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Taxation to Minimise the Social and Economic Costs of Alcohol Consumption

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ABSTRACT

This paper considers alternative approaches to the evaluation of the economic cost of alcohol consumption in Australia. It calculates the impact of alternative tax rates on beer, wine and spirits separately and the welfare cost of these taxes in terms of the distortion caused to consumption patterns. Two separate analyses are carried out. First optimal taxation is calculated which minimises the total welfare plus economic cost. Secondly, the benefits of life are separated from other benefits and the impact of tax expressed in terms of the cost per life year gained.

Taxation to Minimise the Social and Economic Costs of Alcohol Consumption

1 Introduction

Alcoholic products have been the subject of intensive research. However, the focus of attention has differed significantly between studies. One large body of research has concentrated upon the own and cross price elasticities of demand for different alcoholic beverages. While some of the authors in this group have been concerned with the "welfare costs" of taxation — the cost arising from the distortion of consumption patterns — there has generally been little discussion of the broader costs associated with the consumption of alcohol. By contrast, a second group of authors has been primarily concerned with the "social cost of alcohol" — the individual and economic costs arising from alcohol related mortality and morbidity. In this group of primarily non-economic studies there has been virtually no recognition or discussion of the "welfare costs" that might arise from the use of taxes as a means of reducing alcohol consumption and the related social costs of alcohol. The purpose of the present paper is to bring together these two streams in the literature and to consider alcohol taxation as a form of intervention designed to minimise both social and welfare costs.

In Australia alone there have been at least twelve studies of the price and cross price elasticities of alcoholic products (see Crowley and Richardson, 1991). While the reason for such detailed attention is not always explicit there are at least two possible motives. First, alcohol taxes are high. In Australia excise, customs and sales taxes are equivalent to about 30% of the cost of production (refer Appendix 1). Consequently, the taxes are an important source of government revenue. Secondly, Australian taxes result in a particularly high loss of welfare. Excise and sales taxes in Australia have traditionally favoured the consumption of wine and discouraged the consumption of beer and spirits. There appears to be no economic rationale for this pattern and it almost certainly results in a significantly greater loss of consumer welfare than would arise from an optimal, revenue neutral, tax (Clements and Johnson, 1982; Clements, 1983).

A third possible reason for the interest in price elasticities is an implicit recognition that

taxation may be used to reduce consumption and the associated social costs of alcohol. In the second group of studies — those explicitly concerned with these social costs — there has been greatest attention given to quantifying variables that are easily measured. For example, Cook (1981, 1982) and Cook and Tauchen (1982) have established a relationship between the taxation of liquor and deaths from cirrhosis. The more general relationship between alcohol consumption and cirrhosis mortality has been well established using cross sectional data (Hingson, 1985), time series (Rankin, 1983, 1985) and cross national comparisons (Taylor, 1981; Adrian, 1985). A clear relationship also exists between alcohol taxation and traffic accident mortality (Grossman et al. 1987, Phelps, 1988).

While easily measured, these alcohol related deaths are not the only adverse consequence of alcohol consumption. Other social costs include the material costs of alcohol induced traffic accidents; the increased costs of law enforcement and litigation; the material costs to society of the loss of life and the costs to industry of alcohol induced absenteeism, lower productivity and unemployment. There are still further costs that are difficult to measure such as pain and distress suffered by victims of alcohol induced assaults and by the relatives of people killed by alcohol related illnesses. The limited evidence suggests that these less readily quantified effects and especially the adverse effects on productivity may represent the largest component of the social cost of alcohol.

Only one published study appears to have brought together these two strands in the literature. In this, Phelps, (1988) compared social and welfare costs in an attempt to determine the optimal rate of taxation for beer. For each tax rate Phelps calculated both the loss of consumer surplus — the welfare cost — arising from the tax distortion and the number of lives gained because of the lower consumption of alcohol. Depending upon the value assigned to life, the optimal tax rate — where the marginal (welfare) cost of further taxation was equal to the marginal (social) benefits — varied between 22 and 48 percent. Despite its consideration of both social and welfare costs, the study was very limited. Social costs were restricted to the alcohol related road deaths of youths who had consumed beer.

The present study also considers the effects of taxation on the social and welfare costs of alcohol. However, it includes all three alcoholic beverages (beer, wine and spirits) in the analysis and it incorporates an estimate of the full social cost of alcohol. The appropriateness of including all of these costs and the method for estimating them are discussed in section 2 below. In section 3 the effects of various ad hoc taxes on social and welfare costs are compared and in section 4 tax rates are derived which minimise the combined value of these. The optimal tax is firstly calculated so that the same total tax revenue is obtained as in 1988, and secondly, with no such revenue constraint. In the final section, there is an explicit consideration of the problem of evaluating life. It is argued that the use of alcohol tax may be considered as a form of health project or health program where the objective is to save life. When it is conceptualised in this way the results of this "tax program" may be expressed in the same way as other health programs, namely as a net cost per life year gained. The "program" may then be compared with other life saving interventions.

2. SOCIAL COSTS AND THEIR EVALUATION

2.1 What should be included

In their discussion of the social costs of various drugs Collins and Lapsley (1991) identify 5 separate evaluation methodologies. The differences are less concerned with the techniques than with the prior question of what to include in the measurement of social costs. They correctly argue that this should be determined by the purpose of an analysis. Two specific issues are important here. The first concerns the distinction between "internal" and "external" costs and the second is the difference between "incidence" and "prevalence" based estimates of the cost of mortality.

Internal versus External Costs

An argument associated with the libertarian view of society is that many of the costs described here as "social costs" are actually borne by the individual who decides to purchase the beverage and that, consequently, they have already been taken into account or that, as an ethical proposition, the state should not interfere to alter the "internal" or private consequences of an individual's own decisions. This position is stated most clearly by Manning et al. (1989) who classify costs of smoking and alcohol as internal or external as shown in Table 1. The same authors argue that "one goal of an economically efficient tax on smoking or tobacco is to have the smoker bear the costs that he imposes on others when deciding whether or how much to smoke" (p. 1064). The statement is contentious. Depending upon the value system adopted it may (or may not) be equitable to ensure that individuals pay a tax equal to the full cost imposed upon others since this tax could *potentially* compensate those who actually bear the final cost. However, the strategy does not ensure *efficiency* in the absence of certain other conditions. The first of these is that the individual smoking or consuming alcohol is aware of the internal costs. There are few grounds for believing that this will occur. In the case of alcohol the immediate reason for its harmful effects is that after drinking commences it impairs the capacity to make the sort of calculation assumed here. More importantly it is highly unlikely that individuals could make an accurate assessment of the internal cost. As set out in Table 1 this would require an objective assessment of the probability of alcohol induced death, disability, sickness and property loss — factors about which there is some objective evidence available to specialists in the area but which is not widely known to the public. In the absence of this information there would be no mechanism for internalising these costs in the decision to drink.

