Appellation, Variety, and the Price of California Wines

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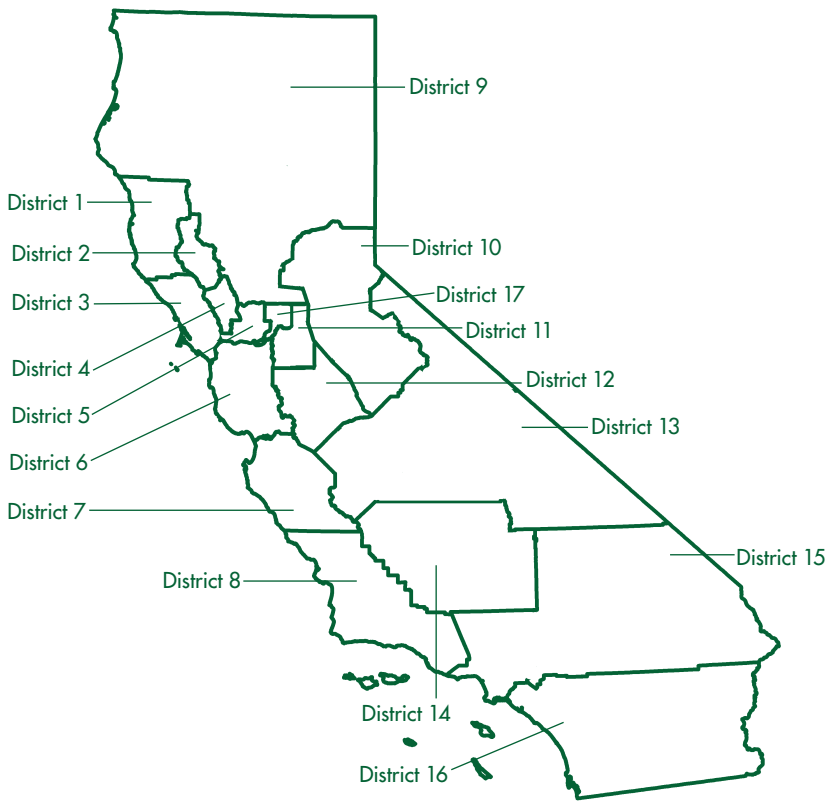
Using more than 8,800 observations on California wines across 63 appellations, we show how variety and appellation interact to affect premium wine prices, holding constant such factors as vintage and tasting score. Results averaged by grape crush district indicate clearly where variety and appellations interact positively and negatively.

California grape and wine producers have become more sensitive over recent decades to the importance of terroir in wine attributes and wine prices. The match between local soil, climate, and other characteristics in producing wines with particular attributes has garnered much attention from grape producers, winemakers, wine writers, and consumers. Producers have devoted considerable effort to find and develop specific regions recognized for particular grape varieties, such as Cabernet Sauvignon in the Napa Valley, Chardonnay in the Carneros area of Napa and Sonoma counties, and Zinfandel in the Sierra foothill counties. Clearly attributes of outputs are affected by the characteristics of raw material, and this seems especially important for wine. Here we examine not wine attributes *per se*, but the effects of input characteristics (grape variety and appellation as representatives of terroir) on the price of wines made from those grapes.

The primary purpose of this study is to shed light on how the price of wine may be affected by its appellation, variety, and other attributes. Within the hedonic price framework, we estimate the price variation across wines that is attributable to an appellation, variety, and other characteristics of the wine. By using somewhat more elaborate statistical methods than previously applied, we are able to estimate an appellation effect separately for each major grape variety for each of 63 appellations. More specifically, we adapt a random effects approach to estimate impacts of appellations on wine prices in order to reduce the number of parameters that must be estimated while allowing for a different variety impact in each appellation.

Figure 1. California Grape Crush Districts



Appellation of Origin for California Wines

California produces more than 90 percent of U.S. wine (650 million gallons out of 716 million gallons in 2005) and supplies about two-thirds of the wine consumed in the United States. All wines marketed in the United States are required to state on the label where the grapes were produced. The origin, usually appearing just above the varietal designation on the label, contains this information, and must be a region drawn with official boundaries. Unlike the notion used in Europe, in the United States the term appellation does not generally imply additional information about variety or production methods. An appellation can be an entire

