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## Article

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# Segmenting wine markets with diverse price functions: Evidence from California red and white wines sold in British Columbia

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## Abstract

Previous hedonic price studies on wine market segments, exploring diverse price functions, are constrained by pre-determined price breakpoints, the total number of segments, or both. Using British Columbia Liquor Distribution Branch (BCLDB) retail price data of California red and white wines, this study adopts an endogenous approach to explore the total number of market segments and identify breakpoints in price dispersion simultaneously. Results show that red and white California wines are grouped into two (breaking at Can\$14 per bottle) and three (breaking at Can\$16 and \$30 per bottle) price segments, respectively. Also, implicit prices of wine attributes such as grape variety and geographic origin differ for red and white wines across market segments.

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**Keywords:** Wine; Hedonic; Segmentation

## 1. Introduction

To satisfy the needs of heterogeneous consumers over the years, the wine industry in North America has undergone substantive changes with winemakers designing products with multiple attributes. Researchers have employed varied analytical techniques to study differentiated wine products that differ in price and product characteristics across market segments. The existence of segmented markets stems from differences in the structure of demand, supply, or both across segments (Freeman, 1993). Market segmentation does not necessarily imply that consumers are divided into distinct groups; instead, it is more likely that consumer preferences for food products will differ across market segments (Costanigro

and McCluskey, 2011). For example, given that consumers are a heterogeneous group with varied wine preferences, they are likely to buy a wine for a gift at one price segment and purchase another with similar attributes from another price segment. Costanigro et al. (2009), in estimating a multiple-class hedonic model and identifying four wine classes, suggested that as the attributes of wines diverge consumers will purchase and consume wine products for different purposes. Apart from differences in implicit prices across sub-markets, market segmentation can be brought about by the usage of product characteristics.

This paper employs British Columbia Liquor Distribution Branch (BCLDB) retail sales data of California red and white wines and estimates hedonic price functions to determine the existence of different market segments for red and white wines with similar product attributes. Most previous hedonic studies on wine prices ignored the existence of market segments and pooled price functions across product characteristics and geographical boundaries, and with few exceptions examined market segments but constrained with the pre-determined breakpoints

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or the total number of segments (Costanigro et al., 2007; Kwong et al., 2011). The contribution of this study is the adoption of an endogenous approach to identify both the total number of market segments and price breakpoints simultaneously for California red and white wines sold in British Columbia. The structure of the paper is as follows: in the first section we review the wine literature in particular studies related to wine segmentation. This is followed by the theoretical model, data description and sources, and the model specification. The results and discussion are presented in the fourth section which is followed by the conclusion section.

## 2. Literature review

Previous studies on wine market segments and various price functions are conducted from two strands: one examines consumer characteristics or purchase behavior (for example, the reason to buy wine as a gift or for own casual consumption); the other emphasises the relationship of price categories of products and their attributes. Researchers have applied varied analytical approaches in the investigation of differentiated wine products and potential market segments. Cluster analysis was often employed to examine market segments of consumers, which requires large panel datasets about consumers to ensure reliability and stability of results over time. Food marketers often lack information about consumers (unless they purchase and process data from commercial market intelligence firms such as AC Nielsen) but do have information pertaining to sales and prices of their products and corresponding product characteristics. Such data offer opportunities to conduct hedonic analysis or choice experiments that aim at identifying market segments, but with the emphasis not on consumer characteristics, but on various price functions and effects of their attributes.

### 2.1. Market segmenting on consumer characteristics or purchase behavior

Marketing researchers employed several clustering algorithms to classify consumers into clusters, especially when the market segment is not clearly defined. This approach was employed to segment U.S. households into four clusters (local enthusiasts, local detractors, local advocates, and local non-advocates), and ascertain their attitudes towards local wines (Kolyesnikova et al., 2008). Johnson and Bastian (2015) used a fine wine technique as a segmentation baseline and then employed cluster analysis to identify three Australian consumer wine segments (wine enthusiasts, aspirants, and no-frills wine drinkers) to study wine-related behavior based on demographics, wine expenditures, and knowledge of wines. The wine-related lifestyle (WRL) technique employed to segment South African wine consumers found that market segmentation based on lifestyle behavior is much more robust when combined with consumer socio-demographic and product involvement decisions (Bruwer et al., 2017). Remaud et al. (2009) combined a choice experiment with segmentation

analysis to show that Australian wine consumers' valuation of eco-friendly wines differs by price segments.

### 2.2. Market segmenting on price functions and their attributes

The hedonic technique has been applied to improve understanding of how consumers employ labelling and packaging information to make wine purchase decisions. Costanigro et al. (2007) and Kwong et al. (2011) found hedonic price functions that account for different price categories can result in different market segments for product attributes. Frequently, this method has estimated implicit quality signal prices or the implicit value consumers are willing to pay for the attribute. The hedonic technique uses various functional forms and estimation methods to establish a relationship between prices and quality signals or product attributes. The hedonic price function (e.g., Cembalo et al., 2014) has been applied in multiple demand studies to measure the contribution of individual quality attributes to prices. Since wine products consist of multiple attributes, empirical applications have analyzed the contribution of objective and subjective factors such as sensory quality characteristics that are measurable in explaining wine prices.

Wine bottle labels in New World countries were meant to be a true declaration of wine content information and conveyed quality signals in terms of the vintage, geographic origin, and grape variety. The research emphasis of New World wines has been placed on the relationship between brand proxies (e.g., geographic region, variety, vintage, name of winery), expert quality rating scores of sensory traits, specialty labels (e.g., vineyard, estate, reserve), and wine prices or price sub-classes in hedonic model specifications (e.g., Costanigro et al., 2007; Kwong et al., 2011).