A less uncompromising position is adopted by Phelps (1988) who discusses the two extreme positions in which the individual youth is and is not aware of the probability of alcohol induced traffic death. It is assumed that in the case of fully informed individuals there is no net cost from the death of the drinking driver and only from the death of passengers. This position highlights the second necessary condition for the efficient internalising of "internal costs". Efficiency must be defined entirely in terms of *expected* utility. That is, the concept of efficiency must relate entirely to ex ante factors. There is, consequently, no inefficiency associated with the situation in which a person gambles with their life and loses unless their death affects others. This is not a concept of *efficiency* that would be widely accepted as being useful. From an aggregate perspective it implies that the benefits to those who gamble and win exceed the costs to those who

gamble and lose. In the case of life and death decisions from which there is no error learning by losers this represents a particular ethical position and not simply a concept of technical efficiency.

This ethical basis does not correspond with the values revealed in many economic and public health policies. Numerous interventions are designed to increase the economic well being or productivity of individuals when it is the individuals themselves who will primarily benefit. It is not true, as a matter of observed fact, that health policies have been designed to internalise externalities. Historically, the explicit objective of public health policy has been the minimising of mortality and morbidity and not simply assisting individuals to achieve their private objectives irrespective of consequences. It is likely that an explicit alcohol policy would similarly be based upon total internal and external costs and for this reason the present study does not make a distinction between these. In the final section there is an analysis of the effects of subtracting the private consumption benefits of potential decadents.

Prevalence versus Incidence Costings[1]

The consequences of alcohol consumption and particularly alcohol related deaths are not confined to the year in which the consumption occurs. Consequently, there are two distinct cost analyses which could be carried out. The first is a "prevalence" based study on which the cumulative effects of all past consumption are calculated for a given year. The second is an "incidence" based study which determines the present value of the costs of present consumption. Generally, the two types of analysis will result in quite different "costs". For example in a "steady state" in which there are a stable number of "new cases" occurring each year and where the consequences continue for the same number of years, prevalence based studies will produce higher costs than incidence based studies. The future costs included in the latter study will be subject to discounting whereas the present costs included in the prevalence studies are not. Conversely, if the number of "cases" is expanding rapidly as at the outbreak of an epidemic, incidence based studies may produce a higher estimated cost as a prevalence based study would be based upon an historically small number of cases.

More importantly, the two types of analysis are conceptually distinct and represent answers to different questions. A prevalence study would be appropriate if the research question involved the loss of welfare or GDP each year that was attributable to past illnesses. If the research issue was the consequences of present behaviour or new illnesses then an incidence based study would be appropriate. This implies that it is the latter and not the former that is relevant for policy analysis. Past behaviour cannot be changed, and, as with sunk costs generally, should not influence present policy. For this reason the present study is based on the incidence of alcohol consumption and alcohol related death.

2.2 Estimates of social costs

[1] The nomenclature is adopted directly from the epidemiology literature which draws a distinction between the *incidence* of new illnesses and the cumulative *prevalence* of illnesses in a year.

There have only been a limited number of studies of the full cost of alcohol in the world. Results from six of these are presented in Table 2. Two major conclusions are apparent from this. First, in every study where they are included total cost is dominated by the costs to industry. These range from 50 to 87 percent of the total. In order of importance these costs are the reduced efficiency of alcohol affected workers, the reduction in the workforce due to premature death and the reduction in the workforce due to increased unemployment. By comparison, the direct cost of alcohol associated health services is relatively small. It is larger in the USA where unit medical costs are much higher. Similarly, the estimated costs of alcohol associated crime, support and legal services, research and property damage are comparatively small. The second major conclusion is that the costs as a percentage of GDP vary to such an extent that the consistency of the methods adopted in the different studies must be seriously questioned.

Until recently there was no Australian study that attempted to quantify all of the social costs of alcohol. Two partial studies had been undertaken. In the first, Prichard (1977) notes but does not quantify most of the potential costs. Quantitative estimates are made of the loss of production due to premature mortality. This amounted to 0.46 percent of GDP. The study calculated that 2,589 deaths were related to alcohol in 1965. The figure is plausible in view of the later estimates by the present authors of 2,380 alcohol related deaths for persons under 65. The more recent estimate is lower because of the epidemiological data suggesting that alcohol in moderation has a protective effect on the development of certain disease such as ischaemic heart disease. Prichard provides no estimates for the loss of industrial efficiency due to alcohol abuse. The estimated $40M loss from unemployment is based upon a very limited study of 220 chronic alcoholics. Their rates of unemployment were extrapolated to the estimated 33,000 male and 8,250 female chronic alcoholics in Australia in 1965.

In the second and unpublished study, Drew (1981) attempted to quantify most of the costs associated with alcohol abuse. The major exceptions were the economic cost of early death and the cost of excess unemployment, coincidentally the components of the Prichard study. Drew's estimate which amounted to 1.87 percent of GDP, is of unknown reliability. Each of the unit costs is based upon either an unpublished and unexplained source or upon the author's guesstimate of the cost. In particular, the largest component, the cost to industry, is based upon an unpublished estimate of $2,415 per alcoholic employee and an unreferenced estimate of 216,000 alcoholics in the workforce.

In 1991 two larger studies were published. The first, by Collins and Lapsley (1991) combines prevalence based analyses of mortality costs with the calculated material costs of accidents and of health care costs for alcoholic diseases. In addition, it is argued that 30 percent of alcohol consumption may be classified as "abuse" and the production costs of this are added to the other social costs to obtain an overall figure of $6.0 billion for the cost of alcohol abuse.

The results are not included in the present study for three reasons. First, and as noted earlier, policy analysis requires an incidence and not a prevalence based estimate of mortality costs. Secondly, while a percentage of alcohol consumption may represent "abuse", as defined by its consequences, it does not follow that those "abusing" the alcohol do not receive direct benefit from the consumption. Following the conventional approach it may be assumed that these direct benefits are at least equal to the cost of production which is reflected in the price paid. Thirdly, and most importantly, the analysis

excludes the impact of alcohol on industrial productivity which, from Table 2, has been found to be the largest element of the social cost in overseas studies.

The second recent study is by the present authors (Crowley and Richardson, 1991). In the absence of a reliable Australian analysis of industrial costs it was decided to adapt the estimates derived in the overseas studies rather than omit this highly significant category. As noted above the range of estimates in these studies is unacceptably large despite the similar consumption of the costs. Each of the quantitatively important unit costs is roughly proportional to GDP per capita so that variation in costs as a percentage of GDP should not be too great. Despite this, the lowest estimate for the UK is only 9 percent of the highest estimate (for the USA) relative to GDP. This indicates measurement or methodological problems.

