THESIS

MEASURING CONSUMER WILLINGNESS TO PAY FOR REDUCED SULFUR DIOXIDE CONTENT IN WINE: A CONJOINT ANALYSIS

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ABSTRACT

MEASURING CONSUMER WILLINGNESS TO PAY FOR REDUCED SULFUR DIOXIDE CONTENT IN WINE: A CONJOINT ANALYSIS

As sulfites are often perceived by consumers as causing headaches and migraines, differentiated wines based on their sulfite content may be a profitable marketing avenue. Using stated choice methods, a sample of 223 wine consumers participated in a conjoint experiment where 36 hypothetical wine labels were ranked. Collected data included socio-demographic information, subjective experiences with headaches, and purchasing behavior. The results indicate that quality and price are the primary factors influencing wine choice, while “no sulfites added” labeling does not directly determine the purchasing decision. However, we find strong evidence that, at parity with price and quality, the average consumer is willing to pay $0.64 for no sulfites added in wine. Additionally, a substantial segment (34.08%) of the consumer population is willing to pay a greater premium of $1.23 for no sulfites added, indicating a potential niche market to which marketing promotions could be targeted.

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CHAPTER ONE

INTRODUCTION

1.1 Introduction and Motivation

The United States is the largest wine market by sales revenue in the world, representing nearly $32 billion in total retail value (Wine Institute, 2012). In the last 15 years, American wine production has increased 55%, and both total and per-capita wine consumption has expanded every year since 2001 (Wine Institute, 2011; 2011a). Though wine remains a highly diversified product, the growing popularity of wine has incentivized industry consolidation and a greater degree of uniform production practices. A movement is gaining traction, however, that has led to an increased awareness of sulfites by promoting more natural, sustainable, and heterogeneous production strategies (Goode and Harrop, p. 4, 2011).

While used nearly universally for 2000 years, sulfites are one of the most controversial ingredients in wine production (Vine, Harkness, and Linton, p. 110, 2002). Added in the form of sulfur dioxide (SO_2), sulfites serve as an antioxidant and antimicrobial agent and therefore preserve the wine to enhance taste, coloration, and aging. Vintners commonly apply sulfites throughout the production process, normally adding quantities ranging from 30 to 90 parts per million (ppm) (Burgstahler and Robinson, 1997), but all wines contain small amounts of sulfites naturally due to the presence of yeast during fermentation (Chengchu, Ruiying, and Yi-Cheng, 2006).

At the higher levels, sulfites have led to reported incidences of negative health effects (Vally and Thompson, 2001). The Food and Drug Administration (FDA) estimates that around 1 in 100 people have a severe allergy to sulfites, causing serious health problems including trouble breathing, skin rashes, and stomach pain (cited in Grotheer, Marshall, and Simonne 2005). In response to the severe allergies experienced by some, the Federal Bureau of Alcohol, Tobacco, and Firearms (ATF) and the United States Department of Agriculture (USDA) have mandated that any wine containing greater than 10 ppm of sulfites must contain a warning label and no wine may be sold containing more than 350 ppm of sulfites since 1987. Additionally, wine marketed as organic may not contain added sulfites (Alcohol and Tobacco Tax and Trade Bureau [TTB], 2011a).

A wider share of the consumer population perceives that drinking even moderate amounts of wine, particularly the red varieties, triggers minor health effects including headaches and migraines (Robin, 2010; Gaiter and Brecher, 2000). Medical studies have not reached a consensus on whether sulfites do in fact cause the reported minor health effects, but other ingredients in wine have also been identified as theoretical causes (Mauskop and Sun-Edelson, 2009; Millichap and Yee, 2003). One possible explanation to why sulfites are perceived negatively relates to the labeling rules, which would explain the disparity evident between consumer perceptions and current medical knowledge regarding the role that sulfites play in triggering the adverse effects.

Given that at least some consumers have negative perceptions toward sulfites, wine produced without adding sulfites may be a viable differentiation strategy. In the United States, however, low-sulfite product marketing has predominantly been synonymous with the organic sector. Production techniques have emerged primarily due to the growing organic market that now allow for the reliable preservation of wines made without the use of sulfites. In general, winemakers are more successful in foregoing sulfite use if the wine is produced in a more traditional manner, which includes small-scale production facilities and hand-harvested grapes (Goode and Harrop, p. 158, 2011). The most common specific strategies include maintaining sanitized and climate-controlled production facilities, as well as filling the wine bottles in an oxygen-free environment, all of which help to minimize oxidation and microbial spoilage (p. 160, 2011). The use of ultraviolet (UV) light is another emerging pasteurization technology that, if proven effective and acceptable to buyers, may experience widespread adoption (Evans, 2009; Wine Spectator, 2012a).

Since not adding sulfites is only one required component of organic winemaking, conventional low-sulfite production may be a viable differentiation strategy that can elicit a price premium while keeping costs lower than organic production. In the United States, however, low-sulfite product differentiation is a largely unexploited niche market (e.g. Goode and Harrop, p. 160, 2011). Given the entrepreneurial nature of the U.S. wine industry (e.g. Vine, Harkness, and Linton, p. 21, 2002), it is surprising that winemakers in the United States have not previously explored this potential niche market in greater depth. Perhaps one key aspect that would inform entrepreneurs is how valuable a minimized sulfite level in wine is to consumers, and what share of consumers would consider such a trait as important in their buying decisions.

1.2 Problem Statement

Wine differentiated by its sulfite content has not been widely marketed in the United States except for the organic wine market, where producers must meet an array of production guidelines in addition to not adding sulfites. A variety of past literature has studied consumer preferences for wine, but the included attributes primarily relate to the wine's origin of production, vintage, quality, and price (e.g. Gil and Sánchez, 1997; Cohen, 2009; Jarvis et al., 2010; Costanigro, McCluskey, and Mittelhammer, 2007). Given the common perception that sulfites trigger headaches and migraines, more effective market segmentation and more consumer-driven consumer development will result by better understanding consumers' valuation of low-sulfite marketing and determining whether potential niche markets do in fact exist.

1.3. Objectives of the Study

To the knowledge of the authors, no prior research has studied how consumers value sulfites in wine or quantified potential market sizes for conventional wines differentiated by their sulfite content. The research therefore seeks to understand the perceptions and valuation of wine produced without the use of sulfites. Specific objectives of the research follow.

1. The researchers aim to assess and confirm whether consumers view sulfite content in wine as problematic, especially in relation to sulfites being perceived as a headache trigger. The initial finding will be explored deeper by understand the relationship between how different demographic segments of the consumer population perceive sulfites as triggering headaches after even moderate consumption of wine.
2. The next objective is to quantify willingness to pay for eliminating added sulfites from wine and understanding the tradeoffs made between sulfite content, quality, price, and organic wine in consumers' choice decisions. Willingness to pay for sulfites will then be assessed based on demographic cohorts, as well as for different pricing and varietal categories.
3. Finally, the research aims to provide the wine industry with useful and relevant information relating to potential marketing avenues for low-sulfite wine.

Because markets for conventional wine with no added sulfites do not currently exist, the objectives were addressed via a hypothetical choice experiment using stated preferences methods. The data was analyzed in a conjoint analysis.

1.4 Organization of Thesis

The following chapter outlines the foundational literature relating to sulfites, discrete choice experiments, and wine marketing studies. Chapter Three discusses the methods used to obtain the data, including the underlying theories behind the chosen econometric models. Chapter Four describes the data and descriptive statistics. Finally, Chapter Five summarizes the findings and implications from this research, discusses the limitations of the study including necessary cautions in interpreting the results from an experimental approach, and points to areas that would be beneficial for future study of this wine market segment.

CHAPTER TWO

BACKGROUND

2.1 Introduction to the U.S. Wine Industry

The U.S. wine industry is becoming an increasingly large segment in world production and consumption. Nearly 2.6 billion liters of wine were produced in the United States in 2010, and total annual consumption of wine was estimated at 2.9 billion liters. Furthermore, both total and per-capita wine consumption has grown every year consistently since 2001 (Wine Institute, 2011a). Winemaking occurs in nearly every state, but California leads the nation in production, producing over 2.3 billion liters of wine in 2010, followed by New York and Washington (Wine Institute, 2011; TTB, 2011). As an alternative choice within the conventional domestic market, organic wine is becoming an increasingly large component with an estimated production expansion rate of up to 25% per year (Desta, 2008). Even so, it represents only around 1 percent of total domestic wine sales (Singh, 2009).

Post-prohibition U.S. winemakers have sought to distinguish themselves from their European counterparts by developing entrepreneurial production and marketing techniques. Wines that were once labeled based upon their European origin, such as Bordeaux, are now more commonly marketed by grape variety, indicating a desire to create a unique and independent American brand (Vine, Harkness, and Linton, p. 21, 2002). After the formation of the American Society of Enologists at the University of California at Davis in 1950, innovative practices such as using disease-resistant hybrid grapes helped further lead to a distinguished American industry (p. 18, 2002). As a result, the United States now has some of the most well-known wine varieties and production regions in the world.

2.2 Sulfites

2.2.1 Overview

Sulfur dioxide, a sulfiting compound, is one of the most widely utilized and most versatile food preservative agents (Emerton and Choi, p. 139, 2008). Depending on the food being treated, sulfur dioxide may take the equivalent chemical forms of sodium sulfite, sodium and potassium bisulfites, and metabisulfites (Grotheer, Marshall, and Simonne, 2005; Emerton and Choi, p. 138, 2008). Sulfites in aqueous solution react by the following formula:

(2.1) $SO_2 + H_2O \Leftrightarrow H^{1+} + HSO_3^{1-} \Leftrightarrow 2H^{1+} + SO_3^{2-}$

The direction of the reaction in solution is highly pH dependent. Thus, biologically, antimicrobial amounts of the highly reductive active molecular form (SO_2) are only present in solution at lower pH. In fact, only highly acidic food products, such as citrus juice and wine, actually retain the highly reducing sulfur dioxide compound (Emerton and Choi, p. 138, 2008). In general, sulfite preservatives serve as an antioxidant and antimicrobial agent, which prevent food spoilage. Common applications of sulfites include the treatment of fruits, vegetables, and meat products to enhance the coloration and maintain freshness. Sulfites also help retain vitamins A and C in dehydrated foods (p. 140, 2008) and are even utilized to maintain the strength of some medications (Grotheer, Marshall, and Simonne, 2005).

In winemaking, sulfites have been used nearly universally for over 2000 years (Goode and Harrop, p. 150, 2011). Sulfites serve as an antioxidant, which prevents unsightly browning and a diminished flavor (Gray, 2011). They also prevent the growth of microbes in the form of unwanted yeast and bacteria (Goode and Harrop, p. 151, 2011). Added in the form of SO_2, sulfites are commonly used in three phases. First, winemakers may add a solid form of SO_2 to the grapes while still on the vine in order to prevent mold growth and spoilage. Once the grapes are harvested, a gaseous form or potassium metabisulfite powder is added in quantities that result in around 30 to 60 parts per million (ppm) of free SO_2 during the grape crushing stage, and then again after fermentation stops, immediately prior to bottling (Vine, Harkness, and Linton, p. 110, 2002). In total, producers commonly add around 30 to 90 ppm of sulfites (Burgstahler and Robinson, 1997).

The quantity of sulfites added depends heavily on the acidic pH level and sugar content of the wine. Adding too many sulfites prevents the wine from maturing correctly and may result in a sulfuric aroma or taste. Too few sulfites, however, increase the risk of spoilage (Goode and Harrop, p. 114, 2011). Most red wines are between a 3 and 4 pH level in acidity, with white wines being slightly more acidic (p. 150, 2011). A higher pH level is more conducive to oxidation. Because of this, wine with a 3.5 pH requires twice as much SO_2 as a wine with a pH level of 3.2, all other things constant. In addition, dryer wines require less preservation than wines with more sugar (Vine, Harkness, and Linton, p. 112, 2002). These chemical properties exist because, when added, sulfites take on the characteristic of being either free or bound. Bound sulfites are dissolved immediately and are temporarily lost, especially in sweeter and less acidic wines. While some bound sulfites are released after the free sulfites are fully used, others are permanently lost, which necessitates additional sulfite applications to achieve the same pasteurization objective (Goode and Harrop, p. 151, 2011).

Regardless of the quantity of sulfites applied, all wines contain small amounts of sulfites naturally due to the chemical properties of the yeast during the fermentation process (Chengchu, Ruiying, and Yi-Cheng, 2006; Goode and Harrop, p. 161, 2011). This had led to some confusion in the natural wine market when consumers are sulfite-sensitive (Goode and Harrop, p. 161, 2011). While headaches are more commonly attributed to red wine than white wine, red wines actually need fewer added sulfites, because they contain higher levels of tannins and anthocyanins, both of which react with oxygen and serve as a buffer between the sulfites and oxygenation. White wines, while more acidic, do not contain this buffer and are therefore more difficult to produce without the use of added sulfites (p. 152, 2011).

2.2.2 Health Impacts from Sulfites

Adding SO_2 to wine is a common practice and yet it remains highly controversial (Vine, Harkness, and Linton, p. 110, 2002). The Food and Drug Administration estimates that 1 in 100 people lack the enzyme necessary to process high levels of sulfites (cited in Grotheer, Marshall, and Simonne 2005). In this case, allergic consumers oftentimes face severe reactions including asthmatic-like symptoms, skin rashes, and stomach cramping, sometimes after ingesting even small amounts of wine. Each allergic individual has a different tolerance level, but 300 ppm of sulfites has been found to be a typical threshold needed to induce an asthmatic reaction, which is above the normal application range of 30 to 90 ppm for most winemakers (e.g. Vally and Thompson, 2001; Burgstahler and Robinson, 1997). Likewise, the allergic reaction time varies between individuals, but it usually occurs within 30 minutes of sulfite ingestion, which often necessitates rapid medical attention (Grotheer, Marshall, and Simonne, 2005).

There is also a common perception that sulfites cause less severe health effects to a wider share of the population, such as headaches and migraines, after consuming even moderate amounts of wine, particularly the red varieties (Gaiter and Brecher, 2000; Grotheer, Marshall, and Simonne, 2005). While not entirely discredited, there is a lack of scientific consensus that sulfites are the actual cause of the reported headaches outside of the severe allergic reactions. In fact, histamines and phenolic flavonoids, which are present at higher quantities in red wine, may be more of a headache trigger than the sulfite content (e.g. Mauskop and Sun-Edelson, 2009;

Millichap and Yee, 2003). When wine is consumed outside of moderation, sulfite sensitivity may also be confused with the alcohol hangover headache (AHH), which is indeed more likely to be triggered by red wine and other dark alcoholic beverages, such as bourbon, due to the higher presence of congeners which cause a magnesium deficiency (Mauskop and Sun-Edelstein, 2009).

2.2.3 Regulations

One possible explanation for the perception that sulfites trigger headaches and migraines may relate to the regulatory environment surrounding wine production and labeling. In response to the severe allergies that some consumers experience after ingesting sulfites, the Federal Bureau of Alcohol, Tobacco, and Firearms (ATF) has mandated that a sulfite warning be included on the labels of wine containing greater than 10 ppm of sulfites, measured as sulfur dioxide, since 1987. The statement must be displayed on the front, back, strip or neck label of the bottle (Government Printing Office, 2011). In addition, no wine sold via interstate commerce may contain more than 350 ppm of sulfites. Finally, wine labeled as “organic” and “100% organic” may not contain any added sulfites. Moreover, a lab analysis must confirm that the natural total sulfite content in wine marketed as organic is less than 10 ppm (TTB, 2011a; Vine, Harkness, and Linton, p. 110, 2002), which is below the level in which most sulfite-sensitive individuals experience negative health effects (e.g. Vally and Thompson, 2001).

Any wine being sold in interstate commerce is required to obtain approval from the Alcohol and Tobacco Tax and Trade Bureau (TTB), which ensures that the wine labeling requirements are met. While labeling and production regulations specifically target sulfite use, it is interesting to note that other possible headache and migraine triggers such as histamines and phenolic flavonoids are not required components of the warning label (TTB, 2011a). This may add to the confusion surrounding sulfites as a trigger of minor adverse health effects experienced by some.

2.2.4 Alternative Wine Production Technologies

In response to a growing niche movement oriented toward more natural production practices, "vins sans souffre" (wine without added sulfites) is becoming more mainstream worldwide (Goode and Harrop, p. 142, 2011). This is made possible, in part, because of the increased hygiene of equipment during production as well as climate controlled storage facilities. Wines that can make assurances for hygiene without the use of sulfites may be a particularly unexploited niche market in the United States (e.g. p. 160, 2011).

In order to produce wine without the use of sulfites, certain practices are implemented to reduce the risk of oxidation and spoilage. During the growing phase, harvesting healthy high-quality grapes at their optimum ripeness helps prevent future spoilage due to micro-organism growth (p. 160, 2011). Spoilage can also be prevented by maintaining proper yeast cultures and a higher production temperature during fermentation (Battenkill, 2002), and after harvest, stainless steel storage bins are easier to clean between batches (Goode and Harrop, p. 160, 2011). Furthermore, recent technology has enabled bottles to be gassed with nitrogen and filled in a vacuum to minimize the wine's contact with oxygen (p. 160, 2011). While the risk of spoilage is higher with wine preserved without sulfites, if the wine has not oxidized within three weeks after bottling it will likely age similar to traditional wines (p. 160, 2011).

