AMERICAN ASSOCIATION OF WINE ECONOMISTS

AAWE WORKING PAPER
No. 9

Editor
Victor Ginsburgh

RED, WHITE AND “GREEN”: THE COST OF CARBON IN THE GLOBAL WINE TRADE

Tyler Colman
Pablo Päster

October 2007

www.wine-economics.org

Red, White, and "Green": the Cost of Carbon in the Global Wine Trade

Tyler Colman
New York University
DrVino.com
thc3@nyu.edu

Pablo Päster
Sustainable Solutions Group, URS Corporation
Pablo_Paster@URSCorp.com

Abstract: Climate change is altering a wide range of human activities, including wine making. While wine may appear to be one of the most natural alcoholic beverages, it is not without carbon inputs and emissions, which contribute to the very change in climate that is altering both wine and wine making. In this paper, we use a carbon life cycle analysis to develop a model for quantifying carbon inputs in a bottle of wine. Current regulatory arrangements do not capture the carbon costs of wine effectively since most costs are externalized. We conclude with estimates of the cost of carbon under various regulatory regimes, which suggest how wine producers and consumers can reduce the carbon footprint of wine.

I. Introduction

The world's vineyards are getting warmer. England, known in Adam Smith's day for trading wool for wine, is now not only making wine, but making wine that the critic Jancis Robinson calls "far from a joke now" (Robinson 2007). Even Germany's Mosel Valley, which was previously the northern limit of quality wine production, has seen temperatures on the hillside vineyards rise with a concomitant increase in wine quality and vineyard prices, as Ashenfelter and Storchmann have demonstrated (Ashenfelter and Storchmann 2006). During the 1960s and 1970s in Bordeaux, vintages used to fluctuate between awful and outstanding but, for the last decade, the range has been almost exclusively between very good and outstanding.[1] And in presently hot areas of grape cultivation, such as California and Australia, climate change has led to rising alcohol levels in wines and irrigation issues in the vineyard. Some atmospheric scientists even predict the virtual eradication of the current premium American vineyards over the next century (White et al. 2006). The issue of *terroir*, or using the vineyard site as the key explanatory variable for determining a wine's quality, appears under threat from a shifting climate.

While many industries have a significant impact on global climate change, the wine industry is not innocent from altering vineyard microclimates. Most industries benefit from public goods such as natural resources, ecosystem services, and clean water, but they also incur costs that are passed on to society. These externalized costs include non-product output such as carbon dioxide ($CO_{2)}$ emissions, chemical effluent, and other wastes that contribute to the global tragedy of the commons. Understanding the type and magnitude of these externalities helps prepare companies and industries for potential impacts from regulation on such externalities (such as California's AB32), helps promote accountability to consumers, and helps to identify opportunities for innovation and cost-savings.

In this paper we calculate the carbon life cycle of wine. As wine producers become more aware of carbon use and emissions from their industry, they tend to focus only on the vineyard and the winery for emissions reductions. Here, we go beyond that to

---

[1] Changes in wine making partially explain this phenomenon. But the weather also has played a role as Marcel Ducasse, winemaker for 20 years at Chateau Lagrange in St. Julien, was adamant to underscore on his farewell stop in New York City on January 18, 2007.

include the crucial issue of transportation. Thus, this paper also contributes to the debate about "food miles," a shorthand way of telling the consumer about the "carbon footprint" of food transportation. In January 2007, the British retailer Tesco announced that every product sold would have a "carbon rating" displayed on its label (Rigby, Harvey, and Birchall 2007). Tesco is opening its first retail stores in the US later this year, with promises to "outgreen" Whole Foods Market (Birchall 2007). Saunders and Barber (Saunders and Barber 2007), agricultural economists from Lincoln University in New Zealand, argue that it is not the number of miles that food travels that is most critical in determining its carbon footprint, but whether organic practices are used. They found that organic lamb from New Zealand sold to British consumers used less carbon than conventional lamb grown in Britain. We examine the role of organic viticulture and compare it to conventional standards to determine whether organic methods override transportation components.

A growing, global wine market

America has developed a thirst for wine in recent decades. While milk and water originally gave way to soda and juice on American tables, wine has been the latest beverage to capture the attention of Americans. The American wine market will become the largest consumer of wine in the world, surpassing France and Italy as early as 2008 (American per capita consumption is still relatively low, which could set the stage for stronger overall growth). Fully 49% of table wines in the United States sell for below $5. "Premium" ($9 - $16 per bottle) and "ultra-premium" ($16+) wine comprise 24% of the market according to Adams Wine Handbook 2006.

Americans are willing to pay, and producers in California, who account for 90 percent of American wine, have heard the call. Starting in the early 1990s and snowballing into the new millennium, boutique wineries have set up ambitious plans to make high quality wines, sold in limited quantities directly to the consumer. Cutting out the economic inefficiencies of the distribution system can almost triple profits, so many small wineries exclusively implement this sales channel to hasten a return on capital, a process that may externalize additional environmental costs.