A review of the methodologies adopted in these studies increases the grounds for concern. The original UK estimates by Holtermann and Burchell (1981), later upgraded by Maynard and McDonnell (1985), were based upon a study of the work loss of 73 male alcoholic patients in 1973/74. Apart from the problems of sampling bias and sample size the method ignores the loss of production resulting from alcohol abuse by non-alcoholics. Further, UK unemployment in 1973 was 2.06 percent. This rate subsequently increased sixfold and it is well below the present level in Australia. In an environment of high unemployment alcohol could well have a more significant effect upon the perceived suitability of a person for workforce participation than in a much tighter labour market.

For their own study Maynard and McDonnell used the results of a nationwide survey which sought information on the number of days lost from work in the past three months. The difference between heavy and light drinkers was multiplied by the number of heavy drinkers. The technique is very conservative. It ignores the days lost by light or moderate drinkers and these are likely to be quantitatively the most important because of the large number of such drinkers. Further, the average cost associated with moderate drinking will be subtracted from and not added to the estimate of days lost by heavy drinkers. The study does not include an estimate of reduced productivity at work. Maynard and McDonnell also analysed the difference between heavy and light drinkers revealed in a nationwide survey of unemployment. A problem recognised with this approach is the determination of the direction of causality. Unemployment is likely to cause drinking just as drinking causes unemployment. Between 40 and 100 percent of the excess unemployment was attributed to alcohol. The resulting costs were 15 to 37 times greater than in the updated Holtermann and Burchell estimate which was again based upon a very limited survey of alcoholics. Despite this, the latter was included in the final value of total cost. By contrast, Chetwynd drew upon nationwide results to calculate the cost of unemployment. In the absence of New Zealand data the impact of alcohol upon productive efficiency was calculated by adopting a US estimate by the Comptroller General that there would be a 25 percent loss of productive efficiency by those defined as abusing alcohol.

The much higher estimates by Berry and Boland (1977) and adaptation and correction of these results by Schifrin (1983) are based upon a similar methodology to the one rejected by McDonnell and Maynard, but in which the effect of alcohol abuse was estimated by subtracting the household income of an alcohol abuser from the average income in a peer group. The methodology assumes that an individual's income reflects their productivity and, consequently, it has the potential to include the full cost to industry.

However, it may be significantly biased if the relationship between income and alcohol is confounded by other social variables or if the direction of causation in the correlation is unclear.

To obtain an upper and lower limit to Australian costs Crowley and Richardson extrapolated from each of the major overseas studies to Australia using the assumption that industrial costs were directly related to both GDP per capita and alcohol intake per capita. Health care costs were scaled according to relative per capita health expenditures in the different countries. For the reasons outlined above, the UK estimates of the costs to industry appear to be unacceptably low. Consequently they were replaced by the apparently more reliable estimates from New Zealand. Incidence based estimates of mortality costs were calculated from Australian mortality data using the recently revised aetiological fractions of Armstrong and Holman (1990). These replaced the estimates in each of the original studies. In effect the final estimates are an amalgam of the Australian cost of mortality and the effects of lower productivity, employment and other costs as extrapolated and adapted from the overseas studies. The final results are presented in Table 3.

3. COMBINING SOCIAL AND WELFARE COSTS

In principal, the optimal set of taxes should minimise the combined value of social and welfare costs. This is equivalent to determining the tax rates which would result in the greatest improvement from the status quo. For this reason tax reform may be visualised as equivalent to a project where the benefits are equal to the reduced social cost of alcohol less (plus) any increase (decrease) in the welfare cost of these taxes.

To determine the final net effect of tax reform the following four factors must be taken into account:

- the magnitude of the tax change;
- the effect of this change on consumer prices;
- the relationship between consumer prices and demand; and
- the effect of *incremental* changes in alcohol consumption upon both social and welfare costs.

Taxation and Consumption

In principle, a change in taxation may not result in a change in the price of the taxed commodity. Especially in the short run it is possible that some part of the tax will be absorbed by producers or retailers as reduced profit margins. Alternatively, it is possible that the impact of the tax will be passed "backwards" by lowering payments to the factors of production — wine growers, labourers etc. Abdalla and Duffus (1988) showed that for bulk wine, producers did indeed pass some of the tax burden back to the grape growers. In a competitive industry this is unlikely to occur in the long run. Consequently it is assumed in the analysis here that the incidence of the tax falls entirely upon consumers. That is, prices are increased by the full amount of any new tax.

Australian estimates of the price elasticity of demand for alcoholic products vary to a surprising extent. This is the outcome of the varying time periods, statistical procedures and databases analysed. Some have estimated elasticities that are conditional upon the allocation of a pre-determined part of the budget to the alcohol sub-group; others have been unconstrained. Some have distinguished short run from long run elasticities. This variability of approach has also characterised overseas studies of alcohol elasticities (Godfrey, 1987).

The various Australian estimates have been reviewed elsewhere (Crowley and Richardson 1991). The methodologically most rigorous results to date appear to be those produced by Clements and Selvanathan. In their 1989 paper Clements and Selvanathan extended the application of the systems approach to alcohol consumption that they initiated in an earlier 1983 paper. It examined data for Australian alcoholic beverages from 1955-56 to 1985-86 and calculated both conditional and unconditional price elasticities using maximum likelihood procedures. The authors assume linear demand equations. Further elasticity estimates are to be published in 1991, but at the time of writing these are not available. Clements and Selvanathan estimated own price elasticities for beer, wine and spirits of -0.43, -0.37 and -0.83 respectively. The only significant cross price effect was found between the price of beer and the quantity of spirits, between which there was an elasticity of -0.5. This indicates that an increase in beer prices depletes an individual's "alcohol budget", which results in a decrease in

consumption of spirits. The cross price elasticity between other alcoholic beverages were sufficiently small that, for simplicity, they are ignored here.