Table 1. Descriptive Data Statistics		
Variables	Mean, Median or Sample Share	Data Range
Price ($)	27.80 (28.50)[1]	$5.17-$316.93
Expert Rating Score	87.00 (3.79)	68-99
Age (years)	2.63 (0.79)	1.00-7.00
Release Year	1998(median)	1995-2001
Vintage Year	1997(median)	1989-2000
Reserve	14%	
Estate Bottled	2%	
Grape Variety		
Cabernet Sauvignon	30%	
Chardonnay	28%	
Pinot Noir	14%	
Merlot	14%	
Zinfandel	14%	
Appellation Type		
AVA	78%	
County	15%	
CA	7%	

[1] *Numbers in parentheses are standard deviations.*

state (or group of states) or a county (or groups of counties). However, appellations are also commonly based on districts specified as American Viticultural Areas (AVAs), which can be as small as a few acres. The use of an AVA requires an approval from the Bureau of Alcohol, Tobacco and Firearms of evidence of an area's distinctive combination of soil, climate, and topography, which in turn contribute to identifiable regional wine character. The first AVA in California was approved only in 1980, and since then the number of AVAs has increased rapidly in California, reaching over 100 in 2006.

Most AVAs in California are concentrated in the north and central coastal areas of California, which stretch from the north in Mendocino County to the south in Santa Barbara County. These coastal areas are known for high-quality premium wines, and a high concentration of AVAs in coastal areas is consistent with our economic intuition in that wineries producing higher-quality wine naturally have a greater incentive to differentiate their products through appellation labeling.

To designate the appellation on the wine label, the wine has to meet certain content requirements. To be labeled as the product of an AVA, at least 85 percent of the grapes used to produce the wine must be from within the designated viticultural area. For a county or state appellation, a minimum of 75 percent of the grapes must be from that region, with an exception of the "California" appellation, which requires that 100 percent of grapes be produced in California. When a variety is specified, 75 percent of the grapes must be of that variety and when vintage year is specified, 95 percent of the grapes must have been harvested in that year. Some wines are also labeled as "estate bottled." To use this label, the wine contains only grapes grown in the named appellation on land controlled by the bottling winery and made in one continuous process at the site of winery. The common label term, "reserve" has no legal content in the United States.

Data

Bombrun and Sumner collected and compiled the California wine data from bimonthly issues of the *Wine Spectator* from January 15, 1995 to December 31, 2001. The California data were extracted from the magazine's "Buying Guide," which publishes ratings of new releases from around the world, along with a short profile of each release. We used two criteria for an observation to be included in the sample used here. The observation is identified with one of the five popular grape varieties—Cabernet Sauvignon, Chardonnay, Merlot, Pinot Noir, and Zinfandel—and with an appellation which is represented by at least six

Table 2. Estimation Results	
Variables	Parameter estimate
Fixed Effects	
Constant	-2.47 (-11.36)*
Expert Rating Score	0.06 (55.08)*
Age	0.07 (9.11)*
Reserve	0.14 (13.80)*
Estate Bottled	0.02 (0.83)
Release Year	
1995	-0.38 (-11.25)*
1996	-0.33 (-11.00)*
1997	-0.30 (-11.15)*
1998	-0.20 (-8.46)*
1999	-0.19 (-9.11)*
2000	-0.05 (-2.82)*
Appellation type	
AVA	0.45 (2.37) *
County	0.28 (1.43)
N	8806

Note: Numbers in parentheses are t-values for a two-tailed test of the hypothesis that the coefficient is difference from zero.
**Different from zero at a 1% level of significance.*

observations. In total, our sample consists of 8,806 observations, representing 63 appellations including 51 AVA appellations, 11 county appellations, and one state (California) appellation.

For each observation, the data include the *Wine Spectator* tasting score (based on 100 points), the appellation of origin, the grape variety, the price per 750 ml bottle, release year, vintage year, and whether the wine is labeled as "reserve" or "estate bottled." Wine prices are deflated using the general CPI based on year 2000. Table 1 presents more detailed data information by wine attribute.

Empirical Approach

Given that most information on individual wine labels comes in categorical form, most statistical analysis on wine prices employs dummy variables to represent categories (or clusters) and estimates their effects using least squares. However, given the large number of appellations, it is difficult to use standard simple methods to

effectively estimate separate effects for each appellation. With five varieties and 63 appellations, including fixed effects for each independent effect would require including 66 dummy variables in the regressions and including the full set of appellation/variety interactions would require more than 300 dummy variables. Although such an approach would allow estimation for some appellations, in many cases we do not have enough data to estimate precisely all the required parameters. At the same time, we want to use a statistical approach that allows the estimated impact of, say, the Napa Valley appellation on price to be different for Cabernet Sauvignon than it is for Zinfandel. To estimate the effects of appellation separately for each variety, we employ a multi-level, mixed statistical approach that has been developed and used widely among researchers in statistics and biostatistics.