Wine is also an important product in world trade, with the United States and the United Kingdom being the largest importing countries. The UK imports practically all of the wine it consumes. By contrast, about two-thirds of the wine consumed in the US is also made in the US, although that percentage has been falling as imports have come to play a more important role (2006). Today, the most important foreign country to provide wine to the US market is Australia; no brand is more prevalent than Yellow Tail. Started in 2001 with an already large production of 250,000 cases, the brand has grown exponentially and is expected to surpass the 10 million case mark in 2007, making it the largest wine brand.

In the next section, we discuss the assumptions behind our carbon calculator. Then in section three, we study the journey of three wine bottles including a boutique American winery, Yellow Tail, and an organic wine from France and derive a carbon figure for each path. Finally, we provide an estimate for carbon intensity in the global wine trade. We conclude with suggestions for policy makers, wine makers, and wine consumers.

II. The Carbon Calculator

To quantify the carbon emissions of a bottle of wine we have developed a model, whose variables can be easily changed to compare various production and transportation scenarios. The model begins with the carbon emissions related to the cultivation of grapes, including the production of agrichemicals and the combustion of fuel. Next, we consider the CO_2 emissions from fermentation, based on the sugar content of the pressed grapes, the production and transportation of the barrels and bottles, followed by the shipping of the final product.

While several other externalized costs are associated with the wine industry including habitat and land use, labor rights, and chemical application issues, in this study we discuss only the greenhouse gas emissions from wine production and distribution (2001). All results, unless stated otherwise, are in terms of carbon dioxide equivalents (CO_2e). This measure accounts for the varying global warming potential (GWP) of different gases; methane (CH_4), for example, has a GWP over 23 times that of CO_2.

Compared to many other crops, grapes yield relatively little output per hectare. Grapes considered in this study yielded between 400 and 800 kilograms (kg) per hectare, whereas corn can yield between 30 and 80 metric tons per hectare.[2] Grapes require between 50 and 100 kg of agrichemicals (biocides and fertilizers) per ton while corn requires around 40 kg per ton. Grapes can also require a large amount of water relative to their output; between 1.2 and 2.5 megaliters per hectare, or 550,000 liters per ton. Not only does this water use potentially lead to the depletion of local aquifers, but it also requires energy for pumping, and carries excess agrichemicals into riparian ecosystems. The exact amount of water used depends highly on local climate, regulatory laws, preferences of vineyard managers, and weather patterns; it is certainly an issue of great concern in Australia where this year's drought resulted in a complete loss of the grape harvest in some areas.[3] As global climate change becomes more severe, some areas may experience prolonged drought while others will suffer constant floods and there will be increased volatility and uncertainty in climate patterns. White et al. have predicted a decline of potential premium winegrape production area in the conterminous United States by 81 percent in this century as a result of climate change (White et al. 2006).

Fossil fuel combustion is by far the largest anthropogenic contributor to the rise in atmospheric CO_2 levels. Wineries tend to use mechanized equipment less intensely than field crops but the fuel used is still 130 liters per ton, compared with 22.7 liters per ton for corn. The combustion of fossil fuels such as diesel and gasoline creates about 3 kg of CO_2 per kg of fuel. Electricity and natural gas use in wineries contributes over 100 grams (g) of CO_2 per bottle of wine. The California electric grid emits about 0.51 ton of CO_2 per megawatt-hour, while grid energy in other parts of the world ranges widely, depending on the energy production portfolio mix.

Crushed grapes have a sugar content of between 22 and 28°Bx (°Bx or Degrees Brix is a measurement of the mass ratio of dissolved sucrose to water in a liquid; (Boulton and Vernon Singleton 1996). In recent years wine makers have been harvesting

---

[2] UC Davis Cost Studies, http://coststudies.ucdavis.edu/

[3] http://www.terradaily.com/reports/Australian_Drought_Turns_To_Flood_As_California_Dries_Out_999.html

later, yielding a higher sugar content. Since we know the sugar content of the crushed grapes, we can use simple chemistry to determine the amount of CO_2 produced in the fermentation reaction. Glucose is converted into two molecules of alcohol and two molecules of CO_2, as shown in the following equation:

$$C_6H_{12}O_6 \rightarrow 2(CH_3CH_2OH) + 2(CO_2)$$
Glucose -> Alcohol + Carbon Dioxide

Glucose has a molecular weight of 180.16 $g \cdot mol^{-1}$ and CO_2 has a molecular weight of 44.01 $g \cdot mol^{-1}$. Since two CO_2molecules are created from every glucose molecule, we know that 180.16 g of glucose yields 88.02 g of CO_2. This yield represents a 48.86 percent conversion ratio (88.02 g / 180.16 g) so that 1 liter of juice at 22°Bx (22 percent glucose, by weight) releases 107 g of CO_2.