Producing wine with reduced or removed sulfites continues to be a labor and capital-intensive process, but alternative preservation methods are emerging that may create greater cost-efficiencies. The use of ultraviolet (UV) light is one method that is currently being used by some wine producers. UV light has been utilized to pasteurize other foods in the past but until recently has not been used by the wine industry (Wine Spectator, 2012a). The UV pasteurization machine is roughly the size of two refrigerators, which serves to fully mix the wine to ensure that it is entirely exposed to the UV lamps (Evans, 2009). UV light kills active yeast and bacteria, but one concern is that it is not very effective in preventing oxidation (Wine Spectator, 2012a).

Similar to UV light, hydrogen peroxide has also been used to neutralize sulfites on food, but oxidation concerns have kept hydrogen peroxide from being widely applied to wine. Ozkan and Cemeroglu (2002) conducted a study of immersing apricots treated with SO_2 in hydrogen peroxide. When immersing apricots, a twelve minute exposure to 1% hydrogen peroxide concentration was effective in removing 66% of the SO_2. McFeeters (1998) also found that adding hydrogen peroxide to fermented cucumbers was an effective method of removing the SO_2 content. While adding small amounts of hydrogen peroxide to wine does neutralize the sulfites, it is a major oxidizing agent. Therefore the use of hydrogen peroxide without some method in place to prevent oxidation, will not be adopted as a recommended practice in winemaking (e.g. Goode and Harrop, p. 151, 2011)

2.3 Discrete Choice Literature

Within the context of conjoint analyses for product attributes, previous literature has commonly applied both the stated preference (direct) discrete choice approach as well as the revealed preference (indirect) discrete choice approach. Both methods seek to model and estimate consumer preferences among a set of alternatives.

2.3.1 Revealed Preferences

The revealed preference method of valuation is one strategy commonly utilized, where actual behavior is observed in order to infer an individual’s preferences among a set of alternatives. Tradeoffs between different modes of transportation are commonly studied using the revealed preferences method, because data is relatively easy to obtain and interpret by observing actual commuting patterns (Kroes and Sheldon, 1988; Brownstone, Bunch, and Train, 2000). For choice experiments that rely on more precision, however, the revealed preference method is not desired because exogenous factors that influence a participant's behavior cannot be fully measured. In addition, revealed preference experiments are only useful when quantifying an already existing attribute that is distinctively labeled and marketed, not one that is hypothetical or in an underdeveloped market segment (Kroes and Sheldon, 1988; Adamowicz, Louviere, and Williams, 1994).

2.3.2 Stated Preferences

For food and wine marketing studies, the stated preferences approach is more frequently used, where preferences are elicited directly by asking respondents to choose among a series of hypothetical alternatives. This approach has the benefit of allowing for more exactness in the experimental design, as well as the flexibility to better control for exogenous factors that may otherwise influence preferences. One downside to the stated preference approach is that one's choices may not fully represent real-life decisions due to the hypothetical nature of the questionnaire and a tendency to overstate willingness to pay (WTP) for an attribute (Kroes and Sheldon, 1988). Adding a "cheap talk" script, where participants are explicitly told the importance of providing careful and realistic responses, appears to reduce this bias (e.g. Carlsson, Frykblom, and Lagerkvist, 2005).

2.3.2.1 Experimental Design

To add precision to the estimated coefficients, variables, or treatment effects, experimental designs are commonly implemented in stated choice studies. Unlike data obtained from behavioral observations, stated choices are generally elicited from controlled surveys. A common design includes directing participants to choose among a series of product alternatives, where each product alternative contains varying attribute levels, such as price (e.g. Scarpa et al., 2010). While not entirely necessary with larger samples, implementing a carefully-developed experimental design allows for the model to be estimated with the smallest sample size possible, and may make the process more time-efficient. This is particularly useful when participants are compensated and the compensation is dependent on the expected time to complete the survey.

Stated preference experimental designs are developed by either using a full factorial design or a fractional factorial design. The first requires that each alternative is compared to every other alternative. The latter uses statistical methods to derive an abridged choice set that can be used to infer preferences (Choice Metrics, p. 60, 2011). The number of choices within a full factorial design increase exponentially as the number of possible alternatives increase (Hu et al., 2011). Therefore, efficient, orthogonal, or orthogonal optimal in the differences (OOD) D-optimal designs are commonly-implemented to restrict the number of choice iterations in an experiment (Choice Metrics, p. 60, 2011). Efficient designs allow for parameter estimation with minimal standard errors, but they require prior knowledge about the parameters (p. 89, 2011). Orthogonal designs ensure that the attributes being compared are uncorrelated, and as a result, prevent multicollinearity in the estimates (p. 64, 2011). The OOD D-optimal design is orthogonal in nature, and it ensures that all attributes are traded in the design (p. 79, 2011).

The choices that participants make in a stated choice experiment inform the estimation of preferences among alternatives, but different survey structures may yield better results than others. Earlier choice literature has asked participants to rank a full list of products within a single choice set (e.g. Beggs, Cardell, and Hausman, 1981; Gil and Sánchez, 1997). More recent literature has utilized the panel fractional factorial setup where each individual ranks a set of alternatives in multiple choice sets. This is seen in Onozaka and Thilmany McFadden's (2011) study quantifying WTP for sustainable production claims on apples and tomatoes. The experiment utilized a D-optimal orthogonal design containing 8 choice sets, each with 2 alternatives. Hu et al. (2011) also designed an orthogonal survey where 3 choice sets were presented to respondents, each containing 2 alternatives to quantify consumer perceptions for local production labeling of blackberry jam.

2.3.2.2 Analysis

Once an experimental design is implemented, choosing the analysis method depends on what the research objectives are. While ordinary least squares (OLS) and weighted least squares (WLS) methods are sometimes used in stated choice experiments (e.g. Gil and Sánchez, 1997), a more common application in analyzing preferences involves logit estimation which is based on the random utility model (ARUM) (e.g. Koning and Ridder, 2003):

(2.2) $U_{ik} = V_{ik} + \varepsilon_{ik}$

Where the utility of individual *i* choosing alternative *k* is derived based on a vector set of attributes *V* plus a random error term.

The vector set of attributes is linearly defined as a function of estimates (β), where each estimate represents a product attribute. Hence, the indirect utility framework allows for an estimation of how product attributes influence utility. Link functions are then applied to predict the marginal effects that changes in an attribute or alternative have on utility. Depending on the nature of the data, a variety of link functions are used in analyzing conjoint experiments, but they share common ground in the underlying indirect utility framework.

A common application of stated choice experiments is to understand how different socio-demographic groups perceive a product. Multinomial logit is a useful regression tool, because it accounts for individual-specific regressors. Nganje, Kaitibie, and Taban (2005) utilized multinomial logit methods to explore how individual socio-demographic factors influence the risk perceptions of consuming buffalo meat. Participants were asked whether they perceived specialty meat consumption as being “safe”, “somewhat safe”, or “somewhat unsafe”. These three categorical variables were then regressed as a function of the respondents’ individual-specific characteristics to conclude that socio-demographic and experience characteristics do significantly influence risk perceptions.

In wine marketing choice studies, riskiness is often associated with the high information asymmetry between the consumer and what is actually within the product, which is known only to the producer (Lockshin et al., 2006). Since the wine label provides signals for consumer expectations, a variety of studies have identified labeling attributes that significantly influence choices across specific consumer groups. For example, Lockshin et al. (2006) conducted a market share simulation and found that consumers can be segmented as being either high-involvement or low-involvement, where highly-involved consumers are more engaged in the market.

Quality awards listed on the label for small brands at the lower price points were found to significantly increase the market share, particularly with low-involvement consumers. High-involvement consumers, on the other hand, tended to prefer wine in the higher price points and were less influenced by the award (2006). Mtimet & Albisu (2006) also segmented the wine market based on market involvement levels, where highly-involved consumers were defined as purchasing wine every day, or some days during the work week. By utilizing main-effect and interaction-effect multinomial logit models, the results indicated that designation of the wine’s origin was important for occasional consumers, while the wine’s age had a relatively larger impact on utility for high-involved consumers. High-involvement consumers also expressed less preference for wines under €8.80.

Instead of identifying a specific group or market segmentation, some experiments have used a demographic-specific viewpoint when quantifying how product attributes are valued. Jarvis et al. (2010) studied how a specific age cohort perceived different wine label designs. The choice set contained 64 alternatives, nested within 16 choice tasks, with 4 choices per task. Using a multinomial logit, the results indicated that 18 to 30 year olds are significantly impacted by the wine label's image, followed by a slogan, variety, and region of production.

Other stated choice experiments shift the focus away from individual-specific estimates and instead look at how varying product-specific attributes influence choice. Outside of the indirect utility framework, Gil and Sánchez (1997) use OLS and WLS and vary price, age (labeled as "current year" or "old"), and origin of the wine in an orthogonally-designed choice experiment. The design included nine product profiles, and participants were asked to rank all nine wines in one choice scenario. The study concluded that production origin is the most important attribute in the purchasing decision for wine, and that price and vintage year were not significant in determining choice for aggregated consumers. Socio-demographic characteristics were later segmented and analyzed using the same OLS model, and again with logistic modeling.

Conditional logit is another useful method that allows for alternative-specific variation. Loureiro and Umberger (2007) applied a conditional logit model when estimating consumer choices for beef. The model included attribute-specific variables such as price, tenderness of the meat, food safety, and traceability of the meat's origin. Conditional logit models have the additional benefit of allowing the alternative-specific variables, which relate directly to the product itself, to be interacted with individual-specific attributes in order to predict structural differences based on demographics. Burton et al. used a conditional logit model and interacted the alternative-specific variables with the socio-demographic variables. The experiment pointed to the conclusion that gender was a statistically significant factor in determining how genetically modified food is valued, while other attributes such as chemical use, local production, and consumption risk, were not valued differently across individual-specific cohorts (2001).

Conditional logit models are limited by their dichotomous dependent variable; namely, that individuals either select an alternative or they do not. In a choice experiment, this means that respondents are limited to select only their "most preferred" alternative within each choice set. The exploded conditional logit model, therefore, serves as an extension of conditional logit by allowing the alternatives to be ranked. This methodology greatly increases the number of observations obtained from each individual, because each participant can select both their "most preferred" and "least preferred" alternative. In a choice set with 3 alternatives, this best-worst setup allows for a full ranking to be derived from each choice set while minimizing the respondent's cognitive burden (Louviere et al., 2008; Potoglou et al., 2011; Scarpa et al., 2010).

Ranked data analyzed via exploded logit has not been widely utilized in wine marketing studies. Cohen (2009) gathered ranked data but did not analyze it with the exploded logit when looking at how Australian and Israeli consumers purchase wine. Outside of wine marketing, a variety of best-worst experiments have been conducted. Scarpa et al. (2010) used the best-worst approach in their WTP analysis of proposed policies for Alpine transhumance region and confirmed that it decreased the number of needed iterations by 2/3 while still maintaining the same standard errors. Punj and Staelin utilized a ranking design to estimate how students rank graduate schools based on cost, quality, test scores, distance, and other variables. Using the regression results, they estimated the marginal probability of a student actually matriculating at a given school (1978).

In experiments allowing for respondents to provide information in multiple choice sets, the standard errors need to be adjusted to account for the dependence between the individual and his or her responses. Defining a variance-covariance matrix clustered on each participant is one method to account for this dependency, because the observations are assumed to be independent across the choice groups, rather than each individual. Hence, this setup improves the accuracy and reliability of the standard errors (e.g. Williams, 2000; McGowan et al., 2010).

A more recent attempt to account for individual clusters for ranked data includes the identification of latent class groups where different cohorts have varying preferences, as well as identifying a random coefficient. Generalized linear latent and mixed modeling (GLLAMM) is one overarching procedure that allows for such research (Skrondal and Rabe-Hesketh, 2003). Unlike variance-covariance clustering, GLLAMM models the heterogeneity across individuals by defining random coefficients. Bishai, et al. apply this alternative method in a study to derive willingness to pay for the Meningococcal vaccine for German and French parents. The experiment included 229 participants responding to 18 choice sets, each with 3 varying vaccine scenarios. Using GLLAMM, the estimates accounted for different intercepts between each subject, and between each question (2007).

CHAPTER THREE

DATA AND METHODOLOGY

3.1 Survey Design

In order to analyze consumer preferences, the data for this study was obtained by recruiting participants to take an online survey. Since having participants rank all possible wine choices was not feasible due to the large number of hypothetical wines, an OOD D-optimal experimental design was utilized.

Fractional factorial survey designs are either efficient or orthogonal. Efficient designs allow for parameter estimation with as low standard errors as possible, but they rely on previous knowledge on what the magnitude of the parameter values are likely to be (Choice Metrics, p. 89, 2011). In contrast, orthogonal designs are defined by their attribute level balance across the experiment, namely that levels of attributes across the choice design are uncorrelated (p. 64, 2011). In an experiment with *J* choice scenarios and two attribute columns *p* and *q*, each with two varying levels of -1 or 1, the orthogonal design is satisfied if (3.1) (p. 64, 2011):

$$(3.1) \quad \sum_{j=1}^{J} X_{p1,q1,s} X_{p2,q2,s} = 0, \forall\, (p_1, q_1) \neq (p_2, q_2)$$

Equation (3.1) implies that the correlation matrix *jk* is specified as an identity matrix (p. 64, 2011). Orthogonality, by definition, also ensures that an estimated model does not suffer from multicollinearity. When the number of choice iterations is still too large for a single respondent to reliably complete them, orthogonal designs may additionally allow for blocking. In a blocked design, each respondent only completes a fraction of the choice set and, when all responses are combined, orthogonality ensues (p. 66, 2011).

The orthogonal optimal in the differences (OOD) D-optimal design requires a specific type of orthogonality, where the differences between attribute levels are maximized, forcing respondents to trade between all the attributes. This is useful in increasing the amount of information obtained from each respondent, and it does not require prior knowledge about the parameter magnitudes. The OOD D-optimal design assumes that all product alternatives within the choice set have the same attributes and attribute levels, otherwise optimality cannot be achieved (p. 79, 2011).

Wine Spectator was chosen as a basis for the quality definitions due to its extensive collection of wine reviews, as well as its use in previous wine marketing studies (e.g. Costanigro, McCluskey, and Mittelhammer, 2007). Following Costanigro, McCluskey, and Mittelhammer's (2007) finding that pricing segmentation exists within the wine industry, participants were evenly and randomly assigned to one of three pricing groups: $10-$15; $20-$25; or $30-$35. Participants were also randomly assigned to a "red wine" category or a "white wine" category to test for differences in preferences between general wine varieties. The attributes and attribute levels used in the experiment are defined in Table 3.1, with the quality ratings by *Wine Spectator* defined in Table 3.2.

Table 3.1. Definition of the Attributes and Attribute Levels

Attribute	**Level 0**	**Level 1**	**Level 2**	**Level 3**
"USDA-Certified Organic" Label	No	Yes	-	-
"No Sulfites Added" Label	No	Yes	-	-
Quality Score	80	84	88	92
Price (Participants randomly distributed to 1 of 3 price ranges)	$10.49 $20.49 $30.49	$11.99 $21.99 $31.99	$13.49 $23.49 $33.49	$14.99 $24.99 $34.99

Table 3.2. Wine Spectator Quality Scores (Wine Spectator, 2012)

Rating	**Definition**
95-100	Classic. A great wine.
90-94	Outstanding: A wine of superior character and style
85-89	Very good: A wine with special qualities
80-84	Good: A solid, well-made wine
75-59	Mediocre: A drinkable wine that may have minor flaws
50-74	Not recommended

The full factorial design included 64 (2×2×4×4) possible wines. Using the Ngene software, the reduced OOD choice design was 96.14% D-optimal, with 12 choice scenarios, each containing 3 wines. The output from Ngene is seen in Appendix A. Following the findings in Jarvis et al. (2010) that showed the importance of using pictures in wine labeling, images were included in the choice set depicting whether a wine was organic or made without added sulfites. The "USDA-Certified Organic" label was based on the existing certification seal that USDA allows certified companies to display on food products, while the "No Sulfites Added" label is a fictitious proxy for a label that could be developed (Figure 3.1). The attribute levels for the labels were designed such that any given wine could have one, both, or neither labels.

Figure 3.1. USDA-Certified Organic (1) and No Sulfites Added (2) Labels

(1) (2)

3.2 Survey

3.2.1 Recruitment

The survey was conducted online with the Qualtrics software. An abridged pilot survey was initially tested using voluntary participants. The purpose of the pilot survey was to get a sense of the reliability of the OOD D-optimal design, as well as to provide interested participants a chance to preview the survey. Using the initial framework from the pilot survey, a final, more extensive survey was developed which included more extensive demographic-specific and purchasing behavior questions. In addition, the final survey also included a cheap talk script and a question asking whether participants would be actually willing to purchase the wine selected as "most preferred" within each choice set. Since participants were forced to choose a wine in the main choice set, this additional question provided a more realistic view of how the participants actually purchase wine. A $20 wine voucher redeemable for one bottle of wine was also provided at the end of the final survey to incentivize participation.

Participants were recruited using the customer database of a large wine retailer in Fort Collins, Colorado. The particular retailer was chosen because of its large selection of wines representing a wide variety of categories (production location, local, organic), as well as its location between both a high-end natural foods store and a large grocery store chain, which helped diversify the sample of wine consumers and better represent the consumer population as a whole. A link was emailed to 5,288 potential participants in order to recruit for the initial pilot survey, and they were asked to respond if interested in taking the final survey (Appendix B). Out of the 5,288 customers receiving the initial email, 314 previewed the pilot survey, eliciting a response rate of 5.94%, and 358 people expressed interest in participating in the final survey, which represented a 6.77% response rate.

Of the 358 emails received from people expressing interest, 298 participants were sent a link to the survey in a second email. A project cover letter was attached to the email (Appendix C-D). Two hundred twenty-seven participants started the survey, with a final number of 223 completing it. At the end of the survey, participants were provided with a printable wine voucher. From the time that respondents were contacted in the second email, two weeks were provided to complete the survey and redeem the voucher. The survey responses were kept anonymous and were only tracked by a randomly-generated 9-digit code.

