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Special Issue: Issues in the California Wine and Wine Grape Industry

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Introduction to the Issue

Rachael E. Goodhue and Philip L. Martin

Wine is one of California's best-known agricultural products. Cash receipts from the sale of grapes, including wine grapes, exceed $3 billion a year.

This special issue of *ARE Update* features research on the wine and wine grape industry by members of the Giannini Foundation of Agricultural Economics. Two articles provide overviews of recent trends in the grape and wine industry, another explores the effects of appellation and variety on the prices of California wines, and another addresses grape growers' use of a pest management tool.

"Current Economic Trends in the California Wine Industry," by Rachael Goodhue, Richard Green, Dale Heien, and Phillip Martin provides an overview of forces influencing California's wine industry, including changes in consumers' purchasing patterns, the evolution of the world wine market, and changes in the structure of the wine industry. Consumers are willing to pay for quality wines, but California faces increasing competition from imported wines, both from Old World Europe and New World producers in Australia and South America. Large and small producers are developing different strategies to maintain profitability, while medium-sized wineries face pressures to either grow or shrink.

"Recent Trends in the California Wine grape Industry," by Richard Volpe, Richard Green, Dale Heien, and Richard Howitt documents the evolution of wine grape production in California. Acreage has expanded, most notably along the Central Coast, and the major varieties have changed, with Cabernet Sauvignon and Pinot Noir accounting for more red wine acreage and Chardonnay a larger share of white wine acreage.

"Appellation, Variety, and the Price of California Wines," by Oh Sang Kwon, Hyunok Lee, and Daniel Sumner, evaluates the effect of appellation and variety on wine prices. North Coast appellations have the highest prices, with important interaction effects between the appellation and the variety. For example, Pinot Noir wines from the Central Coast received a price premium well before the 2004 release of the movie "Sideways."

"California Wine Grape Growers' Use of Powdery Mildew Forecasts," by Travis Lybbert and W. Douglas Gubler evaluates the factors that influence grower decisions about whether to use the Gubler-Thomas Powdery Mildew Index (PMI). PMI users tend to produce higher-valued wine grapes, which increases the benefit of the improved disease control associated with the index. Non-users are more influenced by the management costs of using the PMI.

Current Economic Trends in the California Wine Industry

Rachael E. Goodhue, Richard D. Green, Dale M. Heien, and Philip L. Martin

California's wine industry continues to evolve. The number of wine grape growers is growing slowly but the number of wineries has doubled in the past decade. Like other food-sector firms, a combination of economic and marketing forces are encouraging wineries to be either small enough to sell most of their wine directly to consumers or large enough to have clout with distributors and retailers.

Many factors are transforming the California wine industry. Technical innovations in grape growing and wine production are redefining the relationship between winegrapes and the resulting wine. Wine marketing is changing, as is the structure of the wine industry. Consumers are altering their purchasing patterns. This article focuses on three important trends influencing the California wine industry: changes in consumers' purchasing patterns, changes in the international wine market and international wine grape production, and changes in the structure of wine and wine grape production.

Grapes, including winegrapes, table grapes and raisins, were California's second-largest agricultural crop in terms of revenue in 2006, generating 10 percent of the state's $31.4 billion in farm sales. The 2006 wine grape crush of 3.1 million tons was sufficient to make over 2.3 billion bottles of wine. In 2005, the wine grape crush was a record 3.8 million tons; yields averaged eight tons an acre. About 300 million cases or 3.6 billion bottles of wine were sold in the United States in 2006, including 75 million imported cases. About 45 million or 17 percent of the 270 million cases of U.S. wine shipped from U.S. wineries were exported. In 2006, when there were 500,000 acres of winegrapes in California, the average grower price was $547 a ton, making the value of the grapes in an average bottle of California wine $0.75.

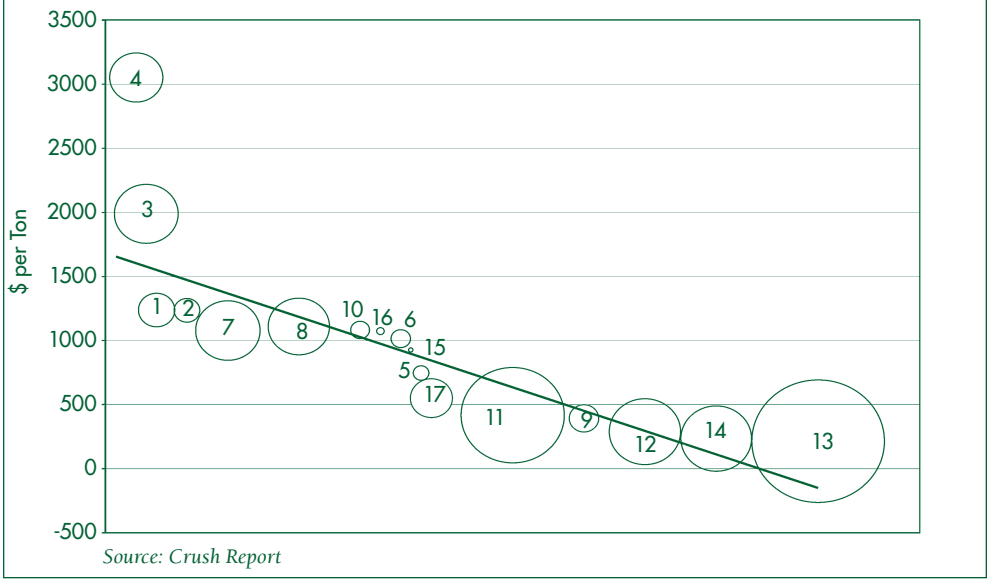
Wine grape acreage, quantities, and prices are reported by the state for seventeen different crush districts, and their diversity is reflected in the total quantities and average prices by district. Table 1 defines each crush district. In 2006, about 30 percent of the state's crush was in the Fresno area, district 13, followed by 18 percent in Stockton area, district 11. Central Valley districts 12 and 14 each accounted for another nine percent of the state's crush, while Napa County accounted for five percent.

The range in prices was wide, from less than $300 a ton in the San Joaquin Valley (making the grapes in a typical bottle worth $0.40), where half of California winegrapes are produced, to

Table 1. Definitions of Crush Districts

Crush District	Counties in Each District
1	Mendocino
2	Lake
3	Sonoma
4	Napa
5	Solano
6	Contra Costa, Alameda, Santa Clara, San Mateo, Santa Cruz
7	Monterey, San Benito
8	San Luis Obispo, Santa Barbara, Ventura
9	Del Norte, Siskiyou, Modoc, Lassen, Humboldt, Trinity, Shasta, Tehama, Glenn, Butte, Plumas, Colusa, Sutter, Yuba, Sierra, and northern parts of Yolo and Sacramento counties
10	Nevada, Placer, El Dorado, Amador, Calaveras, Tuolumne, and Mariposa
11	Includes northern part of San Joaquin and southern part of Sacramento
12	Includes southern part of San Joaquin
13	Includes northern part of Kings and Tulare
14	Includes southern part of Kings and Tulare
15	Los Angeles and San Bernardino
16	Riverside, Orange, Imperial, and San Diego
17	Includes southern part of Yolo and southwestern part of Sacramento

Figure 1. Price per Ton by Crush District, 2006
(Size of bubble represents tons crushed)



Source: Crush Report

over $3,000 a ton in the Napa Valley ($4 a bottle). Few other commodities have 10-1 differences in grower prices, and even wider retail price differences. Figure 1 plots the average price per ton of winegrapes by district on the vertical axis, and arrays crush districts from the highest average price per ton (Napa County, district 4) to the lowest (Fresno area, district 13). The size of each bubble represents the tons crushed in the district.

