. Introduction

We conducted a laboratory experiment designed to generate consumer WTP for attributes of California Cabernet Sauvignon under different information conditions. Participants received new information about four Cabernet Sauvignons produced in California in each round of the experiment. After receiving each piece of information, each participant submitted a bid for each of the four wines. The research also generated a rich dataset of participant characteristics based on a survey administered during the experimental session. The results allow a novel examination of consumer valuation of objective label attributes and sensory attributes.

In this experiment, participants simultaneously received identical, controlled information about four wines. After each release of new information, participants submitted bids for each wine in an experimental auction. The experimental auction created incentives for participants to report WTP truthfully. Participants could do no better than to bid their true maximum WTP for a good. The experiment permitted unbiased estimation of the systematic effects that consumer characteristics have on valuation of wine and wine attributes.

A sample of 236 participants bid on four wines in nine rounds, resulting in over 8,000 bids on wine attributes. Participants also submitted 944 hedonic, "liking" ratings. The analysis of the laboratory experiment provides measures of consumer valuation of wine attributes, and evidence of the consumer characteristics that contribute systematically to valuation of wine attributes.

The design of the experiment permitted consistent measurement of consumer WTP for wine attributes, an examination of consumer valuation of the sensory attributes of Cabernet Sauvignon, and study of the effect of participant characteristics on wine attribute valuation. To

that end, the experiment released information about the wines to participants and elicited bids from participants sequentially, allowing a clear identification of changes in WTP in response to release of information. The experiment design permits analysis of causal relationships among wine attributes, consumer characteristics, and WTP for wine attributes.

2. Steps in the Laboratory Procedure

The laboratory research proceeded in two steps. In the first step, a sensory panel trained to differentiate sensory attributes analyzed a set of 20 commercially available Cabernet Sauvignons. The data generated in the sensory analysis helped in the selection of a sub-group of wines that had different sensory profiles, were from different appellations, received a range of expert ratings, and were available at a range of prices at retail. The laboratory valuation experiment was the second step of the research process. Participants received information on the subset of wines selected for the consumer research in a sequential process, which is described in detail below.

The next section reports results from the sensory analysis of the set of 20 California Cabernet Sauvignons and the criteria used to select the subset of wines for the consumer research, and then presents the results of the analysis of consumer WTP for wine attributes.

3. Conduct of the Consumer Valuation Experiment

Across 12 sessions from April 1, 2009 to July 9, 2009, 236 people participated in the valuation experiment. The consumer panel received information about attributes of the wines and submitted bids for the wines, representing their WTP. Participants understood that the decisions they made in the research could lead to an actual wine purchase. The Becker-DeGroot-

Marschak (BDM) Mechanism (Becker et al., 1964) provided participants with the incentive to consider their bids carefully.

Authors have discussed at length the incentive problems created in hypothetical choice scenarios. A number of papers have established the occurrence of hypothetical bias. Cummings and Taylor (1999), List (2001), and Lusk (2003) study the effects of hypothetical bias on valuation. Therefore, participants needed a reason to weigh their valuation decision carefully. Researchers have used experimental auctions for this purpose for nearly two decades. Therefore, an experimental auction using the BDM elicited WTP measures from participants.

3.1. Laboratory Experiment Procedure

Each participant received a 10-page packet when they signed in, which contained a set of instructions explaining the research.[1] For the instructions and demonstration of the computer interface, participants sat as a group in a central room; the sensory booths—accessed through a door in the central room—formed a "U" around the back and two side walls of the central room. The researcher read the instructions aloud in front of the group. The Becker-DeGroot-Marschak mechanism (1964)—used to incentivize truthful reporting of valuation—was explained and motivated to participants with examples, hypothetical auctions, and a binding candy bar auction. Participants were encouraged to ask questions about the procedure, and the researcher presented hypothetical outcomes and asked questions to gauge understanding.

Before the binding auction rounds, subjects filled out a demographic questionnaire. Participants then proceeded to their booth for the binding auction. The experiment comprised nine rounds. In each round, participants received information on four wines. The group of wines was constant in rounds 1-4. In rounds 5-9, participants received the same categories of

[1] Materials included in the packet are in the Appendix.

information on a second group of four wines. The two groups of wines were identical, but participants received different pieces of information with each group. For instance, if a participant saw the Wine Spectator score for a wine in round 3, they saw the Wine Advocate score for that wine in round 7. The placement of the wines on-screen and the presentation of alternate appellations and expert ratings were randomized to prevent order and group effects on bids.

The categories of information revealed to participants were nearly identical for the group in round 1-4 as for the group in round 5-9, the only difference being that participants received a 20-ml sample of each of the wines in Round 9. Table 1 reveals the structure of the auction—the timing of the release of pieces of information revealed about each wine. Once a round revealed a piece of information, it continued to be available in subsequent rounds. Thus, when Round 3 reported expert rating in Round 3, participants were also able to see the information from rounds 1 and 2 on screen. The only exception to this was the sensory information round, in which participants received 20 mL samples of each wine. In this round, a random ID number between 000 and 999 identified each wine on screen, and matched an ID sticker on each wineglass.

3.2. Consumer Bidding and Release of Information on the Wines

To obtain an initial baseline estimate of participant valuation, in Round 1 and Round 5 (the first round of the second group of wines), participants saw that each of the wines was a Cabernet Sauvignon produced within the state of California.[2] They then submitted a bid for each wine. In Round 2 and Round 6, participants received information on the appellation of origin of each wine. After receiving appellation information, participants submitted bids for each wine.

[2] It was stated explicitly that this did not refer to the appellation listed on the label; it only meant that the grapes used in the wine were grown in California.

In Round 3 and Round 7, participants received information on the expert rating given to each wine.[3] They then submitted bids based on the cumulative information on each wine. In Rounds 4 and 8, participants submitted bids after learning the name of the winery that produced each wine. After round 8, participants received samples of the four wines presented in rounds 5 through 8.