3.2.2 Consumer Information

The full text of the survey is shown in Appendix E[1]. The first section of the survey contained an introduction question summarizing the project, as well as a certification that the participant was 21 years of age or older. Once admitted to the survey, there were four socio-demographic questions asking respondents about their age range, income, gender, and level of education completed. The socio-demographic questions were used to summarize the sample of participants taking the survey and look for initial patterns in the data.

Given that past wine literature has segmented the market between high-involvement and low-involvement consumers (e.g. Lockshin et al., 2006; Mtimet and Albisu, 2006), the survey also integrated questions intended to provide information about the participant's level of knowledge associated with wine, including two questions on whether they belonged to a wine club or subscribed to a wine magazine. The participant's level of consumption was gauged by asking how many bottles of wine in a typical month they purchase. The word "typical" was underlined within the survey so that a more generalized estimate would be obtained to prevent under or overestimation due to a particular month. Participants were then asked how many

[1] The survey was approved on January 20, 2012 by the IRB Coordinator of the Research Integrity & Compliance Review Office, Colorado State University. IRB ID: 131-12H.

bottles of wine they currently had in their home. The consumption level questions were used to see if a connection between market involvement and experiencing headaches existed, as well as to analyze whether market involvement significantly impacted preferences for wine attributes

The next two questions asked participants if first they ever experienced headaches after drinking even moderate amounts of wine and, if so, what factors they believed caused the headaches. Eight factors included within the survey were: drinking organic wine, drinking red wine, drinking white wine, sulfites, tannins, tyramine, histamines, or dehydration. Respondents could also manually type in other factors. The ordering was randomized, and respondents could select as many options as needed.

3.2.3 Consumer Preferences

To test for differences in consumer preferences between red and white wine varieties, two scripts were included in the survey which randomly and evenly segmented the participants:

> For each of the 12 scenarios, imagine that you are at a store purchasing a Chardonnay (white wine). After carefully considering the three wine labels, select one wine that is your most preferred. Then select another wine that is your least preferred.
>
> Or:
>
> For each of the 12 scenarios, imagine that you are at a store purchasing a Cabernet (red wine). After carefully considering the three wine labels, select one wine that is your most preferred. Then select another wine that is your least preferred.

After obtaining the headache trigger perceptions, but before the choice set, participants were then informed about sulfites in general, including their use in winemaking, current medical knowledge connecting sulfites to headaches, and the typical application levels of sulfites in wine (Appendix E). The information was purely objective, and no implication was made that sulfites were the cause of headaches. Even though informing participants about general knowledge surrounding sulfites distorted the quantification of *a priori* consumer knowledge, it was deemed appropriate because potential niche producers would likely seek to inform consumers of at least the basic knowledge surrounding sulfites as part of any marketing campaign. Hence, including basic objective information about sulfites allowed for a more realistic assessment of potential consumer preferences and the role of information in relevant marketing avenues.

Since the stated choice experiment was hypothetical in nature, two concerns were that participants would not actually imagine themselves in a real purchasing situation and that they would not take the survey seriously. A cheap talk script was therefore added before beginning the choice set in order to reduce the potential for biased estimates. Similar to the script used in Carlsson, Frykblom, and Lagerkvist (2005), it read:

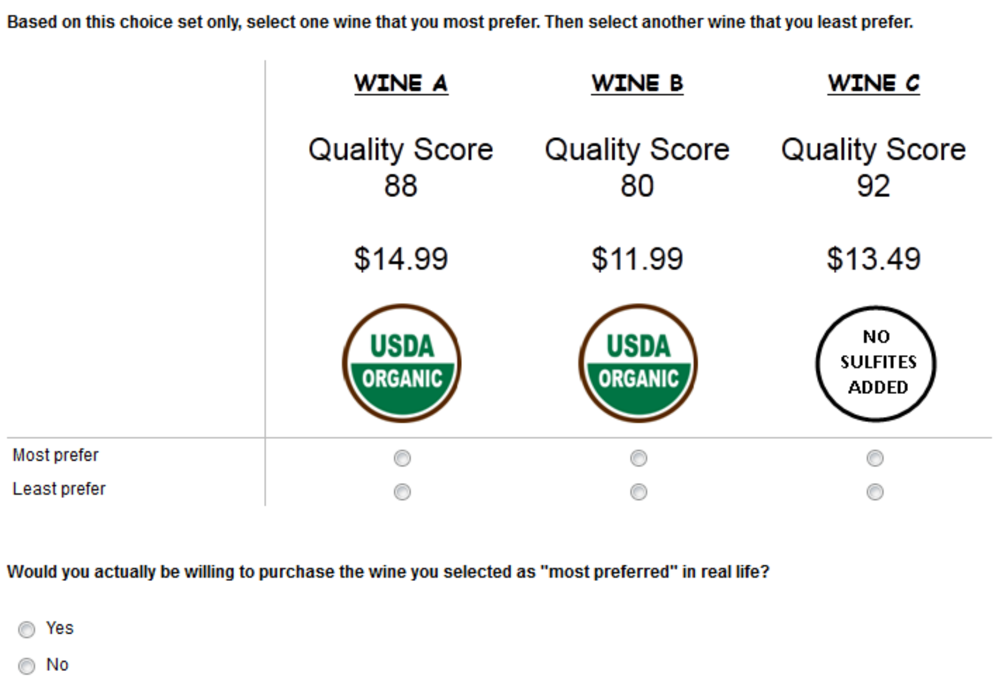
> In other similar surveys, people have answered the questions one way but then act differently in real life. Although the wines in the following choice sets are hypothetical, it is important to take the survey seriously. Our project relies on you answering as accurately and carefully as possible.

The respondents were then directed to the 12 choice scenarios. The order of the choice scenarios was randomized to prevent biased results stemming from participant fatigue. The "most preferred" and "least preferred" setup of the choice set was designed based on Scarpa et al. (2010) and initially developed in Louviere and Woodworth (1990) (cited in Potoglou et al., 2011). This methodology allowed for a full ranking of each choice scenario to be developed, which greatly increased the amount of information obtained throughout the experiment. Each choice scenario also contained a question asking if the participant would actually purchase the wine they selected as "most preferred" to provide a more realistic response than forcing a choice. A sample question is illustrated in Figure 3.2.

After completing the 12 choice sets, participants were then directed to a printable wine voucher which could be redeemed for one bottle of wine at the local retailer, up to $20 in value.

The voucher included the participant's randomly-generated 9-digit code, as well as a date of issue. All vouchers expired 23 days after the initial email was sent out. Providing the voucher enabled access to the wine retailer's customer database. It also incentivized the survey which facilitated the recruitment process.

Figure 3.2. Sample Choice Scenario



3.3 Estimation Procedure

3.3.1 Discrete Choice Theory

The first step in the estimation procedure was to obtain the marginal effects of changes in the wine attributes on utility, which were assessed using the exploded (rank-ordered) conditional logit model and analyzed in STATA. An aggregated model was first estimated including all respondents together. Interaction models were then included to test for differences in responses across socio-demographic characteristics and randomly-assigned price and varietal groups.

Lastly, the quality attribute was squared to test for a nonlinear relationship between quality and marginal utility.

To understand the exploded logit model, it is useful to be familiar with the more basic, dichotomous models, which are all based on the non-panel indirect utility function specified in (2.1). One of the easiest and most widely used models in discrete choice methods (e.g. Train, p. 15, 2009) is the general logit, which accommodates for a binary outcome with a dependent variable of either 0 or 1, where 0 signifies that alternative *k* was not selected and 1 represents a positive selection. The simple, non-panel model is restricted between two alternatives where the probability of individual *i* selecting choice *y* is equivalent to the probability that the utility derived from choice *y* is greater than the utility derived from choice *z* (p. 15, 2009). It is specified as:

$$(3.2) \quad P_{iy} = \text{Prob}(V_{iy} + \varepsilon_{iy} \geq V_{iz} + \varepsilon_{iz} \; \forall \; y \neq z) = (\varepsilon_{iz} - \varepsilon_{iy} \leq V_{iz} - V_{iy} \; \forall \; y \neq z)$$

The error term ε is considered to be an unknown element of utility to the researcher and is therefore treated as a random component (p. 34, 2009). The logit probability of alternative *y* being selected over alternative *z*, while not directly observable, is related to the explanatory variables of the indirect utility function and can be estimated via a link function:

$$(3.3) \quad P_{iy} = \frac{\exp(V_{iy})}{\sum_z \exp(V_{iz})}$$

Since the setup of the survey involved participants going through multiple choice sets, the data was panel in nature. The underlying indirect utility model therefore became specified in a panel framework. For participant *i* within choice set *j* the utility derived from wine *k* is evaluated as a function of indirect utility plus a normally-distributed error term, and the indirect utility function V_{ijk} is the vector of the varying wine attributes included within the choice set (3.4):

$$(3.4) \quad U_{ijk} = V_{ijk} + \varepsilon_{ijk}$$

Where the utility of individual *i* in choice set *j* choosing alternative *k* is derived based on a vector set of attributes *V* plus a random error term, ε_{ijk}, and V_{ijk} = f(organic, sulfite, quality, price).

The binomial or multinomial logit models do not allow for multiple alternatives to be selected in a specific choice set, but panel ranked data can be accommodated by "exploding" a conditional logit model. By itself, the dependent variable estimated by the conditional logit model is dichotomous, which restricts participants to only select their "most preferred" alternative. The link function is specified as (3.5) (Hu et al., 2011; Punj and Staelin, 1978):

$$(3.5) \quad P(Y_{ij} = k) = \frac{\exp(V_{ijk})}{\sum_{k=1}^{3} \exp(V_{ijk})}$$

Where individual *i* is choosing alternative *k* within choice set *j*, and there are K=3 alternatives within each choice set.

By applying the exploded conditional logit function, the likelihood of person *i* ranking the three wines in the order of A, B, C within choice set *j* can be obtained by estimating the conditional logit probability of choosing alternative A from the list of A, B, C, multiplied by the conditional logit probability of choosing alternative B from the list of B and C (3.6) (Chapman and Staelin, 1982):

$$(3.6) \quad \text{Prob(rank A, B, C)} = \text{Prob}(A \mid C) \times \text{Prob}(B \mid C - \{A\})$$

By expanding the conditional logit link function, the likelihood of a specific rank is therefore calculated as (3.7), Where A, B, and C are specific *k* alternatives for individual *i* within choice set *j* (e.g. Train, p. 161, 2009):

$$(3.7) \quad \text{Prob}_{ij}\ (\text{rank A, B, C}) = \frac{\exp(V_{ijA})}{\sum_{k=A,B,C} \exp(V_{ijk})} \frac{\exp(V_{ijB})}{\sum_{k=B,C} \exp(V_{ijk})}$$

Since each choice set in the experimental design contained 3 alternatives wine labels, choosing both a "most preferred" and "least preferred" option allowed for an implicit full ranking within each choice set. The exploded logit specification, then, was utilized to estimate the indirect utility derived from a specific rank. When estimating the likelihood of a specific rank being chosen, this implies that the summation of all possible rank combinations is one. By eliciting multiple functions from a single respondent's choice set, the exploded logit model provides a much greater amount of information than the logit, multinomial logit, or conditional logit, which have been predominantly used in previous wine literature.

3.3.2 WTP Estimation Using Marginal Effects

Once the exploded conditional logit model was determined to be the most appropriate model given the research objectives and experimental design, the next step was to estimate marginal willingness to pay (WTP) for the wine attributes based on the regression estimates. When price is used as a varying attribute within each alternative in a choice experiment, the marginal willingness to pay for an additional unit of the attribute can be calculated based on the estimated indirect marginal utility of money. WTP is therefore estimated as (3.8), where X is the marginal WTP and β represents the population-averaged estimated coefficient for the specified attribute (e.g. Berreiro-Hurlé, Colombo, and Cantos-Villar, 2008; Revelt and Train, 1998; Hu, et al., 2011):

(3.8) $X = -\left(\frac{\beta_{\text{Sulfite}}}{\beta_{\text{Price}}}\right)$

Since utility is an abstract measurement in any given model, the ratio of the price estimate with the sulfite estimate allowed for a direct calculation of how much the respondents were willing to pay for wine with no added sulfites, because utility is consistent within individuals. Because the price levels were defined in $1.50 increments (see Table 3.1), the estimates were linearly transformed by multiplying the ratio by 1.5.

3.3.3 Post-Estimation Panel Logit

After WTP estimates from the aggregated sample and segmented groups were obtained, the final step was to analyze participant responses on whether they would actually be willing to purchase their "most preferred" wine within each choice set. The model was estimated in STATA using the xtlogit population-averaged panel command. A dichotomous variable was created which was defined as 1 if the respondent indicated that they would be willing to purchase their "most preferred" wine, and defined as 0 otherwise. Regressed against the wine attributes, the model allowed the researchers to see how wine attributes were valued in a more realistic purchasing situation rather than in a hypothetical choice set.

Unlike the exploded logit function which inherently produces population-averaged estimates that assume homogeneity in individual preferences, the panel logit function can accommodate for either the random-effects or population-averaged models. Random effect parameters are generally larger than the population-averaged model, as are the standard errors. More formally, the random-effects approach is modeled as (3.10), where individual *i* is making a choice within time period *t*, x is the estimated coefficient, β is the variable, α is the individual-specific intercept, and $\Omega(z) = \exp(z)/(1+\exp\{z\})$. (Cameron and Trivedi, p. 625, 2010):

$$(3.9) \quad Pr(y_{it} = 1 \mid x_{it}, \beta, \alpha_i) = \Omega(\alpha_i + x'_{it}\,\beta)$$

When estimating preferences for the *i*th individual through the population-averaged approach, the individual intercept α_i is integrated out of the model, which makes the individual-specific estimates difficult to compare with the population-averaged estimates (p. 625, 2010). Given the incompatibility between the two approaches and the fact that the exploded conditional logit models were population-averaged, the panel logit model was also estimated using the population-averaged approach.

3.4 Variables

Table 3.3 lists the variables used in the exploded logit models. The dependent variable for the exploded logit model is the respondent's ranking in the choice set, which is a function of the wine attributes. The latent variable analyzed in the exploded logit model, however, represents the estimated utility value based on the varying attribute levels. The main effect dependent variables in Table 3.3 include organic, sulfite, quality, and price. The coefficients for these terms represent the change in marginal utility associated with a one unit change in the attribute, where the marginal change is defined in Table 3.1. The interaction terms include dummy variables, each of which are interacted with the main-effect terms through a variety of exploded conditional logit models (e.g. Burton et al., 2010).

The variables used in the panel logit model are defined in Table 3.4. The dependent variable is WBUY which is a dichotomous variable that either takes on the value of 1 if the respondent indicated willingness to purchase and a 0 otherwise. The price and headache interaction dummy variables were also included along with the main attribute variables.

Table 3.3. Explanatory Variables Included in the Exploded Logit Analyses

Variable	Description
U⁺	Utility
ORGANIC	1 if organic label, 0 otherwise
SULFITE	1 if no added sulfites label, 0 otherwise
QUALITY	Wine spectator quality score
PRICE	Price
MAG*	1 if respondent subscribes to a wine magazine, 0 otherwise
CLUB*	1 if respondent belongs to a wine club, 0 otherwise
PRICE10*	1 if within the $10-$15 category, 0 otherwise
PRICE20*	1 if within the $20-$25 category , 0 otherwise
PRICE30*	1 if within the $30-$35 category, 0 otherwise
WHITE*	1 if within the white wine control group, 0 otherwise
RED*	1 if within the red wine control group, 0 otherwise
HEAD*	1 if reported headaches after drinking wine, 0 otherwise
NOHEAD*	1 if reported no headaches after drinking wine, 0 otherwise
MALE*	1 if male, 0 otherwise
FEMALE*	1 if female, 0 otherwise
INC1*	1 if household income is under $25,000, 0 otherwise
INC2*	1 if household income is $26,000-$50,000, 0 otherwise
INC3*	1 if household income is $51,000-$75,000, 0 otherwise
INC4*	1 if household income is $76,000-$100,000, 0 otherwise
INC5*	1 if household income is $101,000-$200,000, 0 otherwise
INC6*	1 if household income is above $200,000, 0 otherwise
ED1*	1 if less than high school education, 0 otherwise
ED2*	1 if high school completed, 0 otherwise
ED3*	1 if some college, 0 otherwise
ED4*	1 if Bachelor’s degree completed, 0 otherwise
ED5*	1 if Master’s degree completed, 0 otherwise
ED6*	1 if Ph.D/Professional degree completed, 0 otherwise
BUY0*	1 if typically purchase 0 bottles of wine per month, 0 otherwise
BUY1TO3*	1 if typically purchase 1 to 3 bottles of wine per month, 0 otherwise
BUY4TO6*	1 if typically purchase 4 to 6 bottles of wine per month, 0 otherwise
BUY7TO9*	1 if typically purchase 7 to 9 bottles of wine per month, 0 otherwise
BUYOVER10*	1 if typically purchase 10 or more bottles per month, 0 otherwise
OWN0*	1 if currently owns 0 bottles of wine at home, 0 otherwise
OWN1TO3*	1 if currently owns 1 to 3 bottles of wine at home, 0 otherwise
OWN4TO6*	1 if currently owns 4 to 6 bottles of wine at home, 0 otherwise
OWN7TO9*	1 if currently owns 7 to 9 bottles of wine at home, 0 otherwise
OWNOVER10*	1 if currently owns 10 or more bottles of wine at home, 0 otherwise

⁺Dependent variable; *Dummy variables, used for interaction-effects only

Table 3.4. Explanatory Variables Included in the Panel Logit Analyses

Variable	Description
WBUY[+]	1 if respondent actually willing to purchase, 0 otherwise
ORGANIC	1 if organic label, 0 otherwise
SULFITE	1 if no added sulfites label, 0 otherwise
QUALITY	Wine spectator quality score
PRICE	Price
PRICE10*	1 if within the $10-$15 category, 0 otherwise
PRICE20*	1 if within the $20-$25 category , 0 otherwise
PRICE30*	1 if within the $30-$35 category, 0 otherwise
HEAD*	1 if reported headaches after drinking wine, 0 otherwise
NOHEAD*	1 if reported no headaches after drinking wine, 0 otherwise

[+]Dependent variable; *Dummy variables, used for interaction-effects only

CHAPTER FOUR

DESCRIPTIVE STATISTICS AND RESULTS

4.1 Participant Statistics

4.1.1 Socio-Demographics and Headaches

The survey took place between March 8, 2012 and March 31, 2012, with a total of 223 people completing the questionnaire. The first part of the survey included socio-demographic questions in order to assess the sample and evaluate differences across groups in terms of wine purchasing behavior. Table 4.1 summarizes the socio-demographic characteristics overall, as well as the percentage of each group reporting headaches after moderate wine consumption.

