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Abstract:

This paper uses a novel experimental approach to measure consumer willingness to pay for wine attributes in a hedonic framework. The research design allows us to deal with identification issues resulting from the interaction of demand and supply and to examine the effect of supply-side influences in price data. We employ information from observed wine choices and individual fixed effects to account for consumer heterogeneity and sorting. The effects of controlling for supply and addressing sorting and heterogeneity yield estimates of WTP for wine attributes markedly different than those found by past studies. The results demonstrate that consumer sorting is an important force in product markets and that consumer preferences for unobserved attributes drive valuation differences significantly. For instance, consumers in our sample display greater strength of preference over wine varieties than they do for appellations. It is therefore necessary to interpret results carefully when using valuation data that has been generated in controlled conditions.

1. Introduction

What do people value in a wine? This question, which is more complicated than it seems, is of great interest to the $18.5 billion/year U.S. wine industry, wine writers, sommeliers, wine retailers, and economists interested in hedonic pricing theory. An understanding of how consumers value wine attributes is important for restaurants and retailers to meet consumer expectations of product mix and quality. It is also critical for viticulturists and wine-makers choosing what types of grapes to plant and where to plant them. For instance, is wine a product for which "location, location, location"—and the reputation of appellations like Napa Valley—is paramount? Or do people predominately value wine variety?

The answer to this question is complicated. The retail market for wine is highly differentiated—multiple attributes distinguish wines sold over a wide range of prices—and disaggregated data on sales of wine is generally unavailable. Even with access to data on individual wine purchases, separating consumer valuation from confounding factors—such as the cost associated with producing different wines—is very difficult.

In this paper, we estimate consumer valuation for appellation—where the grapes were grown—and grape variety attributes of American wines. A novel experimental valuation tool, tailored to a consumer choice setting, accounted for the usual confounds—i.e., separating consumer valuation from the supply side—as well as consumer self-sorting into specific market segments and other, "behavioral" influences. Participants in the research were consumers shopping in the wine aisle of a small California supermarket chain with an extensive wine inventory who we observed make an initial, un-influenced choice.

Empirical research on consumer valuation of wine attributes is inextricably tied to the hedonic pricing literature. Building from the first studies of implicit prices of product attributes, Rosen's (1974) theoretical presentation of implicit attribute prices—and therefore the price of the attribute bundle—as the result of demand for and supply of attributes has guided subsequent thinking about markets for multi-attribute, differentiated products. Implementing Rosen's theory in empirical settings, however, has proved difficult. Some of the difficulties are common to any empirical study, while others are specific to hedonic contexts. Identifying demand parameters separately from supply is a problem for any empirical study. Identification refers to the parsing of market data to estimate separately demand-side or supply-side parameters. Brown and Rosen (1982), Bartik (1987), and Epple (1987) all identified problems with the empirical approach, ranging from lack of appropriate data to endogeneity between attribute prices and quantities. Since then, authors wanting to estimate parameters of the demand for or supply of attributes have worked to develop methods to address those problems.

This paper belongs to a branch of the hedonic literature that has exploited exogenous changes in an attribute to allow identification of attribute valuation. Nerlove (1995) obtained data from the Swedish state alcohol importer on wine sales and attributes to estimate consumer valuation of wine, arguing that the supply of wine was exogenous for the Swedish market. Most developments in hedonic estimation, though, have come in the realm of public economics, and in particular, valuation of school quality and neighborhood amenities.

Black (1999) studied housing prices in narrow bands around school attendance zone boundaries. This strategy reduced the effect of consumers sorting—self-locating

according to differences in neighborhood amenities, but required assumptions on the preferences and similarity of buyers on either side of the boundary. However, Black (1999) was unable to observe or account for all individual-level characteristics or housing or neighborhood attributes, which are at the core of sorting. Bayer et al. (2007) extended this work to incorporate neighborhood demographic data, such as racial composition, but also required assumptions on preferences and buyers, and had unobserved consumer characteristics and product attributes.

This paper furthers methods for the estimation of consumer valuation of product attributes. We estimate marginal willingness to pay (WTP) for wine attributes in the neighborhood of a wine selected by each consumer in our sample. These consumers valued six exogenously selected wines. The researchers observed all of the attributes of the alternative wines available to the participant during the experiment, minimizing risk of unobserved product attributes biasing WTP estimates. Collecting six WTP observations per consumer permitted us to use the fixed effects estimator to control for unobserved (and observed) consumer characteristics.

We find that marginal WTP for wine attributes changes dramatically when we resolve identification and sorting issues fully. Our initial estimates of WTP for appellation and variety attributes—not controlling for identification or sorting—correspond closely to past estimates, with high WTP for prestigious appellations like Napa Valley and little variation in WTP for grape varieties (Bombrun and Sumner, 2003). However, once we implement the full suite of controls, participants appear to have stronger preferences—represented by the estimated WTP parameters—over grape varieties than over appellations. In fact, WTP for appellation is only statistically

significant for two appellations compared to Central Valley appellations: Monterey County and San Luis Obispo County. Participant WTP for Napa Valley and Napa and Sonoma County sub-appellations is not significantly different from WTP for Central Valley sub-appellations.

The paper proceeds as follows. The next section (2) situates this paper within the empirical hedonic pricing and related experimental economic literatures. Section 3 provides background on the American wine market and sales, locally and nationally. Most of our discussion within these sections focuses on appellation and variety attributes—the attributes of interest in this paper. Section 4 presents the theoretical framework of the research. The design of the experiment replicates the theoretical specification of Rosen's (1974) model of demand for product attributes. Section 5 describes the details of the experiment and provides descriptive statistics of the data generated and collected in the experiment. In section 6, we develop the econometric specifications to analyze the data. We examine three models: the first regresses WTP data on attributes; the second controls for the supply side, solving the identification problem, and addresses behavioral economic effects; and the third resolves sorting, identification, and behavioral economic effects. Section 7 contains results and interpretation of the estimation, and Section 8 concludes the paper.

2. Applied Hedonic Pricing Studies and Experimental Economics

Economists use hedonic pricing models to estimate the value of the attributes of a good, both for attributes that are external to the good studied, such as the effect of access to parks or open space on housing prices, and for product attributes that are bundled in a good, e.g. the value of an extra point from the *Wine Spectator* magazine. Both types of

good have been widely studied. The housing literature has provided estimates of consumer valuation of environmental externalities such as air pollution (Palmquist, 1984) and valuation of public goods, such as school quality and neighborhood amenities (Black, 1999; Bayer et al., 2007). Consumer products studied include cars (Griliches, 1961), breakfast cereal (Stanley and Tschirhart, 1991), wine (Nerlove, 1995), and personal computers (Pakes, 2003). Though hedonic pricing analysis is a widely used empirical tool, the conditions necessary to move beyond estimation of first-stage, implicit attribute prices rarely occur, which limits estimation of the parameters of the consumer valuation function or supply function. Empirically, the two main issues that researchers must overcome are identification and sorting.

A great deal of research has been devoted to identification and sorting (Brown and Rosen, 1982; Bartik, 1987; Epple, 1987; Ekeland et al., 2004; Bayer et al., 2007). Identification (famously discussed by Working (1929)) is the problem of identifying demand parameters separately from supply parameters in market-generated data. The interaction of demand and supply determines the prices and quantities of goods traded in the market. Without thorough information on changes in supply, it is very difficult to trace out demand, and vice-versa. Sufficient controls or instruments for the supply side of the market rarely exist, particularly for multi-attribute goods like wine.

Sorting refers to correlations between consumer characteristics and product attributes that arise when consumers locate themselves in the product space. Sorting is a problem for WTP estimation if the consumer characteristics correlated with a product attribute are unobserved. The relationship between unobserved variables and WTP can lead to estimates that conflate WTP for product attributes with the influence of the

unobserved consumer characteristic on WTP. A number of strategies for recovering parameters estimates have been proposed, including methods that impose on the data distributions of preferences in the population, and "quasi-experimental" methods.

The quasi-experimental literature exploits exogenous discontinuities in an attribute of interest to control for unobserved product attributes and consumer characteristics. A branch of this literature studying school quality valuation found that the inclusion of school attendance boundary fixed effects, to control for unobserved neighborhood amenities and consumer characteristics, reduced estimates of WTP for school quality significantly (Black, 1999; Bayer et al., 2007; Ferreira, 2010). Black (1999) found that looking at housing prices in a narrow band around the school attendance boundaries reduced the estimate of marginal WTP for increased school quality by 50 percent compared to standard methods, and Bayer et al. (2007) estimated marginal WTP for school quality to be 75 percent lower than standard hedonic estimates by including additional neighborhood and household characteristics.

A correlate to the spatial location choice in housing markets exists in consumer product markets. Just as households choose a neighborhood, consumers locate themselves in the spectrum of available goods. This makes estimates of WTP for consumer goods vulnerable to the influence of unobserved variables. The researcher's inability to observe the characteristics of the consumer that affect their location in the market may result in estimates that confound the location choice with attribute valuation. Though the quasi-experimental literature has made progress in accounting for sorting and observable consumer, housing, and neighborhood characteristics, there are additional gains to be

made in identification, sorting, and accounting for unobservable consumer characteristics and product attributes.