Incremental Social Costs

To determine the impact of taxation, it is necessary to know the relationship between an *incremental* change in alcohol consumption and *incremental* social costs. This relationship cannot be inferred directly from the estimates of the total social costs reported earlier. Further, the evidence that is directly relevant to this question is very fragmentary. In the absence of a satisfactory estimate of the marginal cost the assumption is made that marginal and average costs are equal. The available evidence suggests that this is probably a conservative assumption and that the incremental cost may well be greater than the average cost. For example, Rankin et al. (1983) found that cirrhosis deaths rose exponentially with alcohol intake per capita. Walsh (1987) reported a 4 percent decline in road deaths as a result of a 10 percent increase in alcohol price. As the overall price elasticity of demand for alcohol is in the order of 0.4 this implies a 4 percent reduction in deaths with a 4 percent decline in consumption. But as all road deaths are not alcohol related this, in turn, implies a disproportionate impact of marginal consumption on death rates. Consistent with this, Grossman et al. (1987) found that incremental price changes had the largest effect upon the consumption of beer amongst young drivers. By contrast with this evidence, Kendell et al. (1983) found that an 18 percent decline in alcohol consumption induced by rising taxes reduced adverse effects as defined in their study by only 16 percent. However, even this result implies that the average effect is a reasonable approximation of the true marginal effect. In Section 4 of the paper the implications of a more conservative assumption are explored.

Welfare Costs

The major cost of taxation is the distortion it causes in people's consumption patterns. There is a loss of welfare associated with a reduced consumption of a desired commodity and the substitution of a less desired product. This issue is somewhat complicated by alcoholics who are physically and psychologically dependent upon alcohol. It is questionable whether they derive benefits from consumption as judged by independent or "external" criteria. However, the value basis of consumer surplus analysis is the libertarian view that individuals are the best judges of their own welfare and no adjustment is made here to reflect this arguably inappropriate assumption in the case of alcoholics.

The usual (partial) approach to the measurement of these costs is illustrated in Figure 1a. It is assumed that long run supply is horizontal and that the industry is competitive. An increase in the taxes dT increases prices from F to G. Consumption falls from Q_0 to Q_1. The reduction and output Q_0 Q_1 reduces consumer benefits by the corresponding area under the demand curve, i.e. by the area Q_1Q_0AB. Some of this lost benefit is matched by a reduction in production costs. This is equal to changed production times unit cost, i.e. by the area Q_0Q_1DE. The remaining net cost is the (partial) measure of the welfare loss, i.e. area DEAB. This has two parts. First, there is a loss of "consumer surplus", i.e. an amount consumers would have been prepared to pay for the produce but did not pay. This is shown by the area ABC (the area below the demand curve but above the original price line). Secondly, there is a loss in the tax revenue of ACDE. Total welfare may therefore be calculated as the change in consumer surplus plus the change in tax

revenue.

Anticipating the results later in the paper, Figure 1 illustrates the potential for increased welfare through a redistribution of alcohol consumption. Average tax values for 1988/89 are shown for beer wine and spirits in parts A, B and C respectively and in each case Q_0 indicates present (1988/89) consumption. With these quantities the value of the net consumer surplus per unit of alcohol is equal to the tax wedge. A one litre reduction in wine consumption would reduce net welfare by $3.80. A corresponding litre increase in the consumption of spirits would increase welfare by $34.30.

Ad hoc Tax Changes

The results of eight ad hoc changes to the tax base or tax rate are shown in Table 4. The social benefits (negative social costs) are based upon an averaging of the upper and lower estimates presented in Table 3 and a proportional relationship between social cost and alcohol consumption. The welfare costs are calculated from the assumption of a fixed price elasticity of demand.

Compared with the consumption patterns in 1988/89 revenue neutral taxes based either upon alcohol content or the cost of production would have increased the consumption of absolute (pure) alcohol, although the increase would have been small. This is a result of the large price elasticity for spirits, the product for which the price would fall. The tax rates with both of these options are very similar reflecting the fact that the cost of producing a litre of alcohol is coincidentally similar for each of the beverages. Despite the increased social costs associated with these two options the result is an overall increase in net economic benefits as a result of the very significant and negative "welfare costs" of the change. Both options result in a significant reduction in the distortion introduced by the highly uneven tax rates in 1988.

The implication of this latter result is that it is possible to increase consumption benefits by changing the tax *base* and simultaneously reduce social costs by increasing the tax *rate* — there is such a thing as "a free lunch". This possibility is illustrated in Table 4 by the tax increases of 20 and 30 percent with both of the alternative tax bases. While this decreases the welfare benefit it increases social and economic benefits.

These outcomes are illustrated in Figure 2, which also includes the consequences of increasing the alcohol based tax by 40 and 50 percent. From the Figure it is clear that each tax base results in a different trade-off between social gain (the reduced social cost) and welfare gain (reduced distortion). It is also clear that the diagram does not include the optimal tax rate and that additional benefits could be achieved by further tax increases.

4. OPTIMISING TAX

To investigate the tax that would minimise social cost and maximise welfare benefits, three simplifying assumptions are made. The first is that the average and marginal cost of producing each of the three alcoholic products are equal, that is, there are constant returns to scale. The second is that the market is sufficiently competitive that, in the long run, taxes will be fully passed on to consumers as higher prices. The third assumption is that over the relevant range, the demand for each of the products is a linear function of price. The assumptions imply a demand function of the form:

$$Q_i = \acute{a}_i - \sum_{j=1}^{3} b_{ij} P_j$$

which may be rewritten as —

$$Q_i = \acute{a}_i + \sum_{j=1}^{3} b_{ij} MC_j - \sum_{j=1} b_{ij} (P_j - MC_j)$$

$$Q_i = a_i - \sum_{j=i}^{3} b_{ij} T_j$$

where a_i is the net value of the first two terms in the previous expression and P_i, T_i, MC_i are price, unit tax and the marginal cost of producing the product i. Q_i the quantity is measured in litres of absolute (pure) alcohol.

The objective function to be maximised is the net value of the welfare benefits less social costs of consumption. This may be subject to the constraint that total tax revenue is equal to a pre-determined amount, R. The welfare benefit of consumption is equal to the consumer surplus plus tax revenue. For each product, i, this is equal to —

$$[a_i - \sum_j b_{ij} Q_j] \frac{Qi}{2b_i} + T_i Q_i, \; i \neq j$$

The social costs are assumed proportional to the consumption of absolute alcohol —

$$k \sum_{i=1}^{3} Q_i$$

In matrix notation the final lagrangean function including the revenue constraint may be expressed as —

$$L = \tfrac{1}{2} \; Q^T \mathbf{D} Q + Q^T T - k Q^T e + \lambda \, (R - Q^T T) \qquad ....(1)$$

$$Q = A - \mathbf{B}T$$

where

$$\mathbf{B} = \begin{bmatrix} b_{11} & b_{12} & b_{13} \\ b_{21} & b_{22} & b_{23} \\ b_{31} & b_{32} & b_{33} \end{bmatrix} \qquad \mathbf{D} = \begin{bmatrix} b_{11} & o & o \\ o & \frac{1}{b_{22}} & o \\ o & o & \frac{1}{b_3} \end{bmatrix}$$

and Q, T, and A are vectors of alcohol quantities, taxes, and the intercept terms in the linear demand equations. R is revenue; $e = [\,1\ 1\ 1\,]^T$ and the superscript T indicates the transpose of the vector or matrix.