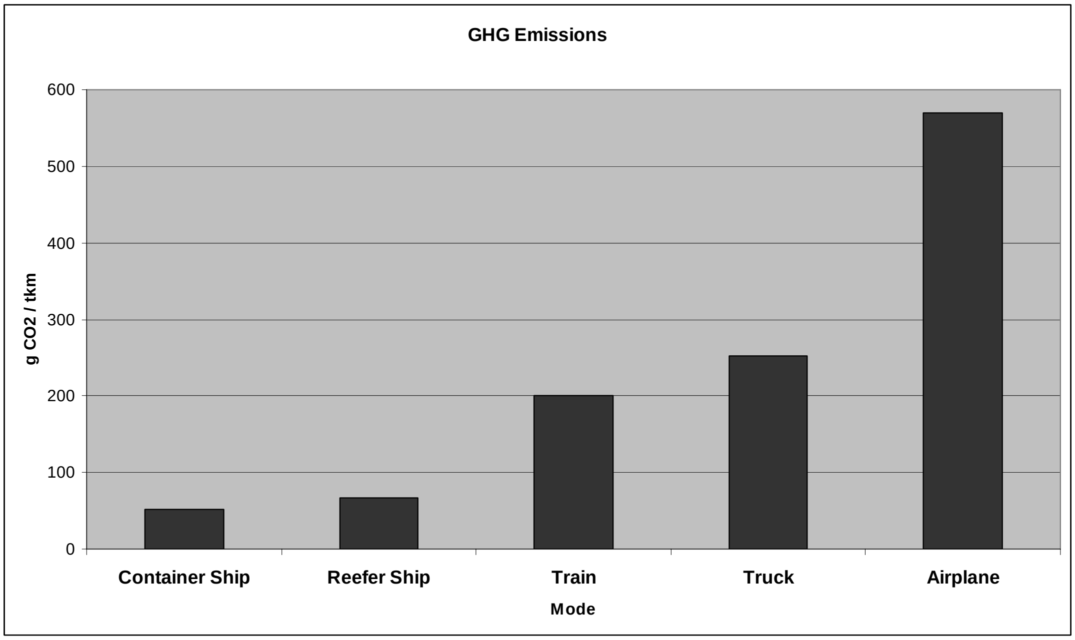
While this amount represents the very real emissions of a greenhouse gas, the net impact of grape cultivation and fermentation is negative: grape vines sequester CO_2 that they then convert into glucose and cellulose. While some carbon is partially converted into biomass and locked away it will be mostly released as CO_2 or CH_4 when the plant decays at a future date. The carbon in the glucose will return, almost completely, to the atmosphere during fermentation. Since small amounts of carbon may remain sequestered in biomass, soil, or residual sugars in the wine the overall long-term carbon balance of fermentation is negative. The CO_2 emitted during fermentation represents less than 3 percent (around 100 g) of the overall CO_2 emissions resulting from the production and delivery of one bottle of wine.

While many French vineyards have been established for hundreds of years, vineyards in other countries, such as in the Napa Valley of California, are being established on recently forested land. An increase in demand for California wines has meant that some crop fields are also converted for grape cultivation. Due to the increase in global demand for wine, new crop is being planted on land that was previously used otherwise in a natural state. Much of this land is being converted from prime agricultural land or from forest. California land that is switched from annual crops to vineyards sequesters 68 g $CO_2 \cdot m^{-2} \cdot yr^{-1}$(Kroodsma and Field 2006). Such a land-use change can decrease that parcel's ability to sequester $CO_2$and the burning or decay of the removed biomass contributes $CO_2$and CH_4 to the atmosphere. Converting marginal agricultural land, or land that has been overgrazed, may actually help restore a healthy balance to the local ecosystem by increasing the biological productivity of the area, but not as much as restoring it to its natural state. Allowing native or adapted cover crops to grow among the grape vines, maintaining or planting hedgerows, seeding unpaved roadways and other areas, and planting trees and shrubs can increase carbon sequestration. Also, avoided tilling decreases the return of carbon to the atmosphere from decomposing plant matter.

The greatest climate impact from the wine supply chain comes from transportation. This transportation impact begins with the delivery of agrichemicals, barrels, and bottles, but is primarily accumulated during the final product shipment to the customer. While unrefrigerated container shipping is most efficient, it also takes a long time. And air cargo, which can deliver product to virtually any destination around the world in a matter of hours, has an emissions factor of over 11 times that of container shipping. Emissions factors for cargo are in terms of $g \cdot t^{-1} \cdot km^{-1}$, or grams of CO_2e per ton of cargo per km transported. The emissions factor applied for container shipping is 52.1 $g \cdot t^{-1} \cdot km^{-1}$ (CE Delft 2006). The trucking emissions factor used is 252 $g \cdot t^{-1} \cdot km^{-1}$, and trains emit 200 $g \cdot t^{-1} \cdot km^{-1}$(GHG Protocol).[4] The emissions factor used for refrigerated container shipping is 67.1 $g \cdot t^{-1} \cdot km^{-1}$ (2003). Finally, we use 570 $g \cdot t^{-1} \cdot km^{-1}$ for air cargo (CE Delft 2006).

