We Should Drink No Wine Before It’s Time

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\textbf{Abstract:} We consider the impact of taxes on the quantity and quality produced and consumed of goods for which market value accrues with age, such as wine, in a perfectly competitive long-run general equilibrium market economy.
1. Introduction

Though often considered a relatively small specialty commodity, wine is in reality a substantial global industry. Anderson (2001) estimates that the total value of wine consumption in 1999 at US$100 billion. In 1998, nearly 7 billion gallons of wine were produced in over 60 countries from grapes grown on over 19 million acres of vineyards. However, wine consumption and production is subject to heavy taxation in virtually every country in the world. Economic distortions are therefore widespread, globally impacting consumption, production, and wine quality. Wine taxes can be split into 3 broad categories.

In order of decreasing importance, wine is subject to: Excise Taxes or wholesale taxes, value-added or sales taxes, and import duties/other taxes. Wittwer, Berger, and Anderson (2001) assert that 16% of the average global cost of a bottle of wine is attributable to excise taxes or their equivalent, 6% to sales/VAT taxes or their equivalent, and 1% to import duties. Excise taxes are simply a per unit volume tax paid by the proprietor of the bonded wine facility on all wine for domestic sales. In the United States, these taxes are paid at both the federal and state levels. In accordance with section 5401 of title 26 of the United States Tax Code, US$1.07 per gallon of table wine is to be paid to the federal government. All states require additional taxes, and nearly all of these state taxes are volumetric. The median state excise tax is US$.73 per gallon, but the charges range from a low of $.11 in Louisiana to a high of $2.25 in Florida. Many other countries employ excise taxes as well, including Canada, New Zealand, England, France, and Japan. On the other hand, some nations choose to impose percentage, or ad valorem, taxes on wine premises. Notable examples include Mexico and Australia’s new 29% wine equali-
zation tax (WET). A few prominent wine producing and consuming countries have no excise or similar taxes on wineries or wholesalers, including Italy, Spain, Germany, and China.

Nearly every major wine consuming country imposes a goods-and-services tax (GST) or a value-added tax (VAT). Such taxes are placed directly on wine consumers, as a percentage of the purchase value. In the United States, 44 states levy sales taxes on the purchase of alcoholic beverages. Many local governments in these states levy further sales taxes. Comparable global examples include Australia’s 10% GST and New Zealand’s 12.5% GST. European Union VAT’s range from 15-25%, China imposes a 17% VAT, and the Argentinean VAT is 21%.

Many other taxes are levied on the consumption, production, trade, and sale of wine. However, while quite substantial in some markets, these taxes play a significantly smaller role in the distortions of the global market. For example, import tariffs can be extremely high for exports to Asian nations (for example, 50% of total value for Chinese imports in 2000) but tend to be less than 5% of the total value of a premium quality wine for most developed nations (Berger and Anderson 1999). And importantly, trade levies are essentially non-existent within regions covered by trade agreements, like the EU and North America (NAFTA). Many other miscellaneous wine taxes exist globally, at all levels of government, and include levies such as special winery occupational taxes (US), licensing fees (US, Australia), and environmental fees (Canada).

Trends in wine taxation are also quite pronounced. Overall wine taxation has unambiguously risen in the past 2 decades and continues to do so. While tariffs are decreasing
with trade liberalization and the WTO, the relatively larger excise taxes and goods and services taxes (or their respective global equivalents) are increasing. For example, between 1985 and 1998, the United States federal excise tax on table wine increased by 238%. During the same period, 16 states increased their excise taxes by an average of 69%. More recently, the state of Illinois raised its tax rate more than 300%. The wholesale tax rate in Australia has more than doubled since the middle 1980’s and the rate has increased in each of the past several years in New Zealand. In November of 2000, Japan proposed to double its excise tax rate. Volumetric excise taxes and *ad valorem* wholesale taxes, GSTs, and value-added taxes clearly play a large and increasing role in the wine industry.

Taxes are an important share of the cost of wine in many countries. Wine taxes can be split into 3 broad categories. In order of decreasing importance, wine is subject to excise taxes, value-added and sales taxes, and import duties and other related taxes. Wittwer, Berger, and Anderson (2001) calculate that 16% of the average global cost of a bottle of wine is attributable to excise taxes or their equivalent, 6% to sales/VAT taxes or their equivalent, and 1% to import duties.