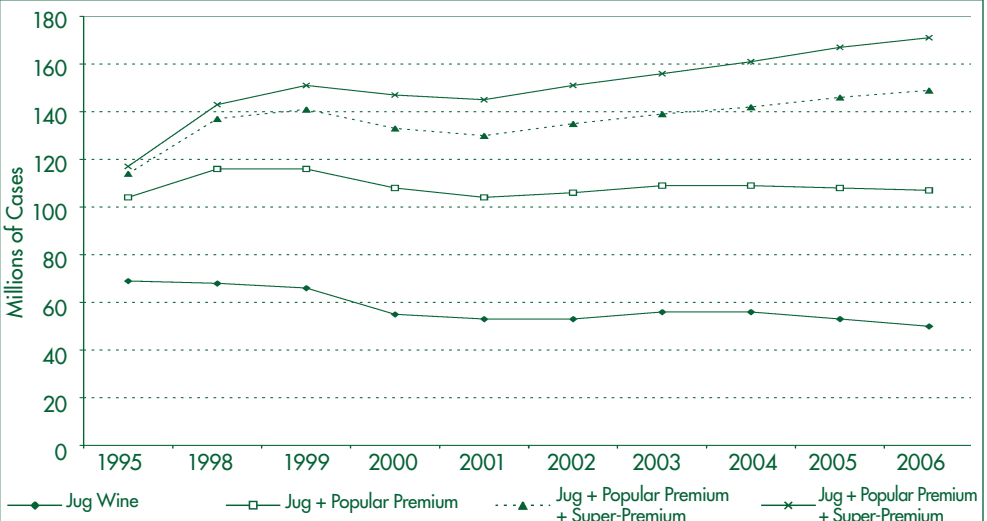
Consumption: Better Wine, and More of It

Americans drink relatively little wine, on average 2.4 gallons or 12 bottles a year, which is a tenth of what adults in France or Italy drink. Furthermore, U.S. wine consumption is concentrated among regular wine drinkers. The 30 million Americans who drink wine regularly drink 90 percent of the wine consumed in the United States, an average of 12 gallons or 60 bottles a year.

There have been three important changes in U.S. wine consumption over the past two decades. First, Americans upgraded their palettes, with many moving from inexpensive jug wines with retail prices of less than $3 a bottle to better-quality wines costing more, including popular-premium wines costing $3 to $7 a bottle, super-premium wines costing $7 to $14 a bottle, and ultra-premium wines costing over $14 a bottle. Second, consumers everywhere have come to appreciate the quality of California wine, and more Americans are drinking especially red wine for health reasons. Third, Americans increasingly prefer the consistent taste of fruity wines produced in New World California, Argentina, Australia, Chile, and New Zealand to the "mystery in every bottle" wines from Old World Europe.

The industry uses four retail price categories, based on a 750 ml bottle, to classify wine. Figure 2 reports millions of cases sold for each category.

Figure 2. U.S. Wine Sales by Retail Price Category: 1995–2006



Source: Selected Gomberg-Fredrickson Reports. Retail prices for a 750 ml bottle.

The volumes are "stacked," so that the top line, labeled Ultra-Premium, reports total sales volume. Ultra-Premium sales volume is the difference between this line and the line below, labeled Super-Premium. Figure 3 reports sales in each category as a percentage of total wine sales. Consequently, unlike Figure 2, the effect of growth in total wine sales on sales in individual price categories is not observed. Together, the two figures show that total wine sales have increased in the United States, and that most of the gain has come in higher-priced categories. Sales of the cheapest category, jug wine, have declined in absolute volume as well as a percentage of total sales.

Only the volume of wine sold in each category is reported, not the revenue obtained. We used the average retail price of a bottle of wine in each of the categories (assuming $18 for the ultra-premium category, $2 for the jug wine category, and the midpoints for the other categories) to estimate nominal revenue, $5.6 billion in 1995, $10.7 billion in 2000, and $14.6 billion in 2007 (Table 2).

Prices rose over this period (the Consumer Price Index rose from 163 in 1998 to 201 in 2006; an increase of

Figure 3. Percentage of U.S. Wine Sales in Each Retail Price Category: 1995–2006

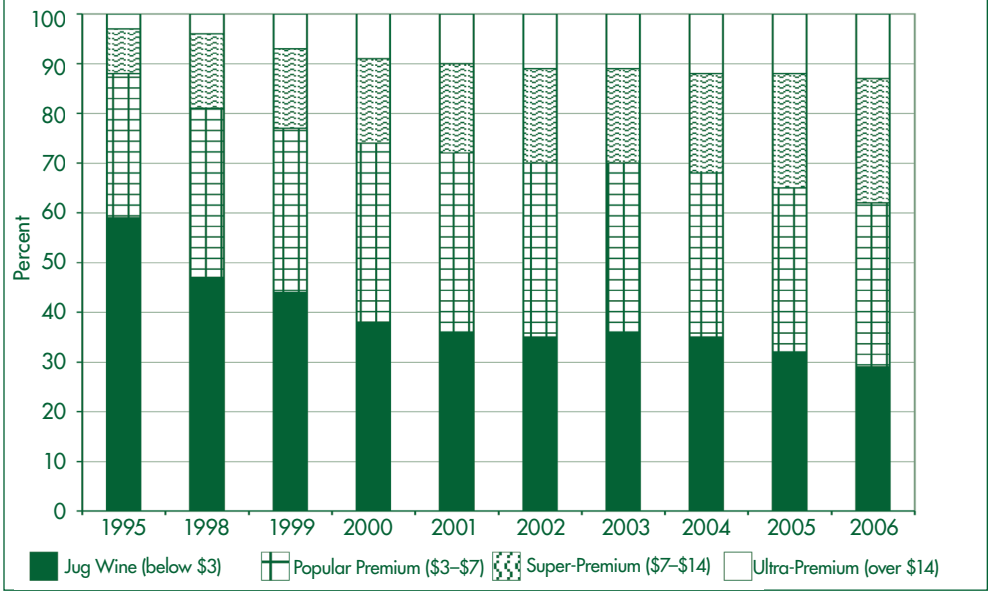


Table 2. U.S. Wine Revenues by Price Categories, 1995-2006

Wine Category	Retail Price	1995	1998	1999	2000	2001	2002	2003	2004	2005	2006
		Implied Revenue ($millions)									
Ultra-Premium	Over $14	648	1,188	2,182	3,110	3,197	3,413	3,694	4,061	4,428	4,752
Super-Premium	$7 to $14	1,273	2,696	3,087	3,087	3,326	3,604	3,780	4,108	4,738	5,292
Pop.-Premium	$3 to $7	2,070	2,886	2,970	3,156	3,078	3,168	3,150	3,180	3,270	3,396
Jug Wine	Below $3	1,666	1,627	1,577	1,320	1,262	1,262	1,351	1,334	1,260	1,205
Total		5,656	8,398	9,815	10,673	10,864	11,447	11,975	12,683	13,696	14,645
		Revenue Shares (Nominal)									
Ultra-Premium	Over $14	11%	14%	22%	29%	29%	30%	31%	32%	32%	32%
Super-Premium	$7 to $14	22%	32%	31%	29%	31%	31%	32%	32%	35%	36%
Pop.-Premium	$3 to $7	37%	34%	30%	30%	28%	28%	26%	25%	24%	23%
Jug Wine	Below $3	29%	19%	16%	12%	12%	11%	11%	11%	9%	8%
Total		100%	100%	100%	100%	100%	100%	100%	100%	100%	100%

Source: Selected Gomberg Fredrickson Reports and authors' calculations.

24 percent), so some of the increases in wine revenues were due to inflation. In order to assess the changes in volume reported in Figure 2, we corrected for inflation by calculating the Paasche and Laspeyres price indices since 1995, finding that wine prices declined 7.5 percent (Paasche) to 6.3 percent (Laspeyres), meaning that inflation-adjusted wine prices decreased. This decline may be one reason that consumers upgraded the quality of the wine they bought.

Health considerations may also have contributed to increased wine sales. The well-known "French Paradox," first popularized by the television program *60 Minutes* in 1991, posits that the moderate consumption of red wine by the French tends to offset the negative effects of their high-fat diet, leading to a lower heart disease rate than in the United States. This positive effect of wine on health may have encouraged American consumers to buy more wine.

New World, Old World: Taste, Production, and Trade

The quality of California wines was recognized during the Paris surprise of May 24, 1976. On that day, French experts in a blind tasting in Paris ranked Stag's Leap Cabernet Sauvignon and Chateau Montelena Chardonnay the best red and white wines, encouraging Americans interested in food and wine to drink more California wines.

Many Americans seem to prefer the New World style of wine making, from California, Chile, Australia, to Old World European wines. New World wine producers aim for a consistent taste across vintages of a wine made from one variety of grapes. This taste is often described as fresh and fruity, with an alcohol level of 13-14 percent, rather than the 11-12 percent common in European countries that receive less sun. New World wineries that blend several varieties of grapes usually include the percentage of each.

Old World European producers in France, Italy, and Spain have a different winemaking style. Winemakers emphasize "terroir," meaning that the wine reflects the soil and weather where the grapes were grown, so that different vintages can have very different tastes. Many Old World wines need to be cellared to attain their full potential, which means they should not be drunk right away, even though the vast majority of wine drunk in the United States is consumed soon after purchase. Most Old World wines are blends of several varieties of grapes, and are often sold with a geographic indicator (e.g., Burgundy). American consumers are often unfamiliar with these names, so they typically select a New World varietal wine rather than an Old World "mystery in a bottle."

