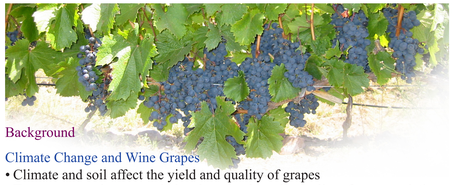

Economic Effects of Climate Change on California Wine Industry - Research in Progress

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Background

Climate Change and Wine Grapes

- Climate and soil affect the yield and quality of grapes
- Temperatures above certain level may reduce the quality of some varieties and at some point may not be suitable for some wine regions
- Climate change may lead to the outbreak of existing diseases, such as Pierce Disease and Downy mildew, as well as new diseases
- The impact of climate change is not likely to be uniform across all varieties and regions
- Adaptation may moderate the climate change effects

Why Grapes Are Different from Other Crops?

- Studies found that quality and yield of grapes depend upon the interaction among soil, topography, CO_2 levels and climate (Terroir)
- Wine grape growing regions are more restricted by the soil type and characteristics
- Different grape varieties require different average temperature for maturity
- High sensitivity to quality of grapes which affects the quality and price of wine. Average winegrape prices vary by climatic region from $150/ton to $3,000/ton in California

Why the Wine Industry is Important?

- About 4,600 Grape growers in California. Value of crushed grapes in 2005 $2.3 billion (crush report)
- California wine industry is ranked fourth in the global wine market (volume) (wine institute)
- About 2,300 wineries in California. Retail value of California wine industry is estimated $16.5 billion in 2005 (excluding export and direct sales) and export is estimated $670 millions (wine institute)
- Premium wine accounted for 66% of sales value (retail price above $7)
- Related industries may be influenced ('cluster effect')

Figure 1: Effect of Climate on Quality and Price of Wine

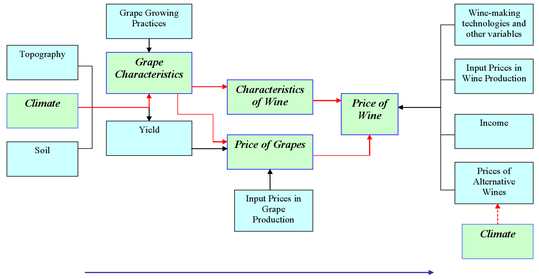


Figure 1 is a schematic description of the relationship assumed between climate and characteristics and price of wine. It is assumed that climate, topography and soil affect the characteristics and yield of grapes, which then affect the price of grapes and the characteristics of wine. Price of wine is affected by the wine characteristics and price of grapes as well as by other variables.

Project Objectives

- Estimate a relationship between climate and quality of extra premium wines in several top wine regions around the world. The estimation will be done by using hedonic model and historical data. Quality may be represented by wine scores
- Estimate the share of high-rated wines (e.g. score above 88) out of total wines produced in each region as a function of weather variables by using cross section and time series historical data
- Simulate the effect of climate change on the high-rated wines produced in each region in year 2050.
- Draw implications for wine and grape price, quantity and producer surplus (industry returns to inputs)

Map 1. France Wine Regions

Map 2. California - Sonoma and Napa Counties

Map 3. Australia - Adelaide Region (Barossa Valley)

Weather Data

Studies found that the average, minimum and maximum temperatures during the growing season (April-October in the Northern Hemisphere, October-April in the Southern Hemisphere) affect characteristic of grapes and wines. Figure 2 to Figure 6 below include average temperature data during the growing season for five wine regions that produce Cabernet Sauvignon or Pinot Noir starting from 1970 to 2005.

Figure 2: Napa, California

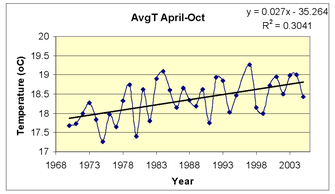


Figure 3: Sonoma, California

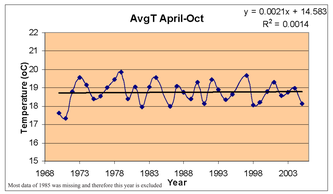


Figure 4: Dijon (Burgundy), France

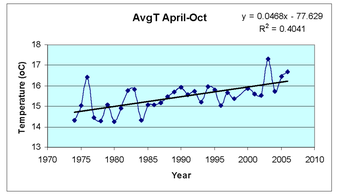


Figure 5: Merignac (Bordeaux), France

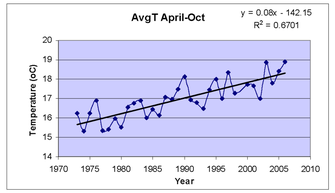
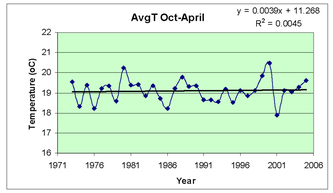


Figure 6: Adelaide (Barossa Valley), Australia



As presented above, climate change across these winegrape growing regions is not uniform (see trend equations). For example, during the last three decades average temperature in Bordeaux increased on average by 2.64°C, while in Napa it increased on average by 0.945°C and in Sonoma, on average, it didn't change. It is also important to consider the average change in minimum and maximum temperature during the growing season (see table 1). In some cases such as Adelaide, Australia and Sonoma, California, minimum and maximum temperatures changed but moved in opposite directions so on average, the average temperature does not change.