We define the model over three characteristics: appellation, grape variety, and vintage year. We also include the variety-appellation interaction and specify random effects over these four random variables. We then estimate an equation that relates the price of wine to observable sets of wine attributes using a model that both includes fixed and random effects. Fixed effects include the *Wine Spectator* score, the wine age, the reserve label, the "estate bottled" label, and six indicators representing the year of release. However, given our focus on appellations, we elaborate our model in two important ways. First, the appellation random term is specified as the sum of both fixed and random effects. The fixed portion of appellation effects represents only the effect of appellation type, either AVA, county, or state. Second, as noted, we allow the possibility of a cross effect that captures the interacting effect between appellation and grape variety. This interaction term is also random given this term represents the cross effect of two random variables.

Estimation Results on Fixed Effects

The basic estimation results of the regression model are presented in Table 2 where the dependent variable is the logarithm of the price. Most parameter estimates are statistically significant from zero at the one percent level. A single point increase in the *Wine Spectator* score raises the wine price by six percent, holding other variables constant. Age of the wine also has a significantly positive effect on price. The effect of the reserve label is statistically significant and large (14 percent), while the effect of the "estate bottled" claim on the label is not statistically significant. The effects of various release years are measured relative to 2001 and are all negative. These effects are systematically smaller for more recent years, indicating the monotonically positive increase in wine price over time, with the accumulated increase over the six-year data period of 38 percent. Finally, an AVA appellation increases the wine price by 45 percent, relative to the price of a wine with the California appellation. A county appellation also has a positive price effect but is not statistically significant.

Table 3. Predicted Appelation-Level Price Effects (%)

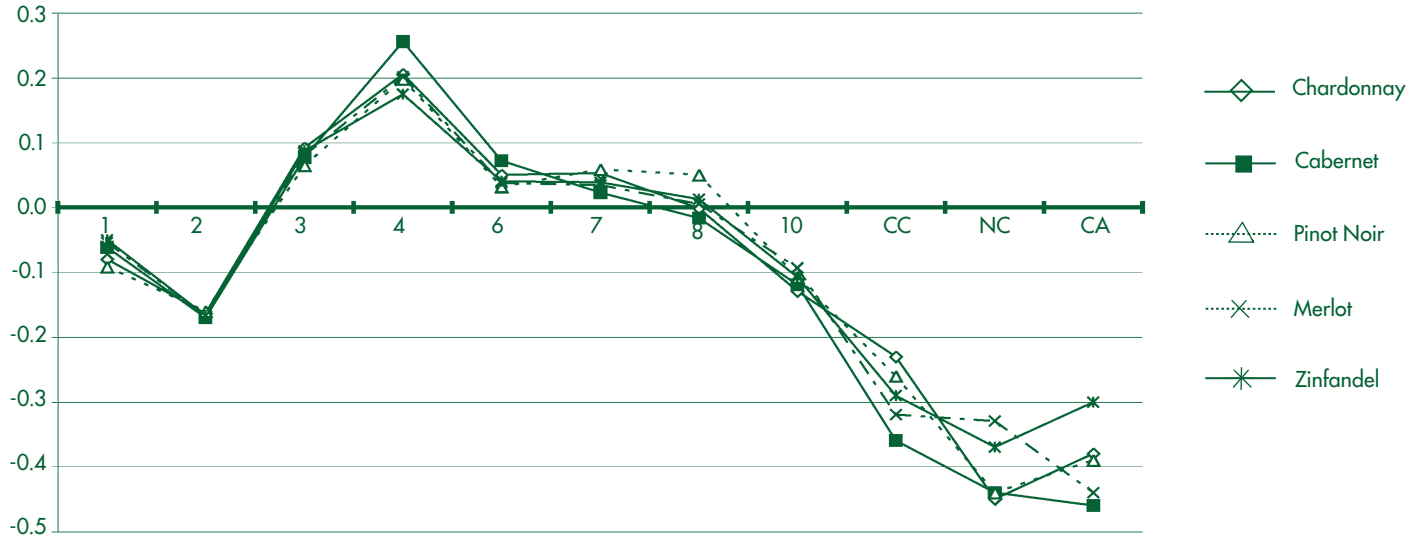
Crush District	Appellation	Cabernet	Chardonnay
4	Rutherford	45%(1)	34%(2)
4	Oakville	41%(2)	33%(4)
7	Mount Harlan	41%(3)	41%(1)
4	Diamond Mountain	38%(4)	33%(3)
4	Stags Leap District	37%(5)	29%(7)
4	Howell Mountain	36%(6)	33%(5)
4	Spring Mountain	30%(7)	26%(8)
6	Santa Cruz Mtns	30%(8)	8%(26)
4	Napa Valley	27%(9)	8%(23)
3	Sonoma Coast	21%(10)	25%(0)
4	Mount Veeder	20%(12)	24%(11)
3	Sonoma Mountain	20%(14)	32%(6)
7	Carmel Valley	18%(16)	17%(16)
9	North Yuba	13%(18)	12%(19)
3	Sonoma Valley	13%(20)	12%(18)
8	Arroyo Grande Valley	12%(22)	10%(20)
10	Fiddletown	8%(24)	8%(25)
3	Knights Valley	8%(26)	10%(21)
8	Santa Maria Valley	5%(28)	3%(31)
2	Guenoc Valley	3%(30)	2%(34)
1	Mendocino	2%(32)	-8%(45)
3	Russian River Valley	1%(34)	3%(30)
7	Arroyo Seco	-1%(36)	-3%(37)
10	Shenandoah Valley	-3%(38)	-3%(36)
8	Edna Valley	-4%(40)	-8%(44)
8	San Luis Obispo	-7%(42)	-3%(38)
3	Dry Creek Valley	-8%(44)	-12%(52)
1	Redwood Valley	-9%(46)	-7%(42)
7	Monterey	-12%(48)	-11%(49)
10	El Dorado	-13%(50)	-12%(51)
10	Amador County	-16%(52)	-14%(53)
11	Lodi	-19%(54)	-22%(56)
2	Clear Lake	-21%(56)	-19%(54)
2	Lake County	-33%(58)	-32%(60)
7	Monterey County	-36%(60)	-24%(58)
	North Coast	-44%(62)	-45%(62)
	California	-46%(63)	-38%(61)