A number of researchers have conducted first stage hedonic analysis of wines, but have not had the data available to estimate demand parameters. The *Wine Spectator* provides the data used in a number of empirical analyses of wine markets (e.g. Bombrun and Sumner, 2003). *Halliday* and *Winestate* have been used as well (Oczkowski, 2001; Schamel and Anderson, 2003). For these studies, researchers examine the relationship between information available to the consumer on the label—including variety, appellation, winery, and vintage—the rating given by the magazine, any special designations (e.g. Best Buy or Cellar Selection), and the number of cases produced by the winery, and the per bottle release price of the wines.

A few studies of wine have used data that the authors argue allow them to deal with the identification issue and to estimate WTP parameters. Nerlove (1995) used data from the Swedish state-importer of alcohol. He used these data to estimate the own-price demand elasticity for wine in Sweden, arguing that the state importation of wines resulted in completely elastic, parallel supply of wines. Ashenfelter (2008) gathered auction data on Bordeaux wines, and along with weather data, used it to predict the prices and quality of the wine. Gergaud and Ginsburgh (2008) used a larger set of auction data to study the effect of natural endowments and technology on wine quality. Auction sales allow observation of valuation of all products offered at the auction; while the broader costs of production are not included, the supply of the product within the auction is fixed. Ashenfelter and Storchmann (2010) studied the effect of physical landscape features on historic vineyard prices in Germany to predict the effect of climate change. In these cool,

northern, marginally productive grape-growing lands, the fixed supply of vineyard sites allowed the authors to argue that they solved the identification problem.

Techniques from experimental economics have become increasingly popular as a way to study consumer valuation of attributes. These techniques are implicitly related to traditional hedonic price analysis, but rely on experimental variation in attributes to identify valuation on the margin. Researchers in this field have used experimental methods to elicit consumer valuation of foods, new technologies, and novel products, or to register consumer responses to new information (Hayes et al. (1995), Lusk et al. (2001), and Fox et al. (2002)). These studies have tended to focus on relatively homogenous products (e.g. pork chops (Melton et al., 1996)).

We have mentioned two market features that directly affect estimation of demand parameters. Identification and consumer sorting may both lead to biased estimates of parameters of the WTP function. The use of experimental economic techniques to study a hedonic market enables the creation of datasets containing enough information to control for identification and sorting. However, experimental economics introduces additional indirect influences that may inadvertently affect estimates of parameters of the WTP function. Each of these direct and indirect factors confounding the estimation of WTP parameters arises primarily either from the demand side or the supply side. Recently, more attention has been paid to the indirect forces in both experimental and real world contexts. In the design of our experiment and the analysis of the resulting data, we account for all four effects that may bias estimates of parameters of the value function.

In addition to directly affecting prices and quantities of goods sold in the market, the supply side also enters into WTP measures indirectly when experiments are used to

elicit WTP data. The indirect influence of the supply side on WTP measures is a subtler issue than the standard identification problem. A number of researchers have found that on average people use particular heuristics to arrive at numerical bids or estimates when lacking information and in situations of uncertainty. The anchoring and adjustment heuristic refers to that process (Tversky and Kahneman, 1974). When formulating an answer, a person refers to a pertinent reference number—the anchor—and then adjusts an estimate from that anchor.

Ariely et al. (2003) provided evidence of the anchoring and adjustment heuristic in an experimental economic valuation setting. To be able to test for an effect in these articles, the researchers controlled the values on which participants anchored. Simonsohn and Loewenstein (2006) used data on housing expenditures to show that a consumer's normal housing expenditure affects the amount they spend when they move to a new market with different housing costs. Beggs and Graddy (2009) find that anchoring affects prices at auction for paintings last sold during a hot or cold market. In many cases, the anchor relevant to a consumer will not be observable by the researcher.

The experimental setting also creates indirect demand side effects. First, consumers locate themselves in the spectrum of available products. Attribute bundles far from their location may lack saliency to both the consumer and the researcher. Additionally, in our study, consumers had different motivations for choosing their original bottle of wine (e.g., some chose it to pair with food immediately; others chose it to age). Loewenstein (2000) discusses how visceral emotions, such as hunger and thirst, affect decision-making and valuation. Others, such as Levitt and List (2007a), have

warned of attributing long-term relevance to short-term outcomes of decisions made under visceral influences induced in experimental settings.

Bushong et al. (2010) provide direct evidence on the effect of saliency on consumer valuation. They performed an experiment examining the effect of physical presence of appetitive goods—items that are governed by appetite—on WTP. Participants bid on food items in one of three conditions: 1) a written description of the good, 2) a photograph of the good, or 3) the good. Bushong et al. (2010) found that WTP was 40-61% higher when the good was physically present than when it was only described or pictured. With refinements to their experiment, they concluded that the valuation differences were due to Pavlovian processes. Pavlovian processes are mechanisms that lead people to experience stronger physical desires, such as hunger or thirst, for appetitive goods when exposed physically to the good. If Pavlovian processes affect wine valuation, studying consumers who were in the act of buying wine provides the ideal setting for collecting data on WTP for wine attributes.

3. The Domestic Wine Market & Context for the Experiment

About $18.5 billion of wine was sold in a variety of settings in the U.S in 2010. Retail sales by volume in grocery, liquor, and drug stores in the United States are dominated by wines in the $0 to $9 range—79.5 percent of wine sales occur in that range according to Nielsen ScanTrack data for the year ending May 1, 2010. We limited the wines eligible for the experiment to wines with original shelf prices of at least $10. At lower price levels, too few appellations and varieties were sold to provide enough alternative wines for the experiment to function, and at higher price levels, product differentiation increases. While this range ($10 and above) represented only 20.5 percent

of the market by volume for the year ending May 1, 2010, by value it comprised 41.2 percent of the market (Nielsen Scantrack, 2010).

Many attributes differentiate one bottle of wine from another. These attributes include appellation—the geographically delimited location in which the grapes used in the wine were grown; the variety of grape used to produce the wine; the vintage, or year in which the grapes were grown; the winery; sensory and chemical descriptions and attributes of the wine; and third party assessments of a wine's quality (e.g. *Wine Spectator* ratings).

3.1 Attributes of Interest: Appellation and Variety

In this paper, we focus on two important wine attributes. The appellation is the region in which the grapes were grown. Appellations provide different climatic and soil conditions, which affect the sensory qualities of the wines (Ashenfelter (2008) and Ashenfelter and Storchmann (2010)). Appellations also accrue reputations, which are thought to influence consumers' purchasing decisions and valuation of a wine. Grape variety contributes different sensory attributes to a wine.

Two categories of appellation apply in the American wine market. The first category includes county and state appellations, defined by political boundaries. The second category, the American Viticultural Area (AVA), applies to distinct geographical characteristics (climate, soil, etc.) that differentiate grapes. There are nearly 200 AVAs, including some renowned AVAs such as Napa Valley. These appellations reflect different growing conditions for wines, and can produce a range of sensory attributes in the wine due to differences in climate, soil composition, and other environmental factors. Another significant function of wine appellation is as a quality signal (Landon and Smith,

1998). The variation in reputation of wine appellations and different levels of comprehension of wine appellations and varieties creates the ideal conditions to study consumer valuation of a product differentiated by multiple attributes.

Wine variety is also a very important attribute in the wine market. Wine grapes, once planted, require three years to begin producing fruit, and are considered to be fully productive after five years (Smith et al., 2010). The decision to establish a vineyard or replant a vineyard represents a significant investment on the part of the grower. Sales data indicate large differences in sales by grape variety. Nielsen scanner data (2010) report national sales by volume and price. Nationally, the three most significant varieties by volume and sales were Chardonnay, Cabernet Sauvignon, and Merlot. The seven varieties we study—Cabernet Sauvignon, Chardonnay, Merlot, Pinot Grigio, Pinot Noir, Sauvignon Blanc, and Zinfandel—accounted for 59.4 percent of sales by volume, and 67.1 percent of sales by value in the Nielsen data. The data do not, however, contain shelf prices, so we are unable to calculate these numbers solely for wines that qualify for our experiment. In our local data on sales of wine by grape variety, the data show that Chardonnay, Sauvignon Blanc, and Cabernet Sauvignon are the three highest-selling varietal wines, comprising 41 percent of total wine sales by volume (Nugget Markets, 2007). The seven varietal wines specifically studied in the field experiment—the three listed above along with Merlot, Pinot Grigio, Pinot Noir, and Zinfandel—account for 66 percent of local wine sales volume.

3.2. Other Product Characteristics That Affect WTP

Other wine attributes likely contribute to consumer WTP. We cannot control for all additional attributes, but do include vintage of both original and alternative wines and

expert rating of the original wine choice as controls. We deal with winery name and label design differently. We randomly draw each alternative wine presented to a participant from the total pool of relevant alternative wines, which removes a possible source of bias in our valuation estimates since the influence of winery name on valuation thereby becomes part of the error term.

The expected valuation of the winery attribute is mean independent of the appellation and variety variables. By accounting for the shelf price, and unobserved quality captured by that variable, we generate independence between the expected value of the variables of interest—appellation and grape type—and the alternative variables, such as winery name. With market price held constant, the difference between the expected value of the original winery's name and the expected value of alternative winery's names for all alternative wines is distributed normally. If this were not true, and the expected value of labeling a wine with a specific winery were positive, the retailer (or winery) could adjust the price to increase profit per sale, or more shelf space could be dedicated to the wine. With our design, we elicit the valuation for appellation and variety conditional on market price averaged across wineries producing wines at that market price.