Differentiating (1)

$$\mathbf{D}Q + \mathbf{B}^{-1}[A - Q] - Ke - (\mathbf{B}^T)^{-1} Q - \lambda [B^{-1} (A - Q) - (\mathbf{B}^T)^{-1} Q] = 0 \qquad ....(2)$$

$$[\mathbf{D} - (1 - \lambda)(\mathbf{B}^{-1} + \mathbf{B}^{-T})]Q = k\,e - (1 - \lambda)\,\mathbf{B}^{-1} A \qquad ....(3)$$

Finally,

$$Q = [\mathbf{D} - (1 - \lambda)(\mathbf{B}^{-1} + \mathbf{B}^{-T})]^{-1} \cdot \{Re - (1 - \lambda)\,\mathbf{B}^{-1} a\} \qquad ....(4)$$

$$T = \mathbf{B}^{-1} A - \mathbf{B}^{-1} Q.$$

In the simplified case where social cost k = zero, and cross price elasticities are 0 ($b^{ij} = 0$, $i \neq j$) the expression reduces to the simple Ramsey rule that tax as a percentage of price should be inversely related to the price elasticity of demand.[2] In this case the removal of the constraint on tax revenue, ($\lambda = 0$) results in

$$T_i = k$$

This result, which will be important in the discussion below, asserts the intuitively reasonable result that in the absence of a tax revenue requirement the tax per unit of alcohol should equal the marginal

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[2] Dropping all subscripts for each case i Equation 3 reduces to

$$T = \lambda(T - Q/b)$$

$$P - MC = \lambda\,(P - MC + Q\,\frac{dP}{dQ}) = (P - MC + \frac{P}{\varepsilon})$$

$$P - MC = T = \frac{\lambda}{1 - \lambda} \cdot \frac{P}{\varepsilon}$$

$$\frac{T}{P} = \frac{\text{Constant}}{\varepsilon}$$

Where ε is the own price elasticity of demand.

social cost of alcohol, k. As individuals adjust benefits to equal the value of gross price, this ensures that the marginal cost (production plus social) will equal the marginal benefit to the individual. Two sets of optimal taxes were derived from the general solution presented above. In the first, the revenue constraint was removed ($\lambda = 0$) and in the second it was set equal to the 1988/89 tax revenue of $1762 million. Linear equations were constructed which passed through the 1988/89 values of price and quantity, and, at this point had the elasticities calculated by Clements and Selvanathan. With Q_1, Q_2, Q_3 representing wine, beer and spirits respectively this results in the following values:

$$A^T = [38.1 \quad 90.7 \quad 32.0]$$

$$B = \begin{bmatrix} 323 & 0 & 0 \\ 0 & 636 & 0 \\ 0 & 189 & 245 \end{bmatrix}$$

where the units in the vector A are millions of litres of absolute alcohol and the values of Q_i are measured in thousands of litres.

Three scenarios are investigated:

1. marginal equals average social cost where social cost is the same mid value used in Table 4;

2. marginal equals three quarters of average cost; and

3. marginal equals average cost but with the lowest estimate of social cost in Table 3.

Results presented in Table 5 have some novel features. In column 2 the assumption of the average value for social costs results in a negative value for the quantity of spirits. This is not an Ipecac but the result of extrapolating too far with linear demand equations. From the earlier discussion the optimal tax in the unconstrained case must equal the marginal social cost of alcohol. In Scenario 1 (column 2) this results in a price per litre of absolute alcohol of $85. In the case of spirits this is more than double the present tax rate. More importantly, it exceeds the value of the intercept in the linear equation when Q = 0 and the value of beer is set at its optimal value. This would not occur with a constant elasticity demand function.

While extrapolation in this case resulted in optimal quantities that are arguably doubtful, the tax rates for spirits and wine are not affected by the problem. As the unconstrained taxes should be equal to the value of the marginal social cost of alcohol and this is constant (equal to, or two thirds of, the average cost) the tax in these cases is not affected by the linearity of the demand equations. The optimal tax on beer is a function of its impact upon spirits and, consequently, it is affected by the assumed linearity. By contrast with column 2 results in column 1 are plausible. They indicate that with even the most conservative estimate of social costs their inclusion in an optimal tax rate would cause a very significant increase in alcohol taxes. Overall, tax revenue would more than double. The quantity of alcohol consumed would fall by 34 percent to 108 million litres but there would be an overall gain to the community of almost $0.5 billion.

Results in column 3 are based upon a marginal social cost equal to three quarters the average but with the midpoint estimate of the total social cost. The optimal taxes implied are between those in the previous two scenarios. The very low consumption of spirits indicates that the outcome in this case is in the region of the demand curve which is subject to serious error because of the assumed linearity.

Prima facie, the constrained optima also has anomalous results. In each of the three scenarios there is

a negative tax (a subsidy) on beer. This is an outcome of a revenue constraint that *is lower* than the optimal level. In the unconstrained cases tax revenue rose between 80 and 150 percent. In order to achieve the 1988/89 revenue taxes must be lowered. This is most efficiently achieved (i.e. with the least increase in social and welfare cost) by lowering the tax on beer. While a given decrease in this has a greater negative effect upon social cost the quantity of beer consumed is so large that the required loss of revenue is achieved with a smaller tax change than with other strategies. That is, the pattern of taxes is driven in this case by the need to reduce revenue and not by the equation of taxes with social costs. This also explains the almost identical tax rates in columns 5 and 6. When the marginal social cost rises above $64/litre the combination of taxes does not change significantly. (Optimal taxes approach an asymptotic value as the value of k, the unit social cost of alcohol consumption, increases). The optimal combination that simultaneously meets the revenue constraint does not change significantly with further increases in the incremental cost of alcohol.

5. THE VALUE OF LIFE

The analysis to this point has been based upon the assumption that the value of life is equal to the present value of an individuals future production. This "human capital" approach to value has been vigorously challenged in the literature. Most products are evaluated using a willingness to pay criterion and not by their value as an input into another product. Additionally, human capital places a zero value upon the life of retired persons and upon lower paid workers, including women. This value basis would be almost universally rejected. Unfortunately, the alternative "willingness to pay" approach to evaluating life does not produce conceptually or practically more secure results. Some recent studies are summarised in Appendix 2. They reveal over a tenfold difference in the value inferred from both stated and revealed preferences for a marginal reduction in the risk of death. Results are methodologically suspect. They depend upon the context from which the information was gathered. Extrapolation from the value of reduced risk to the full value of life is based upon the expected utility hypothesis and, in this context, the axioms of the theory have been largely discredited (Pope, 1988).