Table 4.1. Socio-Demographic Descriptive Statistics and Headaches Reported

Demographic	% of Sample (n=223)	% of Group Reporting Headache (Overall 34.08% of Sample)
Male	47.98%	32.71%
Female	52.02%	35.34%
Age 21 to 30	17.49%	28.21%
Age 31 to 40	19.73%	27.27%
Age 41 to 50	14.80%	45.45%
Age 51 to 60	33.18%	33.78%
Age 61 to 70	13.45%	40.00%
Age Over 70	1.35%	33.33%
Income Under $25,000	8.52%	36.84%
Income $26,000 to $50,000	19.73%	40.91%
Income $51,000 to $75,000	16.59%	45.95%
Income $76,000 to $100,000	23.77%	32.08%
Income $101,000 to $200,000	27.80%	25.81%
Income Above $200,000	3.59%	12.50%
Less than High School	0.00%	-
High School	1.35%	66.67%
Some College	15.70%	42.86%
Bachelor’s Degree	43.95%	34.69%
Master’s Degree	25.56%	33.33%
Doctorate/Professional Degree	13.45%	20.00%

Including the reported percentage of headaches was deemed particularly valuable in predicting how certain socio-demographic groups would perceive and value sulfites. Age and gender were not shown to have a significant impact on reported headaches. As income increased from the “under $25,000” category to the “over $200,000” category, reported headaches from wine decreased by 2/3. Similarly, respondents in the higher education categories experienced a lower percentage of headaches perceived to be linked to wine consumption.

4.1.2 Purchasing Behavior and Headaches

To get a sense of how involved participants were in the wine market, questions were then asked about their purchasing behavior, including whether they subscribed to a wine magazine or belonged to a wine club. The first column in Table 4.2 shows the distribution of responses for the entire sample, while the second column summarizes percent of each group reporting headaches after moderate wine consumption.

Table 4.2. Market Involvement Descriptive Statistics and Headaches Reported

Demographic	% of Sample (n=223)	% of Group Reporting Headache (Overall 34.08% of Sample)
Wine Club	12.55%	32.14%
Wine Magazine	10.76%	33.33%
0 bottles in typical month	2.24%	60.00%
1 to 3 bottles in typical month	27.80%	33.87%
4 to 6 bottles in typical month	32.29%	33.33%
7 to 9 bottles in typical month	17.49%	38.46%
10 or more bottles in typical month	20.18%	28.89%
0 bottles at home	2.69%	50.00%
1 to 3 bottles at home	24.22%	37.04%
4 to 6 bottles at home	14.35%	40.63%
7 to 9 bottles at home	8.97%	25.00%
10 or more bottles at home	49.78%	31.53%

For participants who purchase 0 bottles of wine in a typical month, the percentage of wine headaches reported was considerably higher than the other purchase groups. Similarly, participants reporting 0 bottles of wine at home also experienced more headaches. This may point to the conclusion that very low-involved consumers tend to avoid wine because of the headaches it causes. The large number of respondents having 10 or more bottles at home (49.78%) also indicates that many consumers may purchase wine for non-immediate consumption or for collection purposes.

4.1.3 Perceptions of Sulfites as a Headache Trigger

The next part of the analysis was to see how sulfites were ranked as a believed cause of headaches. Respondents reporting that they did in fact experience headaches after consuming even moderate amounts of wine were asked to select all of the attributes which they believed caused the headaches. Table 4.3 summarizes the findings.

Table 4.3. Summary of Believed Causes of Wine Headache

Cause	Percentage of Headache Respondents	Percentage of Total Respondents
Sulfites	63.16%	21.52%
Dehydration	57.89%	19.73%
Red Wine	32.89%	11.21%
Tannins	19.74%	6.73%
Other	14.47%	4.93%
White Wine	7.89%	2.69%
Tyramine	1.32%	0.45%
Organic Wine	0.00%	0.00%

Of the individuals reporting headaches after consuming even moderate amounts of wine, 63.16% believed that sulfites were a main trigger. Dehydration and red wine were also selected frequently. Organic wine was not selected by any respondent as a link relating wines to their headaches, implying that consumers may already be aware that organic wine is without added sulfites. White wine was also rarely selected, showing that wine variety may influence headache perceptions. Tyramine was only selected by 1.32% of the population, which may be explained by some respondents not having previous knowledge about the chemical.

4.1.4 Treatment of Wine as a Normal Good

Once demographic and headache information was collected from participants, the OOD D-optimal experimental design allowed for the collection of consumer preferences toward specific wine attributes. Within each choice scenario, respondents were asked whether they would actually be willing to purchase the wine they selected as "most preferred." Since respondents were randomly placed into 1 of 3 pricing categories, this information was useful in testing whether wine consumers consider wine to be a normal good, which helped form expectations on the signs within the regression analysis. Table 4.4 summarizes the mean number of "most preferred" wines out of the 12 choice scenarios that respondents were actually willing to purchase.

Table 4.4. Number of Choices Actually Willing to Purchase (Out of 12 Scenarios)

Price Group	Mean Number Willing to Purchase (Out of 12)
Overall	7.98
Group $10-$15	10.26
Group $20-$25	7.58
Group $30-$35	6.13

Given that each survey contained 12 choice scenarios, the average number of "most preferred" wines that each participant was actually willing to purchase was 7.98, or 66.5% of the choices offered. For participants offered wine in the $10-$15 range, the average increased to 10.26 wines out of 12, or 85.5% of the choices. This share decreases considerably as the price range increases. The results indicate that wine is in fact valued as a normal good, since respondents placed in the higher pricing categories were less willing to actually purchase the presented hypothetical wines.

4.2 Base Exploded Logit

Empirical estimation involved three stages. The first stage used the base exploded logit method to obtain WTP values for each wine attribute. Price and varietal categories, socio-demographic factors, and involvement metrics were then interacted with the attributes to see how they impacted WTP. The second stage tested to see if quality was non-linearly related with utility. Finally, a panel logit model was estimated to determine factors influencing the actual purchase of wine.

With the full ranking of data available for each choice set, an exploded logit model was estimated for the entire sample, across all price and variety categories. The total number of observations was 8028, which is equivalent to 223 respondents having 12 choice scenarios, each with 3 alternative wines. The standard errors were adjusted for the 223 clusters of people to account and adjust for the within-subject dependency between an individual's responses through multiple choice groups. The general indirect utility model is defined as (4.1), with the results and WTP calculations shown in Tables 4.5 and 4.6, respectively.

$$(4.1)\quad U_{ijk} = V_{ijk} + \varepsilon_{ijk} = (\beta_1 ORGANIC + \beta_2 SULFITE + \beta_3 QUALITY + \beta_4 PRICE)_{ijk} + \varepsilon_{ijk}$$

Where U_{ijk} is the utility estimated for person *i* choosing wine *k* choice set *j*, β is the estimated coefficient, and ε_{ijk} is a random error term.

Table 4.5. Base Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
ORGANIC	-0.5196	0.0538	-9.65	0.000	-0.6252 to -0.4141
SULFITE	-0.2748	0.0578	-4.75	0.000	-0.3882 to -0.1614
QUALITY	-1.2139	0.0531	-22.86	0.000	-1.3180 to -1.1098
PRICE	0.6409	0.0344	18.65	0.000	0.5735 to 0.7083

Log pseudolikelihood = -2440.323, n=223 participants in 8028 observations

Table 4.6. Marginal WTP from Base Exploded Logit

Attribute	Marginal WTP (US$)	St. Error	P-value
Organic	$1.22	0.1465	0.000
Sulfite	$0.64	0.1394	0.000
Quality	$2.84	0.2091	0.000

All estimates were significant at the 1% level, indicating that the chosen experimental design was adequate in estimating precise willingness to pay values. While the dependent variable is an estimated utility value, the model's signs were interpreted in terms of ranking. Hence, the coefficients were multiplied by -1 when comparing the coefficient signs to prior expectations, since a ranking of 1 indicates high utility and a ranking of 3 indicates low utility. Willingness to pay was then estimated as the absolute value of the ratio between the attribute and price, multiplied by 1.5 to account for the $1.50 change per price unit.

The aggregated results indicate that consumers value a lack of sulfites in wine at $0.64, which was just over half of the $1.22 value placed on organic wine. One possible explanation for this difference is that the sample as a whole is already aware that organic wine is inherently without added sulfites, which would explain a WTP value for no added sulfites being partially embedded within the organic valuation, but knowing that organic provides other potential benefits as well. At \$2.84, respondents valued a 4-point increase in quality as the most important factor influencing choice.

4.3 Price and Variety Exploded Logit

4.3.1 Price Group

The next step in the analysis was to test whether market segmentation could exist based on individual-specific interaction terms (e.g. Kennedy, 2008, p. 251; Burton et al., 2001). Following Costanigro, McCluskey, and Mittelhammer's (2007) finding that price segmentation exists within the wine market, the first interaction model analyzed whether respondents in this sample valued the wine attributes differently across the three price categories. The dummy variables PRICE10, PRICE20, and PRICE30, were interacted with the attribute-specific variables (e.g. Burton et al., 2001) to create a complete interaction model. The exploded logit model is shown in Table 4.7, followed by the post-estimation WTP calculations in 4.8 and the Wald tests in Tables 4.9 and 4.10, respectively.

$$(4.2)\quad U_{ijk} = V_{ijk} + \varepsilon_{ijk} = (\beta_1 ORGANIC10 + \beta_2 ORGANIC20 + \beta_3 ORGANIC30 + \beta_4 SULFITE10 + \beta_5 SULFITE20 + \beta_6 SULFITE30 + \beta_7 QUALITY10 + \beta_8 QUALITY20 + \beta_9 QUALITY30 + \beta_{10} PRICEINT10 + \beta_{11} PRICEINT20 + \beta_{12} PRICEINT30)_{ijk} + \varepsilon_{ijk}$$

Table 4.7. Price Interaction Model, Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
ORGANIC10	-0.5921	0.0989	-5.99	0.000	-0.7860 to -0.3982
ORGANIC20	-0.5394	0.0943	-5.72	0.000	-0.7242 to -0.3546
ORGANIC30	-0.4368	0.0874	-5.00	0.000	-0.6081 to -0.2656
SULFITE10	-0.2545	0.0950	-2.68	0.007	-0.4406 to -0.0683
SULFITE20[1]	-0.2412	0.0989	-2.44	0.015	-0.4351 to -0.0473
SULFITE30	-0.3327	0.1073	-3.10	0.002	-0.5430 to -0.1225
QUALITY10	-1.1634	0.0891	-13.05	0.000	-1.3381 to -0.9887
QUALITY20	-1.2118	0.0852	-14.22	0.000	-1.3789 to -1.0448
QUALITY30	-1.2824	0.1030	-12.44	0.000	-1.4844 to -1.0804
PRICEINT10	0.7304	0.0638	11.45	0.000	0.6054 to 0.8554
PRICEINT20	0.5556	0.0573	9.69	0.000	0.4432 to 0.6679
PRICEINT30	0.6449	0.0581	11.10	0.000	0.5310 to 0.7587

[1]SULFITE20 is significant at the 5% level, all others significant at 1%
Log pseudolikelihood = -2429.945, n=223 participants in 8028 observations

Table 4.8. WTP from Price Interaction Model

Attribute	Marginal WTP (US$) $10-$15 Category	Marginal WTP (US$) $20-$25 Category	Marginal WTP (US$) $30-$35 Category
Organic	$1.22	$1.46	$1.02
	(0.2250)	(0.3136)	(0.2354)
	0.000	0.000	0.000
Sulfite	$0.52	$0.65	$0.77
	(0.2052)	(0.2700)	(0.2580)
	0.011	0.016	0.003
Quality	$2.39	$3.27	$2.98
	(0.2908)	(0.4659)	(0.3531)
	0.000	0.000	0.000

Standard errors in parentheses, followed by p-values

Table 4.9. Wald Test Summary for Price Interaction Model

Attribute	Null Hypothesis	P-value	Conclusion
Organic	Organic estimates are the same	0.478	Fail to Reject Null
Sulfite	Sulfite estimates are the same	0.798	Fail to Reject Null
Quality	Quality estimates are the same	0.683	Fail to Reject Null
Price	Price estimates are the same	0.124	Fail to Reject Null[1]

[1]At 15% significance, the null hypothesis can be rejected

Table 4.10. Wald Test Summary for Price Interaction Model, WTP

Attribute	Null Hypothesis	P-value	Conclusion
Organic	$(\beta_1/\beta_{10}) - (\beta_2/\beta_{11}) = 0$	0.534	
	$(\beta_1/\beta_{10}) - (\beta_3/\beta_{12}) = 0$	0.539	Fail to Reject Null
	$(\beta_2/\beta_{11}) - (\beta_3/\beta_{12}) = 0$	0.262	
Sulfite	$(\beta_4/\beta_{10}) - (\beta_5/\beta_{11}) = 0$	0.704	
	$(\beta_4/\beta_{10}) - (\beta_5/\beta_{12}) = 0$	0.446	Fail to Reject Null
	$(\beta_5/\beta_{11}) - (\beta_6/\beta_{12}) = 0$	0.742	
Quality	$(\beta_7/\beta_{10}) - (\beta_8/\beta_{11}) = 0$	0.108	
	$(\beta_7/\beta_{10}) - (\beta_9/\beta_{12}) = 0$	0.194	Fail to Reject Null
	$(\beta_8/\beta_{11}) - (\beta_9/\beta_{12}) = 0$	0.621	

All estimates were significant at the 1% level except for SULFITE20, which was significant at the 5% level. The results show an increasing marginal WTP for a lack of sulfites when placed into a higher price category, but there is no significant pattern between the other attributes and the pricing category. In addition, since the confidence intervals overlap considerably, the Wald test points to the conclusion that no significant difference exists at the 10% level. Differences in WTP estimates were also insignificant at 10%, which indicates that all three price categories can be aggregated when quantifying attribute valuation.

4.3.2 Wine Variety

In addition to price group segmentation, respondents were also randomly assigned to either white wine or red wine categories. Since 11.21% of the total respondents ranked red wine as being a primary trigger of headaches, while only 2.69% attributed white wine as being a possible trigger, the results were initially expected to show increased valuation for “no sulfites added” in red wines. To test the hypothesis, the wine variety group dummy variable was interacted with the main attributes to test for a structural difference in attribute valuation. Using the model specified in (4.3), the results are illustrated in Table 4.11, followed by post-estimation WTP calculations in 4.12 and Wald tests in 4.13 and 4.14, respectively.

(4.3) $U_{ijk} = V_{ijk} + \varepsilon_{ijk} = (\beta_1 ORGANICWHITE + \beta_2 ORGANICRED + \beta_3 SULFITEWHITE + \beta_4 SULFITERED + \beta_5 QUALITYWHITE + \beta_6 QUALITYRED + \beta_7 PRICEWHITE + \beta_8 PRICERED)_{ijk} + \varepsilon_{ijk}$

Table 4.11. Variety Interaction Model, Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
ORGANICWHITE	-0.5663	0.0807	-7.02	0.000	-0.7244 to -0.4081
ORGANICRED	-0.4704	0.0699	-6.73	0.000	-0.6074 to -0.3334
SULFITEWHITE	-0.2681	0.0865	-3.10	0.002	-0.4377 to -0.0984
SULFITERED	-0.2857	0.0746	-3.83	0.000	-0.4319 to -0.1395
QUALITYWHITE	-1.1499	0.0707	-16.26	0.000	-1.2885 to -1.0113
QUALITYRED	-1.2843	0.0793	-16.19	0.000	-1.4397 to -1.1288
PRICEWHITE	0.6239	0.0455	13.72	0.000	0.5348 to 0.7131
PRICERED	0.6609	0.0519	12.74	0.000	0.5592 to 0.7626

Log Pseudolikelihood = -2436.419, n=223 participants in 8028 observations

Table 4.12. Marginal WTP from Variety Model

Attribute	Marginal WTP (US$) White Wine Category	Marginal WTP (US$) Red Wine Category
Organic	$1.36	$1.07
	(0.2295)	(0.1797)
	0.000	0.000
Sulfite	$0.64	$0.65
	(0.2124)	(0.1780)
	0.002	0.000
Quality	$2.76	$2.91
	(0.2872)	(0.3042)
	0.000	0.000

Standard errors in parentheses, followed by p-values

Table 4.13. Wald Test Summary for Wine Variety Interaction Model

Attribute	Null Hypothesis	P-value	Conclusion
Organic	Organic estimates are the same	0.369	Fail to Reject Null
Sulfite	Sulfite estimates are the same	0.878	Fail to Reject Null
Quality	Quality estimates are the same	0.206	Fail to Reject Null
Price	Price estimates are the same	0.592	Fail to Reject Null

Table 4.14. Wald Test Summary for Wine Variety Interaction Model, WTP

Attribute	Null Hypothesis	P-value	Conclusion
Organic	$(\beta_1/\ \beta_7) - (\beta_2/\beta_8) = 0$	0.314	Fail to Reject Null
Sulfite	$(\beta_3/\ \beta_7) - (\beta_4/\beta_8) = 0$	0.989	Fail to Reject Null
Quality	$(\beta_5/\ \beta_7) - (\beta_6/\beta_8) = 0$	0.720	Fail to Reject Null

The WTP calculations indicate that respondents within the red wine category value wine with no added sulfites \$0.01 more and quality \$0.15 more than the white wine group. Significant overlap exists between the WTP confidence intervals, however, and post-estimation Wald tests confirm that the estimates are not statistically different. The market can therefore be aggregated for the two wine variety groups.