Wine tax systems vary widely across countries. For example, in the United States, at the federal level wine is subject to a volumetric sales tax (excise tax) and an *ad valorem* sales tax. Many states impose additional *ad valorem* sales taxes, and some tax business inventories, such as wine held by a winery. In Australia, wine is subject to an *ad valorem* sales tax and to an *ad valorem* storage tax, referred to as the Wine Equalization Tax (WET). In France, wine is subject to the Value Added Tax (VAT). Wine stocks are taxed
with either an ad valorem storage tax, or a quasi-volumetric storage tax based on the
wine’s initial declared value that does not adjust for appreciation in wine value over time.

Wine and alcohol in general are generally taxed at a higher rate than most goods and
services are. High taxes on alcohol are justified by the argument that there are large nega-
tive externalities due to alcohol consumption, and taxes force users to internalize these
costs. Beyond these costs, there is the question of the extent to which alcohol and wine
taxes are not only correcting for negative externalities but are true “sin taxes” in the sense
that alcohol consumption in wine or any other form is considered a demerit good, and
taxes are a means of deterrence. Roughly 40 to 45 percent of American adults consume
no alcohol at all (Moulton, Spawton and Bourqui, 2001). In some cases, their decision is
influenced by the belief that alcohol consumption is morally wrong. This suggests that
there may be a moral component to wine taxation. Society as a whole, or certain, poten-
tially influential, groups, may prefer an inefficient tax system in order to reduce wine
consumption below the levels where taxes induce drinkers to internalize externalities.

The purpose of this paper is to investigate the role of taxes in the production, storage
and aging of wine in a long-run general equilibrium setting. Wine is a particularly inter-
esting aged product to examine, for three reasons. First, unlike many other aged products,
a substantial share of the aging process occurs after sale. Most wine is sold by the pro-
ducer within a few years of the initial grape harvest. Wohlgenant (1982) examines vint-
ner aging decisions across vintages as an inventory problem. In contrast, several studies
have examined the rate of return to holding wine over time, and established that there is a
positive return to aging over at least a twenty-year time period for the subsets of wines
they examine, although their conclusions regarding its rate of return relative to other assets differ (Krasker, 1979; Jaeger, 1981; Burton and Jacobsen, 2001). Byron and Ashenfelter (1995) examine determinants of wine prices, and also find that there is a positive return to aging. Because most wine is drunk soon after its purchase, tax distortions affecting the producer’s aging decision potentially may have a large effect on social welfare.

Most previous articles on excise taxes focus on consumption (Alchian and Allen, 1964; Borcherding and Silberberg, 1978; Barzel, 1976; Gould and Segall, 1969; Umbeck, 1980; Leffler, 1982; Kaempfer and Brastow, 1985; Cowen and Tabarrok, 1995; James and Alston, 2002; and Razzonlini, Shughart and Tollison, 2003).

Goodhew, LaFrance, and Simon (2009), hereafter, GLS, analyze the production and time/quality-quantity/tax relationships of a competitive wine industry. We extend GLS to the effects of taxes on the quantity and quality choices of producers, consumers, and the government in a long-run general equilibrium of a perfectly competitive economy.

2. The Model

Let the utility function for a given consumer be \( u(q, \tilde{q}, g, a) \), where \( q \) is the quantity of wine consumed, \( a \) is the age of the wine at the date that the consumer purchases and consumes it, which is assumed to be a perfect signal of quality, \( \tilde{q} \) is a vector of other private goods, and \( g \) is a vector of public goods and services provided by the government, each scaled to have a unit price. We assume that \( u \) is strictly increasing and jointly concave in
all of its arguments.\textsuperscript{1} Define the total expenditure on all goods and services other than wine by \( y = \tilde{p}^\top \tilde{q} + t^\top g \), where \( t \) is a vector of ones, and consider maximizing \( u \) subject to the partial budget constraint,

\[
\tilde{u}(q, y, a, \tilde{p}) = \max_{\tilde{q}, \tilde{g}} \{ u(q, \tilde{q}, g, a) : \tilde{p}^\top \tilde{q} + t^\top g = y \}. \tag{1}
\]

This function is the \textit{variable indirect utility function} (Epstein, 1975; Diewert 1978), and inherits certain useful monotonicity and curvature properties of the utility function. In particular, \( \tilde{u} \) is strictly increasing and jointly concave in \((q, y, a)\). To reduce the notational burden, we drop the argument \( \tilde{p} \) and eliminate the “\( ~\)” throughout the rest of the paper, writing the \textit{quasi-utility function} as \( u(q, y, a) \). These steps reduce the complexity of the problem of interest with virtually no loss in generality or injustice to the economic issues involved.