Differences in wine styles are in part due to differences in production techniques and the role of the government in the wine industry. New World wineries are often vertically integrated, growing some of their own grapes or controlling and influencing grape growing practices with formal or informal contracts (See *ARE Update* Vol. 3 No. 3 for the results of a study regarding contract use in the California wine grape industry). In the Old World, there are many small grape growers, and in many areas cooperatives crush locally grown grapes. Under the traditional geographic indicator systems, long lists of rules govern how grapes are grown and wine is made. Greater flexibility in the choice of production techniques, including irrigation, means that yields are much higher in the New World than the Old World.

The European Union has taken steps to improve the competitive position of its members' wine industries, largely by subsidizing the removal of wine grape acreage that produces low-quality wines, much of which is distilled into industrial alcohol. The European Commission has proposed a loosening of rules regarding grape growing and winemaking, and allowing for the simplification of wine labels. Some European growers and winemakers have opted out of the traditional system and begun to produce varietal wines using New World techniques.

Trade plays a very important role in the world wine industry. Of the 300 million cases of wine sold in the United States in 2006, about a quarter were imported. Of the 270 million cases of U.S. wine shipped from U.S. wineries in 2006, about 45 million cases (17 percent) were exported.

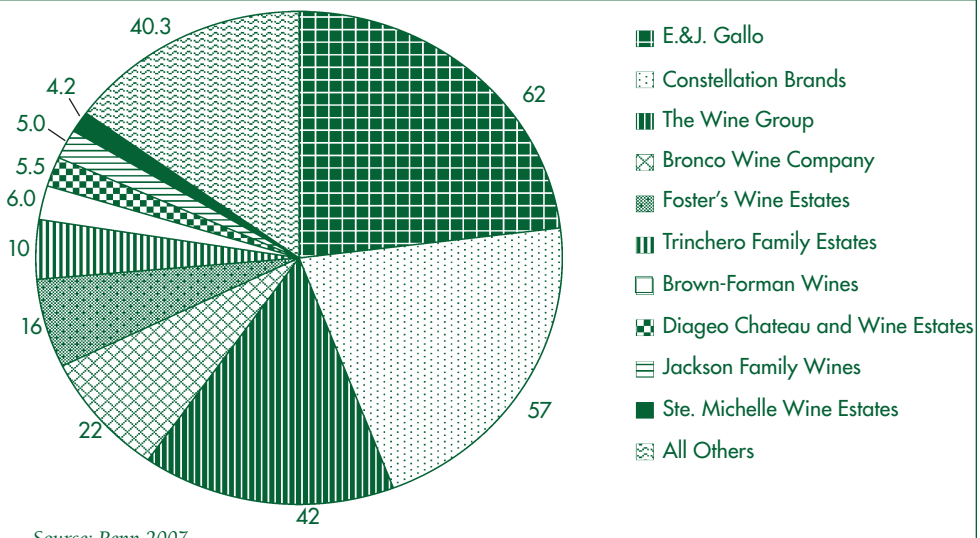
The leading source of wine imported to the United States has shifted from the Old to the New World—imports in 2006 were as likely to be from Australia as Italy. Imported wines are particularly important at lower price points: 40 percent of wine sold for less than $10 per bottle retail is imported, reflecting the popularity of brands such as Yellow Tail from Australia. Bulk imports are also important, although invisible to the final consumer. The United States allows wineries to blend up to 25 percent foreign wine with local wine and label it as local, e.g., California wine.

Developments in other countries may affect the competitive position of California's wine industry. Australia and Chile produce disproportionate shares of the world's wine relative to their populations, encouraging exports. China is a great unknown. The acreage of winegrapes is increasing, and more local production may increase interest in wine drinking, opening the door for imports. However, if local production leads to wine that can be sold abroad, China could become a major exporter. The two possibilities are not mutually exclusive, of course, and the net impact is uncertain.

Structure of the California Wine Industry: A Special Case in U.S. Agriculture?

The California wine grape industry is different from much of U.S. agriculture, reflecting the heterogeneity of wine and the wide range of distribution channels. There is a wide variation in farm gate prices, in the price of wine, and in the farmer's share of the retail wine prices. Equally important is the wide variation in the grower's share of the retail price of wine—integrated grower-winery operations that sell much of their wine to tasting customers receive far more of the average retail price than those growers who sell to wineries who sell to distributors and then to retailers. Unlike products such as corn or wheat, wines vary by grape variety, location, and other factors.

Figure 4. U.S. Wine Shipments for Top Ten Firms and All Others (millions of cases): 2006



Source: Penn 2007

The U.S. food system is marked by fewer and larger farms producing food and fiber, and a similar consolidation in firms that pack and process farm commodities. The total number of U.S. farms, defined as places that normally sell farm commodities of $1,000 or more, has remained steady, but the largest five percent account for an increasing share of the value of total production—almost two-thirds.

The California wine and wine grape industry is different. The number of wine grape growers has increased slightly to almost 5,000 in the past decade, consistent with the stable number of U.S. farms, while the number of wineries doubled to 2,900, the opposite of the general consolidation trend in food processing. However, within the winery sector, there is significant consolidation.

The largest California wineries have long accounted for most wine shipments. Consolidation is often measured by the share of total sales accounted for by the largest firms in the industry. The two largest California wineries have accounted for about 45 percent of wine shipments over the past 15 years, the four largest 60 to 65 percent, and the eight largest 75 percent. Total wine shipments have increased almost 60 percent since 1990, meaning that the largest wineries are shipping more wine despite a stable market share.

California accounts for about 90 percent of U.S. wine production, and the U.S. industry is slightly more concentrated than the California industry. Figure 4 shows that the top three wineries accounted for nearly 60 percent of total wine shipments, and the top ten 85 percent of total shipments.

An important part of the large firms' recipe for success is their ability to offer distributors and large retailers a range of labels at different price points, including U.S.-produced wine and imports. E&J Gallo, the largest winery by sales volume, offers brands ranging from jug wines such as Peter Vella, to fighting varietals such as Turning Leaf, to premium offerings under the Gallo Family Estate label. Gallo also owns the French label Red Bicyclette and distributes the Australian label Black Swan.

Many wineries have grown through acquisitions, several of which are motivated by the quest for more labels or brands. Many wineries also introduce new labels—the number of wine labels is increasing much faster than total wine sales. Over 500 new wine labels were introduced in U.S. supermarkets in 2005, up from 300 the year

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before, bringing the number of active wine brands in supermarkets to 3,000. As a result, the average number of cases sold per label has been declining toward an average 20,000 a year. (www.winebusiness.com/SalesMarketing/webarticle.cfm?dataId=42402.)

Smaller California wineries, and similar wineries throughout the United States, often aim to sell three-quarters or more of their wine directly to consumers, many of whom visit the winery to taste the wine. Small wineries are often defined as those that sell less than 10,000 cases a year, and direct sales eliminate distributor and retailer markups as well as winery-incurred shipping costs. Many wineries have loyalty clubs that ship wine directly to consumers and invite club members to special winery events and offer them discounts on additional wine purchases. One parallel is community-supported agriculture, whereby consumers receive a share of a farm's production on a regular basis for a fee.

Mid-size wineries face challenges. Just as grower-packers who are too large to depend on direct-to-consumer sales, but too small to attract the attention of major distributors or retailers, wineries in the middle between direct sales and multiple labels and marketing clout may have to seek a new business model. Mid-size wineries could shrink and follow the small-producer strategy, grow and follow a large-producer strategy, or become part of a large producer's brand portfolio via mergers and acquisitions.

The Future of California Wine

In many ways, wine is a California success story. The state's wine has gained consumer recognition for its quality and introduced new production and marketing techniques that have contributed to its success and have spread to other New World producers. Larger wineries are developing a portfolio of brands through growth and acquisitions, while smaller wineries are fine-tuning strategies that involve direct sales to consumers. Mid-size wineries may be squeezed in this emerging wine marketplace.

The California wine industry cannot be complacent. It faces challenges that include more competition from other imports and other American wine producers, but the growing reputation for quality, the increasing willingness of consumers to pay for higher quality, and the wine industry's ability to innovate bode well for its success.