[4] WBCSD/WRI GHG Protocol.

Figure 1. Comparative cargo emissions



To make a premium wine, many winemakers around the world choose barrels made from French oak. The forests in France, the Limousin and the Troncais, are almost entirely state-managed and the average age of these trees is 170 year but, since the forest is managed, the net carbon impact of harvesting the old oaks is beneficial. This outcome is because removing an old, slow-growing tree makes room for a young, fast-growing tree that will sequester carbon at a higher rate for the first 20-30 years. While often shipped in pieces and assembled at their destination, the barrels often travel very far, only to be used a few times before being replaced. Our calculator assumes a 50 kg barrel that will hold 225 liters. The barrel is trucked 500 km to Le Havre, a deep-water container port on France's northern coast. From there it will continue to its destination by container ship, then train, and/or truck.

Glass bottles are made of 70 percent silicon dioxide, from highly abundant and inexpensive quartz sand. This relative abundance and low cost mean that it is often more economical to produce virgin glass from regionally available raw materials than it is to transport used glass over long distances for recycling. It is therefore assumed that most wine bottles are made from 100 percent virgin materials. In our calculations, we use the emissions factors of 0.4467 g CO_2e per gram of recycled glass and 0.716 g CO_2e per gram of virgin glass (2003). Since a recent correlation tends to exist between the value of a wine and the mass of its bottle, the climate impact of making and transporting the bottles, as well as the final transportation to the customer tends to be more for high-end wines in thicker bottles.

Some wineries ship in bulk and bottle the wine closer to the consumer. For example, the Norwegian state-owned monopoly, Vinmonopolet, buys wine in bulk for bottling in Norway. The negociants of Bordeaux traditionally sent a large portion of their wines to England in barrels, although the rise of "mis en chateau" bottling in the 1970s reduced this method for the region’s top wines. Patrick Campbell of Sonoma's Laurel Glen makes a wine in Mendoza, Argentina, which he ships in 23,500-liter stainless steel tanks and then bottles in California. This method cuts down the amount of nonproduct, the bottle glass, being shipped over great distances and, therefore, reduces the transportation emissions by between a third and a half, depending on bottle weight. Other options for decreasing transportation weight and reducing packaging weight include boxed wines, polycarbonate bottles, and even the milk-carton-like Tetra-Pak, which are gaining prevalence, if not popularity in Australia, the US, and even France.[5]

III. The life Cycle of Three Bottles of Wine

To see the carbon calculator in action, we put three bottles of wine to the test. Although we could run a multitude of possible configurations, we decided to run three likely cases to show carbon emissions. We sought to have variation in terms of organic and conventional viticulture, as well as a variety of transportation options and distances. Because these factors all vary by the point of final consumption, we held them constant and assumed all bottles were served in Chicago, a top five American market for wine.

[5] The relative environmental impact of corks versus screwcaps is minimal since both materials are extremely light weight. Because of this we use *de minimis* exclusion to disregard the relatively negligible impact of bottle closures. The cork industry is generally environmentally sustainable because it maintains large areas of forested land which could be otherwise used for development or environmentally less favorable forms of agriculture that may require high levels of agrichemicals and water.

Since scant wine is made near Chicago, the choice of Chicago does not favor either coast and the efficiencies of container shipping.

Yellow Tail, a top global wine brand, is the first bottle we examined. The Casella family owns the winery where Yellow Tail is made in Yenda, New South Wales, and grapes come from all over the country to make the approximately 12 million cases sent around the world. Part of the wine's initial success was the simplicity of the product offering: Chardonnay and Shiraz in 750 milliliters (ml) and 1.5 liter bottles. The wines are made using conventional viticulture, the glass is sourced locally, and no oak barrels were used in the production of the wine.

According to W. J. Deutsch, the US importer who owns 50 percent of the brand in North America, the wine is packed efficiently into containers, wrapped in an insulatory blanket, trucked from Yenda to a port, and loaded onto a container ship.[6] The Pacific journey takes about 33 days to Los Angeles (although ports on the Eastern seaboard are used in the summer months). From there the container is loaded on a train or truck and sent to Chicago. The total carbon emitted in transporting a bottle of Australian wine to Chicago is 2.2 kg. However because the 1.5 liter bottles involve shipping 4 kg less glass per case for the same amount of wine, the embodied carbon of a magnum of Yellow Tail is less, 2.0 kg per 750 ml (4.0 kg per 1.5 liter magnum). The total carbon emissions from the production and distribution of one bottle are 3.44 kg.