This first-stage maximization problem assumes a government that collects taxes and provides public services efficiently. To do so, the government levies lump sum taxes, \( i \), to finance public services, and the government budget constraint in each period, in equilibrium, is \( t^\top g = i \). This abstracts away from issues of government failure and helps us focus on the impacts of different wine tax systems, without getting confused or caught up in issues of second-, third- or \( n^{th} \)-best types of equilibria.

\textsuperscript{1} In a dynamic life-cycle model of consumer choice with addtivite separability over time, concavity of the utility function is necessary for the existence of an optimal solution (e.g., Gorman 1965).
The consumer’s budget constraint is \( m = pq + \bar{p}^T\bar{q} + i = pq + y \), is income, where \( m = \pi + m_0 \) is consumer income, \( \pi \) is the profit from wine production, and \( m_0 \) is income from all other sources. We assume that consumers own firms, have infinite lives, are life-cycle dynamic optimizers, can freely borrow or lend at the risk free real rate \( r \), and their rate of impatience is equal to the real market rate \( r \). The last condition is well-known to be necessary for the existence of a long-run intertemporal competitive equilibrium (Arrow, 1982). It also allows us to abstract away from such questions as imperfect capital markets or other market failures, again in order to maintain our focus purely on the impacts of different wine taxation schemes on the overall economy. In the final model specification, we allow for different consumer tastes through a preference index for wine quality. A further simplifying assumption is that consumers do not store wine, but instead consume it at the date of purchase. This lets us abstract away from issues such as differences in the cost of storage between firms and consumers and asymmetric information.

Wine has a homogeneous quality at the date it is produced. Three kinds of cost affect the wine industry: capital, \( k \); variable costs of wine production, \( c(w,k,q) \), where \( w \) is a vector of variable input prices, and variable costs of storing wine, \( p,q \), per period. We assume the short-run cost curve is upward sloping, \( \partial^2 c(w,k,q) / \partial q^2 > 0 \), and the technology for the wine industry has constant returns to scale (CRS), hence \( c \) is 1° homogeneous in \((k,q)\). The entry-exit condition for capital investment in the wine industry therefore implies that \( \partial c(w,k,q) / \partial q \cdot q = c(w,k,q) + k \) in a long-run competitive equilibrium.
Our goal is to analyze and compare long-run equilibria with and without wine specific tax systems. In each of these equilibria, capital stocks (including storage capacity), acres planted and harvested to wine, quantities produced and consumed, and the age of wine when it is sold will have adjusted fully to their corresponding stationary levels. As a result, it is sufficient to consider a snapshot of the equilibrium for production and storage decisions for a given vintage of wine purchased and consumed by consumers of a generic type.

In the presence of storage and aging to improve quality and market value of wine, the date when the vintage is produced precedes the date at which it is sold by the length of time that it is stored by the vintner, $a$. Because we abstract away from any other sources of market failure, such as an imperfect capital markets, and assume that the consumer rate of time preference equals the private market’s real rate of return, we can normalize intertemporal economic values either on the date at which the wine is produced, say $t = 0$, or the date at which it is sold, purchased, and consumed, $t = a$. In this paper, we adopt the latter normalization for all decision makers – i.e., producers, consumers, and the social planner.