In contrast, empirical studies of Old World wines have concentrated on quantifying the effects of reputable production regions (e.g., Landon and Smith, 1998; Caracciolo et al., 2016) and sensory attributes (e.g., Cardebat and Figuet, 2004; Lecocq and Visser, 2006) on consumers' valuation of wine. Recent research has shown the relative unimportance of sensory quality ratings compared to wine reputation variables in affecting prices, which may suggest that consumers rely on wine reputation as quality cues to make purchase decisions (Oczkowski and Doucouliagos, 2014).

California wine brands have expanded over the years and offer consumers a range of wine styles and attribute choices. Wine branding can be considered a multi-faceted (e.g., family brand, vintage, country of origin, regional appellation) hierarchical concept employed by wineries to differentiate their products, while providing consumers with invaluable quality information to recognize a wine label and make a rational product choice (Lockshin et al., 2000). Lockshin et al. (2006) measured the importance of wine region, corporate brand name, awards won, and prices and found low-involvement consumers used price and wine awards, while high-involvement consumers used geographic origin to make their purchase decisions.

The bulk of empirical studies investigating the relationship between wine prices and quality cues (e.g., Cacchiarelli et al.,

Table 1  
Summary of literature review of hedonic wine quality studies.

Authors	Method	Sample coverage	Type of wines/regions	Data source	Research highlights
Schamel (2002)	Hedonic method (pooled)	Wine judging years: 1990–2001	Major wines (Cabernet Sauvignon, Zinfandel, Chardonnay) and regions (Napa, Sonoma, South Central) in California	California Wine Winners publication	Premium wine prices influenced by expert quality assessments and producer/regional reputation
Costamigo et al. (2007)	Hedonic method (retail price segmentation)	California and Washington red wines, 1991–2000	California red wines from principal wine regions	Wine Spectator	Consumers valued wine attributes differently in segmented markets based on price
Benfratello et al. (2009)	Hedonic method (pooled)	1995–1998 vintages	Italian premium quality wines: Barolo and Barbaresco	Wine Spectator and the 'Duemila Vini' Italian Guide	Reputation factors are superior to sensorial attributes in explaining Italian wine prices
Roma et al. (2013)	Hedonic method (pooled)	2010 editions of Italian wine guides, 2004–2008	Sicilian wines (excluding sparkling and reserve wines)	Two Italian guides: 'Duemila' and 'Vini d'Italia'	Geographical region, grape variety, vintage and alcohol have significant influence on price
Levaggi and Brentari (2014)	Hedonic method (retail channel segmentation)	2005–2009	Italian red wines sold in wine shops and large-scale retail trade	Independent consumer association (Guida Vini)	Wine label characteristics are the main determinants of wine prices sold in large-scale retail trade

2014) such as grape variety, alcohol content, vintage, region or country of origin, and producer reputation employed an array of different data sets and variable descriptions. Table 1 shows summary highlights of selected hedonic wine pricing studies. The use of hedonic models shows that California wine prices were impacted significantly by expert quality assessments even after adjustments for grape varieties and appellation regions (Schamel, 2002). A study of 63 appellations across diverse wine-growing areas in California showed that the interaction of grape variety and appellation influenced wine prices even after accounting for vintage and tasting scores (Sang-Kwon et al., 2008). Specifically, the authors found Cabernet Sauvignon wines from Napa commanded relatively high price premiums, which is consistent with recent evidence showing that grape variety is the principal dimension in the classification system of California wines, and consequently exerts a significant impact on its price (Zhao, 2008). Wine prices in major wine regions throughout the world were influenced primarily by geographic region in addition to grape variety, expert wine quality ratings, and age of the judged wines (e.g., Schamel, 2006, 2009).

Another analytical approach of the wine literature relates to choice experiments. The combination of multiple wine attributes, varied consumer characteristics, and frequency of wine consumption has forced researchers to adopt other methodological approaches to understand how consumers value prices and other extrinsic cues in making their wine selections (e.g., Lockshin et al., 2006; Gustafson et al., 2011). Lockshin et al. (2006) found, from a choice experiment survey of shoppers in Adelaide wine stores, that regional awareness (in terms of where the wines were produced) increased the quantum of retail sales of small and large corporate brands. However, the effect differed for low- and high-involvement consumers. The latter were willing to increase their purchases of premium wines (priced more than \$17 per bottle) from reputable wine regions. Those results are consistent with an earlier study that showed California consumers who were highly involved with red wines placed less emphasis on the price cue in evaluating alternatives when compared to low-involvement consumers (Zaichkowsky, 1988). Ontario consumers were influenced to a smaller degree by region of origin or gold medal awards in making their wine purchase selections (Lockshin and Halstead, 2005). Gustafson et al. (2011), using data from a laboratory experiment, showed California consumers were willing to pay more for Cabernet Sauvignon wines from Napa and Sonoma than wines labeled with the generic California appellation. Gustafson (2011) suggests that appellation is a highly-valued attribute in California consumer valuation of wine choices and that some of the positive values attributed to the Napa appellation could be attributed to vineyard and winery management practices that can influence grape and wine quality.

### 3. British Columbia wine market

British Columbia is the second largest wine market in Canada, after Ontario, with British Columbians drinking more wine today than in the past because of growing affluence and changing lifestyles. The average per capita annual consumption

increased by 42.3% from 14.9 l in 2000 to 21.2 l in 2013 in the province (Statistics Canada, 2015). The trend is consistent with the continuing shift towards the consumption of premium quality wines, especially by an aging population who can afford to purchase more expensive wine brands (Goertzen, 2012). The wine economy in BC is a significant sector creating more than 10,000 jobs in about 280 wineries and generating winery sales of 3.9 million cases (9 l equivalent) with the total economic contribution to the BC economy of about Can\$2 billion in 2011 (Rimerman & Company LLP Report, 2013).