Rounds 9a and 9b were specific to the second group of wines. Upon reaching round 9, each participant received the wine samples. After smelling and tasting each wine sample, participants first used the 50-100 point scales to rate each wine in round 9a. Once they had finished rating the wines, they moved on to round 9b. In round 9b, participants bid on each of the wines in the second group one last time. While considering their bids, participants had all of the information received in rounds 5 through 8, as well as the rating they themselves had given the wines in round 9a.

After completing round 9b, participants returned to the central instruction room and completed a "wine knowledge questionnaire." The knowledge questionnaire was left as the last step of the research to avoid priming people of different knowledge levels to actively consider their knowledge or lack of knowledge about wines while they bid.[4]

At the end of the auction, one of the nine valuation rounds was chosen at random by a computer to be the binding round for each participant, and one of the four wines in that round was chosen at random to be the binding wine. The participant's bid for that wine in that round

[3] The expert ratings were drawn from the Wine Spectator and Robert Parker's Wine Advocate, and participants were told that though the screen size prevented us from displaying which of the two a particular rating came from, each rating was drawn from one of those two sources.

[4] Experiments have shown that inducing people to think about different aspects of themselves can affect their behavior. Perhaps the most illustrative example of this is research randomly assigning a group of female, Asian-American university students to one of two groups and prompted to consider their gender or their ethnicity in an essay about multi-gender housing or cultural issues experienced growing up. Both groups then took a math test. Those prompted to consider their ethnicity scored significantly higher than participants prompted to consider their gender.

was then compared to a computer-generated random price. Each round, wine, and experiment price was unique for every participant. If the participant's bid was higher than the random price, the participant purchased a coupon for the wine for the random price. If their bid was lower than the random price, they did not purchase a coupon for a bottle of wine. Finally, a researcher presented the results of each participant's bidding, randomly drawn round, randomly drawn wine, and randomly drawn price to each participant individually. With nine rounds of bidding (1-8, 9b), and bids for four wines per round, the laboratory experiment generated 8496 bids and 944 hedonic "liking" scores. Twenty-one participants were removed from the sample due to evidence that they did not understand the experiment, leaving 215 participants. All subsequent analyses refer to the reduced consumer sample of 7,740 bids and 860 liking scores.

The computer drew the experiment prices from a normal distribution centered slightly below the purchase price of each wine. Thirty-two of the 236 participants (or 14 percent) purchased a bottle of wine. Participants purchased all of the wines except for the Mondavi ($45 at retail), though the majority of purchases were of the Mirassou ($10 retail).

4. Consumer Valuation of Attributes in an Auction Setting

Each participant received new information about each bottle of wine in each round and then submitted a bid for each wine. This bid, b_{ijt}, is based on the attributes, z_j, of a wine j, as well as the characteristics of the participant i, x_i. Participants received information about the wines and submitted bids for those wines sequentially. Recall that participants had a subset of the information on each wine in any round. Therefore, the analysis needs to account for the information available to the participant at a particular point in time. Let the information available to the participant when they submit a bid in a particular round be the information set, S,

at time *t*. Equation 6.1 represents the relationship between the bid and the attributes of the wine and the consumer's characteristics:

(1) $$b_{ijt} = b(z_j, x_i | S_t).$$

The participants received the wines according to a Latin Square design. Latin Square designs eliminate order effects by randomizing the presentation order (in a balanced manner). A Latin Square design ensures that the wines do not systematically appear in any position. For example, it guarantees that the Beringer wine appears in each position on the computer screen as many times as the other wines.[5]

Guidelines for permissible labeling practices and multiple expert rating sources increased variation of appellation and expert rating. Table 2 lists the objective information that was presented for each wine. As mentioned previously, participants received identical information about each wine in the baseline round. If *Wine 1* in table 2 was labeled with the *Knights Valley* appellation (a Sonoma County sub-AVA) in round 2, it was labeled *Sonoma County* in round 6 (or *Knights Valley* in round 6 and *Sonoma County* in round 2). If participants learned that *Wine 3* received an expert rating of *88* in round 3(7), they would see a wine with a rating of *93* in round 7(3). Participants did not know that the wines presented in rounds 1-4 were the same as those presented in round 5-9.

5. Summary Statistics of Data Generated in the Laboratory Experiment

The laboratory experiment generated data on consumer WTP for wine attributes. It also generated a rich set of data on consumer characteristics, including income, demographic information (age, education level, and gender), wine market experience (such as number of

[5] See the screenshot of the laboratory experiment in Appendix 6.A. Participants received information about four wines simultaneously. The information was grouped by wine and arranged vertically on the computer screen.

bottles purchased per month, average price spent per bottle, whether the participant has read wine literature), and wine knowledge, which was measured by a wine quiz. These data were then used to analyze consumer WTP for wine attributes, and to look at the effect of different participant characteristics on valuation of wine attributes.

5.1. Summary Data on the Demographic Variables

Both the laboratory and field participants submitted similar demographic, wine market-experience, and wine knowledge data. The appendix to this chapter contains both the wine experience and demographic questionnaire and the wine knowledge questionnaire. This section compares summary data from both samples.

Table 3 displays wine experience data and demographic data. Participants in the field and laboratory experiment participated in the research in Davis, but it is likely that some participants lived elsewhere. However, census data on Davis provide the best comparison.

Fifty-six percent of the sample is female, which is three percent higher than the general population in Davis. The mean age of participants in the survey is just under 36 years of age, almost exactly four years under the mean age of the legal wine-buying population in Davis. The mean household income of laboratory participants is $64,500, which is $18,000 under the mean income in Davis. Participants in the laboratory experiment were better educated than the population of Davis 25 years of age and above, with mean years of education greater than 16. On average, participants correctly answered 63 percent of the questions on the knowledge quiz.

Participants in the laboratory research said they purchased an average of 4.5 bottles of wine per month, or a little over one bottle per week. Participants reported purchasing a wide range, from one bottle a month on average, to 18 bottles per month. Laboratory experiment

participants report spending an average of $11.59 per bottle and that they have been purchasing wine for an average of 11 years. The mean number of wineries visited per year was 3.77. Over a quarter of participants stated that they had received some type of instruction on wine. Nearly fifty percent read wine literature at the time of the study or had in the past (books or magazines on wine).