Table 1: Change in Temperature (°C) during the Growing Season from 1970 to 2005

	Average Minimum Temperature	Average Maximum Temperature	Average Temperature
Napa, California	1.281	0.5985	0.945
Sonoma, California	2.1	-1.9845	0.0735
Dijon (Burgundy), France	0.6496	2.4576	1.4976
Merignac (Bordeaux), France	2.9799	2.4879	2.64
Adelaide (Barossa Valley), Australia	-2.9696	2.7264	0.1248

Climate and Grape Characteristics

Each winegrape variety requires certain climate conditions in order to produce grapes and wines that are considered by consumers, high quality. Cabernet Sauvignon is usually grown in relatively warmer climate regions. Some of the best Cabernet is grown in Napa, California; Sonoma, California; Bordeaux, France; and Barossa Valley, South Australia. Pinot Noir variety is typically grown in relatively cooler regions. Some of the top Pinot Noir regions are Burgundy, France; Sonoma, California; and Barossa Valley, South Australia. Since these regions are know for their high quality wines, it is assumed that Cabernet Sauvignon and Pinot Noir are grown in the optimal climate range required for achieving high quality. Increase of average, minimum, and maximum temperatures across winegrape growing regions may reduce the suitability of growing these premium varieties in regions that grow them decades and even hundreds of years.

Figure 7: Illustration of Current Average Temperatures in Several Regions and Required Climate Conditions for Premium Quality Cabernet Sauvignon

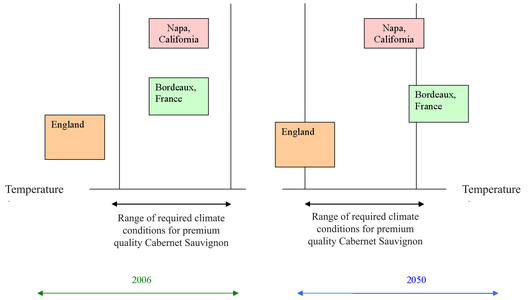


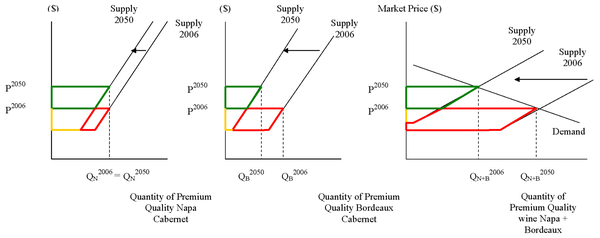
Figure 7 illustrates a hypothetical situation that presents the optimum growing conditions for premium quality Cabernet Sauvignon and the average temperatures in several regions in 2006 and in 2050 (illustration only). In 2006 Napa, California and Bordeaux, France are within the range of the optimum temperatures for growing premium quality Cabernet. England does not have the required climate conditions for growing premium quality Cabernet. However, it may be possible that by 2050 climate conditions in England will allow growing premium quality Cabernet while Bordeaux will almost be unsuitable for growing it. Bordeaux growers may adapt and start growing varieties that are more suitable for the warmer conditions.

Hypothesized Effect of Climate Change on Producers of Premium Quality Cabernet in Bordeaux and Napa

Historical data shows that the average temperature in Bordeaux increased by 2.64°C during the last three decades while in Napa average temperatures increased only by 0.945°C during the same period. As shown in Figure 7, in 2050, Bordeaux climate conditions may no longer be suitable for premium quality Cabernet.

Figure 8 illustrates an example of a potential climate change effect on producers' surplus (industry returns to inputs) of premium quality Cabernet in Bordeaux and Napa. Based on historical data we assumed that both Napa and Bordeaux will experience warming such that their marginal cost production of premium wine grapes will rise. Given rise in marginal costs in both regions price increases. As drawn, costs rise more in Bordeaux than in Napa and the price increase more than offsets the cost increase for the Napa industry.

Figure 8: Theoretical Effect of Climate Change on Producers' Surplus



Bordeaux's supply curve shifts in more than Napa's supply curve, as it experiences higher increase of average temperatures. Although the supply curve of both regions shifts in, Napa gains from the shift while Bordeaux loses. Producer surplus of Napa premium Cabernet producers increases while it decreases for Bordeaux premium Cabernet producers. The green area in the graph represents the gain in producers' surplus due to price increase and the red area in the graph represents the loss of producers' surplus due to rise of costs. In the case of Napa, the green area (gain) is larger than the red area (loss) and therefore Napa has a net gain. However, in the case of Bordeaux, the green area (gain) is smaller than the red area (loss) and therefore Bordeaux has a net loss.

Note: Figure 8 presents only a potential scenario of the effect of climate change on wine industry producers' surplus. This example considers only the effects of hypothetical climate projections. In addition, this illustration does not include other current Cabernet growing regions or regions that may be suitable for growing Cabernet Sauvignon by 2050.

Project Limitations

1. Hard to extrapolate future effect of climate from historical data. Projection model results lack consensus and are not specific to wine growing regions.
2. Several levels of uncertainty:
   - Scope of climate change.
   - The agronomic effect of climate on charecteristics of grapes is not completely known.
   - Hard to predict which new regions may produce extra quality wines. Even if there is no uncertainty regarding climate change scope, other geographical variables such as soil and topography affect the charecterisitcs of grapes and should also be included in the analysis.
3. Price prediction. Other forces in the extra premium wine market may effect prices and cannot be isolated.