4.4 Demographics Exploded Logit

4.4.1 Headaches

The next step in the analysis was to see whether structural differences existed between headache sufferers and non-headache sufferers. Since people reporting headaches attribute a triggering role to sulfites, it was anticipated that headache sufferers would have statistically different preferences toward the presence or nonexistence of sulfites than non-headache sufferers. The results are summarized in Tables 4.15-4.18.

$$(4.4)\quad U_{ijk} = V_{ijk} + \varepsilon_{ijk} = (\beta_1 NOHEADORGANIC + \beta_2 HEADORGANIC + \beta_3 NOHEADSULFITE + \beta_4 HEADSULFITE + \beta_5 NOHEADQUALITY + \beta_6 HEADQUALITY + \beta_7 NOHEADPRICE + \beta_8 HEADPRICE)_{ijk} + \varepsilon_{ijk}$$

Table 4.15 Headache Interaction Model, Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
HEADORGANIC	-0.3991	0.0805	-4.96	0.000	-0.5569 to -0.2413
NOHEADORGANIC	-0.5934	0.0695	-8.54	0.000	-0.7297 to -0.4572
HEADSULFITE	-0.5016	0.1260	-3.98	0.000	-0.7487 to -0.2546
NOHEADSULFITE	-0.1465	0.0542	-2.70	0.007	-0.2527 to -0.0402
HEADQUALITY	-1.1563	0.0910	-12.71	0.000	-1.3347 to -0.9779
NOHEADQUALITY	-1.2537	0.0650	-19.30	0.000	-1.3810 to -1.1264
HEADPRICE	0.6121	0.0604	10.14	0.000	0.4938 to 0.7305
NOHEADPRICE	0.6631	0.0418	15.86	0.000	0.5812 to 0.7450

Log pseudolikelihood = -2429.724, n=223 participants in 8028 observations

Table 4.16. Marginal WTP from Headaches Model

Attribute	Marginal WTP (US$) No Headaches Category	Marginal WTP (US$) Headaches Category
Organic	$1.34	$0.98
	(0.1898)	(0.2153)
	0.000	0.000
Sulfite	$0.33	$1.23
	(0.1242)	(0.3193)
	0.008	0.000
Quality	$2.84	$2.83
	(0.2511)	(0.3729)
	0.000	0.000

Standard errors in parentheses, followed by p-values

Table 4.17. Wald Test Summary for Headache Interaction Model

Attribute	Null Hypothesis	P-value	Conclusion
Organic	Organic estimates are the same	0.068	Reject Null
Sulfite	Sulfite estimates are the same	0.010	Reject Null
Quality	Quality estimates are the same	0.384	Fail to Reject Null
Price	Price estimates are the same	0.488	Fail to Reject Null

Table 4.18. Wald Test Summary for Headache Interaction Model, WTP

Attribute	Null Hypothesis	P-value	Conclusion
Organic	$(\beta_1/ \beta_7) – (\beta_2/\beta_8) = 0$	0.204	Fail to Reject Null
Sulfite	$(\beta_3/ \beta_7) – (\beta_4/\beta_8) = 0$	0.009	Reject Null
Quality	$(\beta_5/ \beta_7) – (\beta_6/\beta_8) = 0$	0.995	Fail to Reject Null

Individuals reporting headaches have a WTP of $1.23 for a lack of sulfites in wine, which is considerably higher than the $0.33 WTP from non-headache sufferers, and nearly double the overall population's valuation for a lack of sulfites. An interesting result that emerges from the model is that headache sufferers are actually willing to pay more for wine without added sulfites than for organic wine. This observation runs contrary to the previous conclusion developed from Table 4.5b which assumes consumers are aware that organic wine is inherently produced without adding sulfites. Post-estimation Wald tests confirm that the estimates for the organic and sulfite coefficients are in fact different between headache and non-headache sufferers. Likewise, the marginal WTP is statistically different for a "no added sulfites" claim between the two groups. Even though quality is not statistically different across the cohorts, it is still the most valued attribute for both headache sufferers and non-sufferers, indicating that wine produced without sulfites and organic wine may be important, yet not the primary factor that determines the ultimate purchase decision.

4.4.2 Education

Due to the initial patterns emerging from the summary statistics showing a potential negative correlation between education levels and reported headaches, interaction terms were next created to test for structural differences in sulfite sensitivity across different education levels. No respondent reported having less than a high school education and only a very small sample reported having only a high school degree; as a result, ED1 and ED2 were excluded from the analysis. The model is presented in (4.5), followed by the results in Tables 4.19-4.21.

(4.5) $U_{ijk} = V_{ijk} + \varepsilon_{ijk} = (\beta_1 ED3ORGANIC + \beta_2 ED4ORGANIC + \beta_3 ED5ORGANIC + \beta_4 ED6ORGANIC + \beta_5 ED3SULFITE + \beta_6 ED4SULFITE + \beta_7 ED5SULFITE + \beta_8 ED6SULFITE + \beta_9 ED3QUALITY + \beta_{10} ED4QUALITY + \beta_{11} ED5QUALITY + \beta_{12} ED6QUALITY + \beta_{13} ED3PRICE + \beta_{14} ED4PRICE + \beta_{15} ED5PRICE + \beta_{16} ED6PRICE)_{ijk} + \varepsilon_{ijk}$

Table 4.19. Education Interaction Model, Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
ED3ORGANIC	-0.4868	0.1307	-3.73	0.000	-0.7429 to -0.2307
ED4ORGANIC	-0.5579	0.0775	-7.20	0.000	-0.7097 to -0.4060
ED5ORGANIC	-0.4441	0.1260	-3.52	0.000	-0.6912 to -0.1971
ED6ORGANIC	-0.5845	0.1506	-3.88	0.000	-0.8797 to -0.2893
ED3SULFITE	-0.4073	0.1444	-2.82	0.005	-0.6903 to -0.1242
ED4SULFITE	-0.2938	0.0911	-3.22	0.001	-0.4724 to -0.1152
ED5SULFITE	-0.3290	0.0960	-3.43	0.001	-0.5171 to -0.1409
ED6SULFITE	-0.1609	0.1118	-1.44	0.150	-0.3801 to 0.0583
ED3QUALITY	-1.3346	0.1318	-10.13	0.000	-1.5929 to -1.0764
ED4QUALITY	-1.0347	0.0723	-14.31	0.000	-1.1764 to -0.8931
ED5QUALITY	-1.4877	0.1169	-12.72	0.000	-1.7169 to -1.2585
ED6QUALITY	-1.4674	0.1642	-8.94	0.000	-1.7891 to -1.1457
ED3PRICE	0.7180	0.0828	8.67	0.000	0.5556 to 0.8803
ED4PRICE	0.6774	0.0555	12.20	0.000	0.5686 to 0.7862
ED5PRICE	0.6692	0.0608	11.01	0.000	0.5501 to 0.7883
ED6PRICE	0.4733	0.0839	5.64	0.000	0.3088 to 0.6378

Log pseudolikelihood = -2403.837, n=223 participants in 8028 observations

Table 4.20. Marginal WTP from Education Model

Attribute	Marginal WTP (US$) Ed3	Marginal WTP (US$) Ed4	Marginal WTP (US$) Ed5	Marginal WTP (US$) Ed6
Organic	$1.02	$1.24	$1.00	$1.85
	(0.3331)	(0.1945)	(0.3089)	(0.6448)
	0.002	0.000	0.001	0.004
Sulfite	$0.85	$0.65	$0.74	$0.51
	(0.3169)	(0.2153)	(0.2135)	(0.3780)
	0.007	0.003	0.001	0.177
Quality	$2.79	$2.29	$3.33	$4.65
	(0.4343)	(0.2689)	(0.3789)	(1.1584)
	0.000	0.000	0.000	0.000

Standard errors in parentheses, followed by p-values

Table 4.21. Wald Test Summary for Education Interaction Model

Attribute	Null Hypothesis	P-value	Conclusion
Organic	Organic estimates are the same	0.842	Fail to Reject Null
Sulfite	Sulfite estimates are the same	0.540	Fail to Reject Null
Quality	Quality estimates are the same	0.002	Reject Null
Price	Price estimates are the same	0.142	Fail to Reject Null[1]

[1]At 15% significance, the null hypothesis can be rejected

The exploded logit model shows that marginal WTP for wine quality is the highest for individuals with a doctorate or professional degree, but this segment also has the highest variability in WTP. No significant patterns emerged for organic wine and wine without added sulfites. The post-estimation Wald test confirms that quality valuation is statistically different across different education levels, but that sulfite and organic attributes are not.

4.4.3 Income

While education levels may be indicative of consumer knowledge towards sulfites, it is more likely an indicator of spending power. To test this, an income-interaction model was created. The estimated model is shown in (4.6), with the exploded logit results, WTP estimates, and Wald test illustrated in Tables 4.22-4.24.

$$(4.6)\ U_{ijk} = V_{ijk} + \varepsilon_{ijk} = (\beta_1 INC1ORGANIC + \beta_2 INC2ORGANIC + \beta_3 INC3ORGANIC + \beta_4 INC4ORGANIC + \beta_5 INC5ORGANIC + \beta_6 INC6ORGANIC + \beta_7 INC1SULFITE + \beta_8 INC2SULFITE + \beta_9 INC3SULFITE + \beta_{10} INC4SULFITE + \beta_{11} INC5SULFITE + \beta_{12} INC6SULFITE + \beta_{13} INC1QUALITY + \beta_{14} INC2QUALITY + \beta_{15} INC3QUALITY + \beta_{16} INC4QUALITY + \beta_{17} INC5QUALITY + \beta_{18} INC6QUALITY + \beta_{19} INC1PRICE + \beta_{20} INC2PRICE + \beta_{21} INC3PRICE + \beta_{22} INC4PRICE + \beta_{23} INC5PRICE + \beta_{24} INC6PRICE)_{ijk} + \varepsilon_{ijk}$$

Table 4.22. Income Interaction Model, Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
INC1ORGANIC	-0.6161	0.1705	-3.61	0.000	-0.9503 to -0.2819
INC2ORGANIC	-0.6291	0.1294	-4.86	0.000	-0.8828 to -0.3754
INC3ORGANIC	-0.5097	0.1051	-4.85	0.000	-0.7157 to -0.3037
INC4ORGANIC	-0.5345	0.1067	-5.01	0.000	-0.7437 to -0.3253
INC5ORGANIC	-0.4915	0.1306	-3.76	0.000	-0.7476 to -0.2355
INC6ORGANIC	-0.3022	0.4368	-0.69	0.489	-1.1584 to 0.5540
INC1SULFITE	-0.4558	0.2403	-1.90	0.058	-0.9267 to 0.0151
INC2SULFITE	-0.3330	0.1290	-2.58	0.010	-0.5858 to -00802
INC3SULFITE	-0.1744	0.1615	-1.08	0.280	-0.4910 to 0.1421
INC4SULFITE	-0.1613	0.1137	-1.42	0.156	-0.3843 to 0.0616
INC5SULFITE	-0.3638	0.0976	-3.73	0.000	-0.5551 to -0.1725
INC6SULFITE	-0.8953	0.2001	-4.47	0.000	-1.2874 to -0.5031
INC1QUALITY	-0.8992	0.1734	-5.19	0.000	-1.2390 to -0.5594
INC2QUALITY	-1.2185	0.0972	-12.53	0.000	-1.4091 to -1.0279
INC3QUALITY	-1.0018	0.1058	-9.47	0.000	-1.2091 to -0.7945
INC4QUALITY	-1.0802	0.0970	-11.14	0.000	-1.2704 to -0.8901
INC5QUALITY	-1.6416	0.1317	-12.47	0.000	-1.8998 to -1.3835
INC6QUALITY	-2.4771	0.5625	-4.40	0.000	-3.5796 to -1.3746
INC1PRICE	0.7800	0.1351	5.77	0.000	0.5152 to 1.0448
INC2PRICE	0.7959	0.0742	10.72	0.000	0.6503 to 0.9414
INC3PRICE	0.6108	0.0811	7.53	0.000	0.4519 to 0.7700
INC4PRICE	0.6185	0.0712	8.68	0.000	0.4788 to 0.7581
INC5PRICE	0.5729	0.0723	7.93	0.000	0.4312 to 0.7146
INC6PRICE	0.6286	0.2103	2.99	0.003	0.2164 to 1.0407

Log pseudolikelihood = -2352.49, n=223 participants in 8028 observations

Table 4.23. Marginal WTP from Income Model

Attribute	Marginal WTP (US$) INC1	Marginal WTP (US$) INC2	Marginal WTP (US$) INC3	Marginal WTP (US$) INC4	Marginal WTP (US$) INC5	Marginal WTP (US$) INC6
Organic	$1.18	$1.19	$1.25	$1.30	$1.29	$0.72
	(0.3617)	(0.2627)	(0.3097)	(0.2998)	(0.4318)	(1.2490)
	0.001	0.000	0.000	0.000	0.003	0.564
Sulfite	$0.88	$0.63	$0.43	$0.39	$0.95	$2.14
	(0.4442)	(0.2457)	(0.3979)	(0.2940)	(0.2722)	(0.4396)
	0.048	0.011	0.282	0.183	0.000	0.000
Quality	$1.72	$2.30	$2.46	$2.62	$4.29	$5.91
	(0.3683)	(0.3166)	(0.4678)	(0.4241)	(0.6570)	(2.2882)
	0.000	0.000	0.000	0.000	0.000	0.010

Standard errors in parentheses, followed by p-values

Table 4.24. Wald Test Summary for Income Interaction Model

Attribute	Null Hypothesis	P-value	Conclusion
Organic	Organic estimates are the same	0.950	Fail to Reject Null
Sulfite	Sulfite estimates are the same	0.042	Reject Null
Quality	Quality estimates are the same	0.000	Reject Null
Price	Price estimates are the same	0.277	Fail to Reject Null

Similar to the education interaction model, the valuation of quality increased considerably at higher income levels, where individuals in the highest income category were willing to spend $4.19 more for a 4-point increase in quality than the lowest income category. The post-estimation Wald test confirms that quality is valued differently across various income levels, further confirming the importance of quality as a main attribute, particularly as spending power increases. While sulfites were valued significantly different across the various income levels, there is no consistent pattern between income and sulfites, making specific income cohorts difficult to pinpoint for "no sulfites added" marketing campaigns. Furthermore, the valuation of organic wine is not significantly different across the income groups, showing that income is not a segmenting factor for the valuation of organic wine.

4.4.4 Gender

The final socio-demographic interaction model tested for structural differences based on gender. Because females reported slightly higher levels of headaches reported, it was hypothesized that they would have a higher marginal WTP for wine without sulfites. The results are illustrated in Tables 4.25-4.28.

$$(4.7)\quad U_{ijk} = V_{ijk} + \varepsilon_{ijk} = (\beta_1 MALEORGANIC + \beta_2 FEMALEORGANIC + \beta_3 MALESULFITE + \beta_4 FEMALESULFITE + \beta_5 MALEQUALITY + \beta_6 FEMALEQUALITY + \beta_7 MALEPRICE + \beta_8 FEMALEPRICE)_{ijk} + \varepsilon_{ijk}$$

Table 4.25. Interaction Model by Gender, Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
MALEORGANIC	-0.5638	0.0824	-6.84	0.000	-0.7254 to -0.4023
FEMALEORGANIC	-0.4832	0.0702	-6.88	0.000	-0.6208 to -0.3455
MALESULFITE	-0.2546	0.0889	-2.86	0.004	-0.4289 to -0.0804
FEMALESULFITE	-0.2932	0.0755	-3.88	0.000	-0.4412 to -0.1452
MALEQUALITY	-1.2936	0.0837	-15.46	0.000	-1.4575 to -1.1296
FEMALEQUALITY	-1.1469	0.0681	-16.84	0.000	-1.2804 to -1.0134
MALEPRICE	0.6204	0.0470	13.19	0.000	0.5282 to 0.7126
FEMALEPRICE	0.6606	0.0498	13.26	0.000	0.5629 to 0.7583

Log pseudolikelihood = -2434.47, n=223 participants in 8028 observations

Table 4.26. Marginal WTP from Gender Model

Attribute	Marginal WTP (US$) Male	Marginal WTP (US$) Female
Organic	$1.36	$1.10
	(0.2391)	(0.1802)
	0.000	0.000
Sulfite	$0.62	$0.67
	(0.2178)	(0.1799)
	0.005	0.000
Quality	$3.13	$2.60
	(0.3274)	(0.2681)
	0.000	0.000

Standard errors in parentheses, followed by p-values

Table 4.27. Wald Test Summary for Gender Interaction Model

Attribute	Null Hypothesis	P-value	Conclusion
Organic	Organic estimates are the same	0.456	Fail to Reject Null
Sulfite	Sulfite estimates are the same	0.741	Fail to Reject Null
Quality	Quality estimates are the same	0.174	Fail to Reject Null
Price	Price estimates are the same	0.557	Fail to Reject Null

Table 4.28. Wald Test Summary for Gender Interaction Model, WTP

Attribute	Null Hypothesis	P-value	Conclusion
Organic	$(\beta_1/\ \beta_7) - (\beta_2/\beta_8) = 0$	0.374	Fail to Reject Null
Sulfite	$(\beta_3/\ \beta_7) - (\beta_4/\beta_8) = 0$	0.859	Fail to Reject Null
Quality	$(\beta_5/\ \beta_7) - (\beta_6/\beta_8) = 0$	0.216	Fail to Reject Null

The exploded logit model shows that males value organic wine and wine quality more than females, and that marginal WTP for wine without added sulfites is higher for females. Because of the considerable overlap in the 95% confidence interval, however, the Wald tests show that gender is not a significant factor in segmenting the market.