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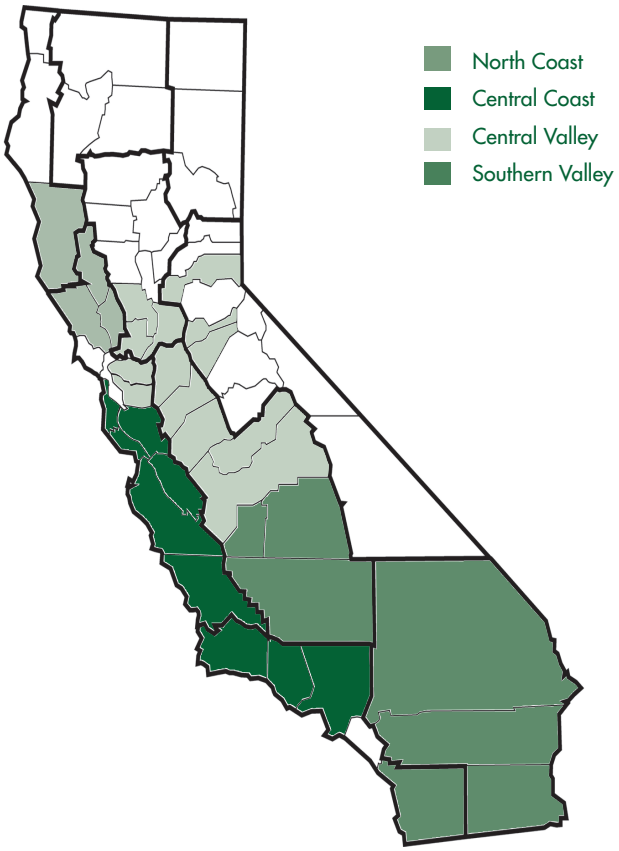
Recent Trends in the California Wine Grape Industry

Richard Volpe, Richard Green, Dale Heien, and Richard Howitt

This article takes an in-depth look at the changes in the California wine grape industry over the last 30 years. In response to rising consumer demand for California wines, the wine grape industry has expanded rapidly in acreage and production. The growth, as we show, has not been uniform across grape varieties or the state's major growing regions.

Wine grapes were responsible for 8.7 percent of the state's total agricultural receipts in 2004, ranking third among agricultural products behind dairy and greenhouse products. Furthermore, California accounts for 92 percent of the wine grape production in the entire United States. The wine grape industry is therefore of great significance to both the state and the nation. The article by Goodhue et al. in this issue details several of the changes being observed within the California wine industry. These are mirrored, by and large, by trends within the wine grape industry. This article tracks the growth and changes of the California wine grape industry across the major varieties and growing regions over the last 30 years. Special emphasis is paid to the changing face of grower returns.

Figure 1. The Major Wine Grape Growing Regions of California



California's Growing Regions

The California Department of Food and Agriculture divides the state into 17 pricing districts for the purposes of data collection and presentation. We organized the most significant pricing districts into four major growing regions: 1) The North Coast, which extends northeasterly from the San Francisco Bay Area and includes the Napa and Sonoma Valleys, 2) The Central Coast, which extends from San Mateo County in the north to Santa Barbara in the south, 3) The Central Valley, which includes the Sacramento and San Joaquin Valleys, and 4) The Southern Valley, the most vast of the four regions including Kern and San Bernardino Counties and all points south. Figure 1 shows the locations of the four major grape growing regions in California.

Figure 2 reports the total grape crush in tons for the four growing regions over the last 30 years. All four regions experienced sharp drops in total grape production in 2006 due to droughts and below-average temperatures throughout late 2005 and early 2006. The most severe impact was felt in the Central Valley, where the drought resulted in strict water cuts for grape growers and, thus, reduced irrigation. Overall, we see that production has increased steadily in the four growing regions. Total production in the Southern Valley has been relatively steady since the early 1980s, and in 2002 the Central Valley became the region producing the most grape crush in California.

Figure 2. Wine Grape Production in California's Growing Regions, 1976–2006

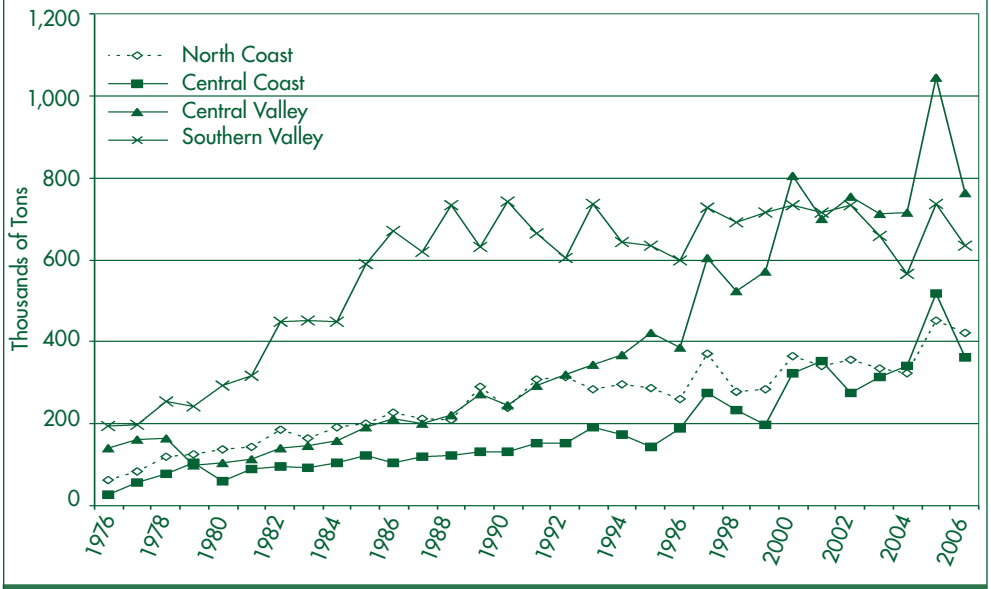


Figure 3. Average Prices Received by Growing Region, 1976–2006

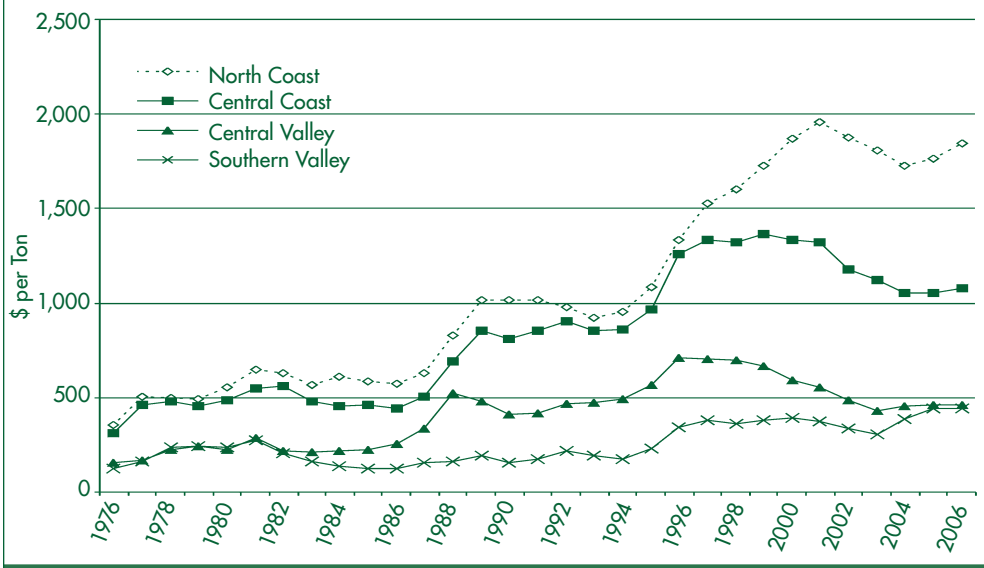
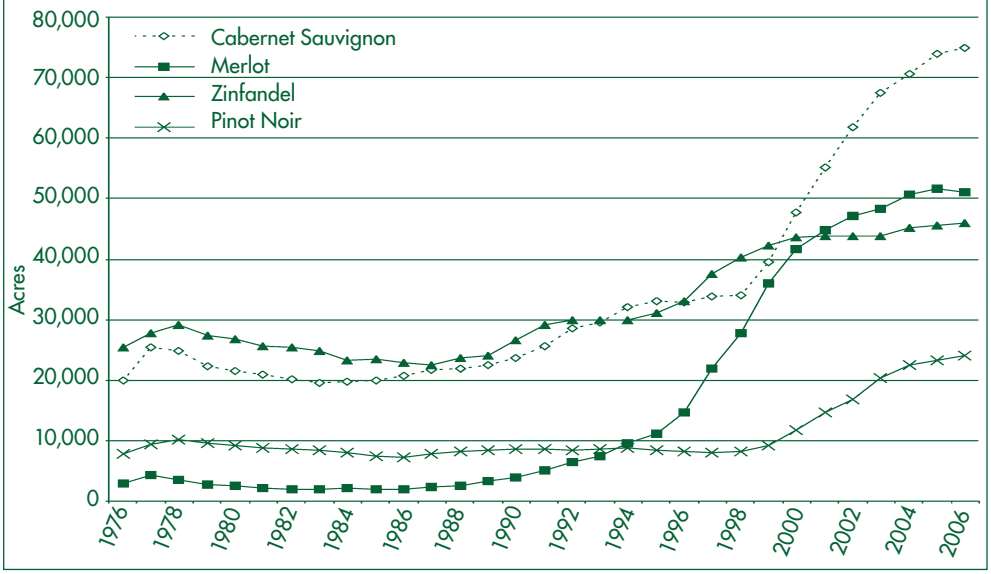


Figure 4. California Red Wine Grape Acreage, 1976–2006



The total production in the high-quality coastal regions has grown relative to that in the inland areas. In 1976 the North Coast and Central Coast combined for 22 percent of California's total grape crush. In 2006 their share was 36 percent. This growth is attributed mainly to the expansion of the Santa Barbara and San Luis Obispo American Viticultural Areas (AVAs). The U.S. Department of the Treasury divides the U.S. wine grape industry into AVAs according to distinctive climate, soil, and elevation conditions. The Paso Robles AVA, in San Luis Obispo County, alone grew from fewer than 20 wineries in 1990 to more than 170 at the turn of the century.