5.2. Summary Data on Willingness to Pay Bids

Mean bids per round and changes in bid from one round to another are listed in Table 4. The mean bid per bottle in the laboratory experiment across all rounds was $7.74. The mean bid is low compared to the mean shelf price of the four wines used in the experiment ($25) and the mean shelf price of California Cabernet Sauvignon wines at our partner supermarket ($12.70). Several reasons account for the lower bids. A significant amount of accumulated evidence suggests that bids for market products tend to be low in an experimental setting. In experiments, since products are presented exogenously to participants, participants are unable to choose their preferred variant. Additionally, only in rounds 4, 8, and 9 did participants have full label information on the wines. On average bids increased every time participants received additional objective label information.

The mean bid in the baseline information rounds, rounds 1 and 5, was $6.59, and was not statistically different between rounds 1 and 5. Average bids increased in each subsequent round (in rounds 1-4 and 5-8) as objective information was revealed, until the tasting prior to round 9.

The most interesting result from the examination of mean bids is the change in mean bid from the winery name round (8) to the full information round (9b). The only change in information available to participants from round (8) to (9b) was that participants received a

sample of each of the wines they were evaluating. As reported in table 4, mean bids decreased by $0.73 per bottle when participants received samples of each of the wines. The opportunity to taste the wine decreased participants' estimates of the utility they derived from the purchase of a bottle of that wine. Other factors may have influenced participants' enjoyment of the wine, though, including the setting (a laboratory booth) or the absence of food, for example.

6. Analysis and Interpretation of Consumer Valuation of Wine Attributes

The appropriate statistical analysis of wine bids depends on the relationship between the wines' attributes. For example, consumers bid on a wine based on revelation of the wines' appellations in one round; in the next round, they received information about experts' ratings of the wines and bid again. If the attributes interact, this relationship needs to be controlled for when estimating WTP. That is, if a Sonoma County Cabernet Sauvignon with a 90-point Wine Spectator rating is valued differently from a Napa Valley Cabernet Sauvignon with a 90-point Wine Spectator rating, both appellation and expert rating variables need to be included in the regression. On the other hand, if appellation and expert rating were completely substitutable pieces of information in expected utility, then bids in the expert rating round would refine the bids based on appellation, which would permit the use of the price levels rather than changes in price. The analysis examines these different scenarios in the next sections.

6.1. Consumer Valuation in Baseline Information Rounds

The first round of the each segment of the bidding process (rounds 1 and 5) gave participants general, baseline information about the four wines and elicited WTP measures from the participants. Specifically, participants learned only that each of the wines was a Cabernet

Sauvignon made from grapes grown in California. The obvious strategy of bidders given the lack of differentiating information was to bid the same amount for each wine.

The experiment presented each wine in every ordered position on the screen an equal number of times. In the design of the research, the wines were designated *wine 1* (*Beringer*), *2* (*Mirassou*), *3* (*Mondavi*), and *4* (*Beaulieu*). A Latin Square design randomized the order of presentation to the participants. For example, one participant received the wines in order 4132, another in 2431, and a third in 1423.

The purpose of the first round was to elicit a baseline level of WTP. It also provided a measure of the participants' comprehension of the experiment procedure. The baseline rounds provided evidence on bidding consistency that screened the data used for the analysis. As mentioned above, inconsistent baseline bidding also led to data from 21 participants being dropped from further analysis.

6.1.1. Consumer Valuation of Baseline Information

The first step in the analysis was to verify that there were no significant differences in bids for the wines in the baseline information scenario. To do this, the bid submitted in the baseline scenario was regressed on dummy variables for each of the four wines. *Wine 1* is the omitted category, or intercept, and has an estimated value of $6.63. There is no statistical significance between any of the wines in the baseline information category. Table 5 reports the results of the regression with the outliers removed.

6.1.2. Consumer Valuation of Baseline Information with Consumer Characteristics

The estimated intercept reported in column 1 of table 5 included the mean effect of all participant characteristics that influence wine valuation. Introducing consumer characteristics with no interaction between characteristics and attributes affects only the intercept. All of the marginal differences between the wines remain constant. Column 2 in table 5 reports the estimated coefficients from the regression of bids on dummy variables for the wines and all consumer characteristics, using robust standard errors clustered on participants.

The two statistically significant parameter estimates in regression 2 are the self-reported mean price paid per bottle of wine, and whether the participant is a wine club member. The parameter estimate of *price per bottle*—the mean price the participant reported spending on a bottle of wine—is 0.25, which implies that for every additional dollar that participants reported spending per bottle of wine, baseline bids for the wines in the experiment increased by $0.25. The second significant variable, *wine club membership*, had a coefficient estimate of 1.59, indicating that wine club members bid $1.59 more for the bottles of wine than non-wine club members did. The significant positive parameter estimates may indicate that the participants who are wine club members and who spend more on wine in general value wine more than their counterparts, or it could be that they estimated that more expensive wines were used for the research.

A few points should be made here. The consumer characteristics that are significant in the baseline rounds may not be significant in later rounds. In fact, the, the factors influencing the bids in later rounds might be very different from those influencing the undifferentiated baseline scenario bids. Discussion of the interaction of wine attributes and consumer characteristics occurs in a later section.

6.2. Consumer Valuation in Appellation Information Rounds

In the *Appellation* rounds, participants received information on the specific appellation of each wine. For the wines used in this research, those appellations were *California*, *Knights Valley* (of *Sonoma County*), *Napa Valley*, *Oakville* (of *Napa Valley*), and *Sonoma County*. Note that though this would have been known by some participants, participants were not told that Knights Valley and Oakville was a sub-appellation within Sonoma and Napa counties. The experiment used a nested appellation structure to look at consumer valuation of appellation and consumer characteristics.

6.2.1. Consumer Valuation of Appellation

Table 6, column 1 shows the analysis of the valuation of Cabernet Sauvignon appellations. The equation estimated is:

(2) $b_{i12} = \alpha_0 + \beta_1 Knights\ Valley + \beta_2 Napa\ Valley + \beta_3 Oakville + \beta_4 Sonoma\ County + \varepsilon_i$.