4.5 Market Involvement Exploded Logit

4.5.1 Wine Magazine Subscription

Market segments by socio-demographic groups consistently indicate that quality is the most important attribute. The next step tested to see whether market participation levels influenced valuation for the wine attributes. Participants were first segmented by whether they subscribed to a wine magazine. This was utilized to detect high-involvement and low-involvement consumers (e.g. Lockshin et al., 2006; Mtimet and Albisu, 2006). The exploded logit model, WTP calculations, and post-estimation tests are presented in Tables 4.29-4.32.

(4.8) $U_{ijk} = V_{ijk} + \varepsilon_{ijk} = (\beta_1 ORGANICMAG + \beta_2 NOORGANICMAG + \beta_3 SULFMAG + \beta_4 NOSULFMAG + \beta_5 QUALITYMAG + \beta_6 NOQUALITYMAG + \beta_7 PRICEMAG + \beta_8 NOPRICEMAG)_{ijk} + \varepsilon_{ijk}$

Table 4.29. Interaction Model by Wine Magazine Subscription, Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
ORGANICMAG	-0.5812	0.1561	-3.72	0.000	-0.8872 to -0.2753
NOORGANICMAG	-0.5166	0.0576	-8.96	0.000	-0.6296 to -0.4036
SULFMAG	-0.2010	0.1663	-1.21	0.227	-0.5269 to 0.1249
NOSULFMAG	-0.2843	0.0620	-4.59	0.000	-0.4057 to -0.1629
QUALITYMAG	-1.4616	0.1722	-8.49	0.000	-1.7992 to -1.1241
NOQUALITYMAG	-1.1912	0.0560	-21.28	0.000	-1.3009 to -1.0814
PRICEMAG	0.4706	0.0969	4.86	0.000	0.2807 to 0.6605
NOPRICEMAG	0.6611	0.0368	17.97	0.000	0.5890 to 0.7333

Log pseudolikelihood = -2429.438, n=223 participants in 8028 observations

Table 4.30. Marginal WTP from Wine Magazine Subscription Model

Attribute	Marginal WTP (US$) Subscription	Marginal WTP (US$) No Subscription
Organic	$1.85	$1.17
	(0.7122)	(0.1498)
	0.009	0.000
Sulfite	$0.64	$0.64
	(0.5530)	(0.1448)
	0.246	0.000
Quality	$4.66	$2.70
	(1.3654)	(0.2045)
	0.001	0.000

Standard errors in parentheses, followed by p-values

Table 4.31. Wald Test Summary for Wine Magazine Subscription Model

Attribute	Null Hypothesis	P-value	Conclusion
Organic	Organic estimates are the same	0.698	Fail to Reject Null
Sulfite	Sulfite estimates are the same	0.639	Fail to Reject Null
Quality	Quality estimates are the same	0.135	Fail to Reject Null[1]
Price	Price estimates are the same	0.066	Fail to Reject Null

[1]At 15% significance, the null hypothesis can be rejected

Table 4.32. Wald Test Summary for Wine Magazine Subscription Model, WTP

Attribute	Null Hypothesis	P-value	Conclusion
Organic	$(\beta_1/ \beta_7) - (\beta_2/\beta_8) = 0$	0.350	Fail to Reject Null
Sulfite	$(\beta_3/ \beta_7) - (\beta_4/\beta_8) = 0$	0.994	Fail to Reject Null
Quality	$(\beta_5/ \beta_7) - (\beta_6/\beta_8) = 0$	0.157	Fail to Reject Null

Respondents who reported subscribing to a wine magazine did not value wine without sulfites or organic wine as statistically different from non-subscribers. A 4-point increase in quality was worth $1.96 more for subscribers than non-subscribers, indicating that more involved consumers place a higher valuation on wine quality, but not organic wine or wine without added sulfites. The Wald test in Table 4.32 indicates that market segmentation based on quality may be approaching statistical significance, but differences cannot be confirmed given the results.

4.5.2 Wine Club Membership

Similarly, Tables 4.33-4.36 illustrate the results of being a member in a wine club. The model is specified in (4.9), results are presented in Table 4.33, and post-estimation tests and calculations are in Tables 4.34-4.36.

$$(4.9)\quad U_{ijk} = V_{ijk} + \varepsilon_{ijk} = (\beta_1 ORGANICCLUB + \beta_2 NOORGANICCLUB + \beta_3 SULFCLUB + \beta_4 NOSULFCLUB + \beta_5 QUALITYCLUB + \beta_6 NOQUALITYCLUB + \beta_7 PRICECLUB + \beta_8 NOPRICECLUB)_{ijk} + \varepsilon_{ijk}$$

Table 4.33. Interaction Model by Wine Club Membership, Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
ORGANICCLUB	-0.5564	0.1226	-4.54	0.000	-0.7966 to -0.3161
NOORGANICCLUB	-0.5230	0.0588	-8.89	0.000	-0.6383 to -0.4077
SULFCLUB	-0.1934	0.1352	-1.43	0.153	-0.4584 to 0.0717
NOSULFCLUB	-0.2873	0.0630	-4.56	0.000	-0.4107 to -0.1639
QUALITYCLUB	-1.7243	0.2057	-8.38	0.000	-2.1274 to -1.3212
NOQUALITYCLUB	-1.1621	0.0545	-21.32	0.000	-1.2689 to -1.0553
PRICECLUB	0.5633	0.0779	7.23	0.000	0.4107 to 0.7159
NOPRICECLUB	0.6534	0.0374	17.47	0.000	0.5801 to 0.7268

Log pseudolikelihood = -2416.633, n=223 participants in 8028 observations

Table 4.34. Marginal WTP from Wine Club Membership Model

Attribute	Marginal WTP (US$) Membership	Marginal WTP (US$) No Membership
Organic	$1.48	$1.20
	(0.4288)	(0.1558)
	0.001	0.000
Sulfite	$0.51	$0.66
	(0.3760)	(0.1490)
	0.171	0.000
Quality	$4.59	$2.67
	(1.0656)	(0.2060)
	0.000	0.000

Standard errors in parentheses, followed by p-values

Table 4.35. Wald Test Summary for Wine Club Membership Model

Attribute	Null Hypothesis	P-value	Conclusion
Organic	Organic estimates are the same	0.806	Fail to Reject Null
Sulfite	Sulfite estimates are the same	0.529	Fail to Reject Null
Quality	Quality estimates are the same	0.008	Reject Null
Price	Price estimates are the same	0.297	Fail to Reject Null

Table 4.36. Wald Test Summary for Wine Club Membership Model, WTP

Attribute	Null Hypothesis	P-value	Conclusion
Organic	$(\beta_1/\beta_7) - (\beta_2/\beta_8) = 0$	0.538	Fail to Reject Null
Sulfite	$(\beta_3/\beta_7) - (\beta_4/\beta_8) = 0$	0.721	Fail to Reject Null
Quality	$(\beta_5/\beta_7) - (\beta_6/\beta_8) = 0$	0.076	Reject Null

Belonging to a wine club does significantly influence valuation placed on quality, but not whether the wine is organic or made without added sulfites. Organic wine is worth slightly more and wine without added sulfites is worth slightly less for club members compared to non-club members. As one might expect, the two models together indicate that high-involvement consumers may place higher value on quality than low-involvement consumers, but the lack of significance in the wine magazine model leads to inconclusive evidence that the market can indeed be segmented based on these involvement metrics.

4.5.3 Bottles Purchased in a Typical Month

To further understand the role of market involvement, the next model was intended to see whether more direct purchasing behavior influenced valuation for quality by segmenting the market based on the number of bottles purchased in a typical month. Given the results from the previous analyses, "no sulfites added" and organic labeling were not anticipated to significantly differ across the purchasing levels. The model is specified (4.10) followed by the results in Tables 4.37 to 4.39.

$$(4.10)\quad U_{ijk} = V_{ijk} + \varepsilon_{ijk} = (\beta_1 BUY0ORGANIC + \beta_2 BUY1TO3ORGANIC + \beta_3 BUY4TO6ORGANIC + \beta_4 BUY7TO9ORGANIC + \beta_5 BUYOVER10ORG + \beta_6 BUY0SULFITE + \beta_7 BUY1TO3SULFITE + \beta_8 BUY4TO6SULFITE + \beta_9 BUY7TO9SULFITE + \beta_{10} BUYOVER10SULF + \beta_{11} BUY0QLTY + \beta_{12} BUY1TO3QLTY + \beta_{13} BUY4TO6QLTY + \beta_{14} BUY7TO9QLTY + \beta_{15} BUYOVER10QLTY + \beta_{16} BUY0PRICE + \beta_{17} BUY1TO3PRICE + \beta_{18} BUY4TO6PRICE + \beta_{19} BUY7TO9PRICE + \beta_{20} BUYOVER10PRICE)_{ijk} + \varepsilon_{ijk}$$

Table 4.37. Interaction by Wine Purchases in a Typical Month, Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
BUY0ORGANIC	-0.6820	0.5577	-1.35	0.177	-1.6729 to 0.3090
BUY1TO3ORGANIC	-0.6197	0.0974	-6.36	0.000	-0.8106 to -0.4288
BUY4TO6ORGANIC	-0.4472	0.0924	-4.84	0.000	-0.6283 to -0.2661
BUY7TO9ORGANIC	-0.6043	0.1291	-4.68	0.000	-0.8574 to -0.3512
BUYOVER10ORG	-0.4275	0.1177	-3.63	0.000	-0.6583 to -0.1968
BUY0SULFITE	-0.1264	0.4957	-0.25	0.799	-1.0979 to 0.8451
BUY1TO3SULFITE	-0.3923	0.1125	-3.49	0.000	-0.6127 to -0.1719
BUY4TO6SULFITE	-0.4003	0.1030	-3.89	0.000	-0.6021 to -0.1985
BUY7TO9SULFITE	0.1212	0.1152	1.05	0.293	-0.1045 to 0.3469
BUYOVER10SULF	-0.2933	0.1021	-2.87	0.004	-0.4933 to -0.0933
BUY0QLTY	-0.6069	0.1605	-3.78	0.000	-0.9214 to -0.2923
BUY1TO3QLTY	-1.1058	0.0944	-11.71	0.000	-1.2908 to -0.9207
BUY4TO6QLTY	-1.2565	0.0965	-13.03	0.000	-1.4456 to -1.0675
BUY7TO9QLTY	-1.2811	0.1110	-11.54	0.000	-1.4986 to -1.0636
BUYOVER10QLTY	-1.4081	0.1446	-9.74	0.000	-1.6915 to -1.1246
BUY0PRICE	0.4564	0.2123	2.15	0.032	0.0404 to 0.8725
BUY1TO3PRICE	0.6824	0.0693	9.85	0.000	0.5466 to 0.8183
BUY4TO6PRICE	0.6614	0.0550	12.03	0.000	0.5536 to 0.7691
BUY7TO9PRICE	0.6745	0.0928	7.27	0.000	0.4927 to 0.8564
BUYOVER10PRICE	0.5863	0.0662	8.85	0.000	0.4565 to 0.7161

Log pseudolikelihood = -2407.742, n=223 participants in 8028 observations

Table 4.38. Marginal WTP from Purchases Model

Attribute	Marginal WTP (US$) BUY0	Marginal WTP (US$) BUY1TO3	Marginal WTP (US$) BUY4TO6	Marginal WTP (US$) BUY7TO9	Marginal WTP (US$) BUYOVER10
Organic	$2.24	$1.36	$1.01	$1.34	$1.09
	(2.2879)	(0.2426)	(0.2365)	(0.3805)	(0.3169)
	0.327	0.000	0.000	0.000	0.001
Sulfite	$0.42	$0.86	$0.91	$-0.27	$0.75
	(1.7777)	(0.2651)	(0.2559)	(0.2753)	(0.2738)
	0.815	0.001	0.000	0.328	0.006
Quality	$1.99	$2.43	$2.85	$2.85	$3.60
	(1.2544)	(0.3389)	(0.3512)	(0.4701)	(0.6190)
	0.112	0.000	0.000	0.000	0.000

Standard errors in parentheses, followed by p-values

Table 4.39. Wald Test Summary for Purchases Model

Attribute	Null Hypothesis	P-value	Conclusion
Organic	Organic estimates are the same	0.590	Fail to Reject Null
Sulfite	Sulfite estimates are the same	0.006	Reject Null
Quality	Quality estimates are the same	0.002	Reject Null
Price	Price estimates are the same	0.726	Fail to Reject Null

Organic valuation is not significantly different across the purchasing levels, nor is price. "No sulfites added" labeling, while statistically different across the various purchasing groups, is likely not a segmenting attribute given the lack of statistical significance in two of the cohorts. The results point to the conclusion that quality valuation may be positively related to the quantity of wine typically purchased, as participants purchasing 10 or more bottles of wine in a typical month show a WTP of $1.61 more than participants who purchase 0 bottles in a typical month.

4.5.4 Bottles Currently Owned

While the number of wine bottles currently owned may be correlated with the quantity of wine purchased in a typical month, the final market participation regression tested whether owning more bottles of wine influenced valuation for the wine attributes. Similar to the previous model, quality was anticipated to be the main segmenting attribute. Tables 4.40-4.42 illustrate the results.

(4.11) $U_{ijk} = V_{ijk} + \varepsilon_{ijk} = (\beta_1 OWN0ORGANIC + \beta_2 OWN1TO3ORGANIC + \beta_3 OWN4TO6ORGANIC + \beta_4 OWN7TO9ORGANIC + \beta_5 OWNOVER10ORG + \beta_6 OWN0SULFITE + \beta_7 OWN1TO3SULFITE + \beta_8 OWN4TO6SULFITE + \beta_9 OWN7TO9SULFITE + \beta_{10} OWNOVER10SULF + \beta_{11} OWN0QLTY + \beta_{12} OWN1TO3QLTY + \beta_{13} OWN4TO6QLTY + \beta_{14} OWN7TO9QLTY + \beta_{15} OWNOVER10QLTY + \beta_{16} OWN0PRICE + \beta_{17} OWN1TO3PRICE + \beta_{18} OWN4TO6PRICE + \beta_{19} OWN7TO9PRICE + \beta_{20} OWNOVER10PRICE)_{ijk} + \varepsilon_{ijk}$

Table 4.40. Interaction by Bottles Currently Owned, Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
OWN0ORGANIC	-0.7953	0.3846	-2.07	0.039	-1.5492 to -0.0414
OWN1TO3ORGANIC	-0.5548	0.1240	-4.47	0.000	-0.7978 to -0.3118
OWN4TO6ORGANIC	-0.5549	0.1319	-4.21	0.000	-0.8134 to -0.2964
OWN7TO9ORGANIC	-0.4138	0.1630	-2.54	0.011	-0.7332 to -0.0943
OWNOVER10ORG	-0.5224	0.0783	-6.67	0.000	-0.6759 to -0.3689
OWN0SULFITE	-0.5291	0.3271	-1.62	0.106	-1.1703 to 0.1120
OWN1TO3SULFITE	-0.2416	0.1065	-2.27	0.023	-0.4504 to -0.0328
OWN4TO6SULFITE	-0.1954	0.1344	-1.45	0.146	-0.4588 to 0.0681
OWN7TO9SULFITE	-0.2187	0.2140	-1.02	0.307	-0.6380 to 0.2007
OWNOVER10SULF	-0.3290	0.0899	-3.66	0.000	-0.5053 to -0.1527
OWN0QLTY	-0.8025	0.1614	-4.97	0.000	-1.1189 to -0.4861
OWN1TO3QLTY	-1.1157	0.0903	-12.35	0.000	-1.2927 to -0.9386
OWN4TO6QLTY	-1.0451	0.1340	-7.80	0.000	-1.3077 to -0.7826
OWN7TO9QLTY	-1.0035	0.1234	-8.13	0.000	-1.2454 to -0.7616
OWNOVER10QLTY	-1.4386	0.0915	-15.72	0.000	-1.6180 to -1.2593
OWN0PRICE	1.1793	0.3475	3.39	0.001	0.4983 to 1.8603
OWN1TO3PRICE	0.6872	0.0658	10.44	0.000	0.5581 to 0.8162
OWN4TO6PRICE	0.5885	0.0946	6.22	0.000	0.4030 to 0.7739
OWN7TO9PRICE	0.8356	0.1109	7.54	0.000	0.6182 to 1.0529
OWNOVER10PRICE	0.5801	0.0496	11.69	0.000	0.4829 to 0.6774

Log pseudolikelihood = -2378.494, n=223 participants in 8028 observations

Table 4.41. Marginal WTP from Bottles Currently Owned Model

Attribute	Marginal WTP (US$) OWN0	Marginal WTP (US$) OWN1TO3	Marginal WTP (US$) OWN4TO6	Marginal WTP (US$) OWN7TO9	Marginal WTP (US$) OWNOVER10
Organic	$1.01	$1.21	$1.41	$0.74	0$1.35
	(0.3133)	(0.2903)	(0.4181)	(0.3125)	(0.2560)
	0.001	0.000	0.001	0.017	0.000
Sulfite	$0.67	$0.53	$0.50	$0.39	$0.85
	(0.3463)	(0.2457)	(0.3596)	(0.3998)	(0.2349)
	0.052	0.032	0.166	0.326	0.000
Quality	$1.02	$2.44	$2.66	$1.80	$3.72
	(0.4020)	(0.3240)	(0.6072)	(0.3470)	(0.4036)
	0.011	0.000	0.000	0.000	0.000

Standard errors in parentheses, followed by p-values

Table 4.42. Wald Test Summary for Bottles Currently Owned Model

Attribute	Null Hypothesis	P-value	Conclusion
Organic	Organic estimates are the same	0.899	Fail to Reject Null
Sulfite	Sulfite estimates are the same	0.830	Fail to Reject Null
Quality	Quality estimates are the same	0.002	Reject Null
Price	Price estimates are the same	0.100	Reject Null

As expected, quality was statistically different across the various ownership categories, as was price. Organic wine and "no sulfites added" labeling, while significant in the estimates, are not attributes that differ across the cohorts. Except for participants owning more than 10 bottles of wine, consistent patterns are difficult to pinpoint for quality valuation. The results point to the conclusion that, instead of segmenting the market by generic involvement levels, a better division might be between collectors and non-collectors. Assuming 10 or more bottles of wine constitutes a collection, this segmentation may be more useful, since participants owning 10 or more bottles had a significantly higher valuation for quality than the other groups.