First consider the demand for wine. The consumer solves

$$q(p, m, a) = \arg\max_{q \in [0, m/p]} u(q, m - pq, a).$$  \hspace{1cm} (2)$$

We assume throughout that the ordinary Marshallian demand function for wine is strictly decreasing in price, strictly increasing in age, and increasing in income. Inverting with respect to $p$ generates the inverse demand function, $p(q, m, a)$, which we assume is
strictly decreasing in quantity and strictly increasing in quality (age) and income. We also make the following technical assumption:

\[
A_u: \quad \frac{\partial u(q,m - p(q,m,a)q,a)}{q \cdot \partial u(q,m - p(q,m,a)q,a)} > \frac{\partial p(q,m,a)}{\partial y} \quad \forall \quad 0 < q < \frac{m}{p(q,m,a)}.
\]

This states that the consumer’s marginal willingness to pay for additional wine quality per unit of quantity in exchange for other goods or services is greater than the vertical shift in the inverse demand as wine quality increases.²

The following example is used throughout this paper to offer economic intuition and graphical illustrations of the main concepts and arguments:

\[
u(q,y,a) = \left(\frac{-\beta + \gamma q}{\gamma^2}\right) \exp \left\{\frac{\gamma(\alpha_0 + \alpha a + \gamma y - q)}{-\beta + \gamma q}\right\}, \quad \alpha_0, \alpha, \beta, \gamma > 0.
\]

(3)

In this case, consumer types are indexed by the intensity of demand for wine quality, \(\alpha \in [\alpha, \overline{\alpha}] \subset \mathbb{R}_+\). It is straightforward to show that (3) is strictly increasing and jointly concave in \((q,y,a)\) as long as \(q < \min\{-\beta/\gamma, \alpha_0 + \alpha a + \gamma y\}\). It is a simple matter to show that the ordinary Marshallian demand for wine is

\[
q(p,m,a) = \alpha_0 + \alpha a - \beta p + \gamma m,
\]

(4)

so that the inverse demand function for wine is

\[
p(q,m,a) = \frac{\alpha_0 + \alpha a + \gamma m - q}{\beta},
\]

(5)

² As in many other aspects of consumer theory, such as the existence of Giffen goods or Veblen effects, it is impossible to formally prove that \(A_u\) is true for all well-behaved utility functions. However, this property holds throughout the region of economic regularity for the utility function in (3), and can be shown to be true for several other common functional forms.
which implies that the vertical shift upward in the ordinary demand function with increasing quality is

$$\frac{\partial p(q,m,a)}{\partial a} = \frac{\alpha}{\beta},$$

(6)

while the marginal rate of substitution between wine quality and other goods per unit of wine quantity is

$$\frac{\partial u(q,y,a)/\partial a}{q \cdot \partial u(q,y,a)/\partial y} = \frac{\alpha}{\gamma q}.$$  

(7)

From (4) we can see immediately that the necessary and sufficient condition for Slutsky negativity is $$-\beta + \gamma q(p,m,a) < 0,$$ or equivalently, $$\gamma q < \beta$$ for any $$(q,y,a)$$ triple that is an economically regular choice by the consumer. Thus, the consumer’s marginal willingness to pay for an increase in wine quality per unit of quantity, which is (7) always exceeds the vertical rate of increase in the ordinary demand function, (6), at any economically relevant outcome.

The main point is that $$\frac{\partial p(q,m,a)}{\partial a}$$ defines the marginal benefit to a competitive firm when it determines the optimal age at which to sell wine (GLS, 2009), the term $$\frac{\partial u(q,y,a)/\partial a}{q \cdot \partial u(q,y,a)/\partial y}$$ is the consumer’s marginal willingness to pay for an increase in wine quality per unit of quantity, and these two margins are not equivalent. The forces of perfect competition and asset management decisions discipline the former, while the latter would be the focus of a welfare maximizing social planner. The main issue is whether an unfettered private market sells wine that is “too young,” “too old,” or “just right” from the perspective of maximizing consumer welfare (this is all that matters.
in a first-best perfectly competitive long-run equilibrium). The assumption $A^*$ generates the first case, although the methods developed here also apply in tact to the other cases.

Now turn to wine production, storage, and sales. The *ex post* profit for the winery in the absence of wine specific taxes is

$$
\pi = p(q, m, a)q - e^{r_a}[c(w, k, q) + k] - \frac{1}{r}(e^{r_a} - 1)p_s q,
$$

where $k$ the capital investment at time $t=0$, $e^{r_a}$ is the time value of money that brings the total cost of production to the *ex post* date of sale, and $e^{r_a}\int_0^a e^{-rt} p_s q dt = \frac{1}{r}(e^{r_a} - 1)p_s q$ is the $t=a$ cost of storing $q$ units of wine for $a$ time periods before its sale.