Label design and bottle features such as closure type (cork, screw top, or synthetic closures) are also important variables. In the experiment's computer interface, we present consumers with an identical, generic representation of a wine bottle for all original and alternative wines (see Figure 1). Participants know the label design of the original bottle of wine, but not the alternatives. Without information on the label design of the alternative wines, participants will likely make one of two assumptions. They may

assume an average label for each alternative wine, thereby having no mean effect on their valuation of the alternative bottles. Alternatively, participants may require an additional discount for each alternative wine due to the missing label design information. Either assumption, however, does not affect the marginal differences between the alternatives. While each of these two possible outcomes implies a different discount required to switch from the original to the alternative, in neither case will it affect the results of the analysis of consumer WTP for the alternative wines.

4. Hedonic Theory and Consumer Valuation

Rosen's (1974) derivation of the consumer value function from the utility function guided the design of the experiment. In this section we lay out the theoretical underpinnings of the experiment. In the next section, we describe the implementation of the experiment.

We assume consumers choose the good that offers their preferred bundle of attributes, subject to their income and relative prices. As is commonly assumed in markets for differentiated, multi-attribute goods, the utility a consumer attains can be modeled as a function of the attributes of the product they consume.

The market for American wines consists of K wines. Each wine can be described by a vector of attributes, $\mathbf{z_k}$, where k = (1,…,K). Included are attributes such as the appellation of the wine, the variety of grapes used to make the wine, the vintage, or year the grapes were grown, the winery name, label design, bottle closure, expert rating, and sensory qualities of the wine itself, amongst others. A consumer's utility depends on the attributes of the wine they consume, and on consumption of a composite numeraire good, x. Consumers differ in their income, y, and have heterogeneous characteristics and

preferences, represented by the vector, $\boldsymbol{\alpha}$. Let each consumer be indexed by i = (1,…,I). Then, utility can be represented by $U(\mathbf{z_k}, x, \boldsymbol{\alpha_i})$. Each consumer, i, chooses a wine k (comprising a vector of attributes $\mathbf{z_k}$) and quantity of the numeraire good, x, to maximize their utility, subject to a budget constraint:

(1) Maximize $U(x, \mathbf{z_k}|\boldsymbol{\alpha_i})$ subject to $y_i \geq x + p(\boldsymbol{z_k})$.

The price of the numeraire good, x, is normalized to one. Now we define a value function for each consumer. Each participant's value is a function of the good's attributes and participant characteristics (including preferences). To generate the value function, we establish a reference level of utility, u_i^0, and define an indifference surface over which x and $\mathbf{z}$ vary, while u_i^0 is held constant,

(2) $u_i^0 = U(x, \mathbf{z_k}|\, \boldsymbol{\alpha_i})$.

As long as utility monotonically increases in x, the relationship can be inverted to solve for x,

(3) $x = U^{-1}(\mathbf{z_k}|\, \boldsymbol{\alpha_i}, u_i^0)$.

Equation (3) can then be inserted into the budget constraint, and by rearranging terms, we obtain an expression of the value function—a consumer's maximum WTP for the good as a function of the good's attributes, the consumer's income, preferences, and the reference level of utility. In general terms, the value function can be written as:

(4) $v_i(\boldsymbol{z_k}|y_i, \boldsymbol{\alpha_i}, u_i^0) \equiv WTP_{i,k}$.

If a consumer purchases any amount of a good, the consumer's WTP for that bundle of attributes must be greater than or equal to the market price. To be specific, if a consumer buys some wine k, then $WTP_{i,k} \geq p_k$, where p_k is the market price of the wine.

We also have that consumer surplus—the term $(WTP_{i,k} - p_k)$—must be greater for the selected good than for any other good available:

(5) $(WTP_{ik} - p_k) \geq \left(WTP_{ij} - p_j\right),\ \forall\, j,k.$

That is, consumer i's chosen good k must provide at least as much consumer surplus as any other good j available to consumer i.

Equations 4 and 5 are the point of departure for this paper. The field experiment begins with the observation of a consumer's wine choice. The choice is consistent with equation (4) at the optimized vector of wine attributes subject to prices and income facing each consumer. Consequently, the reference level of utility for participants is u_i^*, where u_i^* is the level of utility resulting from the constrained optimization problem of equation (1) for consumer i. At the optimal set of attributes, $\mathbf{z_k}^*$ and the reference level of utility, an individual's value function,

(6) $v(\mathbf{z_k^*}|\boldsymbol{\alpha_i}, u_i^*, y_i) = WTP_{i,k}{}^*$,

defines the most this consumer will pay for wine with bundle of attributes k*.

The value function when the value of the first attribute, variety—denoted z_{k1}—changes from that of the chosen wine, $z_{k1}{}^*$ (say, Cabernet Sauvignon), to another value, z_{j1}, (Pinot Noir, perhaps) is

(7) $v\left(z_{j1}, z_{k2}, \ldots, z_{kN}\middle|\boldsymbol{\alpha_i}, u_i^*, y_i\right) = WTP_{j1,\mathbf{k_{-1}}}$.

Willingness to pay for a change in an attribute, z_1, then, is

(8) $v\left(z_{j1}, z_{k2}, \ldots, z_{kN} \middle| \boldsymbol{\alpha_i}, u_i^*, y_i\right) - v(z_{k1}, z_{k2}, \ldots, z_{kN} | \boldsymbol{\alpha_i}, u_i^*, y_i) = \Delta WTP_{i1}$.

Participants submit their WTP—the representation of the value function—at the original utility level, given the variation in one attribute of interest from their original bottle of wine. That is, participants bid the price for the alternative wine at which they would be as willing to buy the alternative bottle as the original bottle.

5. Experimental Design, Procedure, and Descriptive Statistics

We collected valuation data from consumers using an experimental design built on the Becker-DeGroot-Marschak mechanism (BDM) (Becker et al. 1964). The BDM mechanism gives participants incentives to value bottles of wines accurately and seriously for two reasons. First, participants may have to purchase the products they are valuing, so they have an incentive not to overstate their WTP. Secondly, the feature of the BDM that separates consumers' submitted WTP from the randomly-drawn "experiment price" implies that participants may miss out on an opportunity to purchase a product at a price they would be happy to pay if they understate their WTP.

Eligible participants were customers of a local grocery store who had chosen a bottle of American wine, with a non-promotional price equal to or greater than $9.99. When it appeared that they had made a decision, the researcher approached the customer, informing them about the research, and invited them to participate. For participating, each person received a $10 gift card to the grocery store in which the experiment occurred. The steps of the experiment from recruitment to completion of the experiment follow.

Step 1) After agreeing to participate in the research, each participant was taken to a private computer terminal away from the main shopping area. The potential for

scrutiny and non-anonymity to affect participant responses has been established by a number of studies (List et al., 2004; Levitt and List, 2007b).

Step 2) The participant completed a questionnaire collecting demographic information and wine purchasing habits. The questionnaire included questions about frequency of wine purchase, average price paid per bottle, and wineries visited per year, as well as standard consumer demographic data.

Step 3) The participant and researcher together read a set of instructions and examples illustrating the research (the appendix contains a copy of the instructions), and completed a practice round of the experiment. The researcher went through the instructions and the practice experiment with the participant to check for comprehension of the experiment (Kagel and Roth, 1995). The researcher remained nearby and available at all times to answer any questions the participant had during the experiment.

Step 4) When the participant was ready to begin, a computer program developed for the project created a list of six alternative wines available in the store which had similar attributes to the wine the participant chose before being invited to participate in the research. The program used the appellation, variety, and shelf price of the participant's original bottle of wine to generate the sample of alternative wines. Three of the alternative wines were of the same appellation, but a different variety, while the other three alternatives were from different appellations, but of the same variety. Shelf prices of the original and alternative wines were held constant to ensure that participants were valuing wines in a familiar and relevant price range. The participant completed the data-generating part of the experiment privately, corresponding to six

observations of the difference in WTP for the alternative and original wines described in equation 8. The computer displayed the six alternative wines one at a time. For each alternative bottle, the participant could see the attributes of the original wine—including the shelf price—and the alternative wine. Instead of displaying a price for the alternative wine, there was a slider bar, which the participant moved to set their WTP. Once the participant had determined their WTP, they pressed a button at the bottom of the page to confirm their decision.

Step 5) After the participant submitted their WTP for each bottle of wine, the computer drew a random experiment price and displayed it onscreen before the participant observed the next alternative wine.

Step 6) The participant completed a wine knowledge quiz. We left the quiz until this point so that the quiz would not affect participants' valuation responses. As the quiz was difficult, we did not want to cause participants to think about how much they did or did not know about wine while they were valuing the alternative bottles (Steele and Aronson, 1995).

Step 7) The computer displayed the results of each of the six rounds of valuation. The randomly selected binding round was also displayed, and the computer stated whether or not the participant would purchase their original bottle of wine or the alternative.

Step 8a) For those buying the original bottle of wine, the experiment ended here.