Note: Rankings by variety are provided in parentheses.We have a vast amount of results consisting of a 5x63 matrix for five varieties and 63 appellations. Thus, we present here only selected results by choosing two most representative varieties and appellations which include first top 10 and even number ranks for the rest of appellations (following the order by Cabernet Sauvignon).

Predictions on Individual Appellation Effects

By computing the predicted value on our random terms, we obtained the full appellation effect for each of 63 appellations by each variety. The full appellation effect is the sum of the appellation-specific fixed effect, the random effect of appellation alone, and the cross effect between appellation and variety. Appellation effects are evaluated relative to that of the 'average' appellation, and we report representative results in Table 3 for only two varieties, Cabernet Sauvignon and Chardonnay. The appellations are ordered by the magnitude of the appellation effect for Cabernet Sauvignon. The values presented in Table 3 can be interpreted as the percent by which the wine of this appellation exceeds the price of the "average" appellation for each variety.

Figure 2. Full Appellation Effects, Averages by Crush District



Note: Appellations are assigned to grape crush districts 1 though 8 based on their locations. For crush district 10 (primarily the Sierra foothills) in this figure we added two appellations (North Yuba and Dunnigan Hills) from crush district 9 and the Lodi appellation from crush district 11. We combined the Cucamonga appellation from crush district 15 to the data for crush district 8. No other crush districts were represented by appellations in the data. Given that the North Coast (NC), Central Coast (CC) and California (CA) appellations include broad non-contiguous areas, which spread into several districts, they are shown separately in the figure and not assigned to crush districts.

variety. Thus, looking at the first entry in the table, the price of a Cabernet Sauvignon wine produced with grapes grown in Rutherford was 45 percent higher than that of a Cabernet Sauvignon wine produced from grapes from the 'average' appellation with the same other characteristics.

The results in Table 3 provide insights into appellation-variety interactions and provide statistically sound measures of the pattern of prices by appellation and variety (holding such factors as age, vintage, year, and score constant). Notice that there is considerable consistency of appellation effects in terms of ranking for both varieties across the appellations, except for Santa Cruz Mountains and Napa Valley. Their ranks are 8th and 9th for Cabernet Sauvignon, but for Chardonnay they are much lower—26th and 23rd. In general, such variation in ranks tends to be even greater for the results on other varieties (not shown in Table 3). For example, Howell Mountain ranks third for Merlot but only 18th for Zinfandel, and Russian River Valley ranks 34th for Cabernet Sauvignon but 19th for Zinfandel.