The second bottle of wine is a wine from Coulée de Serrant in the Loire. Nicolas Joly owns the property and makes the wine. With an MBA from Columbia University, Joly first started working in investment banking. But he returned home to Savennières in the Loire to take over the wine making from his mother. In the early 1980s he had a transformation to biodynamic viticulture, a form of organic agriculture, and maintains a small amount of diverse animals on the property to provide natural fertilizers and pull the till. Since then he has become a leading international figure for biodynamic wine makers

[6] Details from telephone interview with Kelly Cox of WJ Deutsch, July 25, 2007.

and wrote the leading book on the subject.[7] His vineyard is widely considered to be one of the best in the Loire.

While the organic viticulture may have a decreased impact on local riparian habitat, the relative difference on carbon is small since fertilizer and biocide usage is much less per hectare for grapes than it is for other, higher yielding crops. While many other environmental factors are involved in the organic vs. conventional debate, it appears that greenhouse gas emissions play a relatively minimal role.

According to Vintus,[8] the American importer of Joly's wines, the wines are picked up by a climate-controlled truck at the property and taken to the port of Le Havre, where the wines may be combined with other wines in the importer's portfolio, such as Champagnes. All the wines continue in a refrigerated container across the Atlantic and are off-loaded into a cooled warehouse in New Jersey. Then the Illinois distributor sends a truck and returns full of this and other wines. It is then dispatched from the local warehouse to restaurants and shops. The embodied carbon of this bottle is 2.12 kg.

The third bottle comes from a hypothetical cult winery in Napa practicing sustainable agriculture (limited petrochemical inputs). This bottle is by far the heaviest of the three. The production is limited so the winery finds the most profitable sales channel to be selling directly to the consumer through a mailing list. All shipments are assumed to be sent via overnight express delivery given the desire to limit temperature fluctuations on the wine. The total carbon of this bottle is 4.5 kg, primarily due to the heavy weight and shipping by air.

To consider other options, we calculated two other scenarios. In the first, a half bottle (375 ml of wine) makes its way from Bordeaux to Chicago. Because of the glass to wine ratio, this wine has a large carbon figure of 4.6 kg (normalized to 750 ml). Second, the wine Mendoza that is shipped in a bulk tank and bottled in California, then sent to Chicago by truck is much less carbon intensive than many wines from south of the

---

[7] Joly, Nicolas. 1999. *Wine from Sky to Earth: Growing & Appreciating Biodynamic Wine*. Austin, TX: Acres USA.

[8] Telephone interview, July 23, 2007.

equator with a total of 2.23 kg. These scenarios are plotted on Figure 2. Next we held the mode of transport constant (container and truck) from Australia, France, and California to San Francisco, Chicago, and New York in Table 1 to provide an overview of the impact of transportation miles to various wine-drinking markets.

Figure 2. The carbon intensity of several different wines (normalized to the 750 ml bottle, grams of CO2/tkm)

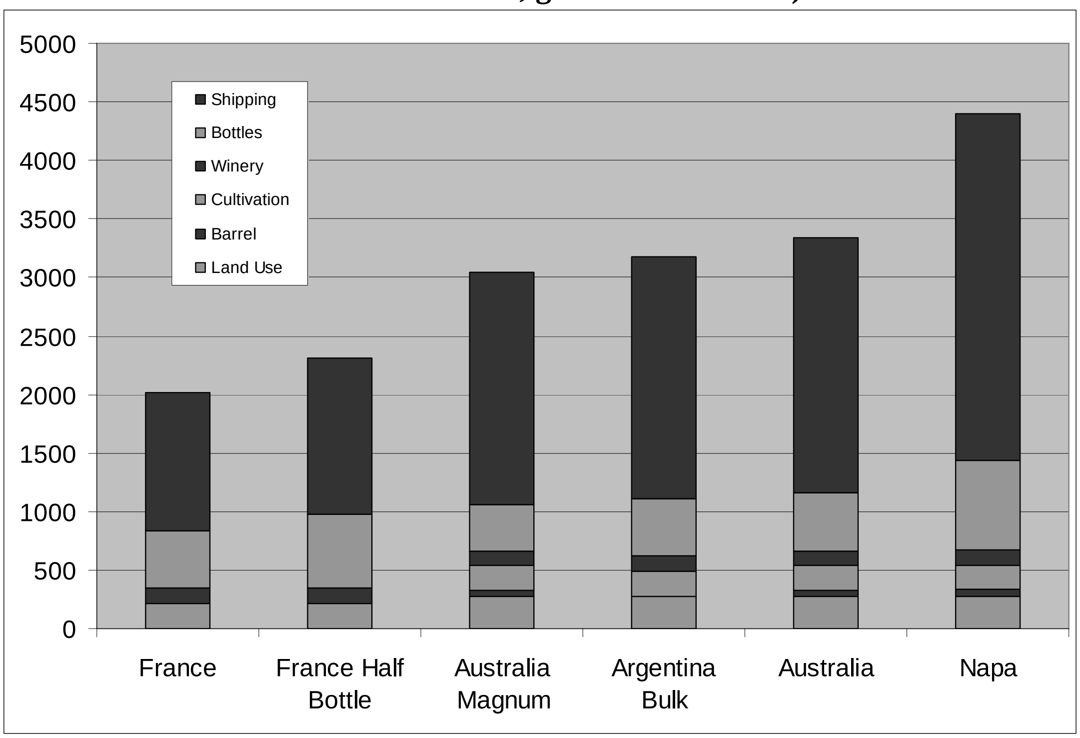


Table 1
Comparison of carbon intensity: a sample of select routes (in grams of C02)