Step 8b) Those purchasing the alternative wine from the binding round gave their original bottle to the researcher, who returned it to the wine aisle and brought the

alternative bottle to the participant. The researcher then wrote out a coupon for the experiment price of the alternative bottle of wine.

The consumer only purchased the alternative wine if the randomly drawn experiment price was below the consumer's WTP. Because the experiment price paid by consumers was, by definition, below their WTP, the experiment only required consumers to purchase the alternative wine if they received a higher level of utility by switching. That is, the consumer only bought the alternative wine at a price below the amount that they stated made them indifferent between the original and the alternative wine, leaving them with additional surplus.

We recruited 250 consumers to participate in the research. With six alternative wines presented to each participant, we observed 250 uninfluenced, original wine choices and 1500 valuations of alternative wines. Table 1 displays data on the wines originally selected by participants. The mean shelf price of the originally selected wines was $13.83 with a standard deviation of $5.86. Though all wines included in the research had original shelf prices of $10 or above, we did not remove a wine from the sample if it went on sale. Therefore the minimum shelf price for a bottle of wine in the survey was $4 and the maximum, $48. The mean WTP for the alternative wines was $11.46, with a standard deviation of $5.79. The minimum WTP submitted for an alternative wine was $0; the maximum WTP was $48.

Figures 2 and 3 graph the shelf price of participants' original wines, with error bars representing the minimum and maximum shelf prices of the alternative wines presented to them in the experiment. Figure 2 clusters participants by variety. Figure 3 groups participants by the appellation of the original wine and graphs, again, the shelf

price of the original wine, with bars plotting the minimum and maximum shelf prices of the alternative wines. These figures show how closely the shelf prices of the alternative wines were related to the shelf price of the originally chosen wine.

Table 2 reports selected summary statistics of participant demographic information and wine purchasing behavior. Participants' mean number of 750-milliliter bottles of wine purchased per month is 6.4, or a little over 1.5 bottles per week. Participants report spending an average of $13.12 per bottle, which was similar to the mean shelf price of $13.85 for the original bottles selected by participants. On average, participants had been buying wine for over 12.5 years. Just over half—52 percent—of the participants were female. The mean age of participants was 38.24 years. Mean household income was just under $80,000 per year. Participants had received a mean of 16.41 years of education. These data track closely with the population of Davis, California (U.S. Census, 2008).

6. Data Analysis

The empirical difficulties identified in section 2—identification, sorting, anchoring, and salience—make estimating the parameters of the WTP function for product attributes difficult. In this section, we describe how our experimental design and econometric specifications control for the effects of these factors on consumer valuation.

6.1. Indirect Influence on Demand from the Supply Side

Generating the WTP data with an economic experiment means that costs of production do not directly affect participants' WTP for the wines offered. The participants could submit any amount they chose as their WTP for a particular wine However, to make the alternative wine choices relevant and salient, the list of alternatives

had attributes, and therefore shelf prices, that were similar to the participant's originally chosen wine. For example, a participant originally choosing a Central Coast wine, with a mean price of $10.42 per bottle, was more likely to be presented with a "California" among the set of alternative wines than "Napa Valley" which tends to be more expensive. Similarly, a consumer originally choosing a Pinot Noir was more likely to be presented a Cabernet Sauvignon than a Merlot, because there are more Cabernet Sauvignons offered in the price range of Pinot Noir than there are Merlots. The experimental procedure therefore introduced correlation between the shelf price—and thus, WTP bids—of the alternatives offered and the shelf price of the original wine. To control for these supply side factors in the WTP observations, the econometric model requires controls for the shelf prices of the alternative wines. Table 3 shows the average shelf prices of the originally selected wines and the pool of alternatives at the experiment site by variety. Table 4 presents the same data by appellation.

6.2. Estimating Consumer Willingness to Pay for Attributes

The design of the experiment suggests a natural method for analyzing the data. We collected 1474 usable outcomes of the WTP function for the bundle of attributes constituting each alternative wine. Independent variables available in the research include the appellation of the wine, the grape variety, vintage and consumer characteristics, including gender, education, income, and wine knowledge and experience.

First, we estimated the equation:

(9a) $WTP_{ijt} = \beta_0 + \rho\Delta Vint_j + \sum_j\left(\beta_{APP,j}Appellation_{ijt} + \beta_{VAR,j}Variety_{ijt}\right) + \varepsilon_{ijt}.$

Equation 9a states that WTP by individual i for wine j in round t—the outcome of the value function in (7)—is a linear function of a constant term, the difference between

the vintage of the alternative and original wines, the appellation and varieties of the alternative wines, and an error term.[1] Equation 9a corresponds to the first-stage hedonic regression that researchers are able to estimate with typically available data. It does not use information about store prices or anchors, or any of the data on consumers. To eliminate the possibility that variables unaccounted for are confounding the estimates of WTP for wine attributes, we need to introduce controls for those variables. We next discuss the specific aspects of the research that allow us to avoid confounding unobserved variables with estimates of WTP parameters.

6.3 Eliminating Identification, Saliency Problems, and Anchoring from WTP data

We have discussed four factors in measuring WTP data that must be dealt with: identification, sorting, saliency, and anchoring. The experimental design and econometric analysis presented in this section cleans out the direct influence of the supply side of the wine market, maximizes product saliency to participants, and deals with the effects of anchoring.

The use of experimental economics eliminated the influence of the supply side, and thus the risk of identification problems from the data generated in the research. One major impetus behind the rise of experimental economic methods is the ability to observe consumer WTP directly without influence from the supply side. Participants in this and similar research submitted their WTP in an experimental auction, a valuation scenario featuring real economic decisions. Using a randomized price-setting mechanism provides experiment participants with the incentive to reveal their true WTP for the product.

[1] All models were also run with a natural log transformation of the continuous variables. The sign, ordering, and significance of the variables remained unchanged. The linear models had a higher R^2 and adjusted R^2, so we report those results in this paper.

A second concern, and one not directly addressed by the experimental design, is that participants may have anchored on the shelf price of their originally selected bottle of wine. Typically, a researcher will not know if a consumer has anchored on a price. Though we do not directly observe the prices participants (may) have anchored on, the shelf price of the alternative wine is an instrument that can control for both the supply side, and for the unobservable anchor.

We addressed concerns about product saliency through the design of the experiment. By presenting wines in a narrow attribute and price space around the originally selected wine, we maximized the probability that the alternative wines were products the consumer would consider purchasing. Holding the shelf price constant also prevented the introduction of unobserved (to the researcher) product quality. The second econometric specification (Equation 9b) introduces the shelf price of the alternative wine as an instrument to control for identification and anchoring:[2]

(9b) $WTP_{ijt} = \beta_0 + \gamma P_j + \rho \Delta Vint_j + \sum_j \left(\beta_{APP,j} Appellation_{ijt} + \beta_{VAR,j} Variety_{ijt}\right) + \varepsilon ijt.$

Equation 9b adds the shelf price of the alternative wine (P_j) to 9a to control for anchoring. Estimated parameters from equation 9b no longer include the direct (identification) or indirect (anchoring) effects of the supply side, but sorting may still confound WTP parameter estimates.

6.4. The Effects of Sorting on WTP Estimation

[2] Design features of the experiment meant to maximize saliency may have contributed to the effects of identification and anchoring. Saliency in and of itself poses no risk to accurate estimates of WTP parameters. However, if the research does not try to make products salient, it creates the risk that WTP estimates will be irrelevant because, for instance, the consumer might never consider buying a particular product.

The final force that can bias the estimation of parameters of the WTP function is sorting. Even in a setting that offers as much control as an economic experiment, it will not be possible to measure all relevant consumer characteristics and product attributes. Correlation between unobserved consumer characteristics and product attributes can lead to the misattribution of valuation to observed attributes.

To deal with sorting, we collected six WTP observations per participant. Collecting multiple observations per consumer permits the use of an individual fixed effects estimator, which measures deviations in WTP from a participant's mean WTP. Using individual fixed effects controls for the effect of unobserved (and observed) consumer characteristics from the WTP data. The econometric specification using the full complement of controls for supply side, anchoring, and sorting is:

(9c) $WTP_{ijt} = \beta_0 + \gamma P_j + \rho \Delta Vint_j + \sum_j \left(\beta_{APP,j} Appellation_{ijt} + \beta_{VAR,j} Variety_{ijt}\right) + \alpha i + \varepsilon ijt.$

Equation 9c employs the most complete set of controls for the supply side and unobserved wine attributes and participant characteristics. The fixed effects estimator eliminates the vector of observed and unobserved consumer characteristics, α_i. We believe that the parameters estimated from 9c represent accurately measured parameters of the consumer value function.

7. Estimating Consumer WTP for Wine Attributes

Table 5 presents the results of the regression equations 9a, 9b, and 9c. The first regression, *Conventional Hedonic Analysis (9a)* in Table 5, represents the most common data availability scenario. Parameters estimated in 9a cannot be interpreted as

parameters of a WTP function. Both of the omitted variables, γP_j and α_i, end up in the error term, and because both are correlated with the observed wine attributes, consumer WTP estimates reflect cost of production.