Despite the sizable province-based wine industry, most of the wine British Columbians drink is imported from the United States, followed by imports from Italy and France. Table 2 shows that BC wine imports from California increased in both value and volume over time. Import value increased from Can \$26.1 million in 2000 to Can\$51.9 million in 2014 (98% higher). However, the sales volume experienced a slower growth (8%). In contrast, the British Columbia Vintners Quality Alliance (BCVQA), which requires wine to be made exclusively from BC grown grapes, has grown in popularity over the years and its domestic market share accounted for 20.2% and 14.6% of value and volume, respectively, at the end of the 2014 fiscal year (BC Wine Institute Annual Report, 2013/14). Other BC wine (non-VQA “Cellared in Canada” and made mostly from imported grapes) market shares totalled 23.9% in value terms. Among imported wines, the market share of those imported from the United States (mostly from California) was 12.6%, considerably larger than that of imports from Italy and France, 7.6% and 7.3%, respectively (BC Wine Institute Annual Report, 2013/14).

#### 4. Modeling approach

Following Rosen (1974), the empirical relationship between wine prices and wine product attributes is expressed as follows:

$$P(z) = P(z_1, \dots, z_n), \tag{1}$$

where P is the actual transaction price and z is a vector of extrinsic and intrinsic attributes. Consumer wine choice is based on utility maximization, which requires consumer choice ( $z_1, z_2, \dots, z_n$ ) and x (i.e., other goods) subject to the consumers’ budget constraint (y). The partial derivative of the price function with respect to the ith wine attribute is denoted as

$$Pz_i = Uz_i / Ux, i = 1, \dots, n, \tag{2}$$

where the marginal implicit price for  $z_i$  is equal to the ratio of the marginal utility, assuming the utility function, given as U ( $x, z_1, \dots, z_n$ ), is strictly concave. In our study, the vector z includes objective measures of wine attributes (red or white type, name of winery or vineyard operator, grape variety, country, region, sub-region, and alcohol content) listed on the bottle’s label when the wine is first purchased by the consumer. Estimating a hedonic price function, therefore, indicates the implicit market equilibrium price of the attribute. Based on Costanigro et al. (2007), the wine market is segmented by price categories, and the conventional hedonic price modeling

Table 2  
British Columbia wine imports (value and volume) from selected countries, 2000–2014. Source: Gervais (2015). Statistics Canada trade data tabulation request. Agriculture and Agri-Food Canada, global Analysis Division.

Year	California		Rest of United States		France		Italy		Spain		South Africa		Argentina		Chile		World	
	Can\$ Million	Million Ltr.	Can\$ Million	Million Ltr.	Can\$ Million	Million Ltr.	Can\$ Million	Million Ltr.	Can\$ Million	Million Ltr.	Can\$ Million	Million Ltr.	Can\$ Million	Million Ltr.	Can\$ Million	Million Ltr.	Can\$ Million	Million Ltr.
2000	26.1	11.9	1.8	0.6	17.1	3.4	11.4	3.1	3.8	0.7	2.4	1.1	1.4	0.4	12.7	5.8	101.0	32.9
2001	23.9	12.3	1.3	0.3	13.7	2.8	10.7	2.8	3.2	0.7	2.3	1.1	1.2	0.3	11.4	6.7	90.5	32.5
2002	24.5	13.2	1.0	0.2	16.7	3.4	13.6	3.5	3.2	0.7	3.1	1.5	1.3	0.3	10.9	7.0	103.8	36.5
2003	22.8	12.7	1.3	0.3	16.4	3.1	15.0	3.9	3.5	0.8	2.9	1.5	1.4	0.5	10.8	7.2	109.7	37.5
2004	25.3	14.3	1.3	0.2	16.6	2.8	13.3	3.0	3.9	0.8	5.1	1.6	2.2	0.7	11.7	7.1	124.5	39.9
2005	26.0	13.3	1.6	0.3	17.8	3.2	13.9	3.2	4.5	1.4	5.7	2.9	3.3	2.1	10.8	6.2	138.4	44.3
2006	28.6	13.6	1.6	0.2	22.6	3.7	17.2	3.9	5.4	1.2	6.3	2.4	4.1	2.1	12.6	5.4	162.1	47.1
2007	33.2	14.9	2.1	0.4	24.6	3.5	20.1	4.4	6.1	1.2	5.2	2.3	6.9	3.6	17.4	9.2	189.2	54.9
2008	41.4	18.6	2.3	0.6	32.9	3.9	22.9	4.7	6.9	1.4	6.2	2.8	8.9	4.3	20.7	10.9	216.3	62.4
2009	34.4	13.1	1.3	0.3	22.1	2.7	20.1	4.9	6.1	1.2	4.7	1.6	12.1	4.3	18.1	11.2	172.7	53.2
2010	34.9	12.7	1.9	0.3	23.7	3.6	21.3	5.1	7.9	3.7	5.1	1.7	11.9	3.2	16.6	8.1	178.4	57.2
2011	35.8	12.2	2.2	0.5	24.5	3.4	22.1	6.4	12.4	9.3	5.1	2.4	11.9	3.7	14.1	5.2	179.3	58.0
2012	40.3	9.9	2.7	0.3	38.6	4.4	24.3	6.3	14.0	11.5	7.7	6.4	14.4	5.4	14.2	4.7	197.6	61.8
2013	45.2	9.6	2.8	0.5	31.9	4.5	24.4	5.4	12.2	5.5	7.9	7.1	14.5	5.2	16.4	8.6	202.8	58.6
2014	51.9	12.9	3.1	0.6	31.6	3.3	27.3	5.1	13.8	5.7	7.8	5.3	15.0	3.6	19.7	12.5	230.0	67.2

Notes: Wine imports include table wine, fortified wine (e.g., Sherry, Port), Icewine, Sparkling wine and Champagne.



is applied to each set of segmented markets shown below:

$$P = P_m(z), \text{ for } P \in (L_m, H_m], m = 1, \dots, s, \quad (3)$$

where  $m$  denotes a market segment,  $L_m$  and  $H_m$  are the corresponding lower and upper price boundaries, and  $s$  denotes the total number of segments.