4.6 Testing for Non-Linearity

The previous models assumed that increases in quality produced the same marginal increase in utility at all levels. Because quality was defined in four 4-level increments, however, it was possible to test whether quality levels were linearly or non-linearly related to utility. It was hypothesized that quality increases at the very high levels would be worth more than quality increases at the lower levels. To test for this non-linearity, an exploded logit was estimated that included a squared quality term, which is specified as (4.8) and presented in Table 4.43.

(4.12) $U_{ijk} = V_{ijk} + \varepsilon_{ijk} = \beta_1 ORGANIC + \beta_2 SULFITE + \beta_3 QUALITY + \beta_4 QUALITY^2 + \beta_5 PRICE + \varepsilon_{ijk}$

And: $\frac{\partial V}{\partial Quality^2} = \beta_1 + \beta_2 + \beta_3 + 2\beta_4 QUALITY + \beta_5 + \varepsilon_{ijk}$

Table 4.43. Non-Linear Quality, Exploded Logit

Variable	Coefficient	Robust St. Error	Z	P-value	95% Confidence Interval
ORGANIC	-0.5206	0.0538	-9.68	0.000	-0.6260 to -0.4152
SULFITE	-0.2820	0.0575	-4.90	0.000	-0.3947 to -0.1692
QUALITY	-1.0844	0.0739	-14.67	0.000	-1.2293 to -0.9395
$QUALITY^2$	-0.0455	0.0181	-2.51	0.012	-0.0810 to -0.0100
PRICE	0.6378	0.0343	18.60	0.000	0.5706 to 0.7050

Log pseudolikelihood = -2438.194, n=223 participants in 8028 observations

Given that the squared quality estimate is significant, the results indicate that the valuation of quality is indeed non-linear, and that the marginal utility of quality at the higher levels exceeded the marginal utility of quality at the lower levels. This finding was especially interesting given that quality was the dominating attribute throughout the analysis, and it points to the conclusion that WTP for quality might actually be understated for high-quality wines. Since quality was already found to be a dominant attribute and the primary research focus was on sulfites, however, the linear model was deemed an appropriate approximation of consumer WTP at the different quality levels.

4.7 Determinants of Actual Purchase

4.7.1 Aggregated Model

The final step of the analysis studied how the probability of a participant saying they would actually purchase their “most preferred” wine related to the wine’s attributes. To estimate the model, a WBUY variable was created, where it was defined as 1 if the respondent said they would actually purchase the wine, and 0 otherwise. Since only the “most preferred” wine was analyzed, the number of observations was reduced by 2/3 to 2676. Unlike the exploded logit model where the intercept drops off because of algebraic simplification within the conditional logit link functions (Gould, 2011), the logit model included an intercept. The signs of the estimates were also interpreted directly because a 1 indicates higher utility than a 0 value. The main results are displayed in Table 4.44, followed by the marginal effects in Table 4.45.

Table 4.44. Logit Specification for Buying Wine – Aggregated

Variable	Coefficient	St. Error	Z	P-value	95% Confidence Interval
ORGANIC	0.0844	0.0524	1.61	0.107	-0.0183 to 0.1871
SULFITE	0.0778	0.0514	1.52	0.130	-0.0228 to 0.1785
QUALITY	0.2593	0.0319	8.13	0.000	0.1969 to 0.3218
PRICE	-0.2319	0.0234	-9.91	0.000	-0.2778 to -0.1860
Constant	0.1999	0.1435	1.39	0.164	-0.0814 to 0.4813

n=223 participants in 2676 observations

Table 4.45. Marginal Effects – Aggregated

Variable	Marginal Effects	St. Error	Z	P-value	95% Confidence Interval	X
ORGANIC	0.0186	0.0116	1.61	0.108	-0.0041 to 0.0414	0.6431
SULFITE	0.0172	0.0114	1.51	0.131	-0.0051 to 0.0394	0.5960
QUALITY	0.0571	0.0071	8.08	0.000	0.0432 to 0.0709	2.4563
PRICE	-0.0510	0.0052	-9.87	0.000	-0.0612 to -0.0409	0.9294

n=223 participants in 2676 observations

For both the logit model and the post-estimation marginal effects, price and quality are significant at the 1% level, whereas organic and sulfite estimates are significant at 15%. The marginal effects can be interpreted as the change in probability of purchase based on a marginal change in the attribute. Therefore, an organic wine increases the probability of purchase by 1.86%, a wine without sulfites increases the probability of purchase by 1.72%, a 4-point increase in the quality score increases the probability of purchase by 5.71%, and a $1.50 increase in price decreases the probability of purchase by 5.10%, all else equal.

4.7.2 Price-Interaction Model

Since price and quality are shown to significantly impact a purchasing decision, the next step in the panel logit analysis was to see how higher price ranges changed the purchasing decision. It was hypothesized that being placed in a higher price category would decrease the likelihood of a purchase. The results are shown in Tables 4.46-4.47.

Table 4.46. Logit Specification for Buying Wine – Price Segmentation

Variable	Coefficient	St. Error	Z	P-value	95% Confidence Interval
ORGANIC	0.0848	0.0569	1.49	0.136	-0.0267 to 0.1962
SULFITE	0.0840	0.0559	1.50	0.133	-0.0255 to 0.1935
QUALITY	0.2864	0.0352	8.13	0.000	0.2174 to 0.3555
PRICE	-0.2441	0.0254	-9.60	0.000	-0.2939 to -0.1943
PRICE20	-0.9620	0.2938	-3.27	0.001	-1.5379 to -0.3861
PRICE30	-1.4610	0.2939	-4.97	0.000	-2.0371 to -0.8850
Constant	0.9285	0.2358	3.94	0.000	0.4664 to 1.3907

n=223 participants in 2676 observations

Table 4.47. Marginal Effects – Price Segmentation

Variable	Marginal Effects	St. Error	Z	P-value	95% Confidence Interval	X
ORGANIC	0.0189	0.0127	1.49	0.137	-0.0060 to 0.0438	0.6431
SULFITE	0.0187	0.0125	1.50	0.134	-0.0057 to 0.0431	0.5960
QUALITY	0.0635	0.0079	8.06	0.000	0.0481 to 0.0790	2.4563
PRICE	-0.0541	0.0057	-9.46	0.000	-0.0654 to -0.0429	0.9294
PRICE20	-0.2206	0.0676	-3.27	0.001	-0.3530 to -0.0882	0.3318
PRICE30	-0.3340	0.0648	-5.15	0.000	-0.4611 to -0.2070	0.3363

n=223 participants in 2676 observations

Compared to the $10-$15 price range, simply being placed into a $20-$25 price ranged decreased the likelihood of purchase by 22%. Similarly, being in the $30-$35 range decreased purchase likelihood by 33%. The large influence that the wine's price has on the likelihood of a purchase indicates that, while real valuation of sulfites and organic wine exist, it is of utmost importance that a wine is within the desired price range. After a desired price and quality are reached, niche markets may be available for organic wine and wine produced without added sulfites, but it is likely these schemes are more to gain new customers or strengthen loyal and return buyers, rather than securing a premium. But, perhaps a small premium is possible if it stays within a desired price range, especially among segments most motivated to seek out "no sulfites added" options.

4.7.3 Headache-Interaction Model

To test for the existence of a niche market based on sulfite content, the final step in the analysis segmented headache sufferers from non-headache sufferers on the likelihood of purchasing a low-sulfite wine. Tables 4.48 and 4.49 illustrate the results.

Table 4.48. Logit Specification for Buying Wine – Headache Segmentation

Variable	Coefficient	St. Error	Z	P-value	95% Confidence Interval
HEADORG	0.1003	0.8954	1.12	0.263	-0.0752 to 0.2758
NOHEADORG	0.0783	0.0636	1.23	0.218	-0.0463 to 0.2030
HEADSULF	0.1575	0.0919	1.71	0.086	-0.0226 to 0.3376
NOHEADSULF	0.0444	0.0617	0.72	0.472	-0.0766 to 0.1653
HEADQLTY	0.2914	0.0532	5.48	0.000	0.1872 to 0.3956
NOHEADQLTY	0.2465	0.0374	6.58	0.000	0.1731 to 0.3199
HEADPRICE	-0.2523	0.0399	-6.32	0.000	-0.3304 to -0.1741
NOHEADPRICE	-0.2225	0.0281	-7.92	0.000	-0.2776 to -0.1674
Constant	0.1907	0.1436	1.33	0.184	-0.0907 to 0.4721

n=223 participants in 2676 observations

Table 4.49. Marginal Effects – Headache Segmentation

Variable	Marginal Effects	St. Error	Z	P-value	95% Confidence Interval	X
HEADORG	0.0218	0.0193	1.13	0.257	-0.0159 to 0.0596	0.2160
NOHEADORG	0.0172	0.0139	1.24	0.217	-0.0101 to 0.0445	0.4271
HEADSULF	0.0341	0.0195	1.74	0.081	-0.0042 to 0.0724	0.2123
NOHEADSULF	0.0097	0.0135	0.72	0.472	-0.0168 to 0.0363	0.3838
HEADQLTY	0.0641	0.0117	5.48	0.000	0.0412 to 0.0870	0.8333
NOHEADQLTY	0.0542	0.0083	6.53	0.000	0.0380 to 0.0705	1.6229
HEADPRICE	-0.0555	0.0088	-6.35	0.000	-0.0726 to -0.0384	0.3236
NOHEADPRICE	-0.0490	0.0062	-7.86	0.000	-0.0612 to -0.0368	0.6058

n=223 participants in 2676 observations

Consumers who suffer from headaches are 3.41% more likely to purchase a wine made without added sulfites, whereas non-headache sufferers are only 0.97% more likely to make a purchase. The estimates for headache sufferers are statistically significant at 10%, while statistically insignificant for non-headache sufferers. The model indicates, however, that the positive marginal effect for low-sulfite wine is offset by the negative marginal effect for price, even when linearly adjusted for the $1.50 pricing increments, further confirming the importance of price in the purchasing decision. There is also little difference between how headache sufferers and non-headache sufferers value organic wine, pointing to the conclusion that some consumers do not in fact realize that organic wine is also produced without added sulfites. Quality continues to be the most important attribute. In fact, headache sufferers are nearly 1% more likely to purchase a higher quality wine than non-headache sufferers.

4.8 Summary of Analysis

A variety of models were presented in both the exploded conditional logit and panel logit regressions to see how the consumer population overall, as well as specific consumer cohorts, valued and purchased wine. There was evidence that several criteria could be used to differentiate between types of buyers, but even so, the quality attribute consistently valued across the groups. Other attributes, such as organic and low-sulfite differentiation, while significant overall, were not found to be important segmenting factors in the wine market.

The next section applies the results of the empirical analysis to more specific conclusions, including tangible and immediate marketing and production strategies that are implied from the results. Future research directions and limitations of the current methodology conclude the discussion.

CHAPTER FIVE

MARKETING IMPLICATIONS, LIMITATIONS OF RESEARCH METHODS, AND FUTURE RESEARCH NEEDS

5.1 Marketing and Supply Chain Implications

Although wine markets are increasingly seen as an interesting research topic, most existing research focuses on historically high-profile attributes, including variety and place-based factors such as viticultural areas, rather than emerging niche attributes that focus on the non-sensory drinking experience such as a wine's sulfite content. In contrast, the research objectives of this study were to assess whether consumers perceive sulfites negatively, especially in regard to triggering headaches; quantify willingness to pay for wine produced without sulfites; and provide useful information to the wine industry that may infer the existence of niche market segments for low-sulfite wine. This initial work focused on consumer perceptions and potential interest in wines assuring such production practices that yield some interesting results for the industry.

One of the main implications for the wine marketing literature is that consumers value a lack of sulfites in wine, but quality consistently holds a higher value. In fact, the empirical analysis indicates that WTP estimates for quality may even be underestimated at very high levels. While increasing marginal utility is uncommon in economics, it can be explained as the "phenomenon of superstars" which describes how some premium wines can elicit a much higher price than average wines (e.g. Rosen, 1981). From a marketing standpoint, showcasing a wine's quality may yield significant gains, particularly if the wine is already at a high quality level. Possible avenues to effectively showcase a quality wine include promoting the wine through rating agencies, such as *Wine Spectator*, and emphasizing the wine's quality at festivals and tastings. As the empirical results illustrate, high-income and more-involved consumers may be particularly receptive to these marketing campaigns.

Organic wine and sulfite content, while still significantly valued, were shown to be of secondary importance in the purchasing decision. So, the additional attributes are more likely to be used to gain market share, customer loyalty or for new vintners to gain attention and access to the market, rather than as a mechanism to increase price. Or, at least, the amount of premium that can be secured must be evaluated in the context of where the wine is priced within current prevailing price ranges used by retailers. Headache sufferers are the most likely initial consumers of low-sulfite wines, but the lack of added sulfites may prove ineffective in mitigating the wine headache. Therefore, implementing brand loyalty campaigns, such as promoting a wine club, may become an important and effective strategy to retain customers even if the wine is positioned to be attractive to certain groups (such as those who suspect sulfites affect their health) .

In addition to the cohort of consumers experiencing wine headaches, the growing natural wine movement (e.g. Goode and Harrop, p. 141, 2011) may yield a significant competitive advantage for those producing low-sulfite wines. In fact, marketing low-sulfite wine as a “natural” product could potentially give it a place in the less crowded all-organic sections of wine retail stores, which may further blur the consumer distinction between organic and sulfite-differentiated wines. From a production standpoint, less consumer differentiation would allow for a similar price premium to be charged for low-sulfite wine, while keeping production costs and risks relatively lower than organic production. As the empirical results indicate, there already exists some confusion over the difference between organic and low-sulfite wines, and although winemakers must remain ethical in only promising the assurances they can make (no added sulfites), if that claim is of paramount importance to consumers, it may allow them to mitigate the risks and production costs of a full organic transition.

While sulfite-differentiated wines do have positive marketing implications, producers should still be cautious in foregoing to the use of sulfites due to the higher risk of oxidation and spoilage of the wine. In fact, consumers may be actively deterred from purchasing a low-sulfite wine if they perceive that quality may suffer due to these risks. Offering a money-back guarantee would remove the barrier to making a purchase, but it would also shift the risk to the producer. A variety of production strategies have been shown to reduce the risks involved with low-sulfite production, though, including producing wine in smaller batches, using higher-quality grapes, and implementing gentler harvesting techniques (e.g. Goode and Harrop, p. 158, 2011). This may imply particular benefits for wineries with an on-site supply chain and small batch processes to monitor, since imported grapes can experience stress and microbial contact during transport and may not be harvested at the optimal ripeness. Furthermore, emerging wine regions known for smaller-scale production may be able to better carve out a regional identity by exploiting the low-sulfite market.

5.2 Limitations

There are a few main limitations to the research methods and regression analysis that warrant attention. First, the participants recruited to take the online survey were all customers at the same wine retailer in Fort Collins, Colorado. While likely fairly representative of wine consumers overall, there is the potential of some sample selection bias, particularly with education levels, since Colorado State University is located within Fort Collins. While wine consumers are generally more affluent than the general population (e.g. Olsen, Thach, and Nowak, 2007), 82.96% of this study’s sample held at least a Bachelor’s degree which is far higher than general population given that only 35.9% of Colorado residents hold a Bachelor's degree or higher (United States Census Bureau, 2012). Additionally, only participants who had access to the internet were recruited to the survey, potentially excluding certain individuals from the experiment.

Another limitation relates to the survey design itself. In order to understand how consumers would respond to potential marketing campaigns for low-sulfite wine, a fictional label was created indicating that a wine was made without added sulfites. Consumer responses, therefore, were representative of whether the label exists or not, rather than what is actually contained within the product. Clarifying this informational asymmetry may be more informative of how consumers actually value sulfites, rather than how they tend to respond to marketing campaigns aimed at promoting a particular attribute. Valuation might also be more accurately estimated by grouping participants into pricing groups based on their self-reported purchasing behavior, rather than random segmentation. Alternatively, narrowing the price ranges and adding precision to the marginal effects might improve accuracy.