	SF	Chicago	NY
Napa	1201	2243	2651
Australia	2567	3601	4017
France	3227	2117	1811
Argentina Bulk	1701	2730	3178

IV. Discussion and conclusions

These findings have several conclusions for economists, producers, and wine consumers. For economists, while the greenhouse gas emissions from the production and distribution of wine currently are without consequence, this situation may change in the future. Upstream industries such as power generation and downstream industries such as transportation will likely be regulated on their carbon emissions in the future, if they are not already. This regulation, typically through a cap-and-trade scheme such as the European Union's Emissions Trading Scheme imposes costs on less efficient companies as they must purchase additional emissions credits from more efficient companies. Doing business with the more efficient companies will result in a certain degree of insulation from price volatility.

Assuming average greenhouse gas emissions of 2 kg per liter and a global production volume of 2,668,300,000 liters in 2001,[9] the global GHG emissions from wine production and distribution are 5,336,600 tons. If the total global anthropogenic GHG emissions are 6.3 billion tons, the production and distribution of wine represents 0.08 percent of global GHG emissions. While this percentage seems small, it is equivalent to the fossil fuel combustion emissions of roughly 1,000,000 passenger vehicles over a year.

[9] http://www.wineinstitute.org/communications/statistics/keyfacts_worldwineproduction02.htm

As domestic and international regulatory paradigms advance either carbon trading markets or a carbon tax is likely to play a greater regulatory role--or even a combination of the two. Exactly how these schemes will materialize, who wins and who loses, and what effect they will have is highly dependent on the perceived urgency of the climate change matter coupled with sufficient political will.

In both systems, negative externalities such as greenhouse gases and acid rain are given a monetary value, thereby internalizing them, in order to efficiently allocate these scarce "bads." This scarcity stems from a government setting a "cap" on emissions and encouraging the "trade" of emissions credits. However this government-imposed cap is highly subject to influence from political agendas, rather than scientific calculations. Such a market failure occurred in the European Union Emissions Trading Scheme (EU ETS) recently when the regulators over-allocated emissions credits. This resulted in great profits for utility companies as they sold off their surplus credits and, ultimately, a crash in the market. Currently market prices per ton of CO2 in the voluntary Chicago Climate Exchange are around $3.50, while the price in the mandatory markets in the EU is above 20 **€** ($27.75).

Since emissions trading schemes are aimed at the largest emitters of greenhouse gases, such as power plants and refineries, the wine industry may escape direct carbon emissions regulation. More likely, however, is that it would be indirectly affected as upstream suppliers of electricity and agrochemicals and downstream suppliers such as transportations services become regulated, to the degree which they are dependent on fossil fuel energy. Suppliers that use renewable resources will have far smaller GHG emissions. While organic agriculture does not have a significant impact on the emissions inventory of wine production the cost of conventional agriculture will be more impacted by future cost increases in fossil fuel-based fertilizer and biocides.

Another option for regulating carbon emission comes from government setting a price, rather than a volume. Although this carbon tax may have once seemed far-fetched, the idea has been recently been suggested by a surprisingly wide array of politicians and economists such as Al Gore, Barack Obama (who supports an aggressive form of cap-and-trade), George Osborne (Britain's Shadow Chancellor of the Exchequer), and Gregory Mankiw, former chairman of the Bush Council of Economic Advisers (Mankiw 2007; Osborne 2007). Such a carbon tax could be applied at the supplier (and major emitter) level, such as in emissions trading, or it could be applied at the consumer level whenever fossil fuel-based products are purchased. The impact on the wine industry would not differ much between the two different schemes, emissions or taxation. What is clear is that the additional cost at present is felt only by those companies that offset their emissions voluntarily and that future cost increases due to emissions reduction efforts will be proportional to the fossil fuel dependence of a supply chain.