## 5. Data sources and description

British Columbia wine importers such as the BCLDB have strong relationships with the large California wine industry. The latter offers great diversity in wine styles and wines produced from varied regions and climatic conditions. California's premium wine sales have soared recently. Sales of table wines priced above \$20 per bottle rose 17% by volume and 15% in terms of value (Shanken's Impact Newsletter, 2013). Much of the growth was attributed to younger consumers entering the market segment earlier than the preceding generation.

In our study, the data refers to weekly BCLDB retail sales for selected California red and white wine brands in the period from April 1, 2009 to May 31, 2011. The applied retail data include sales through BC liquor stores, restaurants, bars, private liquor stores, and independent wine stores. The data refer to the important California wine brands merchandized in BC coupled with a complete data set for each wine brand over the sample period. A total of 3707 observed red wine prices and another 4112 white wine prices are analyzed in our study. Wines retailed by the BCLDB are identified by SKUs (stock-keeping units). Each SKU corresponds to the description on the wine label such as the unit price, grape variety, producer brand name, country of origin, geographical region of production, sub-region (e.g., Napa in the case of California), and alcohol content. Alston et al. (2011) noted that the alcohol content of California premium red wines has risen substantially since 1980, and this may be explained by a combination of vineyard management practices and wineries responding to changing consumer preferences for more intense and riper flavored wines.

Table 3 shows the descriptive statistics for red and white wine including the unit prices and alcohol content. All wine volumes are sold in 750 ml bottles, the most common bottle size for the red and white wines imported from the U.S. to Canada. Retail wine prices are adjusted for inflation using the Canadian Consumer Price Index (CPI) for alcohol beverages purchased from stores (Statistics Canada, 2013). The average prices of white wines are relatively higher than those of red wines, while the red wine alcohol content slightly exceeds that of white wines.

Certain variables such as vintage, expert quality ratings, and special labels are not included in our analysis. Unlike previous studies (Costanigro and McCluskey, 2011) that reported vintage data in a simplified manner (1991,...,1999), our vintage data was reported in various formats (e.g., 2007/08, 2009) by SKUs. Therefore, our study excludes vintage information because the collected information is not homogeneous within the sample. The data available for this study do not provide information related to expert rating scores as is

Table 3

Descriptive statistics for California red and white wine retail prices, alcohol content and bottles sold. Source: Schultz (2012). Tabulation Data Request for California red and white wines sold in British Columbia. British Columbia Liquor Distribution Branch (BCLDB), Vancouver, British Columbia.

Characteristic	Mean	Std dev	Min	Max	Count	Median
Red wine						
Price (\$/bottle)	17.72	9.92	3	61.94	3707	15.68
Alcohol content (%)	13.78	0.58	12.5	15	3707	13.6
White wine						
Price (\$/bottle)	20.44	11.37	3	56.63	4112	17.54
Alcohol content (%)	13.49	0.63	12	15	4112	13.5

Note: all bottles have a standard 750 ml volume.

commonly reported by other data sources such as the Wine Spectator. Our data set had few wines with the special label information such as reserve, estate, and vineyard listed on the label. The proportion of wines with special labels is negligible (e.g., only 7 out of 3707 red wines have the reserve label) and was omitted in the current study. This study identified family brand names based on SKU, reflecting the designation stated directly on the label. Beringer, Delicato, Gallo, and J.Lohr are brand names identified among the red wines, while Beringer, Cakebread, Mirassou, and Robert Mondavi are those identified for white wines. Beringer Vineyards have the largest share and account for 15% of the white wines and 11% of the red wines.

Table 4 lists the main California wine regions and grape varieties. About 28% of red wines are from the Central Coast, while 30% originate from the North Coast, namely Napa and Sonoma. A relatively larger percentage (46%) of white wines is from Napa and Sonoma, with another 20% being from the Central Coast. Wines from the Central Valley, including wines from the Lodi American Viticultural Area, account for a smaller percentage of red and white wines in this study, a region noted for inexpensive high volume wines. Five (Cabernet Sauvignon, Merlot, Pinot Noir, Syrah, and Zinfandel) and three (Chardonnay, Pinot Grigio, and Sauvignon Blanc) grape varieties are associated with red and white wines, respectively. Our data show that there are no blended grape varieties. Cabernet Sauvignon accounts for a large share of red wines (33%), followed by Zinfandel (20%) and Pinot Noir (17%). The bulk of white wines are Chardonnay accounting for 61% of the white wines, followed by Sauvignon Blanc (21.3%) and Pinot Grigio (17.4%). White grape varieties such as Chardonnay tend to thrive in the cooler Sonoma, while Cabernet Sauvignon grapes perform better in the warmer wine regions such as Napa. Table 4 also illustrates the incidence of grape variety occurrence by region and the associated average prices in each group. For example, Zinfandel and Cabernet Sauvignon represent the major shares among grape varieties for California red wines, while Chardonnay from Napa Valley and the Central Coast represent the largest shares among white wines. In addition, wines from Napa Valley have the highest average prices (red wine Can\$30.6, white wine Can\$32.24). Red wines made from Cabernet Sauvignon grapes and white

Table 4  
Average red and white wine price and share in sample data according to grape variety by wine region.