Wine producers are assumed to be price takers with respect to quantity and to have complete information on how the market value of wine increases with its age. For each type of consumer, the perfectly competitive condition for wine quantity is

$$
p(q, m, a) = e^{r_a} \frac{\partial c(w, k, q)}{\partial q} + \frac{1}{r}(e^{r_a} - 1)p_s.
$$

That is, the competitive market price at sale for all wine of a given age/quality equals the sum of the current value of the marginal cost of production plus storing a unit of wine for the length of time from when it is produced and sold.

The zero profit entry/exit condition for capital, combined with a CRS production technology implies that $c(w, k, q) + k = \frac{\partial c(w, k, q)}{\partial q} \cdot q \equiv \tilde{c} \cdot q$, where $\tilde{c}$ is the long-run unit cost wine production, since $\frac{\partial c(w, k, q)}{\partial k} \cdot k + \frac{\partial c(w, k, q)}{\partial q} \cdot q \equiv c(w, k, q)$.

The following example for the production technology is used throughout the paper for economic intuition and graphical illustrations of the main concepts and arguments:
\[ c(w,k,q) = \varphi(w)(q - \delta k)^2 / 2k, \] (10)

so that the marginal cost curve, \( \partial c(w,k,q)/\partial q = \varphi(w)(q - \delta k)/k \) is linear in quantity and the long-run marginal and average total cost of wine production for all vintages and qualities is given by \( \bar{c} = \sqrt{\varphi(w)/(2 + \delta \varphi(w))} \). This property allows either a single (large) firm that is subject to the forces of perfect competition or a distribution of firms of any size selling various qualities and quantities to serve all consumer types in the market for wine. This allows us to abstract away from issues such as imperfect or monopolistic competition and the precise structure of the competitive equilibrium (e.g., Jones, 1984).

The competitive arbitrage condition for the optimal age of wine at the date of sale is

\[
\frac{\partial \pi}{\partial a} = \frac{\partial p(q,m,a)}{\partial a} q - r e^{\sigma a}[c(w,k,q) + k] - e^{\sigma a} p_s q = 0, \tag{11}
\]

Given the zero profit entry/exit condition, this is equivalent to the arbitrage condition in CLS,

\[
\frac{\partial p(q,m,a)}{\partial a} = e^{\sigma a} \left[ r \frac{\partial c(w,k,q)}{\partial q} + p_s \right] = r p(q,m,a) + p_s. \tag{12}
\]

These developments lead immediately to the following result.

**Proposition:** For all consumer types, perfect competition produces more wine of lower quality than is optimal for the consumer (or a social planner).

### 3. Wine Taxes, Quantity, and Quality

Now introduce wine specific taxes into the economy. GLS evaluated four types of wine specific taxes: an ad valorem sales tax assessed as a percentage of price and collected at sale; volumetric sales tax assessed at a fixed rate per unit and collected at sale; an ad
valorem storage tax assessed as a percentage of each period’s market value and collected each period prior to sale; and a volumetric storage tax assessed at a fixed rate per unit collected each period prior to sale. They obtained a spanning result for two-tax systems that also applies to the present problem.

An ad valorem sales tax is assessed as a fixed percentage of the market price, and collected when the vintner sells the wine. The ex ante discounted present value of the tax paid at time \( a \) is \( e^{-ra}\tau^r_p p(a)q \), where \( \tau^r_p \in [0,1] \) is the ad valorem sales tax rate, so that the ex post current value of this tax is \( \tau^r_p p(a)q \). A volumetric sales tax is assessed as a fixed monetary amount per unit volume and collected at sale. In this case, the discounted present value of the tax paid at time \( a \) is \( e^{-ra}\tau^r_q q \), where \( \tau^r_q \geq 0 \) is the volumetric sales tax rate, and the ex post tax is \( \tau^r_q q \). An ad valorem storage tax is assessed as a fixed percentage of the market price of wine, \( p(t) \), and is collected continuously throughout the storage period. The ex ante present value of this paid is \( \int_0^a e^{-r(t-a)}\tau^s_p p(t)qdt \), while the ex post tax is \( \int_0^a e^{-r(t-a)}\tau^s_p p(t)qdt \), where \( \tau^s_p \in [0,1] \) is the ad valorem storage tax rate. A volumetric storage tax is assessed as a fixed monetary amount per unit volume and is collected continuously throughout the storage period. The ex ante present value of the tax paid is \((1-e^{-ra})\tau^s_q q / r\) and the ex post tax is \((e^{ra} - 1)\tau^s_q q / r\), where \( \tau^s_q \geq 0 \) is the volumetric storage tax rate. Note, in particular, that the only change between dates 0 and \( a \) is the
impact of discounting.