The categorical variable *California* was omitted to prevent collinearity. The regression was estimated with robust standard errors clustered on participants and random effects.[6] Bids for the appellations included in the model are all positive, and all coefficients on appellations are statistically significant at normal levels. The coefficient on *Knights Valley* is 0.65, and *Napa Valley* is 2.19. *Oakville*'s estimated coefficient is 1.63, and the coefficient on *Sonoma County* is 1.92. All of these coefficients represent the premium participants are willing to pay compared to the California appellation with no additional information except for grape type.

It is unsurprising that the estimated WTP is lowest for wines labeled *California*. According to the estimates, *Napa Valley* is preferred (or provides the highest expected utility),

[6] A Hausman test confirmed that the random effects model was appropriate.

closely followed by *Sonoma County*, then by *Oakville* and, finally, *Knights Valley*. *Oakville*, a sub-appellation of *Napa Valley*, and *Knights Valley*, a *Sonoma County* appellation, tend to sell at higher prices in the market place than the larger appellation.[7]

There are two immediate explanations for the data, one of which is testable, and one of which is not. Participants on average may not have been familiar with *Oakville* or *Knights Valley*. Using wine experience variables and scores on the knowledge quiz, effects of wine experience and knowledge on valuation can be examined by interacting wine experience variables with each individual appellation. The second hypothesis is not testable. Participants may have assumed that the wines used in the experiments represent wines sold at a relatively uniform price in the market, in which case, they would expect that these wines would represent below-average quality for the two higher-priced appellations. The next section discusses results of the analysis incorporating consumer characteristics into the regression of bids on appellations.

6.2.2. Consumer Valuation of Appellation and Consumer Characteristics

Column 2 in table 6 presents the estimated coefficients from regression 2—the regression of bids on appellations and consumer characteristics. The coefficients on the appellation variables scarcely change from regression 1 to regression 2. The estimated coefficient for *Sonoma County* decreases from 1.92 to 1.88, but this is the largest change (and is not statistically significant). The statistically significant consumer characteristics are the same characteristics that were significant in the analysis of baseline bids: *Price per Bottle* and *Wine Club Member*. The coefficient on *Price per Bottle* is larger in the appellation round than in the baseline round—0.35 versus 0.25. The interpretation of the coefficient is that for each additional dollar a participant reported spending on average on a bottle of wine, bids were $0.35 higher. For

[7] Kwon et al. (2008) find that prices are higher for sub-AVAs than for the larger appellation.

instance, a participant who reported a *Price per Bottle* of $20 would bid $3.50 more per wine in the appellation rounds of the experiment than a participant who reported a *Price per Bottle* of $10. *Wine Club Member*, a categorical variable, increased the bid level by $1.53. In this specification, both consumer characteristics affect the general level of the bids, and not the differences in WTP between appellation attributes.

6.3. Consumer Valuation in Expert Rating Information Rounds

Expert rating is generally maintained to be a very important source of information for consumers when making their wine choices. Repeated studies have shown that additional expert rating points are highly valued by consumers (see, for instance, Landon and Smith (1998) or Costanigro et al. (2007)). There are a multitude of wine rating organizations and publications. Participants in the laboratory experiment received ratings from Robert Parker's Wine Advocate and the Wine Spectator in rounds 3 and 7.

6.3.1. Consumer Valuation of Expert Rating

Participants received information on the ratings awarded to wines by the Wine Advocate (Robert Parker) and the Wine Spectator in the third and seventh rounds. Ratings for the wines used in the experiments ranged from 77 to 93, and the Wine Advocate did not review the Beaulieu or the Mirassou. Dummy variables for each rating were created: one for those wines not reviewed (*NR*), *77*, *85*, *88*, and *93*.

The coefficients estimated in this analysis are mostly intuitive. Higher ratings ought to yield higher bids, which was the case. It was unclear, however, how participants would interpret wines that were not reviewed by either wine rating publication. To analyze the data, bids in

rounds 3 and round 7 are regressed on the dummy variables for appellations, to control for the information participants already had, and the different expert ratings, with the 77-point rating being the omitted category. California is, again, the omitted appellation category. The estimated specification is

(3)

$$bid_{i23} = \alpha_0 + \beta_1 Knights\ Valley + \beta_2 Napa\ Valley + \beta_3 Oakville + \beta_4 Sonoma\ County + \beta_5(Not\ Reviewed) + \beta_6(85\ Points) + \beta_7(88\ Points) + \beta_8(93\ Points) + \varepsilon_i$$

The estimated coefficients are ordered as expected. The estimate of the intercept, which contains both the California appellation and the omitted 77-point category, was $5.65. The parameters on *Napa Valley*, *Oakville*, and *Sonoma County* continue to be statistically significant. *Knights Valley* no longer is estimated to have a significant effect on WTP, however. Wines not reviewed had an estimated coefficient of a $0.54 premium over the 77-point wine. A rating of *85 points* led to bids $1.96 higher than the omitted 77-point category. The *88-point* wines had an estimated coefficient of $2.29. Finally, participants were willing to pay $5.05 for a rating of *93 points*.

6.3.2. Consumer Valuation of Expert Rating and Consumer Characteristics

Table 7 displays results from the analysis of bids submitted with information on appellation and expert rating regressed on wine attributes (the specification in column 1), and bids regressed on wine attributes and consumer characteristics (column 2).

The linear addition of consumer characteristics again does not change the estimates of the attribute coefficients significantly, and all estimated attribute coefficients remain statistically significant. The intercept does decrease notably, reflecting the introduction of continuous (non-

dummy) variables such as wine knowledge quiz score, average price paid per bottle, age, and household income, which explain much of the variation previously captured by the intercept. After the introduction of the continuous variables, the intercept reflects the estimated bid with these variables measured at zero, so the previous estimated intercept has been decomposed into the contributions of different consumer characteristics.