Variety\Region	California	Central Coast	Central Valley	Napa Valley	Sonoma County	Col. total
Red wine						
Cabernet Sauvignon	11.23(11.0)	34.81(2.8)	–	30.60(17.0)	11.30(2.4)	23.14(33.3)
Merlot	13.92(5.7)	16.09(5.7)	–	–	13.92(2.8)	14.79(14.2)
Pinot Noir	–	17.69(8.5)	–	–	15.97(8.2)	16.85(16.7)
Syrah	8.42(4.9)	16.53(8.5)	15.66(2.8)	–	–	13.94(16.2)
Zinfandel	12.82(11.2)	12.18(2.8)	19.14(5.7)	–	–	14.54(19.7)
Row total	11.82(32.7)	18.18(28.3)	17.98(8.5)	30.60(17.0)	14.69(13.4)	17.72(100)
White wine						
Chardonnay	10.23 (12.4)	18.13(17.5)	–	34.34(22.3)	22.47(9.1)	23.07(61.3)
Pinot Grigio	11.31(10.2)	–	11.22(7.2)	–	–	11.27(17.4)
Sauvignon Blanc	15.88(4.2)	13.92(2.5)	–	25.88(7.3)	19.55(7.2)	20.34(21.3)
Row total	11.52(26.8)	17.60(20.1)	11.22(7.2)	32.24(29.6)	21.18(16.4)	20.44(100)

Note: percentages are in parentheses.

wines made from Chardonnay are priced higher than wines made with other grape varieties.

## 6. Estimation approach-segmenting markets

Wine is a multi-attribute product with each bottle of wine representing a different bundle of attributes noted by geographic origin, grape variety, alcohol content, and price. A combination of attributes and environmental claims attracts a specific group of customers, while a diverse mixture of attributes is likely to influence the attitudes and purchase decision among customers. Price can be used to stratify the wine market into different segments with prices signaling wine reputation in the consumer market hierarchy (Zhao, 2008). Wine consumers from segmented markets can use price and wine labeling information such as alcohol content, grape variety, and geographic origin as clues to assess the quality of a product. Such extrinsic attributes act as risk-reducing agents in helping consumers to choose and increase the likelihood of repeated purchases of a product (Lockshin, 2002).

Numerous approaches permit the separation of wine into different product categories or classes. Marketing researchers typically apply segmentation techniques and group consumers with similar socio-demographic characteristics and patterns of wine purchasing behavior to target sales and develop advertising strategies (Santos et al., 2006; Kolyesnikova et al., 2008). Levaggi and Brentari (2014) separated Italian wines based on different retail outlets (wine shops vs. large scale retail stores) and found extrinsic attributes on the bottle label are the principal price determinants for wines sold by large-scale retail outlets. Costanigro et al. (2007) minimized the sum of squared errors (SSE) and used the Wald test to detect and test breakpoints in the price distribution of their California red wine sample. Four different wine price categories (< Can\$13, \$13–\$21, \$21–\$40, and > \$40) were identified in estimating the optimal number of structural breaks. A similar market segmentation approach was adopted by Kwong et al. (2011) in the Ontario wine study. Two breakpoints separated the Ontario sample into lower (< Can

\$18) and higher (> Can\$18) priced wines. However, the method Kwong et al. (2011) employed to separate Ontario red wines into lower and higher prices is somewhat ad hoc since it was based on the price ranges for ultra-premium wines reported by *Wine Business Magazine*. Separating Ontario's higher price (> Can\$18) and lower price (< Can\$18) wine categories appears too simplistic since it does not consider the range in prices on either side of the price distribution.

The current study contributes to the literature on segmented hedonic models by allowing the number of market segments to be identified by the data rather than predetermined as reported in Costanigro et al. (2007). The detection of the total number of segments and examination of the breakpoints follows several steps. The starting point is the calculation of the log-likelihood values by using one breakpoint and two market segments - the simplest case. As the breakpoint changes over the price range, each price segment requires the calculation of the associated log-likelihood value. Based on the structure of observed price data, the price ranges of red and white wines used to locate the breakpoints are [Can\$8, Can\$30] and [Can\$11, Can\$34], respectively. The second step determines the number of market segments based on the pattern of log-likelihood values obtained from the previous step (i.e., monotonicity and the number of local maximum points). The number of local maximum points corresponding to the log-likelihood value is the optimal number of breakpoints in the data. If more than two market segments are identified in the data, then the log-likelihood value of the associated price grid (n dimensions for n breakpoints) needs to be examined to determine the location of the breakpoints. The third step involves the comparison of pooled versus segmented modeling. The likelihood ratio tests whether the market segment modeling as identified above fits significantly better than the data from the pooled modeling method.

## 7. Hedonic model specification

In the current study, the hedonic price function makes the assumption that wine is a heterogeneous product. Rosen's

(1974) framework permits the consideration of demand and supply factors influencing the price of a bottle of California wine as explained by geographic region of origin, grape variety, family brand name, and alcohol content. Previous hedonic studies (e.g., Kwong et al. 2011; Roma et al. 2013) employed quantity of wine purchased as a proxy for the rarity effect. However, including retail sale quantity in the specification can lead to endogeneity bias since price and quantity are simultaneously determined. Therefore, our model specification excluded retail sales quantity. In our panel data estimation standard errors are corrected and adjusted for autocorrelation and heteroskedasticity.