7.1 Results of the Conventional Hedonic Model: 9a

The results from *Conventional Hedonic Analysis* show a significant degree of dispersion in implicit prices for wine varieties. The estimated parameter on *Cabernet Sauvignon* is 0.63, meaning that consumers valued *Cabernet Sauvignon* only $0.63 more than *White Blends*. Consumer WTP for *Chardonnay* is estimated to be $0.45 below *White Blends*. *Merlot* has an estimated coefficient of 0.51. None of the three estimated parameters is statistically significant. One statistically significant parameter estimate was for *Pinot Noir*, which is $2.76 higher than WTP for *White Blend*, the reference category. The coefficient estimate for *Pinot Grigio/Gris* was also statistically significant, being $1.99 below *White Blend*. Consumer valuation of appellations spans a similar range. In column 1, *Napa Valley* is valued $6.10 more than *California*.

As WTPs, the variety results seem odd. *Cabernet* Sauvignon, *Chardonnay, and Merlot* are all popular wine varieties that we expect would be preferred to *White Blend*. However, for the most part, the ordering of WTP for appellations is consistent with expectations of wine experts. The difference in WTP between *Napa Valley* and *California* represents about 45 percent of the mean price of the originally chosen wine, which was $13.85. Consumers value *Napa Valley* and Napa and Sonoma sub-appellations most highly, and coastal appellations in *Lake County*, *Mendocino*, *Monterey*, and *San Luis Obispo* are valued more than inland appellations in the Central Valley or the Sierra Foothills.

The results of *Conventional Hedonic Analysis* are very similar to the findings reported in Bombrun and Sumner (2003), the study with the product set closest to ours. Those authors analyzed suggested retail prices reported by the Wine Spectator on 8460 California wines from 1989-2000. They found that the *Napa Valley* appellation was associated with a price $5.99 higher than a wine labeled with the *California* appellation. For wine varieties, they only looked at *Cabernet Sauvignon, Chardonnay, Merlot, Pinot Noir,* and *Zinfandel*. The only statistically significant estimate of grape varieties was *Pinot Noir*, which was priced $1.47 more than *Merlot*.

7.2. Removing supply-side influence and anchoring: 9b

The estimating equation presented in 9b, *Consumer WTP Using Alternative Price*, controls for the supply side and anchoring. Our best estimate of the anchors affecting participants is the price of the wine they originally chose, so we use the shelf price of the alternative wines presented to participants to control for anchoring and supply side cost differences. The shelf price of the alternative wine accounts for the price range the participant was considering when invited to participate in the experiment. Again, participants could submit any value they wished for the alternative wines, so the supply side did not affect the WTP data directly.

Estimates of WTP for appellation and variety attributes change significantly from *Conventional Hedonic Analysis* to *Consumer WTP Using Alternative Price*. First, when we include shelf price as a regressor, the intercept decreases from 9.80 to 0.18, while shelf price has an estimated coefficient of 0.63, implying that consumers choosing pricier original bottles of wine required higher discounts to switch to any alternative bottle. Changes in the estimated parameters of wine attributes are attributable to differences in

the supply side of the market. For example, WTP for *Napa Valley* is $4.06 in *Conventional Hedonic Analysis* and $1.71 in *Consumer WTP Using Alternative Price*. The difference between the two estimates, $2.35, is attributable to costs of production. California, Central Coast, and Santa Barbara County, estimated to be negative in *Conventional Hedonic Analysis*, become positive once shelf price is included in the regression. For *Pinot Noir*, $0.29 of the $2.76 WTP estimated in *Conventional Hedonic Analysis* comes from production cost differences, while $2.47 is consumer WTP. *Consumer WTP Using Alternative Price* does not account for consumer characteristics, however. Because attributes occur with varying frequency in different price ranges, and people sort into different locations of the attribute spectrum, individual characteristics become correlated with wine attributes.

7.3. Eliminating the effect of sorting, identification, and anchoring: 9c

Individual Fixed Effects with Shelf Price incorporates individual-specific fixed effects into the analysis, and includes the shelf price of the alternative wine as a regressor. Significant changes occur in WTP for varieties when individual fixed effects are included. Four wine varieties are valued statistically significantly more than *White Blend* at the 5% significance level or lower (p-value ≤ 0.05).[3] For appellations, only *Monterey* and *San Luis Obispo* are valued more than Central Valley appellations at marginally significant levels (p-value ≤ 0.10).

The changes in parameter estimates obtained using *Individual Fixed Effects with Shelf Price* versus *Conventional Hedonic Analysis* provide striking evidence of the importance of accounting for individual sorting in hedonic estimation. Measures of model fit, R^2, increases substantially when we implement the full suite of controls for sorting,

[3] An additional 3 varieties are valued significantly more than *White Blend* at the 10% significance level.

the supply side, and behavioral influences on the data. Regressions 9a to 9c provide increasingly precise levels of control of unobserved variables correlated with the attributes valued and with the dependent variable: WTP. Preferences for wine variety—in terms of WTP—become increasingly dispersed and significant as the identification problem is resolved and individual sorting is addressed. The differences between equation 9a and equation 9c provide insight into why we see such significant changes in valuation. P_j and α_i are correlated with consumer WTP, but are also correlated with the wine attributes. When both P_j and α_i are part of the error term (as in 9a), they introduce correlation between the dependent and independent variables.

One important result is the effect of identification issues and consumer sorting on WTP for wine appellations. The estimate of WTP for *Napa Valley* is positive and statistically significant in 9a. However, in comparing results across columns, the magnitude of the estimate of WTP for *Napa Valley* in *Individual Fixed Effects with Shelf Price* is very small (and not statistically significant) compared to the estimated WTP for *Napa Valley* in *Conventional Hedonic Analysis*. Whereas the largest difference in WTP for appellation was $6.39 in *Conventional Hedonic Analysis* (the WTP for Napa and Sonoma Sub-appellations minus WTP for *California*), the largest difference in *Individual Fixed Effects with Shelf Price* is $0.69 (WTP for *Monterey* minus WTP for *Central Valley*).

Though appellations are still valued—with WTP for some appellations estimated to be significantly higher than WTP for *Central Valley*—the largest WTP estimates are not for *Napa Valley*, *Sonoma County*, or Napa Valley and Sonoma County sub-appellations such as *Carneros*, *Oakville*, and *Russian River Valley*, but are instead for

Monterey County and its constituent sub-appellations. Figure 4 shows parameter estimates for selected appellations and variables for *Conventional Hedonic Analysis*, *Consumer WTP Using Alternative Price*, and *Individual Fixed Effects with Shelf Price*, with 95% confidence intervals for each estimate.

An interpretation of our findings of WTP for wine appellations in *Individual Fixed Effects with Shelf Price* is that appellation functions primarily as a quality signal—at least for the part of the market we studied. Once participants have chosen a wine in a certain price segment of the market, appellation seems not to affect consumer WTP nearly as significantly as past research suggests. This paper supports—though does not prove—recent findings showing that more precise controls for unobserved variables dampens estimates of valuation for quality-related attributes like appellation. Our results corroborate other recent findings reported in articles such as Black (1999), Bayer et al. (2007) and Dubois and Nauges (2010), showing that accounting for unobserved quality or amenities significantly reduces WTP measures for measurable quality attributes.

8. Conclusions

This paper develops and implements a novel procedure to measure consumer WTP for non-marketed attributes of a differentiated product. We designed an experimental economic approach that manages the common empirical problems of 1) identification of demand and supply attributes separately and 2) sorting of consumers. This approach furthermore allows us to deal with product salience concerns in experimental settings and potential biases from consumer anchoring. As we control for unobserved participant characteristics (culminating in the use of individual fixed effects in regression modeling), estimates of consumer valuation of wine varieties increases. For

instance, WTP for *Pinot Grigio* compared to *White Blend* increases from -$1.99 in *Conventional Hedonic Analysis* to $1.37 when individual fixed effects are used. Additionally, four wine varieties—*Chardonnay*, *Pinot Grigio*, *Sauvignon Blanc*, and *Other White Varieties*—switch from being negatively to positively valued compared to *White Blend*. For appellations, WTP generally decreases in absolute value, including WTP for prestigious appellations like *Napa Valley*.

It is striking how the estimates of WTP change when we account for identification, and sorting and anchoring. The *Conventional Hedonic Analysis* results, which closely mirror many of the findings of Bombrun and Sumner (2003), do not resemble the *Individual Fixed Effects with Shelf Price* results. When supply-side influences, sorting, and anchoring effects are eliminated from WTP estimates, valuation of wine varieties increases significantly and much of the WTP for appellations disappears. The results suggest that much of the valuation of specific appellations seen in other research is attributable to costs of production. When we also control for unobservable consumer characteristics, marginal valuation of Napa Valley is not greater than other appellations, implying that other inputs can substitute for the reputation that appellations communicate. Other experimental studies that find that consumers value appellation may be measuring valuation differences stemming from the anchors of individual participants (e.g. Combris et al., 2009). In the segment we study, the American wine market is highly competitive, and consumers do not significantly value one appellation over another.