Figure 3 reports the average prices received in the four growing regions. The prices are weighted by the crush counts of the major varieties. There has nearly always been a significant difference between the prices received in the coastal regions and those of the inland regions. Starting in the late 1980s, this gap began to grow wider to reflect the increasing preference among American consumers for high-quality table wine. In the late 1990s, a significant margin developed between the North Coast and Central Coast prices. The average prices received for grape crush in the North Coast, which is home to the most famous AVAs in the United States, are now significantly higher than those received anywhere else in the state. Average North Coast prices, driven in part by the surging prices of Pinot Noir grapes, are flirting with the $2,000/ton benchmark while even those of the Central Coast remain closer to $1,000 per ton.

For several years the grapes of the Central Valley yielded higher returns than those of the Southern Valley. Average prices received in the Central Valley have fallen in recent years, however, as much of the production boom in that region has been associated with low-priced Chardonnay

grapes. As of 2006, Chardonnay grapes accounted for 75 percent of the total white grape production in the Central Valley, which are in turn crushed and processed into cheap wines with wide-scale distribution. Among the growing regions, average prices for Chardonnay grapes are the lowest in the Central Valley by a significant margin.

Major Wine Grape Varieties -

The analysis covers eight of the largest wine grape crops in California as of 2006. These include four reds—Cabernet Sauvignon, Merlot, Zinfandel, and Pinot Noir, and four whites—Chardonnay, Sauvignon Blanc, French Colombard, and Chenin Blanc. The total crush for these eight varieties statewide grew from 422,000 tons in 1976 to 2.2 million tons in 2006. Over the same time span, the average prices per ton received by growers grew from a statewide average of $235 to $916 in nominal dollars. Both of these trends reflect a major expansion, both domestic and international, in demand for California wines. However, the growth in production and revenues has not been uniform across growing regions or varieties.

Figures 4 and 5 show how the acreage for the eight major California winegrapes has changed over the years. Acreage tells a clearer story than does crush, as acreage is less affected by weather shocks such as droughts or the ebbs and flows of the international wine market. Acreage for the four major red varieties was very stable until the mid-1990s, at which point acreage began to expand rapidly for both Cabernet Sauvignon and Merlot. Cabernet acreage has experienced the most growth of all of California's major winegrapes in the last 15 years. The crop reached 75,000 acres and 430,000 tons crushed in 2006, making it easily the largest red grape crop in the state.

Among white grapes, the acreage and production of Chenin Blanc and French Colombard have fallen steadily since the mid-1980s. Both of these varieties were once grown extensively throughout the state but, over time, production has fallen dramatically in the North Coast and Central Coast. The production of these two grapes, among the more easily grown in California, is now concentrated in the inland regions. With the exception of Colombard grapes grown in the San Joaquin Valley, these grapes are typically not used in blends and today they are used primarily to produce low-priced jug wines.

The versatile Chardonnay grape has continued to expand over the years, only beginning to plateau at the turn of the century. At 91,000 acres and over a half-million tons of crush in 2006, it remains the largest grape crop in the state. The overarching trend of increasing red grape production and decreasing white grape production is due in part to the breadth of studies that have demonstrated the health benefits of moderate red wine consumption.

Figures 6 and 7 report the prices received for the eight major wine varieties. The returns are statewide averages, weighted by growing regions. Since the mid-1990s, Pinot Noir prices have pulled significantly ahead of those of the other major red varieties, corresponding with the growing reputation

Figure 5. California White Wine Grape Acreage, 1976–2006

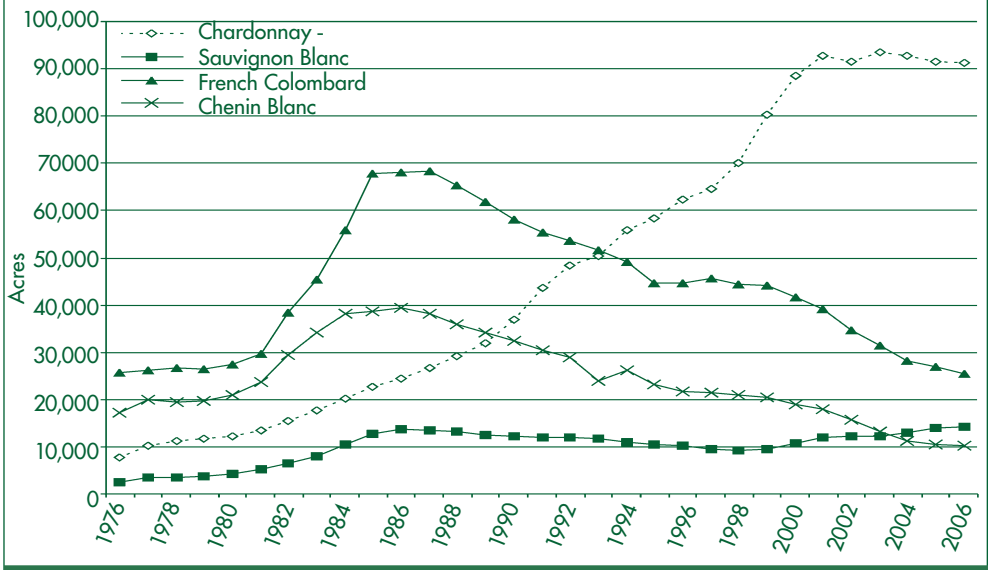


Figure 6. California Red Wine Grape Prices Received, 1976–2006

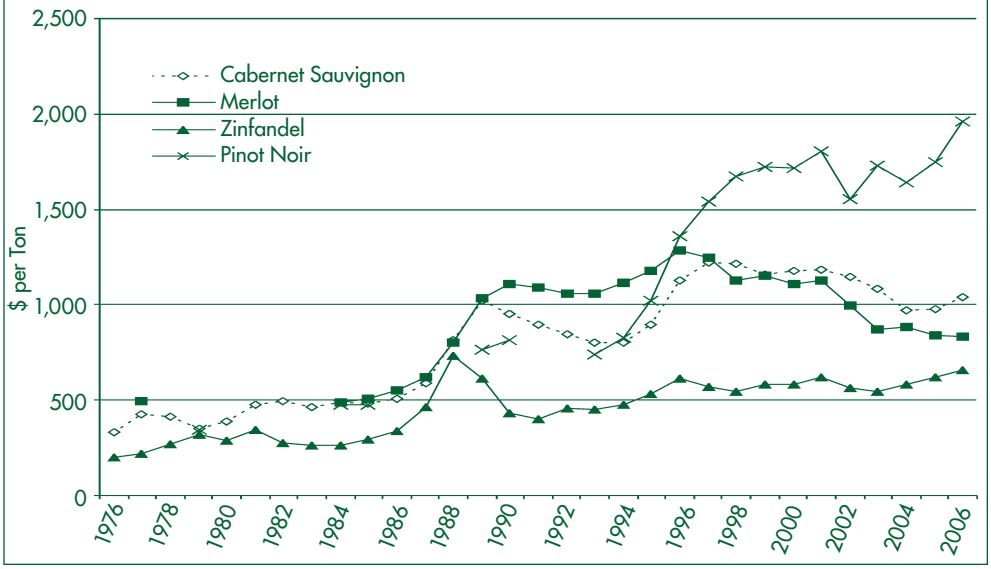
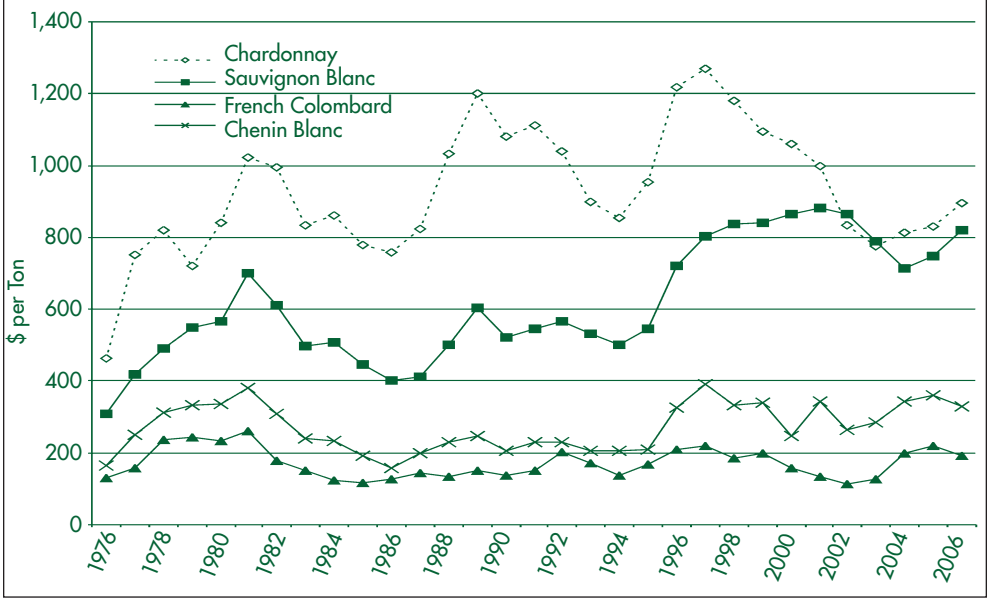