To further examine these results, we summarize the information using grape crush district averages. Figure 2 shows the results from the estimation of individual appellations aggregated by crush district. Several observations stand out from Figure 2. First, the districts with the above-average appellation effects are located in the coastal regions, including Napa, Sonoma, and Monterey, and the lowest effects are found with broad appellations, Central Coast, North Coast, and California. Second, while appellation effects vary considerably across districts, they vary relatively little across grape varieties for a given crush district. For example, in district 2 (Lake County) there hardly is any difference in appellation effects for different varieties. Only when we consider the broad regional appellations do the results for a district vary by variety. District 4 (Napa County) exhibits an unusually high appellation effect for Cabernet Sauvignon compared to other varieties. Further, for the three broad appellations, where appellation effects vary widely across varieties, Cabernet Sauvignon consistently ranks the lowest among all varieties.

These results suggest that variety effects across appellations are strongest for Cabernet Sauvignon. For a winery using grapes with an appellation below the average reputation, Cabernet Sauvignon is a least favored

Table 4. Cross Effects between Appellation and Variety, Averages by Crush District

Crush District	Cabernet	Chardonnay	Pinot Noir	Merlot	Zinfandel
1	0.4%	-1.6%	-2.9%	1.2%	1.4%
2	-0.9%	-0.3%	0.0%	-1.0%	-0.8%
3	-0.3%	1.4%	-1.4%	0.1%	0.9%
4	5.5%	0.5%	-0.3%	0.0%	-2.7%
6	2.4%	0.4%	-1.5%	-0.7%	-0.2%
7	-1.8%	1.1%	1.9%	-0.7%	-0.3%
8	-2.8%	-1.0%	4.1%	-0.6%	0.2%
10	-1.1%	-2.2%	0.0%	1.5%	-0.2%
Central Coast (CC)	-8.1%	5.2%	2.2%	-4.1%	-1.2%
North Coast (NC)	-5.5%	-5.6%	-5.4%	6.4%	2.2%
California (CA)	-7.0%	1.2%	0.6%	-4.4%	9.7%

grape because of the negative price effect associated with the appellation.

To investigate further on the relationship between the appellation and grape variety, we separated only the cross effects between variety and appellation and present the crush district averages in Table 4. Cross effects can be best understood in the following example. Consider a wine produced from the Napa Valley appellation. A buyer may be willing to pay a certain premium because the wine is produced from the Napa Valley grapes, which have a reputation of producing high-quality wine. Further, the buyer may be willing to pay an additional premium if the wine in question were a Cabernet Sauvignon, because the Napa Valley appellation is well-known for fine Cabernet Sauvignon. Both effects are included in the full appellation effect reported in Figure 2, and our statistical approach allows us to isolate the cross effect between the variety and appellation.

These isolated cross effects, averaged at the crush district level and presented in Table 4, show the price effect attributable only to a certain combination of appellation and variety. For example, as discussed earlier, the full appellation effect for Cabernet Sauvignon from the California appellation is much lower than that for Zinfandel from the same appellation. The price spread between Cabernet Sauvignon and Zinfandel for the California appellation is 16.7 percent, holding all other attributes constant (Figure 2). Our results in Table 4 show that this 16.7 percent price spread is the sum of negative seven percent of cross effect specific to Cabernet Sauvignon and positive 9.7 percent of cross effect specific to Zinfandel.

Table 4 shows that in most cases, the cross effects are small—less than two percent. However, there were some instances associated with significant cross effects. The highest cross effects are identified in district 4 (Napa) for Cabernet Sauvignon, district 8 (southern coastal area) for Pinot Noir, Central Coast for Chardonnay, North Coast for Merlot, and California for Zinfandel.

California produces more than 90 percent of U.S. wine and supplies about two-thirds of the wine consumed in the United States.

Conclusion

Our estimation results confirm some beliefs common among wine aficionados. For example, wines from Napa have high prices even controlling for many other observed characteristics. Cabernet Sauvignon wine from Napa commands an especially high price, even controlling for other factors such as the quality score assigned by wine experts. We also find that appellations along the South Coast (identified as district 8) have particularly high prices for Pinot Noir wine, again controlling for other factors.

What exactly constitutes this appellation effect is an issue that requires careful discussion. In our framework, the appellation effects account for the price of an appellation net of the effects of all other observable attributes including the effects of the wine score. Considering that each appellation produces wine of specific characteristics and reputation, our appellation effect may measure reputation *per se*, if specific wine quality is associated with the *Wine Spectator* score. There may be many reasons why consumers are willing to pay for reputation. Given imperfect verification of product quality, consumers may be willing to pay a premium for information from past success. Or, consumers may be simply paying premiums because certain appellations convey some positive signal about the buyer, independent of the taste of the wine itself. An alternative interpretation is that the score does not reflect fully the characteristics of value and appellation is a useful guide for consumers in determining their willingness to pay for wine.

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