With consumer characteristics added linearly to the estimation equation, the estimated coefficients on the wine attributes change little. As in the regressions in previous rounds, only two participant characteristics have a statistically significant affect on WTP: the mean *price paid per bottle*, and *wine club membership*. The estimated coefficient for *Price per Bottle* is 0.40; for every additional dollar participants reported spending per bottle of wine on average, their bids increased by $0.40. Secondly, *wine club membership* increased bids by $1.55. A categorical variable, the estimate suggests that members of wine clubs bid $1.55 more on average across all four wines than non-members. The consumer characteristics *Price per Bottle* and *Wine Club Member* are consistent predictors of higher bids across rounds.

6.4. Consumer Valuation in Winery Name Information Rounds

The next piece of information that participants received was winery name. Column 1 of table 8 reports the results of the regression of bids on appellations, expert ratings, and winery names. For the analysis, *Beaulieu Vineyards* was the omitted winery name variable. *California* and *77 Points* continued to be omitted categories. The regression of bids on appellations, expert ratings, and winery names yielded a positive, statistically significant estimate of the intercept of $6.63. Two appellations still significantly explain bids. The coefficient estimate for *Napa Valley* adds $0.94 to the intercept. *Oakville* has an estimated coefficient of $1.46. Three expert rating

scores are statistically significant. An *85-point* rating increased bids by $1.53, while *88-points* had an estimated coefficient of $2.27. A *93-point* rating increased bids by $4.66. The only winery name that affects bids is *Mirassou*. The estimated coefficient on *Mirassou* is -$0.76.

Column 2 of table 8 reports the results of the regression of WTP on appellations, expert ratings, winery names, and participant characteristics. Estimated coefficients of the wine attributes do not change with the addition of participant characteristics. The only statistically significant participant characteristic in this specification is the *price paid per bottle*, with an estimated coefficient of 0.43.

6.5. Consumer Valuation in Sensory Information Rounds

After the release of information on a wine's appellation, expert rating, and the winery that produced it, participants in this research received a sample of each wine to smell and taste. Following sensory examination of the sample, consumers submitted bids for the wines again. Table 4 showed that mean bids across all wines decreased with access to samples of each wine by an average of $0.73. Table 9 lists the results of two regressions of bid on each wine that participants sampled. All regressions feature a combination of dummy variables for the different wines and the quality rating, or *Hedonic Rating*, each participant assigned to each wine.

Column 1 in Table 9 contains the estimated coefficients of a regression of bid on the appellation, expert rating, and *Hedonic Rating* variables. Because of the smaller number of observations in the sensory round—half as many as the other rounds—including appellation, expert rating, and winery name creates perfect collinearity amongst regressors, winery name is left out of the regression. The sensory liking variable, *Hedonic Rating*, ranges from 50 to 100 points. In regression 1, none of the appellation variables has a statistically significant parameter

estimate. However, both *Expert Rating 88* and *Expert Rating 93* have positive and statistically significant parameters. The estimated parameter on *Hedonic Rating* is 0.243, or for each additional point a participant scored a wine, their WTP increased by nearly $0.25.

It is interesting to note that even with information about the taste and smell of the wines, the two highest expert ratings retained statistical significance. There are again multiple interpretations of the estimates. Participants may value having a highly rated wine beyond the enjoyment they receive from consuming it. A wine with a high expert rating may be more valuable as a gift or as a wine brought to a dinner party than a non-highly rated wine with the same sensory attributes. Alternatively, it may be that participants did not completely adjust their bids from the previous round. Additionally, a participant may have interpreted the expert rating as adding information about the likely enjoyment of the wine in a more natural setting to information gathered in the lab.

The variable, *Hedonic Rating*, reported in columns 1 and 2 in Table 9 is the quality rating that each participant awarded each of the wines, and reflects each participant's enjoyment of the wine. There was a significant amount of heterogeneity in wine preferences—a segment of the participants in the experiment preferred each wine. Including the *Hedonic Rating* variable in the regression should control for participants' heterogeneous preferences.

When controlling for the effect of heterogeneous consumer preferences, the coefficients on the wine attribute variables capture the effect of the sensory sample on participants' bids for wines enjoyed equally. In this case, the coefficient on each wine is the effect of the objective information on changes in bids for identically scored wines. The parameter estimate of *ER88* was 1.72, and the estimated parameter *ER93* was 1.84. As mentioned above, both parameters were statistically significant. If *Hedonic Rating* captured all of a consumer's value for a wine,

none of the other wine attributes should have explanatory power as regressors. The significance of *ER88* and *ER93* shows that other wine attributes remain relevant in wine valuation. Even with sensory information about the contents of the bottle, consumers value objective information.

Regression 2 in table 9 introduces participant characteristics into the regression specification from regression 1 in 9. Very few parameters are statistically significant here. Three participant characteristics positively affect WTP: *mean price spent per bottle*, *wine club membership*, and *education* (years of schooling). The first two, *price per bottle* and *wine club member* had significant parameter estimates in the analysis of bids in earlier rounds too. In the second specification, *price spent per bottle* increases bids by $0.32. *Wine club members* submit bids that are $1.47 higher on average. *Education*, with an estimated coefficient of 0.36, implies that with an additional year of school, a participant bids $0.36 more in the sensory round.

7. Conclusions

The results of the laboratory experiment confirm many of the previously held notions about valuation of wine by consumers. Participants value Cabernet Sauvignons from Napa Valley and Sonoma County and their sub-appellations more than wines labeled with the California appellation. Bids for wines rated by experts such as the Wine Advocate (Robert Parker) or Wine Spectator increased as the experts' ratings increased.

Including participant characteristics in the models revealed interesting and systematic results. Participants' bids for wines in the baseline rounds did not differ in a statistically significant manner, and the only statistically significant parameters were how much the participant typically spent per bottle of wine and whether the participant was a member of a wine club. The estimated coefficients on both were positive and highly significant. There seem to be

consistent behavioral differences captured by participant characteristics that influence the marginal valuations of wine attributes. The most consistent of these are mean price paid per bottle and wine club membership.

In the laboratory experiment analysis, mean price paid per bottle and wine club membership interact with the wine attributes to affect WTP. Statistically significant differences in the estimated coefficients of both *price paid per bottle* and *wine club membership* were found in the appellation, expert rating, and sensory information rounds. Recall that these are differences in the marginal valuations of wine attributes, not differences in the entire bottle. These differences stem from predictable consumer characteristics. Participants who pay higher mean price per bottle of wine and those belonging to wine clubs respond more to differentiating information than do those participants who typically spend a lower price and those not belonging to wine clubs, demonstrating that even without supply-side influences, there are reasons that price differences exist in the market for different attributes.