Figure 7. California White Wine Grape Prices Received, 1976–2006



of the wine varietal as a high-quality table wine. In the North Coast, Pinot Noir grapes now earn over $2,200 per ton on average. Certain AVAs in Napa and Sonoma Counties receive much more than that. It is worth noting, however, that Pinot Noir production is concentrated in the coastal regions, where returns are significantly higher than in inland areas. Outside of the North Coast, Cabernet Sauvignon grapes yield the highest average returns throughout the state by a significant margin. Zinfandel grapes have consistently earned the lowest average returns of the major red grapes.

Throughout most of the last 30 years, Chardonnay grapes yielded the highest average prices among the major white varieties by a wide margin. In the last five years the gap has narrowed between Chardonnay prices and those of Sauvignon Blanc. This is due primarily to the aforementioned explosion of Chardonnay production in the inland growing regions where prices are lower. In 1976 the Central Valley and Southern Valley combined for a total share of 12 percent of total California Chardonnay production, whereas in 2006, their share was 52 percent. Chardonnay grape prices in the North Coast remain high, surpassing $1,500/ton in 2006, but in the Central Valley where the grapes are destined for use in low-priced, high-distribution wines, prices average one-third of that.

The returns for the Chenin Blanc and Colombard grapes have remained fairly consistent over the years, hovering today at $300 and $200 per ton, respectively. The production of these grapes shifted away from the coastal regions before the coastal grape returns began to rapidly outpace those of the inland growing regions, in the mid-to-late 1990s.

Looking Toward the Future

The major trends in the production of grapes have been driven by changes in consumer demand for wine. As demand continues to grow for premium and super-premium wines, grape growers will continue to see an overall increase in the prices they receive. Statewide production of winegrapes typically used for high-priced table wines will increase, and thus we can expect the growth in Pinot Noir, Cabernet, and Merlot production to continue.

Certain AVAs of the Central Valley, particularly in the San Joaquin and Sierra foothills regions, are making concerted efforts to produce wines of sufficiently high quality to compete with the coastal regions. The production of Colombard and Chenin Blanc continues to shift away from this region and into the Southern Valley so, over time, we may see the average prices received for Central Valley winegrapes increase relative to all other regions of the state. The Central Valley will likely continue to increase its production of red grapes, with the exception of Pinot Noir which requires a cooler climate to flourish. The increase in production of Cabernet, Merlot, and Zinfandel in the Central Valley, while dwarfed by the expansion of Chardonnay, has still been substantial and indicative of the direction in which the region is headed.

The North Coast, and in particular the Napa and Sonoma Valleys, shows no sign of relinquishing its status as the premier grape-growing region in California and, in fact, all of the United States. As tourism in the area continues to boom and Americans increasingly demand super-premium wines, the prices growers receive for grapes in the region will likely continue to distance themselves from those seen anywhere else in California. The production of Cabernet Sauvignon, driven by increasing demands for the wine varietal at high prices, is poised to fully overtake that of Chardonnay in this region. Chenin Blanc and French Colombard, alternatively, are nearing the point at which they are grown in coastal regions in trivial amounts.

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California Wine Grape Growers' Use of Powdery Mildew Forecasts

Travis J. Lybbert and W. Douglas Gubler

Powdery mildew poses a major disease threat to grape growers. While disease forecasts can be a valuable tool, many growers do not use them. We explore forecast adoption and use patterns among California wine grape growers.

Growers face several potential costs and benefits when using the Powdery Mildew Index.

Grape growers in California spend more to control powdery mildew each year than other diseases or pests, yet it still causes considerable crop loss. Growers' only real hope in the annual battle with powdery mildew is proper preventative management. This task is complicated by the explosive episodes of powdery mildew growth that are possible when optimal temperature and humidity conditions prevail. These growth explosions pose substantial production risks to growers; an entire season can be lost with a poorly timed treatment. While powdery mildew forecasts seem to be an especially promising tool in this context, many growers choose not to use them. In this paper, we discuss the economics of using powdery mildew forecasts and use survey data to explore forecast adoption and use patterns among California wine grape growers.

In the early 1990s, plant pathologists worldwide began to develop powdery mildew growth models that could provide growers with forecasts and help them foresee outbreaks in order to time more precisely their preventative powdery mildew treatments. One such model has attracted the attention of growers worldwide: the Gubler-Thomas Powdery Mildew Index (PMI). The PMI, a simple risk index that ranges from 0 (low disease potential) to 100 (high disease pressure), is founded on the observation that powdery mildew growth, sporulation, and infection are largely a function of length of exposure to different temperature ranges. The PMI can be computed using onsite weather stations linked to specialized software and is available for broad areas throughout California's grape growing regions from a variety of external sources.

The PMI has proven to be a useful tool for improving treatment timing and intervals. Field trials have shown that structuring spray application programs according to the PMI reduced fungicides "by two to three applications over the course of the growing season with equal or better disease control" (Gubler et al. 2003, p.10). It is estimated that growers using the index eliminated three and two applications in 2003 and 2004, respectively. The human and environmental benefits of this reduction in fungicide use could be substantial: by one estimate, sulfur applications on raisin grapes would have decreased by one million pounds (an eight percent reduction) if 25 percent of raisin growers used the PMI in 2003.

Despite these favorable trials and grower experiences, PMI adopters are still in the minority among Californian grape growers. This raises questions about adoption constraints. Are growers slow to adopt because they are still learning about the PMI? Or are there structural constraints that discourage the adoption of a flexible spraying regimen? What distinguishes PMI growers from their non-PMI counterparts? This paper uses survey data from California wine grape growers to explore these questions.

The Economics of the Powdery Mildew Index

After over a decade of testing and use of the PMI, important economic aspects of the index are still poorly understood. Growers face several potential costs and benefits when using the PMI. Beyond what growers may have to pay to access PMI information for their vineyard, these potential costs and benefits hinge on mediating factors such as how the PMI is used and the accuracy and relevance of a given PMI for a particular vineyard. Table 1 summarizes these potential costs and benefits and mediating factors.

During periods of low disease pressure, growers using the PMI may be able to stretch treatment intervals and save on treatment costs. Growers who regularly treat at minimum intervals are especially likely to benefit from these PMI-based fungicide savings. Note, however, that treating at minimum intervals also confers a benefit to such growers in the form of implicit production insurance. Thus, fungicide savings from using the PMI may come

Table 1. Potential Costs and Benefits of Using PMI and Mediating Factors

Potential Benefits	Potential Costs	Mediating Factors
Chemical Savings Stretched intervals when disease potential is low	**Information Costs** Onsite weather station or subscription to PMI service	**Disease Pressure** *How high and how variable day-to-day is disease pressure?*
Better Disease Control Better awareness of looming disease pressure used to improve timing of spraying at critical times	**Flexibility Costs** Equipment and operators must be "on call" to spray when PMI indicates	**Degree of Use** *How much does the PMI influence treatment-timing decisions?*
Slowed Resistance Spraying timed to match disease growth and unnecessary spraying eliminated	**Additional Risk Exposure** Stretched intervals between spraying based on PMI	**Model Accuracy** *How much do variables not in the PMI affect disease pressure?*
		Sensory Relevance *How well does the PMI available to a grower reflect actual field conditions?*
		Measurement Errors *How accurate are the data sensors and computations?*

only at the cost of some additional risk exposure. This trade-off may be tricky because—as PMI providers are wont to warn—powdery mildew can be at "economically damaging levels even when the PMI indicates a low likelihood of conditions favoring rapid development of the disease," (http://precisionagrilab.com/gpm) especially if previous treatment and monitoring were poorly executed or otherwise ineffective.