The research reported here demonstrates the importance of obtaining data that allow identification of demand parameters and permit control of consumer sorting when

implementing hedonic pricing theory to measure the valuation of attributes. The ability to control for (typically) unobserved supply factors and individual characteristics lead to markedly different estimates of consumer valuation of product attributes. Evidence from Black (1999), Bayer et al. (2007), and this paper indicate that consumers sort into market segments based on attributes that are not typically observed by researchers. Estimates of WTP for quality attributes, such as appellation or school quality, are reduced significantly when controls for sorting and unobserved consumer characteristics are introduced into the analysis. Black (1999) and Bayer et al. (2007) estimated WTP for school quality at 50–75 percent lower than traditional estimates. In this paper, nearly all of the value of prestigious appellations like *Napa Valley* and other Napa and Sonoma County sub-appellations disappears when sorting and identification problems are resolved. In this paper, we were able to eliminate additional issues with sorting and identification by accounting for unobserved consumer characteristics with individual fixed effects and controlling the information consumers received about the wines so that there were no product attributes observed by participants but not researchers.

The implications of our study results are important for both theoretical and practical purposes. We find evidence that consumers' preferences for unobserved attributes (represented in our data by habitually purchasing in certain price ranges) create correlation between product attributes and consumer characteristics. The unobserved relationship between product attributes and consumer characteristics can lead to incorrect parameter estimates. We also see that, over the price range that we investigate, consumers are willing to pay much different amounts for wine varieties than for appellation once we control effectively for supply side contamination. An explanation is

that there are unobserved wine qualities that consumers sort on that reduce the power of appellation as a quality signal. In this paper, we show that the estimated coefficients from conventional regressions provide very different estimates of WTP than when we control for sorting and identification. It is very important for producers, marketers, retailers, and policymakers to have accurate estimates of marginal valuation of attributes, whether in the market for consumer goods like wine or cars, or the provision of public goods such as school quality, access to open space, or air pollution reduction.

Table 1: Summary Data of Prices for Original and Alternative Bottles

	Field Experiment Summary Data	
	Participant-Selected Wine	*Alternative Wine*
Observations	250	1500
Mean Shelf Price	13.85	14.02
Standard Deviation	5.86	5.80
Minimum Price	4.00	4.00
Maximum Price	48.00	50.00
Mean WTP	-	11.19*
Standard Deviation	-	5.37*
Minimum WTP	-	0.00
Maximum WTP	-	46.50

Source: Experiment.
*: For 26 observations of WTP for the alternative wine, participants mistakenly failed to enter a bid. These observations were omitted from these calculations.

Table 2: Participant Wine Experience and Demographic Characteristics

Variable	Mean	Standard Deviation
Bottles Purchased Per Month (750 ml)	6.41	5.84
Mean Price Per Bottle ($)	13.12	5.02
Years Buying Wine	12.61	11.31
Female (0,1)	0.52	0.50
Age (Years)	38.24	14.48
Household Income ($1000)	79.80	64.06
Schooling (Years)	16.41	1.63

Source: Experiment
Observations: 250

Table 3: Shelf Price of Originally Chosen Wines and all Wines in Inventory by Variety

	Original Wine Mean Price	Store Inventory Mean Price*
Cabernet Sauvignon	14.08	39.03
Chardonnay	12.69	18.40
Merlot	10.21	18.65
Other Red	14.06	18.76
Other White	12.20	12.09
Pinot Grigio	9.38	11.54
Pinot Noir	18.92	24.40
Red Blend	15.82	33.81
Sauvignon Blanc	12.00	13.25
White Blend	-	15.54
Zinfandel	14.51	20.45

Source: Experiment and Nugget Market Wine Inventory, March 2009
Notes: Original Wine Mean Price is the shelf price of the bottle the participant had selected when approached to participate in the experiment. Store Inventory Mean Price is the mean shelf price of the all of the wines available in the store, not weighted by sales value or volume.
*: Median shelf prices tended to be lower than mean shelf prices, particularly for varieties *Cabernet Sauvignon* and *Red Blend*.

Table 4: Shelf Price of Originally Chosen Wines and all Wines in Inventory by Appellation

	Original Wine Mean Price	Store Inventory Mean Price*
California	9.80	9.54
Central Coast[a]	10.42	13.90
Central Valley[b]	14.48	14.19
Mendocino and Lake Co.[b]	14.04	15.22
Monterey Co.[b]	14.70	15.58
Napa Valley	18.54	42.02
Napa and Sonoma Sub Appellations	16.11	33.12
Oregon and Washington[b]	15.74	25.27
San Luis Obispo Co.[b]	16.00	21.11
Santa Barbara Co.[b]	9.17	17.13
Sierra Foothills[b]	13.71	17.77
Sonoma Co.	12.47	18.11

Source: Experiment and Nugget Market Wine Inventory, March 2009
Notes: Original Wine Mean Price is the shelf price of the bottle the participant had selected when approached to participate in the experiment. Store Inventory Mean Price is the mean shelf price of the all of the wines available in the store, not weighted by sales value or volume.
*: Median shelf prices tended to be lower than mean shelf prices, particularly for the *Napa Valley* and the Napa and Sonoma sub-appellations.
a: *Central Coast* includes San Francisco and Santa Cruz appellations.
b: Indicates that the appellation variable includes all constituent sub-appellations

Table 5: Effects of Appellation, Variety, and Vintage on Willingness to Pay

Dependent Variable: WTP	Conventional Hedonic Analysis	Consumer WTP without Supply Side/Anchoring	Consumer WTP without Supply Side/Anchoring or Sorting
	(9a)	(9b)	(9c)
Intercept[a]	9.80**	0.18	-1.64**
	(1.15)	(1.19)	(0.63)
Cabernet Sauvignon	0.63	1.51	1.53**
	(1.15)	(0.94)	(0.66)
Chardonnay	-0.45	0.98	0.94
	(1.12)	(0.94)	(0.66)
Merlot	0.51	1.80**	1.58**
	(1.17)	(0.89)	(0.64)
Pinot Grigio or Gris	-1.99*	0.73	1.37*
	(1.20)	(1.00)	(0.71)
Pinot Noir	2.76**	2.47**	2.45**
	(1.31)	(1.07)	(0.72)
Sauvignon Blanc	-1.53	0.67	1.10
	(1.24)	(1.05)	(0.72)
Other Red Varieties	1.39	1.77*	1.50**
	(1.12)	(0.96)	(0.66)
Zinfandel	1.26	1.39	1.24*
	(1.18)	(0.96)	(0.65)
California	-2.04**	0.51	0.13
	(0.49)	(0.44)	(0.25)
Central Coast[b]	-0.21	0.94*	0.36
	(0.65)	(0.48)	(0.30)
Monterey[c]	2.08**	1.47**	0.69*
	(0.93)	(0.65)	(0.40)
Napa Valley	4.06**	1.71**	0.47
	(0.81)	(0.53)	(0.34)
Napa & Sonoma Sub-AVAs	4.35**	1.43**	0.34
	(0.88)	(0.62)	(0.37)
San Luis Obispo[c]	2.87**	1.25**	0.64*
	(0.77)	(0.57)	(0.38)
Sonoma County	0.12	0.99**	0.28
	(0.61)	(0.46)	(0.32)
Difference in Vintage	0.19	0.09	-0.047
	(0.14)	(0.11)	(0.048)
Alternative Shelf Price	—	0.63**	0.081*
		(0.05)	(0.044)
R2	0.21	0.54	0.78
Adj. R2	0.20	0.53	0.73

Reported values are the estimated coefficient and, in parentheses, the standard error.

Source: Experiment

Notes: Significance: (**) = $p \leq 0.05$; (*) = $p \leq 0.10$
Observations = 1474 for all regressions
a: Omitted reference categories are *White Blend* and Central Valley sub-appellations.
b: *Central Coast* includes San Francisco and Santa Cruz area appellations.
c: Includes all sub-appellations of the county.
The variety categories *Red Blend* and *Other White Varieties* were included, but coefficients are not reported here because the parameter estimates were not significant in any of the models.
The appellation categories *Mendocino and Lake Counties*, *Oregon and Washington appellations*, *Santa Barbara County*, *Sierra Foothills* were included, but coefficients are not reported here because the parameter estimates were not significant in any of the models.

Figure 1: Screen shot of an example choice scenario in the computer-based experiment. Source: Computer program written for the research.