The hedonic regression model is described as follows:

$$\begin{aligned} \ln(P_{it}) = & \alpha + \beta_1(\text{Geographic region}_{it}) + \delta_2(\text{Grape variety}_{it}) \\ & + \gamma_3(\text{Family brand}_{it}) + \Gamma_4(\text{Color}_{it}) + \lambda_5(\text{Alcohol}_{it}) + \varepsilon_{it}, \end{aligned} \tag{4}$$

where  $\ln(P_{it})$  is the natural logarithm of the retail price for the  $i$ th wine ( $i=1, \dots, n$ ) sold in time period  $t$ . The unknown parameters ( $\alpha, \beta_1, \delta_2, \gamma_3, \Gamma_4$ , and  $\lambda_5$ ) correspond to objective wine attributes (geographic region, grape variety, family brand, wine color, and alcohol content), and  $\varepsilon_{it}$  is the error term that is independently distributed with mean zero. The continuous variables are retail unit prices, and alcohol content, while the discrete characteristics defined as binary variables include geographic region, grape variety, and family brand name. “Both alcohol content itself and its squared term are included in the model specification to examine if any non-linear relationship exists between the wine price and alcohol content”.

Gustafson (2011) argued that when the attributes of wine cannot be unbundled, the hedonic price function will likely be non-linear. In general, consumer theory does not provide any guidance on what functional form ought to be used in empirical hedonic model applications. Triplett (2004) argued that the choice of the functional form should be based on the data, which implies the application of the Box-Cox test to several functional forms. This study probed different functional forms (including linear, natural logarithm, and inverse square root) for both red and white wine price series. The Box-Cox test values indicate that the natural logarithmic function was preferred for the data.

### 8. Results and discussion

This study identifies breakpoints of the price level in the red and white wine samples (both the total number and location) that could maximize goodness of fit (indicated by the value of log-likelihood value). The results indicate the existence of two product classes ( $= < \text{Can}\$14, > \text{Can}\$14$ ) for red wines (Table 5a) and three product classes ( $= < \text{Can}\$16, \text{Can}\$16\text{--}30, \text{ and } > \text{Can}\$30$ ) for white wines (Table 6a). Tables 5b and 6b report the values of the log likelihood and the likelihood ratio test for each wine type. The wine data for both red and white California wines are modeled using a multivariate regression and employing the software R (Croissant and Millo, 2008). Equations are estimated for each wine product class as well as the pooled model. Robust standard errors clustered by SKU are calculated and reported,

Table 5a  
Break points and associated total log-likelihood (two groups).

Breakpoints	nlow	nhigh	llk_total
8	303	3404	1357.789
9	303	3404	1357.789
10	303	3404	1357.789
11	685	3022	1161.835
12	888	2819	1433.038
13	1134	2573	1731.121
14*	1441	2266	2056.797
15	1704	2003	1605.942
16	2027	1680	1352.155
17	2132	1575	2014.516
18	2552	1155	1928.483
19	2552	1155	1928.483
20	2640	1067	1530.519
21	2845	862	1281.641
22	3061	646	1099.102
23	3077	630	1090.533
24	3077	630	1090.533
25	3287	420	836.9112
26	3323	384	817.4957
27	3392	315	791.5495
28	3392	315	791.5495
29	3392	315	791.5495
30	3392	315	791.5495

\* Denotes the optimal breaking point.

Table 5b  
Likelihood ratio test, degrees of freedom, and  $p$ -value for segmenting California red wine using cut off point 14.

Likelihood ratio statistics	Degrees of freedom	$P$ -value
3841.11	12	< 0.0001

Note: The null hypothesis is “the pooled modeling fits the data better than the segmented model.” The likelihood ratio test indicates the rejection of the null hypothesis.

Table 6a  
Breakpoints and associated total log-likelihood (three groups).

Lower breakpoint	Upper breakpoint	nlow	nmid	nhigh	llk_total
13	30	1362	2044	706	4604.317
13	31	1362	2136	614	4426.917
13	32	1362	2136	614	4426.917
13	33	1362	2175	575	4289.611
14	30	1502	1904	706	4422.669
14	31	1502	1996	614	4242.998
14	32	1502	1996	614	4242.998
14	33	1502	2035	575	4110.972
15	30	1587	1819	706	4495.452
15	31	1587	1911	614	4328.923
15	32	1587	1911	614	4328.923
15	33	1587	1950	575	4210.192
16*	30*	1685	1721	706	4749.976
16	31	1685	1813	614	4565.324
16	32	1685	1813	614	4565.324
16	33	1685	1852	575	4431.597
17	30	1790	1616	706	4606.135
17	31	1790	1708	614	4419.171
17	32	1790	1708	614	4419.171
17	33	1790	1747	575	4291.190

\* Denotes the optimal breaking point.



Table 6b

Likelihood ratio test, degrees of freedom, and p-value for segmenting California white wine using cut off points 16 and 30.

Likelihood ratio statistics	Degrees of freedom	P-value
7420.7	13	< 0.0001

Note: The null hypothesis is “the pooled modeling fits the data better than the segmented model”. The likelihood ratio test indicates to reject the null hypothesis.

which adjusts for autocorrelation and heteroskedasticity within a panel data structure.

Earlier studies (e.g., Lockshin and Corsi, 2012) formulated expectations regarding selected variables, but because of the applied segmentation approach adopted in this paper, results from this study differ. Among the groups of variables included in the specified models are geographical regional effects. Napa is one of the principal California wine regions producing the best quality Cabernet Sauvignon and dominates the list of top-rated wines in the *Wine Spectator* (Laube, 2012). Although Sonoma is also noted for producing some good quality Cabernet Sauvignon wines, they rarely approach the quality achieved by Napa wines.

Another group variable examined was the effects of brands. Wine brand owners have gradually educated consumers over the years about wine attributes and have played a significant role in the marketing of New World wines in major industrial cities. Steiner (2004) has shown that British consumers consider jointly the grape variety and geographical region as brand proxies for Australian wines sold in the British wine market.

Previous studies (e.g., Thrane, 2004; Roma et al., 2013) have shown that the alcohol content is a favorably viewed attribute and has a statistically significant positive effect on the prices of red French and Italian wines. Interestingly, label claims of California red wine alcohol content sold in Ontario have been underreported when compared to the actual alcohol percentage, and the drivers for this discrepancy may have been tax avoidance by wineries combined with the perception that higher alcohol content diminishes consumer value for certain wines (Alston et al., 2015).