In the absence of other quality signals, appellation is a highly valued and important component of consumer valuation. However, as this research demonstrated, valuation of appellation and other wine attributes differs across segments of the consumer population. Importantly, this implies that own- and cross-price elasticities of demand will differ across segments of the population, and are not consistent with findings based on a typical hedonic price regression on market data.

Further, the sensory round showed significant heterogeneity in preferences amongst participants. At least 15 percent of participants rated each wine as the best wine from a sensory standpoint. Overall, the ranking of wines by experts reflected the average ranking of wines by participants, but many participants exhibited preferences significantly different from those of the

expert raters. Importantly, this research has demonstrated that significant heterogeneity in marginal preferences exists for objective wine attributes, and that there is a significant amount of heterogeneity in consumer preferences for sensory wine attributes.

Table 1: Information Categories and Timing of Release

Information Category	Group 1	Group 2
Baseline Information	Round 1: Bid	Round 5: Bid
Appellation	Round 2: Bid	Round 6: Bid
Expert Rating	Round 3: Bid	Round 7: Bid
Winery Name	Round 4: Bid	Round 8: Bid
Sample (taste/smell)		Round 9a: Liking Score
		Round 9b: Bid

Source: Design of laboratory experiment.

Table 2: Descriptive information on the wines used in the laboratory experiment

Winery	Appellation	Expert Rating	Shelf Price	Cases Produced
Beaulieu Vineyards	Napa Valley California	R. Parker: NA Wine Spec: 77	$20	127,000
Beringer	Knights Valley Sonoma County	R. Parker: 88 Wine Spec: 88	$25	83,500
Mirassou	California	R. Parker: NA Wine Spec: 85	$10	21,639
Robert Mondavi	Oakville Napa Valley	R. Parker: 88 Wine Spec: 93	$45	10,637

Source: Design of laboratory experiment.

Table 3: Wine Knowledge and Experience and Demographic Data

	Mean	Standard Error	Minimum	Maximum
Quiz (%)	0.63	0.17	0.18	1.00
Bottles/Month	4.84	0.32	0	25
Price/Bottle	11.59	0.29	7.5	25
Years Buying Wine	11.04	0.66	2.5	35
Wineries Visited per Year	3.77	0.27	0	20
Wine Club Member (%)	0.19	0.03	0	1
Read Wine Literature (%)	0.47	0.03	0	1
Prefer Red (%)	0.77	0.03	0	1
Class on Wine (%)	0.27	0.03	0	1
Keep Wine Journal (%)	0.14	0.03	0	1
Sensory Trained (%)	0.21	0.03	0	1
Female (%)	0.56	0.03	0	1
Age	35.76	0.86	25	65
Household Income ($1000s)	65.35	3.72	15	200+
Education	16.58	0.10	12	18

Source: Participant Questionnaire, Laboratory Experiment
Notes: 215 observations

Table 4: Mean Bids Per Round

Round	Mean (Std. Error)	Change	Percentage Change
All (Rounds 1-8, 9b)	7.74 (0.36)		
Baseline (Round 1 and 5)	6.59 (0.28)		
Appellation (Round 2 and 6)	7.48 (0.33)	+0.89	+13.51%
Expert Rating (Round 3 and 7)	8.17 (0.39)	+0.69	+9.22%
Winery Name (Round 4 and 8)	8.62 (0.40)	+0.45	+5.51%
Taste/Smell (Round 9b)	7.89 (0.40)	-0.73	-8.47%
Price of CA Cab. Sauv. sold at Nugget Market, weighted by bottles sold.	12.70		
Shelf price of wines used in the laboratory experiment	25.00 (7.72)		

Source: Experiment data generated in rounds 1-8 and 9b.
Notes: There are 1756 observations for each category of information and 7912 observations for the calculations in "All Rounds".
Data provided in the table are means and, in parentheses, standard deviations.

Table 5: Comparison of Bids in Rounds 1 and 5 on Baseline Attributes, and Consumer Characteristics.

	Baseline: Wine Attributes (1)	Baseline: Attributes with Consumer Characteristics (2)
Intercept	6.63**	-0.95
	(0.27)	(3.18)
Wine 2	-0.011	-0.011
	(0.028)	(0.028)
Wine 3	-0.013	-0.014
	(0.028)	(0.028)
Wine 4	-0.011	-0.012
	(0.028)	(0.028)
Quiz		0.41
		(1.76)
Bottles Purchased per Month		0.049
		(0.068)
Price Paid per Bottle		0.25**
		(0.066)
Years Buying Wine		0.054
		(0.052)
Wineries Visited per Year		-0.016
		(0.078)
Wine Club Member		1.58**
		(0.77)
Prefer Red Wines		0.63
		(0.61)
Class Taken		0.63
		(0.59)
Read Wine Literature		0.22
		(0.57)

Table 5 Continued

	Baseline: Wine Attributes (1)	Baseline: Attributes with Consumer Characteristics (2)
Keep Wine Journal		-1.07
		(0.79)
Female		-0.42
		(0.50)
Age		-0.027
		(0.041)
Income ($1000s)		0.010
		(0.0064)
Education		0.20
		(0.18)
Akaike Information Criterion	3398.7	3346.9
Bayes Information Criterion	3431.5	3455.8
Log-Likelihood Score	-1693.4	-1653.5

Notes: Significance: (**) = $p \leq 0.05$; (*) = $p \leq 0.10$ with a two-tailed test.
Reported values are coefficients and standard errors in parentheses.
Number of observations = 1756 observations
Source: Laboratory experiment bids rounds 1 and 4.

Table 6: Comparison of Regressions of Bids in Rounds 2 and 6 on Appellation and Consumer Characteristics.