Finally, it is unclear how changing perceptions would influence the size of potential niche markets. If vintners produce low-sulfite wine and consumers continue to experience headaches, the knowledge gap between consumers and current medical researchers will almost certainly narrow. On the other hand, if low-sulfite wine continues to be perceived as a part of the natural wine movement, the size of the potential niche markets may increase. Moreover, given current interest in supporting local foods and smaller businesses, including small-batch or craft wineries as a product attribute in the choice design would shed light on why consumers actually value low-sulfite wine. Regardless, the suggested results may only imply marketing strategies for the short term, whereas long term strategies might need further analysis and refinement once actual consumer behavior is observed.

5.3 Conclusions

In reference to the research objectives, a variety of conclusions are drawn. The first is that, on par with the previous conjectures from the literature, consumers do in fact perceive sulfites negatively and as a main trigger of headaches after even moderate consumption of wine. In contrast to the small percentage (around 1%) of consumers who have a diagnosed medical allergy to sulfites (e.g. Grotheer, Marshall, and Simonne, 2005), the summary statistics obtained from the survey indicate that 34.08% of the consumer population report experiencing headaches after moderate consumption of wine. Of this group, sulfites are perceived by 63.16% of headache sufferers as being a trigger of their wine headaches, and sulfites were selected more than any other possible trigger. These results point to the conclusion that sulfites are widely perceived negatively, regardless of the medical evidence pointing to other ingredients as also being theoretical triggers (e.g. Mauskop and Sun-Edelson, 2009; Millichap and Yee, 2003).

Analyzing consumer choices and preferences for wine differentiated with a variety of labels using a 96.14% D-optimal design, paired with a ranked exploded logit model, allowed for statistically significant and precise estimates throughout the empirical analysis. Overall, the average consumer values a lack of sulfites at $0.64, but quality and price are considerably more important in determining a purchase decision. This conclusion is supported by the secondary panel logit model, which indicates that a higher price range decreases the likelihood of a wine being purchased by up to 33%. Likewise, a 4-point increase in quality (on a 100 point scale) is over three times as important for a purchasing decision as a lack of sulfites for consumers overall. The high valuation for quality may be partially explained due to the quality score encompassing a variety of quality-related attributes, such as a wine's production year and origin. For successful marketing campaigns, though, the models consistently show that a wine first needs to be within an acceptable quality and price range before organic wine or a lack of sulfites will elicit changes in the purchasing decision.

Nevertheless, headache sufferers value "no sulfites added" labeling considerably higher than any other group in the consumer population, showing the potential for a substantial niche market oriented toward around one-third of the consumer population. Using the dummy-interacted regressors in an exploded logit model, the results show that headache sufferers value low-sulfite wine at $1.23, compared to $0.64 for the aggregated sample and $0.33 for non-headache sufferers. This is significant for producers wishing to charge a price premium for sulfite-differentiated wines; however, even headache sufferers valued quality and a wine's price more than "no added sulfites." So, this reinforces the idea that "no added sulfites" labeling is necessary to gain these consumers' attention, but it is not sufficient, since poor quality would still discourage purchases.

Outside of the headache cohort, low-sulfite product differentiation was not found to be a significant segmenting factor across the demographic groups. In contrast, a wine's quality emerged as the important segmenting attribute, particularly at varying income and market participation levels. The exploded logit models indicated that individuals with more than $200,000 in household income per year valued a 4-point increase in quality at $5.91, which is considerably higher than the $1.72 value for the lowest income category. Likewise, education levels, which may be correlated with spending power, generally increased the valuation for quality scores. Finally, belonging to a wine club and purchasing more bottles in a typical month, both of which are indicative of higher market participation, were found to be positively related to quality valuation. These results point to the conclusion that as spending power and market participation levels increase, the demand for higher-quality wines increases disproportionately compared to the other attributes.

5.4 Future Directions

The research may be extended upon with three main areas of further study. The first is to better understand why a difference exists between consumer perceptions and current scientific knowledge associating sulfites with headaches. One hypothesized explanation relates to the government labeling rules, where warning labels must be included on wine containing sulfites. This, in essence, creates a "lightning rod" for potentially-false positive beliefs. An experiment that tests different labeling practices, such as including additional chemicals on an ingredients label and stating the actual amount of sulfite content in the wine, may prove useful in understanding the disparity and advocating for alternative labeling guidelines. Recommending changes to labeling policy may prove challenging, however, without more research related to the health outcomes associated with moderate wine consumption.

The second area warranting further research relates to understanding how consumers value the additional production practices for organic wine compared to wine only produced without added sulfites. Consumers were initially assumed to have some knowledge about sulfite regulations, particularly with organic wine. This hypothesis was supported by the fact that no participants selected organic wine as a perceived headache trigger, since organic wine cannot contain added sulfites. The initial exploded logit analysis for the aggregated sample also seemed to confirm this conclusion, as organic wine was worth $1.22, while a lack of sulfites was only valued at $0.64. Once the interaction models were run, however, the extent of consumer knowledge associated with the sulfite regulations became less clear. Assessing consumer valuation of organic wine would better inform producers whether the sulfite content plays a role in a consumer's choice for organic wine, or if low-sulfite wine should be treated as an independent, rather than embedded, niche market. Given the additional risks and production costs of organic winemaking, the results of a future study would also assist producers in developing more profitable differentiation strategies.

Finally, an emerging regression tool used to identify latent class groups and random coefficients for ranked multi-level data is generalized linear latent and mixed modeling (GLLAMM). Analyzing similar studies utilizing both the exploded logit and the GLLAMM program to derive WTP estimates, and determining whether estimates were substantially improved, may contribute some information to how others select the estimation methods for future wine marketing (and other consumer) analyses.

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APPENDIX A

Orthogonal in the Differences (OOD) Choice Design

Set	WINE A				WINE B				WINE C			
	organic	sulfite	quality	price	organic	sulfite	quality	price	organic	sulfite	quality	price
1	1	0	2	3	1	0	0	1	0	1	3	2
2	0	1	0	2	0	1	2	0	1	0	1	1
3	1	0	3	0	1	0	1	2	0	1	0	3
4	1	1	1	2	1	1	3	0	0	0	2	1
5	0	0	1	1	0	0	3	3	1	1	2	0
6	0	1	2	1	0	1	0	3	1	0	3	0
7	0	1	3	0	0	1	1	2	1	0	0	3
8	1	1	0	1	1	1	2	3	0	0	1	0
9	0	0	1	3	0	0	3	1	1	1	2	2
10	0	0	2	2	0	0	0	0	1	1	3	1
11	1	0	0	0	1	0	2	2	0	1	1	3
12	1	1	3	1	1	1	1	1	0	0	0	2

D-optimality: 96.14%

APPENDIX B

Initial Recruitment Email

Subject line: CSU wine preference study

My name is Chris Appleby, and I am a graduate student at Colorado State University's Agricultural and Resource Economics department. Dr. Marco Costanigro (the principal investigator) and I are conducting a research project to study consumer preferences when purchasing wine. The name of our research project is "Measuring consumer willingness to pay for reduced sulfur dioxide levels in wine: A conjoint analysis."

We are asking for volunteers to help us take a short online survey. By participating, you will be contributing to the general knowledge of how consumers and producers value different attributes associated with wine. In addition, the results will be used as part of my Master's thesis. Your responses will be anonymous.

1. If you would like to help us in developing the survey and get a sense of what the research is about, a pilot, shortened version of the survey (approximately 10 minutes to complete) can be currently found at https://survey.qualtrics.com/SE/?SID=SV_1BTq7j2MdnBj2jW. There is no compensation for completing this online survey, but the information you provide will be extremely helpful for us in determining the final version of the survey.

2. If you would like to be contacted about helping us with the final online survey (approximately 20-25 minutes to complete), please email us at **CSUwinestudy@gmail.com**. The first 200 participants will receive a $20 gift card voucher redeemable for one bottle of wine at Wilbur's, and we will let you know once we have 200 participants.

Thank you for your help!

Sincerely,

Chris Appleby
Graduate Student
Department of Agricultural and Resource Economics
Colorado State University
Christopher.Appleby@colostate.edu

Marco Costanigro
Assistant Professor
Department of Agricultural and Resource Economics
Colorado State University
Marco.Costanigro@colostate.edu

APPENDIX C

Final Survey Recruitment Email

Subject: CSU wine preference study, final survey

My name is Chris Appleby, and I am a graduate student at Colorado State University's Agricultural and Resource Economics department. Dr. Marco Costanigro (the principal investigator) and I received an email from this address expressing interest in helping us with the final online wine survey.

Please see the attached cover letter and contact us if you have questions. The online survey should take around 20-25 minutes to complete. Your participation is voluntary and your responses are anonymous.

If you are still interested in participating, please visit
https://survey.qualtrics.com/SE/?SID=SV_6eRnzZRNdyTwCa0

When asked for a password, type CSUwinestudy

You will be provided with a $20 wine voucher redeemable at Wilbur's for one bottle of wine. To receive the voucher, please print it when prompted to do so at the end of the survey and bring it to Wilbur's for verification. The survey link will be available until March 17, 2012, or until we receive 200 responses, whichever comes first. The voucher will be redeemable until March 31, 2012.

Thank you for your help!

Sincerely,

Chris Appleby
Graduate Student
Department of Agricultural and Resource Economics
Colorado State University
Christopher.Appleby@colostate.edu

Marco Costanigro
Assistant Professor
Department of Agricultural and Resource Economics
Colorado State University
Marco.Costanigro@colostate.edu

APPENDIX D

Project Cover Letter

Department of Agricultural and
Resource Economics
Fort Collins, Colorado 80523-1172
(970) 491-6325
FAX: (970) 491-2067
http://dare.colostate.edu/

March 8, 2012

Dear Participant:

We are looking for volunteers to participate in a study of consumer preferences in wine. We are asking for participants to fill out an online survey.

To participate, please visit https://survey.qualtrics.com/SE/?SID=SV_6eRnzZRNdyTwCa0 and enter the password **CSUwinesurvey**. The survey will take approximately 20-25 minutes, and you must be at least 21 years of age to participate. The title of our project is "Measuring consumer willingness to pay for reduced sulfur dioxide levels in wine: A conjoint analysis." The Principal Investigator is Marco Costanigro and I am the student Co-Principal Investigator, Chris Appleby. We are both from the Agricultural and Resource Economics department, and this research will provide the data for my Master's Thesis. Funding is provided by SurePure.

The survey will ask a few demographic questions and will ask about your preferences when buying wine. Participants will receive a $20 wine voucher redeemable at Wilbur's. To receive the voucher, you must printed it when prompted to do so. We will track your purchases for research purposes, but your responses in the survey and voucher purchases will remain anonymous. Your participation is voluntary. If you decide to participate in the study, you may withdraw your consent and stop participation at any time without penalty. The survey responses will be accessed by the Principal Investigator and Co-Principal Investigator and may be published in a graduate thesis or academic journal. While there are no direct benefits to you, we hope to gain more knowledge on consumer preferences toward wine.

While there are no known risks to participating in this survey, it is not possible to identify all potential risks in research procedures. The researchers have taken reasonable safeguards to minimize any potential, but unknown, risks.

If you have any questions, please contact Marco Costanigro at Marco.Costanigro@colostate.edu or Christopher Appleby at Christopher.Appleby@colostate.edu. If you have any questions about your rights as a volunteer in this research, contact Janell Barker, Human Research Administrator, at 970-491-1655.

Sincerely,

Marco Costanigro	Christopher Appleby
Principal Investigator	Co-Principal Investigator
Assistant Professor	Graduate Student

APPENDIX E

Wine Survey

Q1.1 Welcome! The following survey will ask a few questions about your demographics and will ask about your preferences when buying wine. Your responses in the survey are anonymous and your participation is voluntary. A copy of the cover letter was sent to you in the latest email. Please take some time to read the cover letter. If you have questions, please contact us before completing the survey. As a reminder, the voucher at the end of the survey needs to be printed in order to be redeemed. Please print the voucher when prompted to do so.

- ❍ Begin the survey (1)

Q1.2 You must be at least 21 years of age to take the survey. Please certify that you are at least 21 years of age.

- ❍ I am at least 21 years of age (1)
- ❍ I am not at least 21 years of age (please exit the survey!) (2)

Q1.3 What is your age?

- ❍ 21-30 (1)
- ❍ 31-40 (2)
- ❍ 41-50 (3)
- ❍ 51-60 (4)
- ❍ 61-70 (5)
- ❍ 71 or above (6)

Q1.4 Please estimate your annual household income.

- ❍ $25,000 or below (1)
- ❍ $25,001 to $50,000 (2)
- ❍ $50,001 to $75,000 (3)
- ❍ $75,001 to $100,000 (4)
- ❍ $100,001 to $200,000 (5)
- ❍ $200,001 or above (6)

Q1.5 What is your gender?

- ❍ Male (1)
- ❍ Female (2)

Q1.6 What is the highest level of education you have completed?

- ❍ Less than high school (1)
- ❍ High school (2)
- ❍ Some college (3)
- ❍ Bachelor's degree (4)
- ❍ Master's degree (5)
- ❍ Doctorate/professional degree (6)

Q1.7 How many bottles of wine in a typical month do you purchase?

- ❍ 1 to 3 (2)
- ❍ 4 to 6 (3)
- ❍ 7 to 9 (4)
- ❍ 10 or more (5)

Q1.8 Approximately how many bottles of wine do you currently have at your home?

- ❍ 1 to 3 (2)
- ❍ 4 to 6 (3)
- ❍ 7 to 9 (4)
- ❍ 10 or more (5)

Q1.9 Do you belong to a wine club?

- ❍ Yes (1)
- ❍ No (2)

Q1.10 Do you subscribe to a wine magazine?

- ❍ Yes (1)
- ❍ No (2)

Q1.11 Do you believe that drinking even moderate amounts of some types of wine give you headaches?

- ❍ Yes (1)
- ❍ No (2)

Q1.12 When drinking even moderate amounts of wine, what specifically do you believe causes you to have the headaches? Select all that apply.

- ❑ Drinking organic wine (1)
- ❑ Sulfites (2)
- ❑ Drinking red wine (3)
- ❑ Drinking white wine (4)
- ❑ Tannins (5)
- ❑ Tyramine (6)
- ❑ Histamines (7)
- ❑ Dehydration (8)
- ❑ Other (please explain) (9) ____________________

Q2.1 Please read the following about sulfite content in wine:

Small levels of sulfites occur naturally in all wine.

The amount of naturally-occurring sulfites is usually less than 10 parts per million (Frey Vineyards Ltd., 2009)

Winemakers commonly add sulfites to wine. Sulfites help preserve the wine, enhance aging, and stop the fermentation process ([Southern Oregon] Wine Institute, 2011)

The average amount of sulfites added to wine is around 125 parts per million (Slinkard, 2012)

The Food and Drug Administration estimates that around 1 in 100 people have an allergy to sulfites. Common reactions include trouble breathing and skin rashes (Grotheer, Marshall, and Simonne, 2005).

Some people connect sulfites to causing headaches when drinking even modest amounts of wine. Scientists have not agreed on whether a link between sulfites and headaches exists (Mauskop and Sun-Edelstein, The Clinical Journal of Pain, 2009).

❍ Continue (1)

Q2.2 Please read the following about the Wine Spectator quality score. Wines receive a quality score anywhere from 50 to 100 by Wine Spectator. The quality score is commonly displayed with wine bottles at stores. The quality scores are defined as:

95-100: Classic: a great wine.
90-94: Outstanding: a wine of superior character and style
85-89: Very good: a wine with special qualities
80-84: Good: a solid, well-made wine
75-59: Mediocre: a drinkable wine that may have minor flaws
50-74: Not recommended

❍ Continue (1)

Q3.1 The next part of the survey will take you through 12 scenarios. For each scenario, you will be presented with three hypothetical wine labels. Each wine label will include a Price and a Quality Score. The Quality Score is based on the Wine Spectator quality score definitions from the previous page. In addition, some wine labels may display the following characteristics:

USDA-certified organic No sulfites added

❍ Continue (1)

Q3.2 For each of the 12 scenarios, imagine that you are at a store purchasing a Chardonnay (white wine). After carefully considering the three wine labels, select one wine that is your most preferred. Then select another wine that is your least preferred. Finally, answer whether or not you would be actually willing to purchase the wine you selected as "most preferred" in real life.

❍ Continue (1)

Q3.3 In other similar surveys, people have answered the questions one way but then act differently in real life. Although the wines in the following choice sets are hypothetical, it is important to take the survey seriously. Our project relies on you answering as accurately and carefully as possible.

❍ Continue (1)

Q4.1 – Q4.12 Based on this choice set only, select one wine that you most prefer. Then select another wine that you least prefer.

	WINE A	WINE B	WINC C
Most prefer (1)	❍	❍	❍
Least prefer (2)	❍	❍	❍

Q4.1-4.12 Would you actually be willing to purchase the wine you selected as "most preferred" in real life?

❍ Yes (1)

❍ No (2)

Q5.1 This is your wine voucher. Please print this page and bring it to Wilbur's for verification.

You will receive a coupon from Wilbur's redeemable for one bottle of wine, up to $20 in value, tax inclusive.

Your survey code: ${e://Field/random}

Today's Date: ${e://Field/Today}

Redeemable until April 1, 2012

Please ensure that this page printed correctly before continuing. Thank you for your time!

❍ Click here to end your session (1)