### 8.1. California red wine results

Results of the three red wine models (Table 7) show substantial differences, including differences between the two price segments. The findings are relevant to wine marketers.

#### 8.1.1. Pooled data model results

The pooled model results indicate regional designations such as Napa (73.9%) and Sonoma (27.1%) fetched price premiums relative to generic California appellation wines. The coefficient parameters regarding grape variety variables capture the premiums or discounts relative to Cabernet Sauvignon. Cabernet Sauvignon wines have the potential to express individual vineyard attributes better than other grape varieties, and this may be the reason why most of them are produced in warmer regions such as Napa

Table 7

Pooled and segmented estimation results for California red wine.

Y = Ln(P)	Pooled	Price segments	
		Lower priced P < = 14	Higher priced P > 14
(Intercept)	46.619** (16.892)	4.662 (8.490)	24.368 (27.944)
Region (Baseline = California)			
Central Coast	0.137 (0.158)	0.143*** (0.012)	-0.131 (0.165)
Central Valley	0.126 (0.191)	–	-0.246 (0.221)
Napa	0.739*** (0.187)	–	0.266* (0.136)
Sonoma	0.271* (0.138)	0.300*** (0.021)	-0.054 (0.095)
Grape variety (Baseline = Cabernet Sauvignon)			
Merlot	0.095 (0.112)	0.177*** (0.022)	-0.070 (0.109)
Pinot Noir	0.283** (0.129)	0.245*** (0.022)	0.149* (0.087)
Syrah	0.037 (0.149)	-0.070 (0.143)	-0.062 (0.207)
Zinfandel	-0.058 (0.143)	0.235*** (0.030)	-0.080 (0.066)
Brand (Baseline = other)			
Beringer	0.204 (0.182)	0.219*** (0.028)	0.035 (0.046)
Delicato	0.265* (0.140)	0.460*** (0.030)	-0.220*** (0.022)
Gallo Family Vineyards	-1.096*** (0.155)	-1.069*** (0.026)	–
J.Lohr	0.360*** (0.112)	-0.263*** (0.018)	0.373*** (0.040)
Alcohol.Percent	-6.678*** (2.467)	0.050 (1.265)	-3.372 (4.121)
Alcohol.Percent2	0.252*** (0.090)	-0.017 (0.047)	0.131 (0.152)
No of observations	3707	1441	2266
Adjusted R <sup>2</sup>	0.79	0.96	0.62

Robust standard errors in parentheses correcting autocorrelation, heteroskedasticity and clustering by SKU.

\*\*\*p < 0.01.

\*\*p < 0.05.

\*p < 0.1.

(Laube, 2012). Pooled model results reveal that Pinot Noir (28.3%) varieties fetch price premiums relative to Cabernet Sauvignon. Pinot Noir has become the signature grape variety in Sonoma with diverse wine styles. Results from the current analysis are consistent with the higher price premium reported by

Costanigro et al. (2007) for Cabernet Sauvignon and Pinot Noir relative to Zinfandel, which is known for producing fruity-flavored brands such as “Gnarly Head”.

Among brand names in the pooled data model results, two significantly influence the price. Whereas the name Gallo Family Vineyards is associated with a large price discount, the brands Delicato and J. Lohr fetch a significant premium of 26.5% and 36%, respectively. Other brands such as Beringer are statistically insignificant and as such contrast with the results from the segmenting red wine price approach.

Two variables measuring the effect of alcohol content on red wine prices suggest the statistical significance and non-linearity of the effect. It appears that if pooled data are used, higher alcohol content is associated with a small price premium with an increasing rate. This result is of importance because it appears that customers prefer higher to lower alcohol content wines.

### 8.1.2. Lower price segment model results

Among regional designations, as compared to pooled data model results, two regions were not included in this segment, namely Central Valley and Napa. However, the regional designations among the lower-priced wines fetched higher premiums relative to generic California appellations than the premiums indicated by the results of the pooled data model. The premium for Sonoma red wines was 30%, and 14.3% for Central Coast wines.

Three grape varietal effects are statistically significant. As compared to pooled data model results, the premium for Merlot is significant and amounts to 17.7%. However, the premium for Pinot Noir is 24.5%, slightly lower than in the case of the pooled data model. The premium associated with Zinfandel, 23.5%, was not significant by the pooled data model, perhaps the most convincing evidence of the benefit of segmenting the price analysis.

The results from this study show that family brand names like Beringer (21.9%) and Delicato (46%) earned price premiums for lower-priced red wines. In contrast, Gallo Family Vineyards and J. Lohr show a price discount for wines in the lower priced category of red wines given that the benchmark category is “Other brands”.

### 8.1.3. Higher price segment model results

The effects of regional designations in the higher priced segment contrast with the results of the pooled and lower priced segment. The price for the Napa designation significantly differs from that of generic California wines with a 26.6% price premium. Such result is consistent with Costanigro et al. (2007), who reported that Napa semi-premium red wines (between \$13 and \$21) earned higher premiums than similarly priced wines from Sonoma or the Bay Area.

The effects of grape varieties indicate a price premium for Pinot Noir. There has been a shift in Cabernet Sauvignon and Pinot Noir production in California over the years towards higher priced and higher quality table wines (Volpe et al., 2010). The segmented price model results indicate that higher-priced wines, made from varieties like Pinot Noir (14.9%), are priced higher relative to Cabernet Sauvignon.

Interestingly, among brands, the Gallo Family Vineyards wines were excluded from the higher priced red wine segment, but two other brands were found to be statistically significant. Delicato is discounted as compared to “Other brands” by 22%. However, the J. Lohr brand fetches a premium of 37.3%, similar to the premium identified in the pooled data model.