	WTP for Appellation (1)	WTP for Appellation with Consumer Chars. (2)
Intercept: California	6.42**	-3.75
	(0.31)	(3.39)
Knights Valley	0.65**	0.66**
	(0.14)	(0.14)
Napa Valley	2.19**	2.17**
	(0.11)	(0.11)
Oakville	1.63**	1.66**
	(0.14)	(0.14)
Sonoma County	1.92**	1.88**
	(0.14)	(0.14)
Wine Quiz		0.96
		(1.87)
Bottles Purchased per Month		0.042
		(0.072)
Price Paid per Bottle		0.347**
		(0.070)
Years Buying Wine		0.022
		(0.055)
Wineries Visited per Year		0.046
		(0.083)
Wine Club Member		1.53*
		(0.82)
Prefer Red Wines		0.60
		(0.65)
Class Taken		0.86
		(0.63)

Table 6 Continued

	WTP for Appellation (1)	WTP for Appellation with Consumer Chars. (2)
Read Wine Literature		0.23
		(0.60)
Keep Wine Journal		-1.18
		(0.84)
Female		-0.43
		(0.54)
Age		0.006
		(0.044)
Income ($1000s)		0.0092
		(0.0067)
Education		0.21
		(0.19)
Akaike Information Criterion	7821. 4	7649.6
Bayes Information Criterion	7859.6	7763.9
Log Likelihood Ratio	-3903.7	-3803.8

Notes: Significance: (**) = $p \leq 0.05$; (*) = $p \leq 0.10$ with a two-tailed test.
Reported values are coefficients with standard errors in parentheses.
Number of observations = 1756.
Source: Laboratory experiment data from rounds 2 and 6.

Table 7: Comparison of Regressions of Bids in Rounds 3 and 7 on Appellation, Expert Rating, and Consumer Characteristics.

	WTP for Appellation and Expert Rating	WTP for Appellation and Expert Rating with Consumer Chars.
	(1)	(2)
Intercept: California, 77 Points	5.65**	-5.44
	(0.42)	(3.70)
Knights Valley	0.61	0.65*
	(0.37)	(0.38)
Napa Valley	0.99**	0.99**
	(0.27)	(0.27)
Oakville	1.47**	1.50**
	(0.36)	(0.36)
Sonoma County	1.15**	1.20**
	(0.37)	(0.38)
Not Reviewed	0.54**	0.54**
	(0.27)	(0.27)
85 Points	1.96**	1.93**
	(0.31)	(0.32)
88 Points	2.29**	2.24**
	(0.26)	(0.27)
93 Points	5.05**	5.01**
	(0.27)	(0.27)
Wine Quiz		0.47
		(2.04)
Bottles Purchased per Month		0.069
		(0.078)
Price Paid per Bottle		0.398**
		(0.077)
Years Buying Wine		0.031
		(0.060)

Table 7 Continued

	WTP for Appellation and Expert Rating (1)	WTP for Appellation and Expert Rating with Consumer Chars. (2)
Wineries Visited per Year		0.004
		(0.090)
Wine Club Member		1.55*
		(0.90)
Prefer Red Wines		0.76
		(0.71)
Class Taken		0.81
		(0.68)
Read Wine Literature		0.35
		(0.66)
Keep Wine Journal		-0.93
		(0.91)
Female		-0.18
		(0.59)
Age		0.021
		(0.048)
Income ($1000s)		0.003
		(0.007)
Education		0.21
		(0.21)
A: Akaike Information Crit.	8891.7	8724.5
B: Bayes Information C.	8951.9	8860.5
L: Log Likelihood	-4434.9	-4337.2

Notes: Significance: (**) = $p \leq 0.05$; (*) = $p \leq 0.10$ with a two-tailed test.
Reported values are coefficients with standard errors in parentheses.
Number of observations = 1756.
Source: Laboratory experiment rounds 3 and 7.

Table 8: Regression of bids for wines in rounds 4 and 8 with appellation, expert rating, winery name, and consumer characteristics.

	Bids with Appellation, Expert Rating, and Winery (1)	Bids with Appellation, Expert Rating, and Winery with Consumer Characteristics (2)
Intercept: California, 77 Points, Beaulieu Vineyards	6.63**	-4.15
	(0.47)	(3.73)
Knights Valley	-0.18	-0.15
	(0.50)	(0.51)
Napa Valley	0.94**	0.94**
	(0.34)	(0.34)
Oakville	1.46**	1.49**
	(0.44)	(0.44)
Sonoma County	0.11	0.13
	(0.50)	(0.50)
Not Rated (ERNR)	0.53	0.52
	(0.37)	(0.37)
Expert Rating 85 (ER85)	1.53**	1.51**
	(0.43)	(0.43)
Expert Rating 88 (ER88)	2.27**	2.22**
	(0.35)	(0.35)
Expert Rating 93 (ER93)	4.66**	4.64**
	(0.35)	(0.36)
Beringer	-0.093	-0.082
	(0.222)	(0.225)
Mirassou	-0.76**	-0.77**
	(0.25)	(0.24)
Mondavi	-0.19	-0.20
	(0.21)	(0.25)
Quiz (%)		-0.24
		(2.05)

Table 8 Continued

	Bids with Appellation, Expert Rating, and Winery (1)	Bids with Appellation, Expert Rating, and Winery with Consumer Characteristics (2)
Bottles Per Month		0.085 (0.079)
Price Per Bottle		0.43** (0.08)
Years Buying Wine		0.014 (0.060)
Wineries Visited/Year		0.007 (0.090)
Member of Wine Club		1.08 (0.90)
Prefer Red Wines		0.82 (0.71)
Taken a Wine Class		0.66 (0.69)
Read Wine Literature		0.39 (0.66)
Keep Wine Journal		-0.60 (0.92)
Female (%)		-0.44 (0.59)
Age (Years)		0.042 (0.048)
Household Income ($1000s)		0.005 (0.007)
Education (Years)		0.16 (0.21)

Table 8 Continued

	Bids with Appellation, Expert Rating, and Winery (1)	Bids with Appellation, Expert Rating, and Winery with Consumer Characteristics (2)
Akaike Information Criterion	9506.4	9322.6
Bayes Information Criterion	9582.9	9474.9
Log Likelihood Ratio	-4739.2	-4633.3

Notes: Significance: (**) = $p \leq 0.05$; (*) = $p \leq 0.10$ with a two-tailed test.
We report estimated coefficients, and standard errors are in parentheses.
Number of observations = 1756.
Source: Laboratory Experiment Data from Rounds 4 and 8.