During periods of high disease pressure, growers who use the PMI may achieve better disease control by shortening their treatment intervals during high forecasted powdery mildew pressure. While the previous PMI benefits might be substantial, this benefit is potentially much more important because powdery mildew outbreaks can quickly spiral out of the growers' control. At critical disease thresholds, the damages sustained by stretching a treatment interval a day or two too long may far outweigh the associated fungicide savings. This suggests there is a clear risk asymmetry due to mistimed treatments: treating too early entails additional but known treatment costs, while treating too late might entail extreme production risks. As an important feature of its economic value, the PMI informs growers about the production risks associated with stretching treatment intervals and how these risks change over the course of a season.

By more accurately matching treatment timing and intervals to powdery mildew population dynamics, use of the PMI may also reduce the build up of fungicide-resistant strains in the pathogen population. Since growers bear the costs associated with fungicide resistance collectively, rather than individually, growers only internalize a portion of this PMI-based benefit. Still, many growers are familiar with the resistance problem and may value this benefit accordingly. As above, this resistance benefit accrues to growers collectively when, without the PMI, they tend to treat powdery mildew at minimum intervals. Once again, reaping this benefit may therefore entail additional exposure to production risk as intervals are stretched according to the PMI.

On the cost side, growers can access PMI information in several ways. The most accurate PMI information for a given grower would be based on data from onsite, high-quality weather stations with high-precision sensors properly placed to get relevant readings. Such a station can cost $3000 or more, and multiple stations may be needed to cover large vineyards. Of course, these stations also provide other useful information in addition to the PMI. Growers can also obtain PMI information based on offsite, external stations. Several private companies offer such PMI information online on a subscription basis. Others, including UC IPM, post the PMI online free-of-charge. Thus, depending on the size of the operation, these information costs range from essentially zero to thousands of dollars in the case of multiple onsite stations, and may include both fixed and variable cost components.

In contrast to upfront information costs, the other costs and benefits in Table 1 hinge on how the PMI shapes a grower's disease-management decisions. To use the PMI effectively a grower must be willing and able to adjust spray schedules within a few days of key changes in the index, requiring additional flexibility in equipment and operators that may be costly and inconvenient.

In sum, most of these PMI benefits and costs hinge on growers' treatment tendencies without the PMI. For growers who otherwise tend to treat at minimum intervals, using the PMI effectively substitutes better information for lesser insurance coverage and saves them treatment costs. For growers who tend to stretch intervals, using the PMI reduces their exposure to production risks, albeit potentially with additional treatment costs.

Who Uses the Powdery Mildew Index and How?

To address this question, we conducted an online survey of California wine grape growers in January and February 2008. The survey included questions on disease management generally, and powdery mildew specifically, on vineyard and vineyard manager characteristics, and on their use of the PMI. Members of the California Association of Winegrape Growers and several other state and local grape growers' associations were

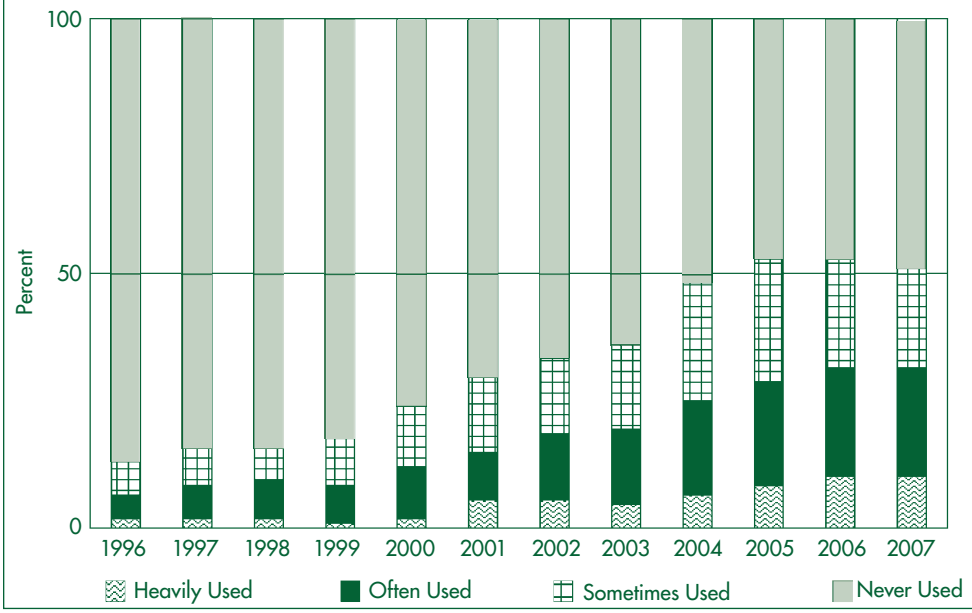
invited to participate in the survey. Ultimately, 108 wine grape growers participated in the survey. Nearly two-thirds of our surveyed growers have used or currently use the PMI to some degree. This seems consistent with Californian wine grape growers generally, who tend to rely on the PMI more than table and raisin grape growers.

Figure 1 shows how use of the PMI has diffused among our surveyed growers since the index was launched in 1996. Most of the growers were familiar with the PMI. Many of those not using the PMI cite their preference for a set calendar spray schedule as the primary reason for not using it. Other cited reasons for not using it include: relevant PMI not available (18 percent), lack of trust (16 percent), and equipment or operator constraints that make flexible spray schedules difficult (13 percent). Related to these flexibility costs, 65 percent of all our surveyed growers are never constrained by availability of equipment, operators or chemicals; only 10 percent are sometimes or often constrained.

Of the growers who have used the PMI, 15 percent have stopped using the index. Many of these disadopters prefer a calendar spray schedule or believe that the PMI model is not well-suited for their growing conditions and, hence, contributes little that monitoring and experience do not already confer.

Table 2 displays the means of selected variables for growers who use or have used the PMI and those who have not. We constructed a factor analytic index of PMI-use intensity using several variables that capture growers' current degree of PMI use and their confidence in the PMI. Table 2 displays correlation coefficients between these selected variables and this PMI-use intensity index. Based on the variables that, on average, seem to be quite different for these two groups, PMI users appear to be more experienced, to be significantly less likely

Figure 1. Intensity of PMI Uses over Time for Surveyed Growers



to own the vineyards they manage, and to manage more acres. PMI users have larger primary vineyards with higher yields and substantially more valuable production per acre.

Although slightly weaker statistically, PMI users also seem to have more education and to rely less on minimum-interval spray schedules. Although more sprayers per land unit should enable a grower to be more flexible and responsive to spontaneous spraying demands, the correlation with PMI-use intensity actually runs in the opposite direction. Given that 90 percent of our surveyed growers never or rarely feel constrained by equipment availability, the lack of a positive correlation is perhaps not surprising.

Table 2. Selected Variable Statistics for Growers Who Use and Do Not Use the PMI

	Mean		Correlation with PMI Use
	Do Not Use PMI (N=34)	Use PMI (N=65)	
Grape experience (years)	11.2	15.8	0.25*
Vineyard ownership {0,1}	0.853	0.600	-0.33*
Acres managed in 2007	310	1,015	0.28*
Higher education (years)	4.6	5.3	0.12
Influence of minimum intervals on treatment timing (% of decision)	16.2	12.7	0.05
Primary vineyard size (acres)	327	717	0.19*
Avg. primary vineyard production (tons)	2,266	4,324	0.12
Yield in 2007 (tons/acre)	4.0	5.1	0.22*
Price ($/ton)	$1,108	$1,429	0.16
Production value per acre	$3,680	$6,443	0.32*
Production value total	$365,655	$3,304,377	0.34*
Sprayers per acre	0.20	0.12	-0.14
Number of weather stations	0.76	1.5	0.24*
Yield insurance {0,1}	0.41	0.43	0.08

** Indicates significance at 10% level*

In addition to the variables in Table 2, we asked growers how important considerations such as yield, costs, environmental impacts, and the flavor, appearance, and price of grapes were to the management of their vineyards. Interestingly, users and non-users differed significantly in their responses to only one of these considerations: PMI users were more concerned about disease resistance build up (p-value 0.06).