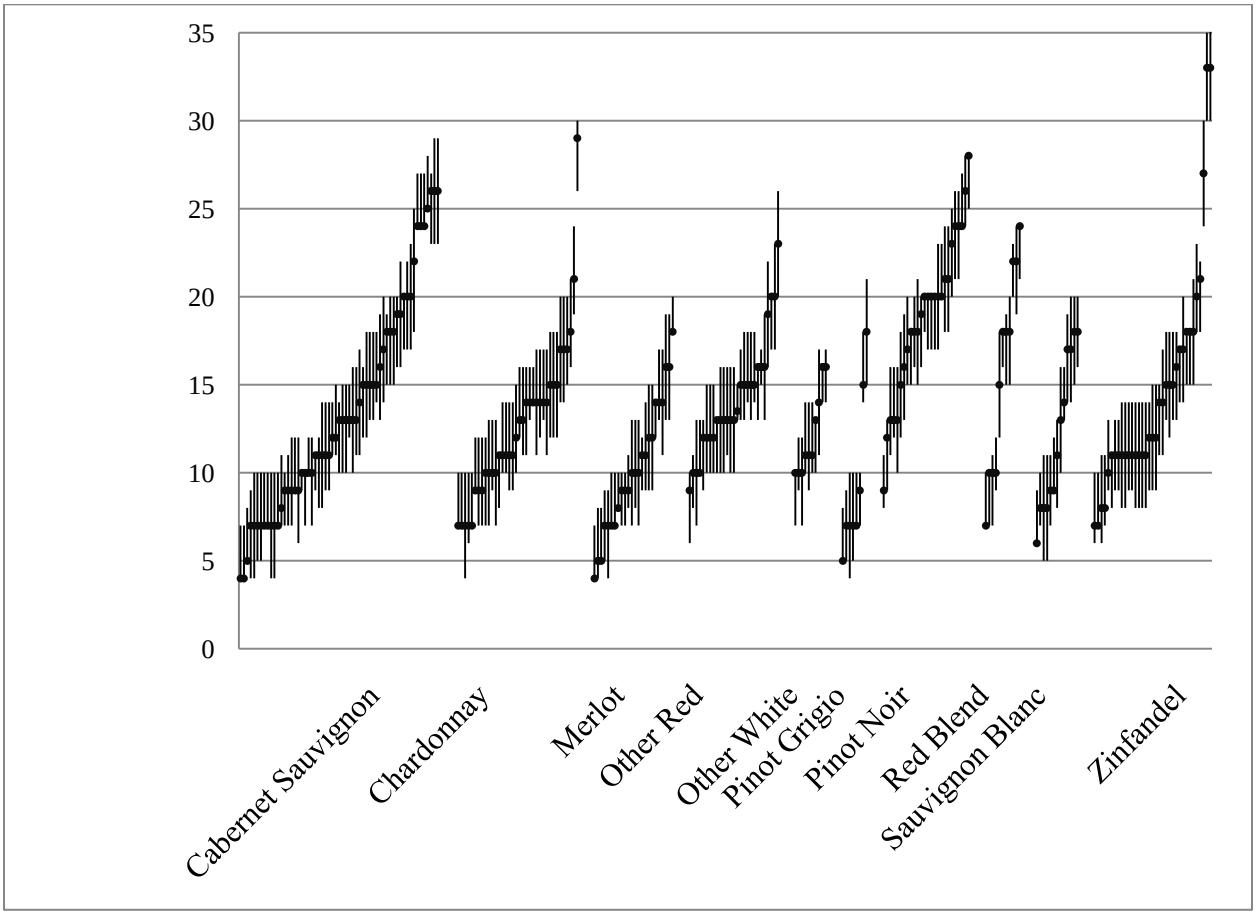

Figure 2: Shelf prices of original wines selected by participants by variety, with bars for minimum and maximum experimental shelf prices of alternative wines presented to participants. There are 250 observations. One observation of Cabernet Sauvignon at $48 is not shown.
Source: Participants' original choices of alternative wines grouped by variety.

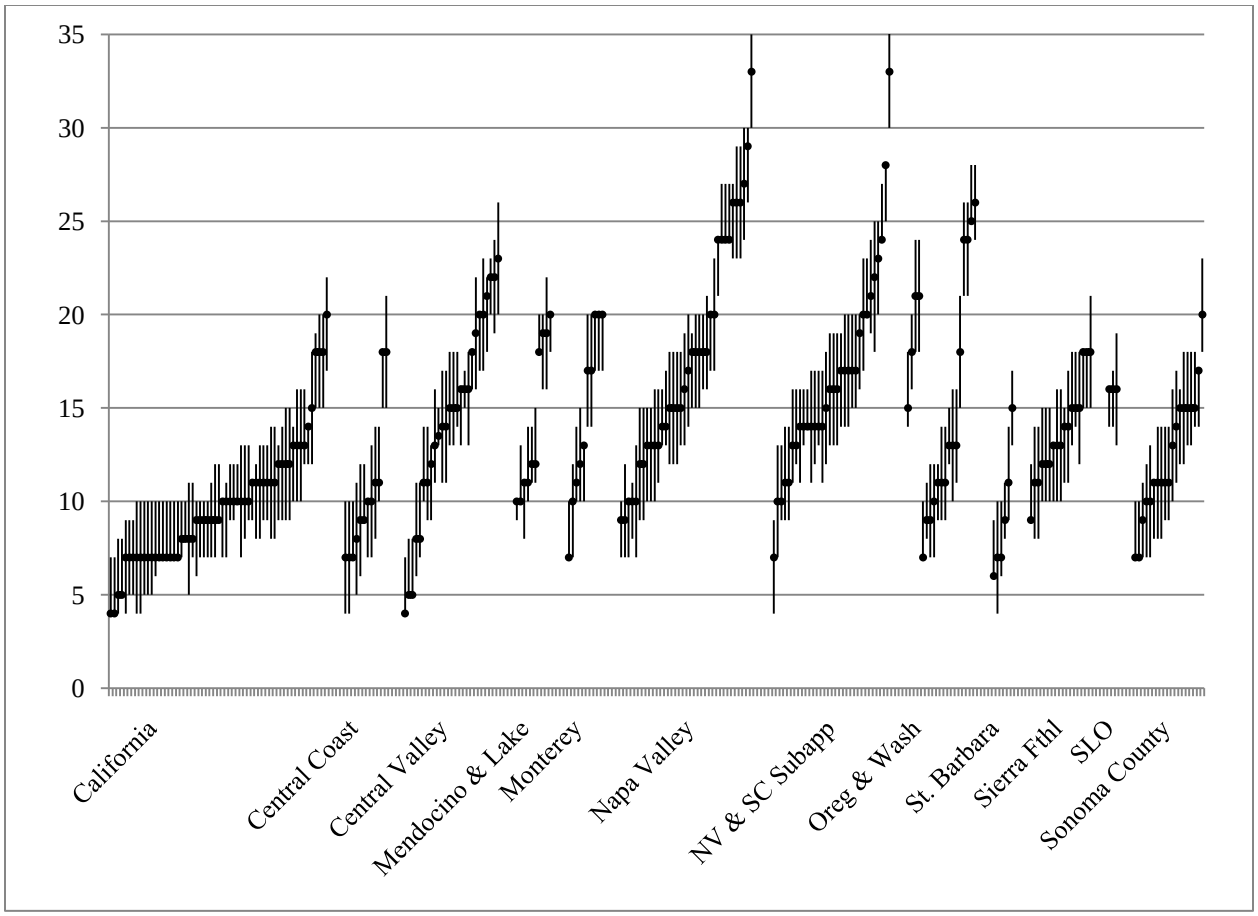

Figure 3: Shelf prices of original wines selected by participants by appellation, with bars for minimum and maximum shelf prices of alternative wines presented to participants. There are 250 observations. One observation of an original choice of *Napa Valley* wine ($48) is not pictured.
Source: Participants' original choices of alternative wines grouped by appellation.