With these definitions, for any wine specific tax system \( \tau = [\tau_\rho, \tau_q, \tau_s, \tau_q^s]^T \), the ex post effective tax rate on wine for the sax system, is

\[
v(\tau) = \tau_\rho p + \tau_q^s + \tau_s \int_0^a e^{r(a-t)} p dt + \underleftarrow{\Gamma_r (e^{ra}-1)\tau_q^s}.
\]

(13)

A firm selling age \( a \) wine – i. e., any firm selling to consumer’s whose preferences are to buy and consumer this quality of wine in equilibrium – earns the ex post profit level

\[
\pi = (p - v)q - e^{ra}\tilde{c}q - \underleftarrow{\Gamma_r (e^{ra}-1)p_s q}.
\]

(14)

With wine specific taxes, the consumer’s budget constraint is

\[
m = m_0 + \pi
\]

\[
= m_0 + (p - v)q - e^{ra}\tilde{c}q - \underleftarrow{\Gamma_r (e^{ra}-1)p_s q}
\]

\[
= pq + y,
\]

(15)

which reduces to \( y = m_0 - vq - e^{ra}\tilde{c}q - \underleftarrow{\Gamma_r (e^{ra}-1)p_s q} \). The planner’s problem is to choose a tax system \( \tau \) to maximize consumer welfare:

\[
\max u(q, m_0 - vq - e^{ra}\tilde{c}q - \underleftarrow{\Gamma_r (e^{ra}-1)p_s q}, a).
\]

(16)

The first-order conditions for this problem are

\[
\frac{\partial u}{\partial q} = \frac{\partial u}{\partial y} = \frac{\partial u}{\partial a} = \frac{\partial u}{q \cdot \partial u/\partial y} = \frac{\partial v}{\partial a} + e^{ra}(\tilde{c} + p_s).
\]

(17)

3 We thus abstract away from tax collection costs and other complications associated with cases where the tax authority must continuously appraise the value of wine that has not yet been sold in order to collect ad valorem taxes.
Thus, incentive compatibility for competitive firms in terms of quantity requires
\[ \frac{\partial u}{\partial q} = v + e^{ra}c + \gamma'(e^{ra} - 1)p_s = p, \]  
(18)
and in terms of quality requires
\[ \frac{\partial u}{\partial a} = \frac{\partial p}{\partial a} + e^{ra}(r\tilde{c} + p_s) = \frac{\partial v}{\partial a} + r(p - v) + p_s, \]  
(19)
where
\[ \frac{\partial v}{\partial a} = \tau'_p \left( \frac{\partial p}{\partial a} - rp \right) + \tau'_p p + rv - r\tau'_q + \tau'_q. \]  
(20)
Regrouping and combining terms, equations (19) and (20) imply that
\[ \frac{\partial u}{\partial a} = \frac{\partial p}{\partial a} = rp + p_s + \frac{\tau'_p p_s - r\tau'_q + \tau'_q p + \tau'_q}{1 - \tau'_p}. \]  
(21)
The expression on the far right is identical to equation (7) in GLS. Hence, their two-tax spanning result applies to this problem without change. That is to say, since there are two margins to be balanced in the first-best solution – wine quantity and wine quality. If subsidies (negative tax rates) are allowed, then any two-tax system can. However, if \( A_u \) is satisfied, then the socially optimal tax system increases quality and reduces quantity.

5. Conclusions

We analyzed the impact of taxes on the quantity and quality produced of goods whose market values accrue with age, such as wine. We have found that a perfectly competitive private market equilibrium oversupplies wine at a lower quality than is socially optimal, and that if subsidies are politically feasible, then any of the two-tax systems considered by Goodhue, LaFrance and Simon (2009) can achieve a socially optimal equilibrium.
References