Table 9: Regression of bid on objective and intrinsic wine information, including the participants' hedonic ratings of the wines, and consumer characteristics.

	Regression of Bid on Appellation, Expert Rating, and Hedonic Score (1)	Regression of Bid on Appellation, Expert Rating, Hedonic Score, and Consumer Characteristics (2)
Intercept: California, 77 points	-11.67**	-24.21**
	(1.10)	(3.66)
Knights Valley	-0.46	-0.31
	(0.74)	(0.74)
Napa Valley	0.67	0.71
	(0.54)	(0.54)
Oakville	0.69	0.80
	(0.74)	(0.74)
Sonoma County	-0.52	-0.48
	(0.67)	(0.67)
Not Rated (ERNR)	0.49	0.47
	(0.64)	(0.65)
Expert Rating 85 (ER85)	0.87	0.91
	(0.79)	(0.75)
Expert Rating 88 (ER88)	1.72**	1.65**
	(0.60)	(0.60)
Expert Rating 93 (ER93)	1.84**	1.92**
	(0.54)	(0.55)
Hedonic Rating	0.243**	0.234**
	(0.011)	(0.011)
Quiz (%)		0.33
		(1.93)
Bottles Per Month		0.105
		(0.074)

Table 9 Continued

	Regression of Bid on Appellation, Expert Rating, and Hedonic Score (1)	Regression of Bid on Appellation, Expert Rating, Hedonic Score, and Consumer Characteristics (2)
Price Per Bottle		0.321**
		(0.073)
Years Buying Wine		0.01
		(0.06)
Wineries Visited/Year		-0.002
		(0.085)
Member of Wine Club		1.47*
		(0.85)
Prefer Red Wines		0.67
		(0.67)
Taken a Wine Class		0.42
		(0.65)
Read Wine Literature		0.38
		(0.62)
Keep Wine Journal		-0.73
		(0.86)
Female (%)		-0.01
		(0.55)
Age		0.055
		(0.045)
Household Income ($1000s)		-0.004
		(0.007)
Education		0.36*
		(0.20)
Akaike Information Criterion	4882.3	4772.1
Bayes Information Criterion	4939.6	4895.4
Log Likelihood Ratio	-2429.2	-2360.0

Notes: Significance: (**) = $p \leq 0.05$; (*) = $p \leq 0.10$ with a two-tailed test.
Number of observations = 860; Source: Laboratory Experiment Round 9a and 9b

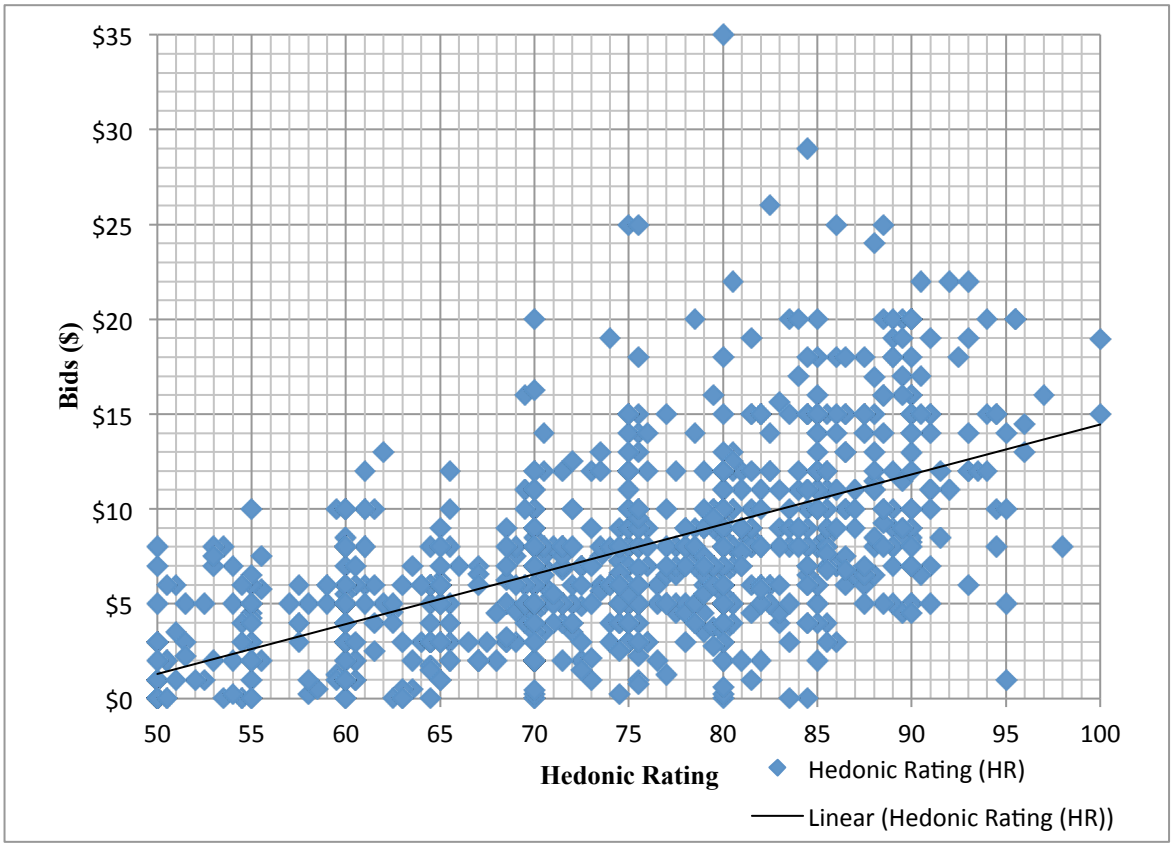

Figure 1: Plot of Bids in Round 9b against Hedonic Rating awarded by each Participant to each wine.
Source: Hedonic ratings from round 9a, bids from round 9b.
Observations: 860