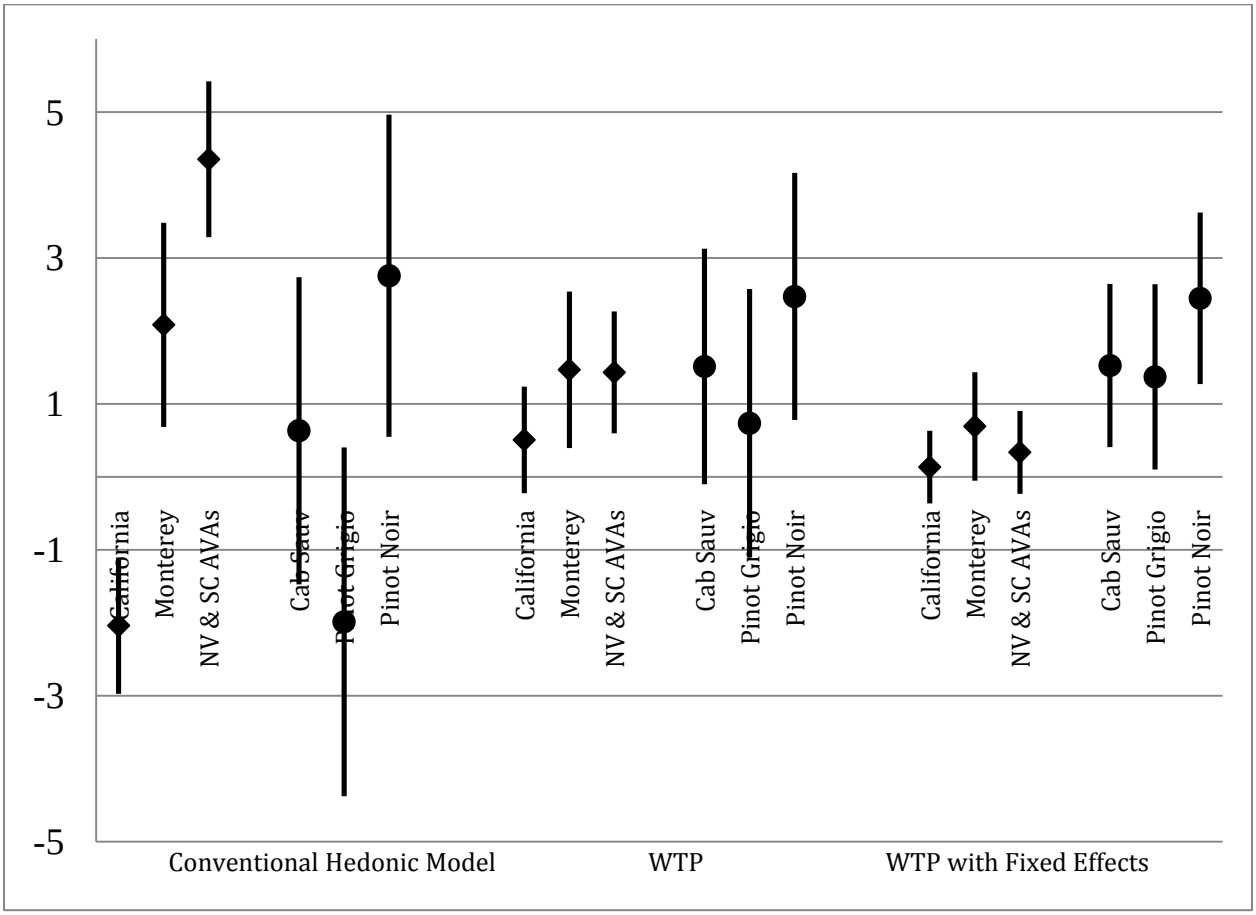

Figure 4: Estimated WTP for Selected Appellations (California, Monterey, and Napa and Sonoma Sub-appellations) and Varieties (Cabernet Sauvignon, Pinot Grigio, and Pinot Noir) with 95% Confidence Intervals
Source: Estimates from Table 5.

References

Ariely, D., G. Loewenstein, and D. Prelec. 2003. "Coherent Arbitrariness: Stable Demand Curves without Stable Preferences." *Quarterly Journal of Economics* 118: 73-105

Ashenfelter, O. 2008. "Predicting the Quality and Prices of Bordeaux Wine." *The Economic Journal* 118(529): F174-F184

Ashenfelter, O., and K. Storchmann. 2010. "Using Hedonic Models of Solar Radiation and Weather to Assess the Economic Effect of Climate Change: the Case of Mosel Valley Vineyards." *The Review of Economics and Statistics* 92(2): 333-349

Bajari, P. and C. Benkard. 2005. "Demand Estimation with Heterogeneous Consumers and Unobserved Product Characteristics: A Hedonic Approach." *The Journal of Political Economy* 113(6): 1239-1276

Bartik, T.J. 1987. "The Estimation of Demand Parameters in Hedonic Price Models." *The Journal of Political Economy* 95(1): 81-88

Bayer, P., F. Ferreira, and R. McMillan. 2007. "A Unified Framework for Measuring Preferences for Schools and Neighborhoods." *The Journal of Political Economy* 115(4): 588-638

Becker, G., M. DeGroot, and J. Marschak. 1964. "Measuring Utility by a Single Response Sequential Method." *Behavioral Science* 9: 226-236

Beggs, A. and K. Graddy. 2009. "Anchoring Effects: Evidence from Art Auctions." *The American Economic Review* 99(3): 1027-1039

Black, S.E. 1999. "Do Better Schools Matter? Parental Valuation of Elementary Education." *Quarterly Journal of Economics* 114: 577-599

Bombrun, H. and D. Sumner. 2003. "What Determines the Price of Wine? The Value of Grape Characteristics and Wine Quality Assessments." *AIC Issues Brief* 18: 1-6

Brown, J. and H. Rosen. 1982. "On the Estimation of Structural Hedonic Price Models." *Econometrica* 50(3): 765-768

Bushong, B., L.M. King, C.F. Camerer, and A. Rangel. 2010. "Pavlovian Processes in Consumer Choice: The Physical Presence of a Good Increases Willingness-to-Pay." *The American Economic Review* 100: 1-18

Cellini, S.R., F. Ferreira, and J. Rothstein. 2010. "The Value of School Facility Investments: Evidence from a Dynamic Regression Discontinuity Design." *Quarterly Journal of Economics* 125: 215-261

Combris, P., P. Bazoche, E. Giraud-Heraud, and S. Issanchou. 2009. "Food Choices: What Do We Learn from Combining Sensory and Economic Experiments?" *Food Quality and Preference* 20: 550-557

Corrigan, J.R. and M.C. Rousu. 2008. "Testing Whether Field Auction Experiments Are Demand Revealing in Practice." *Journal of Agricultural and Resource Economics* 33(2): 290-301

Dubois, P. and C. Nauges. 2010. "Identifying the Effect of Unobserved Quality and Expert Reviews in the Pricing of Experience Goods: Empirical Application on Bordeaux Wine." *International Journal of Industrial Organization* 28: 205-212

Ekeland, I., J.J. Heckman, and L. Nesheim. 2004. "Identification and Estimation of Hedonic Models." *The Journal of Political Economy* 112(1): 60-109

Epple, D. 1987. "Hedonic Prices and Implicit Markets: Estimating Demand and Supply Functions for Differentiated Products." *The Journal of Political Economy* 95(1): 59-80

Ferreira, F. 2010. "You Can Take It with You: Proposition 13 Tax Benefits, Residential Mobility, and Willingness to Pay for Housing Amenities." *Journal of Public Economics* 94(9-10): 661-673

Fox, J. A., D. Hayes, and J. Shogren. 2002. "Consumer Preferences for Food Irradiation: How Favorable and Unfavorable Descriptions Affect Preferences for Irradiated Pork in Experimental Auctions." *Journal of Risk and Uncertainty* 24: 75-95.

Gergaud, O. and V. Ginsburgh. 2008. "Natural Endowments, Production Technologies and the Quality of Wines in Bordeaux. Does Terroir Matter?" *The Economic Journal* 118(529): F142-F157

Griliches, Z. 1961. "Hedonic price indexes for automobiles: An econometric analysis of quality change." Griliches, ed. *Price Indexes and Quality Change: Studies in New Methods of Measurement*. Harvard University Press, Cambridge, MA, 55-87.

Hayes, D., J. Shogren, S. Shin, and J. Kliebenstein. 1995. "Valuing Food Safety in Experimental Auction Markets." *American Journal of Agricultural Economics* 77(1): 40-53

Kagel, J.H. and A.E. Roth. 1995. *The Handbook of Experimental Economics*. Princeton University Press.

Landon, S. and C. Smith. 1998. "Quality Expectation, Reputation, and Price." *Southern Economic Journal* 64: 628-647

Levitt, S.D., and J.A. List. 2007a. "Viewpoint: On the Generalizability of Lab Behaviour to the Field." *Canadian Journal of Economics* 40(2): 347-370

Levitt, S.D., and J.A. List. 2007b. "What Do Laboratory Experiments Measuring Social Preferences Reveal about the Real World?" *Journal of Economic Perspectives* 21(2): 153-174

List, J.A., R.P. Berrens, A.K. Bohara, and J. Kerkvliet. 2004. "Examining the Role of Social Isolation on Stated Preferences." *The American Economic Review* 94(3): 741-752

Loewenstein, G. 2000. "Emotions in Economic Theory and Economic Behavior." *The American Economic Review* 90(2): 426-432

Lusk, J.L., J.A. Fox, T.C. Schroeder, J. Mintert, and M. Koohmaraie. 2001. "In-Store Valuation of Steak Tenderness." *American Journal of Agricultural Economics* 83: 539-550

Nerlove, M. 1995. "Hedonic Price Functions and the Measurement of Preferences: The Case of Swedish Wine Consumers." *European Economic Review* 39: 1697-1716

Oczkowski, E. 2001. "Hedonic Wine Price Functions and Measurement Error." *The Economic Record* 77: 374-382

Pakes, A. 2003. "A Reconsideration of Hedonic Price Indexes with an Application to PCs." *The American Economic Review* 93(5): 1578-96

Palmquist, R.B. 1984. "Estimating the Demand for the Characteristics of Housing." *The Review of Economics and Statistics* 66(3): 394-404

Rosen, S. 1974. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *The Journal of Political Economy* 82: 34-55

Schamel, G. and K. Anderson. 2003. "Wine Quality and Varietal, Regional, and Winery Reputations: Hedonic Prices for Australia and New Zealand." *The Economic Record* 79: 357-369

Simonsohn, U. and G. Loewenstein. 2006. "Mistake #37: The Impact of Previously Faced Prices on Housing Demand." *The Economic Journal* 116: 175-199

Smith, R.J., K.M. Klonsky, and R.L. De Moura. 2010. "Sample Costs to Establish a Vineyard and Produce Winegrapes: Cabernet Sauvignon in Sonoma County, North Coast Region." *University of California Cooperative Extension GR-NC-10*: 1-25

Stanley, L.R. and J. Tschirhart. 1991. "Hedonic Prices for a Nondurable Good: The Case of Breakfast Cereals." *Review of Economics and Statistics* 73: 537-541

Steele, C. and J. Aronson. 1995. "Stereotype Threat and the Intellectual Test Performance of African Americans." *Journal of Personality and Social Psychology* 69(5): 797-811

Tversky, A. and D. Kahneman. 1974. "Judgment under Uncertainty: Heuristics and Biases." *Science* 185: 1124-1131

Waugh, F. 1928. "Quality Factors Influencing Vegetable Prices." *Journal of Farm Economics* 10: 185-196

Working, E. 1929. "What Do Statistical Demand Curves Show?" *Quarterly Journal of Economics* 41(2): 212-235