While a direct carbon tax has logistical challenges and major elections have not been fought with the issue in play (though growing in the wake of Al Gore's Nobel Prize, it may play an increased role in the 2008 presidential race), the cost of these carbon emissions can be calculated. Since any additional emissions today increase the amount we must reduce our emissions at some future date, we can think of today's emissions in terms of tomorrow's mitigation costs. If a federally legislated carbon cap-and-trade system comes into place in the United States the price of carbon will mirror the lowest-cost mitigation measure. As carbon-reduction measures and technologies become widely adopted and reductions are realized, the price of carbon will increase to the cost of the next technology. The most costly, yet effective, carbon mitigation technology is carbon capture and sequestration (CCS). CCS, which essentially captures power plant CO_2 emissions and pipes them deep underground where they are again locked away, comes at a cost of between \$30 and \$40 per ton. At this price the current cost of the global wine industry's greenhouse gas contribution is \$3.33 and \$4.44 billion per year. Table 2 presents data on various levels of carbon pricing and the cost for a bottle of wine.

Table 2. Potential carbon tax impact at various cost/ton levels

Scenario	Cost/Ton	Range (g of CO2e) 2000	-	4500
Current Chicago Climate Exchange Price	\$2.35	\$0.005	-	\$0.011
Proposed Sen. Bingaman "Safety Valve"	\$7.00	\$0.014	-	\$0.032
Current EU Climate Exchange Price	\$28.87	\$0.058	-	\$0.130
Current "True Cost" of Carbon[1]	\$45.00	\$0.090	-	\$0.203
Social Cost of Carbon[2]	\$142.68	\$0.285	-	\$0.642
Arbitrary Upper Limit	\$500.00	\$1.000	-	\$2.250

1 UN Estimate of damages (\$60B in 2003) ÷ Annual Global Emissions

2 http://socialcostofcarbon.aeat.com/

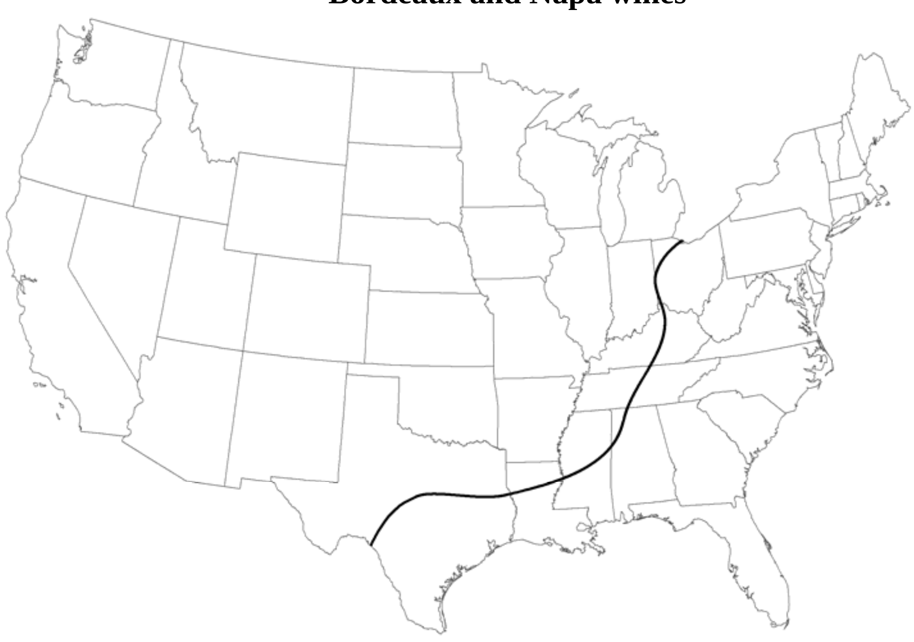
Such a cap-and-trade tax on wine would have two implications. First, it would be regressive since low-priced wines would be taxed at a higher percentage. Granted, the tax would be about \$0.12 per bottle, but as a percentage of final retail price, that affects the low-end to a greater extent on a percentage basis. Second, and paradoxically, it is many of the high-production, low-end wines that have the greatest economies of scale, use the least refrigeration in transit, use the lightest bottles and, therefore, have the lowest carbon inputs and emissions per ounce of wine but would be taxed the most.

For example, wine in the \$3-7 range, such as Turning Leaf Merlot, has an own-price elasticity of -5.7, meaning that quantity will decrease by 5.7% for every 1% increase in price (Cuellar, Lucey, and Ammen 2006). Assuming a bottle of \$4 wine with a carbon tax of \$0.12, or a 3% increase in price, the demand would decrease by over 16%. On the other hand, a high-end wine may have positive a much lower elasticity, where an increased price due to a carbon tax would not greatly affect sales.

Wine producers can minimize the carbon impact in the winery and the vineyard following several conclusions that flow from this analysis. First, cutting down forest or converting highly productive farmland to vineyard should be avoided but converting overgrazed land may have a positive impact on restoring some biological productivity to a parcel. Second, minimize agrichemical use. Third, improve irrigation to maximize water efficiency. Fourth, use imported oak barrels longer, switch to local oak barrels, use oak chips, or, most sustainable of all, use no oak. Fifth, improve the efficiency of winery operations and use renewable energy and biofuels. Sixth, procure recycled-content bottles, manufactured regionally or consider non-glass packaging options. Seventh, reduce shipping distance and select the most efficient mode possible, which means not shipping by air. Finally, once all economically feasible carbon emissions mitigation measures have been put in place, purchase verified carbon offsets for all remaining activities.