## 8.2. California white wine results

The hedonic white wine price model results from the pooled and segmented models are shown in Table 8.

### 8.2.1. Pooled data model results

The pooled model results reveal large price premiums for white wines from Napa (90.5%), Sonoma (63%), and Central Coast (48.4%) relative to the generic California appellation. The wine brand Cakebread Cellars fetched a sizeable premium (42.2%); in contrast, the wine brand Robert Mondavi in the pooled model is price discounted (29%). Unlike most red wine studies (e.g., Thrane, 2004) that showed a positive alcohol relationship to prices, our results revealed a slight positive relationship as well but with an increasing rate.

### 8.2.2. Lower price segment model results

The lower priced wines from Central Coast (51.5%) fetched a much higher premium than wines from Sonoma (4.8%) relative to a generic California labeled wine. The grape varietal Sauvignon Blanc earned a large price premium (93.8%) relative to Chardonnay. Wine brands such as Beringer fetched a premium (34.9%), while Robert Mondavi wines are price discounted (75.8%). The results associated with the brands are different from the pooled model results, which support the estimation of separate price functions for different wine market segments.

### 8.2.3. Mid-price segment model results

Mid-priced wines produced from the Central Coast (23.1%) and Sonoma (9.21%) are price discounted. By contrast, Napa white wines fetch a premium (10%) relative to generic labeled California wine. The grape varietal Sauvignon Blanc wines reported a relatively smaller discount of 10.4%. Mid-priced wine brands such as Beringer and Robert Mondavi are discounted at 38% and 22%, respectively. The alcohol content of wines slightly negatively influences the prices of mid-priced wines in the segmented models with a decreasing rate, but slightly positively in the pooled data model.

### 8.2.4. Higher-priced segment model results

A total of 706 white wine prices are analyzed in the higher-priced segments. Due to the close correlation between regions and grape varieties in such market segments, this study omitted regions which would not provide valuable information in addition to grape variety to avoid the potential overfitting problem. The grape varietal Sauvignon Blanc is discounted at 30.9% as compared to the baseline Chardonnay.

Table 8  
Pooled and segmented estimation results for California white wine.

Y = Ln(P)	Pooled	Price segments		
		Lower priced group ( $p < = 16$ )	Mid-priced group ( $p > 16$ and $< = 30$ )	Higher priced group ( $p > 30$ )
(Intercept)	27.134** (13.306)	55.830 (42.268)	-14.703*** (4.389)	-213.448 (181.394)
Region (Baseline = California)				
Central Coast	0.484* (0.269)	0.515** (0.283)	-0.231*** (0.033)	–
Central Valley	0.023 (0.137)	0.101 (0.077)	–	–
Napa Valley	0.905*** (0.264)	–	0.101*** (0.032)	–
Sonoma County	0.630** (0.274)	0.048** (0.019)	-0.092** (0.046)	–
Grape variety (Baseline = Chardonnay)				
Pinot Grigio	0.098 (0.236)	0.402 (0.266)	–	–
Sauvignon Blanc	0.021 (0.130)	0.938*** (0.24)	-0.104** (0.052)	-0.309*** (0.001)
Brand (Baseline = other)				
Beringer	-0.085 (0.183)	0.349* (0.205)	-0.380*** (0.040)	1.270 (0.861)
Cakebread Cellars	0.422** (0.188)	–	–	0.331 (0.167)
Mirassou	-0.107 (0.177)	0.088 (0.059)	–	–
Robert Mondavi	-0.29* (0.164)	-0.758*** (0.235)	-0.220** (0.110)	–
Alcohol.Percent	-3.892** (1.97)	-8.495 (6.641)	2.580*** (0.658)	31.224 (26.033)
Alcohol.Percent2	0.152** (0.073)	0.334 (0.261)	-0.093** (0.025)	-1.122 (0.933)
No of observations	4112	1685	1721	706
R-square	0.69	0.49	0.86	0.61

robust standard errors in parentheses correcting autocorrelation, heteroskedasticity and clustering by SKU

\*\*\* $p < 0.01$ .

\*\* $p < 0.05$ .

\* $p < 0.1$ .

## 9. Conclusions

California wines have gained a significant share in the BC wine market over the last decade. Our paper allows both the number of total market segments and the identification of the price segments' boundaries to be endogenously determined by the data and model. This is motivated by the fact that attributes might affect prices differently for red and white wines. Our estimation results indicate that there are two and three market

segments for red ( $< \text{Can}\$14$  and  $\geq \text{Can}\$14$ ) and white wines ( $< \text{Can}\$16$ ,  $\text{Can}\$16\text{--}30$ ,  $> \text{Can}\$30$ ), respectively. We speculate that the different segments between the two wine types might be due to the price data structures across wine types. With roughly the same number of total observations and price ranges, about 8% of red wines have CPI-adjusted prices higher than  $\text{Can}\$30$ , while for white wines they are more than doubled (17%).

Overall, the implicit values for attributes of red and white California wines differ by grape varieties and geographic region. Moreover, California white wines from different geographic regions fetch a sizable premium in contrast to similar appellation measures associated with red wines. Also, the premium for Pinot Noir, Merlot, and Zinfandel in the case of lower-priced California red wines was substantial as compared to Cabernet Sauvignon. California mid-priced white wines also fetch a considerable premium with regard to alcohol content. The study results provide insights regarding the development of advertising and brand marketing strategies to enhance the market shares of wines of different price segments and wine styles in an environment characterized by growing imports from New World producers. “Market segmentation analysis can be beneficial to marketers by targeting their product development strategies to consumers of different socio-economic characteristics such as age and family income.

### Conflict of interest

The authors certify that they have no conflict of interest.

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