Two solutions to this dilemma are presented below. The first is the approach used by Collins and Lapsley (1989). In this, the value of life to an individual is separated from the value to others. The former is measured by the value of consumption. It is recognised that this may be an underestimate because of the value of the consumer surplus, but this is often omitted from studies. Value to others includes the individual's material contribution to society plus an intangible value. In effect the full value of an individual's production is combined with the value of the remaining intangible benefit. While appealing to the literature, Collins and Lapsley essentially select a plausible but arbitrary figure of $10,000 per life year to cover this intangible figure. It could also be considered as covering the value of the omitted consumer surplus. The present study similarly selects a value of $10,000 per life year but bases this upon the authority of Collins and Lapsley! The figure is also doubled to determine the sensitivity of results to the assumption.

Table 6 presents estimates of the net economic benefits (social plus welfare) of the various ad hoc changes considered earlier. In columns 2 and 3 the intangible value of a life year is $10,000 and $20,000 respectively. In columns 4 and 5 the foregone value of consumption by those who would have died is removed from the calculation. As discussed in section 2 this adjustment would be made by those who argued that own consumption was an "internal cost" and not a concern to policy.

The results in Table 6 do not vary significantly with the different assumptions. The reason for this is that the value of life represents only about 10 percent of the total benefits, with the greatest benefits being associated with workforce productivity. Thus, for example, with the current tax base, a 20 percent increase in the rate of taxation would only add 1524 life years and variation in the value of this does not have a large impact upon the overall benefit of the strategy.

The second solution to the problem of evaluating life is to avoid the issue altogether. This is the approach adopted in cost effectiveness analysis in which the costs of achieving an objective with alternative strategies are compared without specifying the dollar value of the objective. In health program evaluation this could be gaining an additional life or, more commonly, a life year. While this approach avoids the need to quantify the value of life it usually implies that projects can only be ranked if compared with other projects which result in the same output. In the health economics literature there are now a significant number of such studies which could be compared with alcohol taxation as a means for achieving life years. As an alternative to this approach, in cost effectiveness analysis generally, a purely subjective or political decision can be made that the benefits arising from the project do or do not warrant the project costs.

In Table 7 the earlier results are presented in the format of a cost effectiveness analysis. The dollar

value of life to decadents pre-consumption is removed from the calculations and the net economic "costs" of obtaining a life year are presented for each of the ad hoc tax options. The most interesting feature of these results is that there is no cost associated with obtaining life years in any of the scenarios. Because of the other effects of taxation on social costs there is an overall — and very significant — benefit per life year gained. The exceptions are the two revenue neutral scenarios in which a new tax base is adopted. The results indicate the *benefit* (negative cost) that would be achieved for the *loss* of a life year. The very high values ($210,000 and $150,000) suggest that these are serious policy options. However, the table also indicates that even greater benefits could be achieved without a loss of life by increasing tax rates.

The rather unusual outcome shown in Appendix 2 does not imply that it is inappropriate to express the consequences of tax reform in this format. Rather, it implies that there are very compelling reasons for these changes and that, all else equal, the options outlined here should be preferred to most of the other options for gaining human life years, as the majority of these entail positive costs.

6. CONCLUSIONS

The purpose of this paper was to consider, for the first time, the full economic consequences of alcohol taxation and the full range of tax options available to achieve optimal consumption. Throughout the paper the definition of "optimal" has included both the "welfare" costs of taxation (i.e. those associated with consumption benefits and the tax induced distortion of consumption patterns) and the social cost of alcohol. The latter has included both the "external costs" to others from alcohol induced behaviour and the "internal costs" to the individual. Public health policy has not distinguished between these, either in Australia or overseas.

The chief conclusion reached is that there is a very compelling case for a new tax base and for a very significant increase in the rate of tax. This conclusion is not altered by a recognition of the poor quality of the data from which it is derived. Very significant variation in the parameters do not alter the basic result. The robustness of the conclusion arises, first, from the significant distortions that currently exist in the tax base. The elimination of these, even in the absence of other benefits, would lead to a significant reduction in the welfare cost of taxation. The second reason for the robustness of the conclusion is the magnitude of the social costs associated with alcohol. Even if these were only 30% of the average value used here then it would be advantageous to increase existing tax rates by 20% even without a change in the tax base.

The results support the argument by various public health groups for an alcohol based tax in preference to the present tax base. However, the reason is rather circuitous. The new tax base would not have a significant impact upon social costs if the tax was revenue neutral and might even have a negative effect. However, the welfare benefits of the new base would allow an increased rate of tax such that consumer benefits would increase while social costs simultaneously fell. Almost the same outcome could be achieved with a value based tax as, coincidentally, the production cost of a litre of alcohol is very similar across the three beverage groups.

While the paper investigated the issue of optimal taxes the results are not reliable. The social cost is so large that taxes which are adjusted to internalise these, result in a very large increase in gross prices. This results in an unacceptable level of extrapolation. Further work is warranted to determine the impact of assuming alternative demand functions. Despite these reservations even the most conservative of the optimal taxes imply a major upward revision in the tax rates.

A further qualification with this or with any other cost effectiveness study is that the results have strong distributional implications and these might be deemed more important than the issue of economic efficiency. Increased taxes will penalise some drinkers whose behaviour would not have led to increased social costs. Others will obtain a disproportionate benefit and especially those whose death is averted by increased taxes. A similar redistribution occurs with any life saving public health intervention.

Finally, and to end the paper on a ritual note, there is an obvious need for significantly more research in almost all aspects of alcohol consumption. Two issues are of particular importance. First, the quantitatively largest social costs are the costs to industry. To date there has been virtually no investigation of these in Australia. Overseas studies are methodologically imperfect. Second, optimal tax rates depend upon the marginal and not the average social costs and, again, there is very limited information on the relationship between these. Even with further research it is likely that these costs will remain problematical as measurement methodologies have not been devised which are fully satisfactory. However, the second best solution to ideal measurement is not to ignore quantitatively important issues. It is to use the best evidence available.

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TABLE 1: MANNINGS' CLASSIFICATION OF THE COSTS OF SMOKING AND ALCOHOL CONSUMPTION

Type	Internal	External
Premature death	Smoker and family*	Co-workers and others*
Pain and suffering	Smoker and family*	Co-workers and others*
Medical costs	Copayments	Insurance reimbursements
Sick leave	Uncovered sick loss†	Covered sick loss
Disability	Foregone income not replaced by disability insurance	Disability insurance
Group life insurance	Negligible	Death benefit
Pension	Defined contribution plans	Social Security and defined-benefit plans
Wages	Foregone disposable income	Taxes on earnings
Other costs	Property loss due to fires paid by person	Insured property loss due to fires
Tobacco products	Cigarette purchases	

* Premature mortality and suffering among family members and coworkers is caused by passive smoking. The authors classify costs borne by other family members as internal costs.