Initially, most PMI users received the index from onsite weather stations. As use of the index spread, newer users were more likely to get PMI information second-hand from private companies. By 2003, more users received the index from private companies than from their own weather stations. In 2007, roughly 50 percent received it from private companies, while 30 percent used their own stations.

Because the relevance of the PMI model and susceptibility to powdery mildew varies across grape varieties, we consider correlations between PMI-use intensity and varieties grown (Table 3). Among the wine grape varieties commonly grown by our surveyed growers, Cabernet Franc and Petit Verdot are most strongly correlated with PMI-use intensity. Growers of Chardonnay, Cabernet Sauvignon, Pinot Noir and Gris, and Malbec varieties also seem more likely to proactively use the PMI. These varieties—especially the red wine grape varieties—fetch relatively high prices, which may explain their growers' reliance on the PMI. With these valuable varieties, the value-at-risk throughout the growing season is high and so too is the payoff to better powdery mildew control.

Conclusion

The descriptive results reported in this paper shed some light on how wine grape growers think about the costs and benefits outlined in Table 1. Among potential benefits, better disease control stands out as the driving adoption benefit. PMI users tend to produce high-value grapes and thus enjoy higher returns to better disease control. While PMI users cite chemical savings as a motivation for PMI use, they attach the same importance to saving chemical costs as their non-PMI use counterparts. PMI users do, however, attach more importance to controlling disease-resistance build up than non-users.

On the cost front, many PMI users freely access the index from external sources, but those with onsite weather stations seem more satisfied with the performance of the index. Although most of our growers are not constrained by equipment or operator availability, those deciding not to use or to stop using the PMI often think that the benefits of PMI use do not offset the hassles of deviating from a set spray schedule. Similarly, assessing the importance of the additional risk exposure implied by PMI use (relative to minimum-interval sprays) is difficult. Compared to their peers, PMI users are neither more nor less likely to purchase yield insurance, but they are less likely to own the vineyards they manage and, hence, to bear a personal share of any additional risk exposure.

Table 3. PMI Use Intensity by Selected Wine Grape Varieties

	Share of Growers	Correlation, PMI Intensity	Avg. $/ton 2007 †
WHITE			**$482**
Chardonnay	65%	0.18*	$718
Pinot Gris	34%	0.20*	$588
Sauvignon Blanc	49%	0.14	$687
Viognier	49%	0.03	$761
RED			**$626**
Cabernet Franc	29%	0.26*	$1,359
Cabernet Sauvignon	67%	0.21*	$989
Malbec	29%	0.19*	$1,117
Merlot	55%	0.08	$592
Petit Verdot	29%	0.27*	$1,214
Petite Sirah	39%	-0.02	$881
Pinot Noir	36%	0.18*	$2,094
Syrah	49%	-0.09	$660
Zinfandel	59%	-0.03	$467

† 2007 Grape Crush Report, California Dept. of Food and Agriculture
** Indicates significance at 10% level*

For Additional Information, the Authors Recommend:

Gubler, W.D., M.R. Rademacher, S.J. Vasquez, and C.S. Thomas. 1999. Control of Powdery Mildew Using the UC Davis Powdery Mildew Risk Index. http://www.apsnet.org/online/feature/pmildew/Top.html.

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Appellation, Variety, and the Price of California Wines

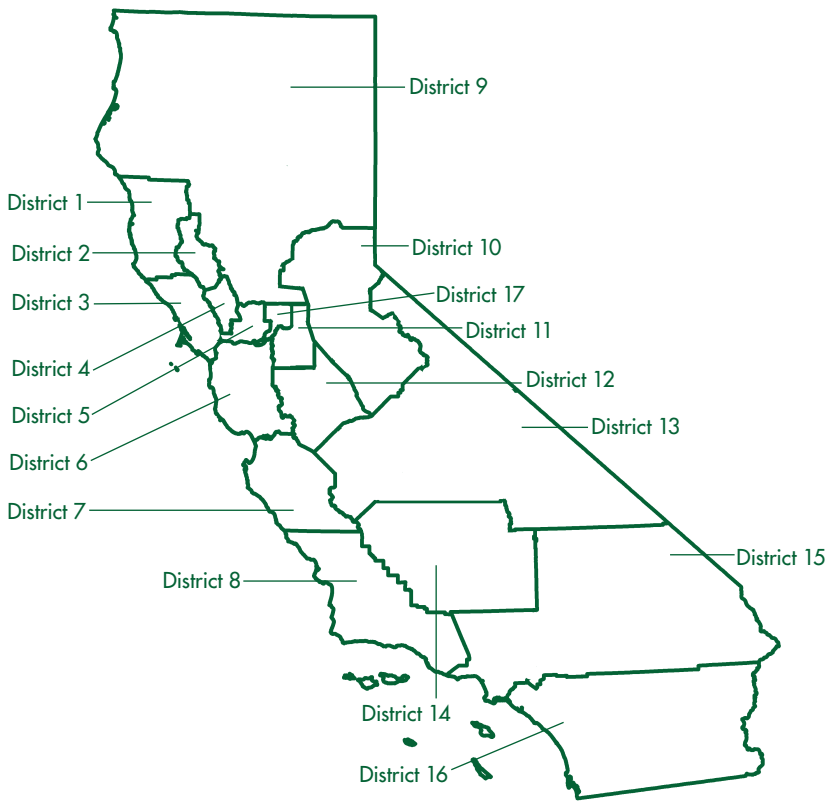
Oh Sang Kwon, Hyunok Lee, and Daniel A. Sumner

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 (%)

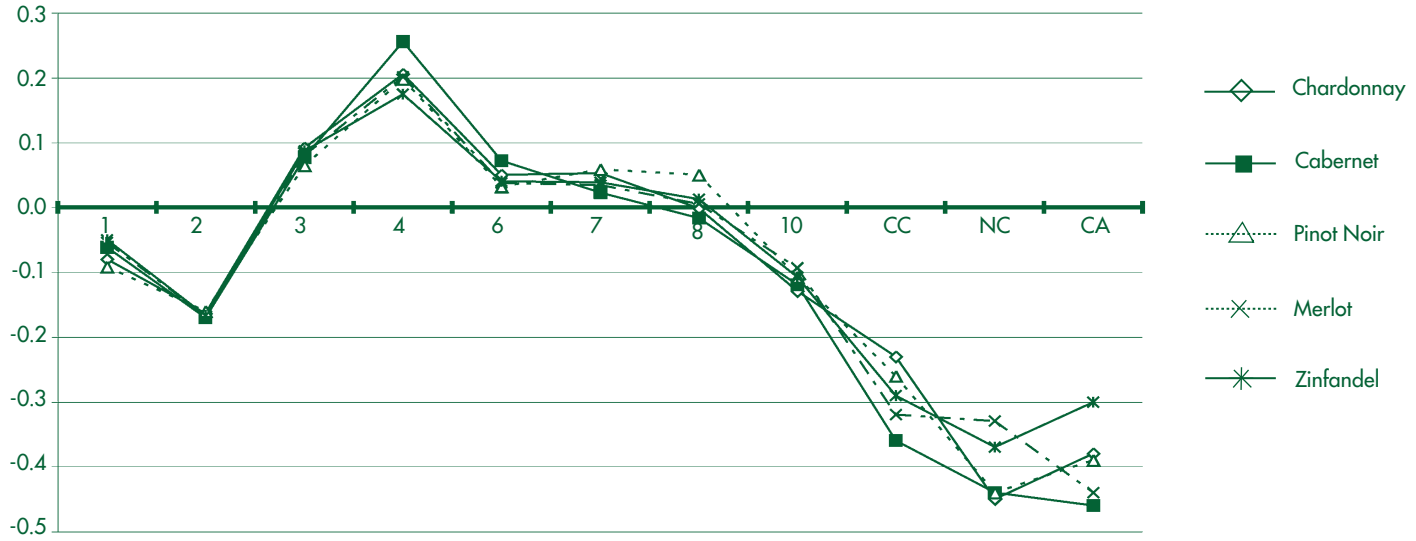
Crush District	Appellation	Cabernet	Chardonnay
4	Rutherford	45%(1)	34%(2)
4	Oakville	41%(2)	33%(4)
7	Mount Harlan	41%(3)	41%(1)
4	Diamond Mountain	38%(4)	33%(3)
4	Stags Leap District	37%(5)	29%(7)
4	Howell Mountain	36%(6)	33%(5)
4	Spring Mountain	30%(7)	26%(8)
6	Santa Cruz Mtns	30%(8)	8%(26)
4	Napa Valley	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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