For the enophile, the conclusions are not always friendly since quality and greenhouse gas emissions are frequently—but not always—at odds. Sending French oak barrels and empty glass bottles to the Southern Hemisphere for high alcohol wines may make wines that are very much in vogue, but they do have an increase in the embodied greenhouse gas emissions in each bottle.

Figure 3
US Map Showing the Approximate GHG Breakeven Point between Bordeaux and Napa wines



Regarding the food miles debate, our results confirm that the carbon inputs of transportation support the finding that distance matters but mode of transport is still key. While "drink locally" is one finding that may not be problematic for residents of California or Bordeaux, it may give New Yorkers or Miamians pause. However, not all miles are the same, since shipping is better than trucking, which in turn is better than air freight, and packaging matters too. As a result, of our three bottles, despite coming from half-way around the world, consuming a glass of wine from a magnum of Yellow Tail has a third less carbon emissions per once than a cult winery from Napa. But the sheer distance hurt the Australian wines and even the Argentine bulk wines as the shorter journey favored the French wine. However, half-bottles increase the glass-to-wine ratio and thus increase the carbon intensity.

To underscore the fact that not all transportation miles are alike, many New Yorkers may be surprised that holding bottle mass constant, it is more “green” to drink wine from Bordeaux (1.8 kg) with a long sea voyage as opposed to a wine from Napa (2.6 kg) with a long truck trip. In fact, efficiencies of shipping drive a “green line” all the way to Columbus, Ohio, the point where a wine from Bordeaux and Napa has the same carbon intensity. Were a carbon tax ever imposed at a meaningful rate, it would have a decidedly un-nationalistic effect for consumers to the east of Columbus, Ohio. Because shipping wine is often really about shipping glass with some wine in it, the bigger the bottle, the smaller the carbon impact per ounce. Of course, wine consumers can give up bottled water, charcoal grilled steaks, driving to work to offset wine consumption—or purchase their own carbon offsets. Is that the price of enjoying wine with a green conscience?

References

2001. Climate Change 2001: Working Group I: The Scientific Basis: United Nations Intergovernmental Panel on Climate Change.

2003. Material intensity of materials, fuels, transport services. Wuppertal, Germany: Wuppertal Institute.

2006. The U.S. Wine Market: Impact Databank, Review, and Forecast. New York: M Shanken Publications.

Ashenfelter, Orley C., and Karl Storchmann. 2006. Using a hedonic model of solar radiation to assess the economic effect of climate change: the case of Mosel Valley vineyards. In *NBER Working Paper No. 12380*. Cambridge, Mass.: National Bureau of Economics Research.

Birchall, Jonathan. 2007. Tesco goes green in US. *Financial Times*, February 13, 2007.

Boulton, Roger, and Linda Bisson Vernon Singleton, Ralph Kunkee. 1996. *Principles and Practices of Winemaking*: Chapman & Hall.

CE Delft, Germanischer Lloyd, MARINTEK, Det Norske Veritas. 2006. Greenhouse Gas Emissions for Shipping and Implementation Guidance for the Marine Fuel Sulphur Directive. Delft, Netherlands.

Cuellar, Steven, Aaron Lucey, and Mike Ammen. 2006. Understanding the Law of Demand. *Wine Business Monthly*, March 15.

Joly, Nicolas. 1999. *Wine from Sky to Earth: Growing & Appreciating Biodynamic Wine*. Austin, TX: Acres USA.

Kroodsma, David A., and Christopher B. Field. 2006. Carbon Sequestration in California Agriculture, 1980–2000. *Ecological Applications* 16 (5):1975–1985.

Mankiw, Gregory. 2007. One Answer to Global Warming: A New Tax. *The New York Times*, September 16.

Osborne, George. 2007. A strong case for switching to green taxation. *Financial Times*, September 12.

Rigby, Elizabeth, Fiona Harvey, and Jonathan Birchall. 2007. Tesco to put ‘carbon rating’ on labels. *Financial Times*, January 18 2007.

Robinson, Jancis. 2007. English Wine - far from a joke now: http://www.jancisrobinson.com/articles/20070525_3.

Saunders, Caroline, and Andrew Barber. 2007. Comparative Energy and Greenhouse Gas Emissions of New Zealand’s and the UK's Dairy Industry. Christchurch, New Zealand: Lincoln University.

White, M. A., N. S. Diffenbaugh, G. V. Jones, J. S. Pal, and F. Giorgi. 2006. Extreme heat reduces and shifts United States premium wine production in the 21st century. *Proceedings of the National Academy of Sciences* 103 (30):11217-22.