† *Covered* means subject to some kind of insurance or income-replacement plan

Source: Manning et al. 1989 page 1605

TABLE 2: PERCENT COMPOSITION OF TOTAL SOCIAL COST

Country	U.K.	U.K.	N.Z.	U.S.A.	U.S.A.	U.S.A.	AUST.
Year	1977/78	1983	1981/82	1971	1977	1980	1991
Author	Holtermann & Burchell	Maynard & McDonnell	Chetwynd & Rayner	Berry & Boland	Schifrin	Harwood	Lapsley & Collins
	High Est.						
Cost to:							
A. Industry							
Efficiency	39.9	39.7	28.7	40.1*	51.6	50.6	3.8
Non-Market/ Housework	0.7	2.6	5.8	n/a	10.7		
Unemploy-ment	8.3	9.0	39.6			4.1	
Death	33.8	35.4	26.9	10.5	5.2	16.1	54.1
SUB-TOTAL	82.8	86.5	100.0	50.6	68.2	77.2	57.9
B. Health Service	8.1	6.0		28.2	17.5	11.5	9.6
C. Other	9.2	7.5		21.0	14.2	11.2	32.5
TOTAL	**100**	**100**	**N/A**	**100**	**100**	**100**	**100**
Percent GDP	**0.42**	**0.54**	**2.29**	**2.95**	**4.75**	**3.47**	**1.77**

* *Includes the cost of unemployment.*

TABLE 3: ESTIMATES OF THE SOCIAL COST OF ALCOHOL TO AUSTRALIA IN 1988 EXTRAPOLATED FROM OTHER STUDIES

STUDY COUNTRY	EXTRAPOLATED AUSTRALIAN COST IN 1989 $1989 BN.	
	UNADJUSTED (2)	ADJUSTED (3)
AUSTRALIA		
DREW & PRICHARD (1)	7.84	8.18
U.K.		
MCDONNELL & MAYNARD	1.82	6.70
N.Z.		
CHETWYND & RAYNER	7.71	6.80
U.S.A.		
SCHIFRIN	15.98	17.40

Notes:

1. Unadjusted estimate scaled by respective values of GDP. Prichard's values for the cost of mortality and unemployment are added to Drew's estimates of other values.

2. Extrapolated from reported figures; unadjusted for omissions or for methodological shortcomings.

3. Adjusted as described in the text.

TABLE 4: AD HOC CHANGES TO THE TAX RATE AND TAX BASE INPUT ON CONSUMPTION AND NET BENEFITS

TAXATION BASE	TAX RATE $			% CHANGE ALCOHOL CONSUMPTION	SOCIAL [1] BENEFITS $M 1988/8	WELFARE [2] COST $M 1988/89	NET ECONOMIC BENEFITS $M 1988/89
		% COST	PER LITRE ALCOHOL				
CURRENT TAX BASE 1988/89	Beer Wine Spirits	22.8 9.9 90.6	10.54 3.80 34.31				
20% INCREASE	Beer Wine Spirits	27.3 11.8 108.7	2.65 4.56 41.17	-2.58	310.9	95.3	215.6
30% INCREASE	Beer Wine Spirits	29.6 12.8 117.8	13.70 4.94 44.60	-3.84	462.7	150.3	312.4
Alcohol Based REVENUE NEUTRAL	Beer Wine Spirits	26.6 31.9 32.5	} } 12.30 }	0.88	-106.0	-196.6	90.6
20% INCREASE	Beer Wine Spirits	31.9 38.3 39.0	} } 14.76 }	-1.54	185.6	-111.0	296.6
30% INCREASE	Beer Wine Spirits	34.5 41.5 42.2	} } 15.99 }	-2.74	330.2	-74.7	404.9
Value Added Tax Revenue Neutral	Beer Wine Spirits	} } 28.0 }	12.96 10.78 10.60	1.13	-136.2	-214.8	78.6
20% Increase	Beer Wine Spirits	} } 33.6 }	15.55 12.94 12.72	-1.22	147.0	-137.7	284.7
30% Increase	Beer Wine Spirits	} } 36.4 }	16.85 14.01 13.78	-2.40	289.2	-88.8	378.0

1. Estimate of social benefits based on mid-value as presented in Table 3. A negative sign refers to social cost associated with increased alcohol consumption.

2. Negative sign refers to consumer welfare gain.

TABLE 5: OPTIMAL TAXES

	1988 VALUES	UNCONSTRAINED TAX			CONSTRAINED TAX REVENUE		
		SOCIAL COST		MC = 1/2 AC	SOCIAL COST		MC = 1/2 AC
		LOW	AVERAGE		LOW	AVERAGE	
TAX RATE $/LITRE ALCOHOL							
Beer	10.54	30.5	92.7	56.7	-1.4	-3.8	-3.8
Wine	3.80	48.0	85.0	63.6	41.6	74.2	74.2
Spirits	34.3	48.0	85.0	63.6	37.6	56.4	56.4
TAX COST %							
Beer	22.7	65.8	200.3	122.6	-3.1	-8.2	-8.2
Wine	9.9	103.7	220.8	165.2	108.1	192.2	192.7
Spirits	90.6	126.8	224.5	168.0	99.3	149.0	149.0
QUANTITY[(1)] million litres							
Beer	85.0	71.3	31.7	54.6	91.6	93.1	90.1
Wine	36.9	22.6	10.7	17.6	24.7	14.2	14.1
Spirits	21.5	14.5	-6.4	5.7	23.0	18.9	18.8
TAX REVENUE ($ million)	1,762.3	3,952.1	3,302.9	4,575.6	1,762.3	1,762.3	1,762.3
Net Economic Benefits ($ million)		440.8	3038.0	930.9	171.4	634.6	85.2

TABLE 6: NET ECONOMIC BENEFITS OF AD HOC TAXES WITH DIFFERENT VALUES OF HUMAN LIFE

METHOD TAX BASE	VALUE OF LIFE				
	HUMAN k APPROACH	**WTP(1) + CONSUMPTION**	**WTP (2) + CONSUMPTION**	**WTP (1), NO CONSUMPTION**	**WTP (2), NO CONSUMPTION**
CURRENT TAX					
20% INCREASE	215.6	231.1	246.6	220.8	236.2
30% INCREASE	312.4	335.5	358.5	320.1	343.1
ALCOHOL BASED					
REVENUE NEUTRAL	90.6	85.3	80.0	88.8	83.5
20% INCREASE	296.6	305.8	311.1	299.7	308.9
30% INCREASE	404.9	421.3	433.8	410.4	426.8
VALUE ADDED TAX					
REVENUE NEUTRAL	78.6	71.9	65.1	76.4	69.6
20% INCREASE	284.7	292.0	299.4	287.2	294.5
30% INCREASE	378.0	392.4	406.0	382.8	396.5

NOTES (1) Value of Life equals $10,000 per life year plus the value of production
(2) Value of Life equals $20,000 per life year plus the value of production

TABLE 7: NET ECONOMIC COSTS PER DISCOUNTED LIFE YEAR GAINED FROM DIFFERENT TAX BASES ($1988/89)

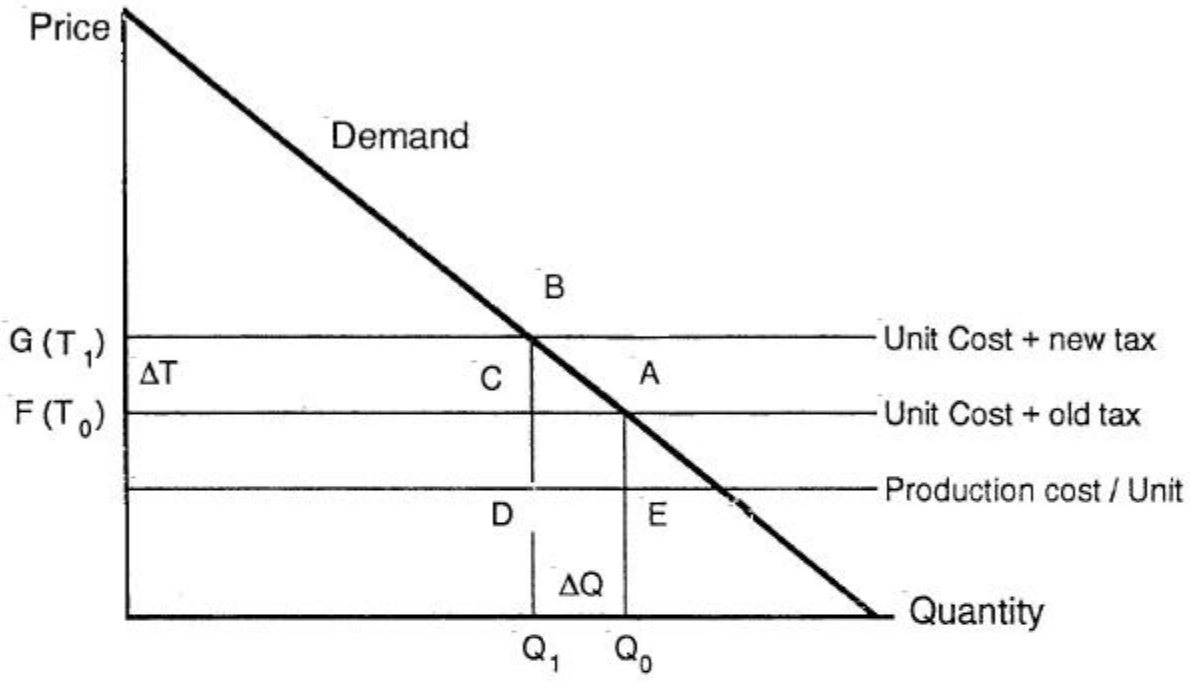
TAX BASE	LIFE YEARS GAINED[1] d = 6%	NET ECONOMIC COSTS $M [2] (Mid Value)	NET ECONOMIC COSTS PER LIFE YEAR GAINED $M [3]
Current Beverage Base			
20% Increase	1527	-164.7	-0.11
30% Increase	2272	-236.6	-0.10
Alcohol Based			
Revenue Neutral	-521	-108.0	(0.21)[4]
20% Increase	911	-266.2	-0.29
30% Increase	1621	-350.8	-0.22
Value Added Tax			
Revenue Neutral	-669	-100.9	(0.15)[4]
20% Increase	722	-245.0	-0.34
30% Increase	1420	-330.6	-0.23

NOTES:
1. Future life years are discounted at 6 percent.
2. Assumes the mid value for the social cost of alcohol presented in Table 3. Net economic cost (benefit) is the addition of the social and welfare costs (benefits).
3. Negative values indicate a net benefit per life year gained.
4. Benefit per life year lost.

FIGURE 1: ILLUSTRATIONS OF CALCULATION OF WELFARE LOSS ASSOCIATED WITH TAX CHANGE

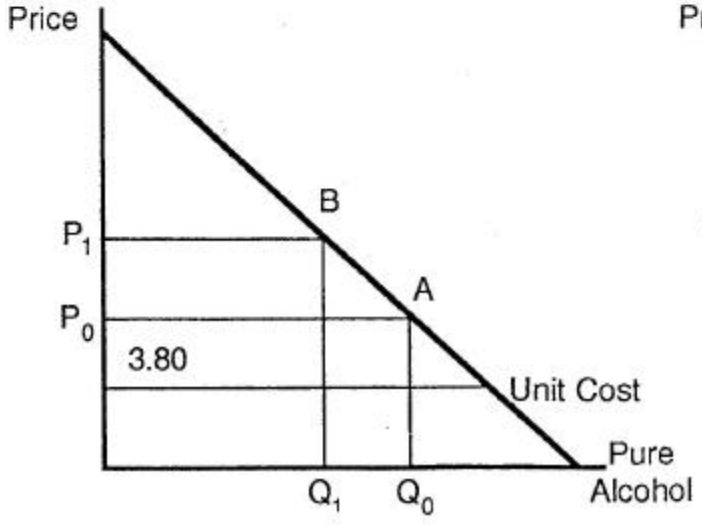
A

Beer



B

Wine



C

Spirits

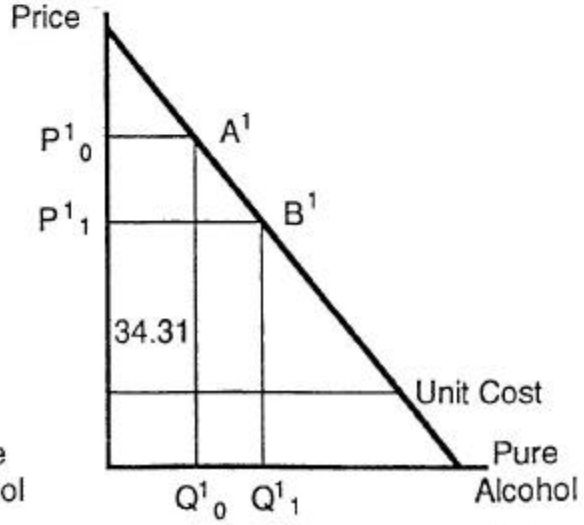
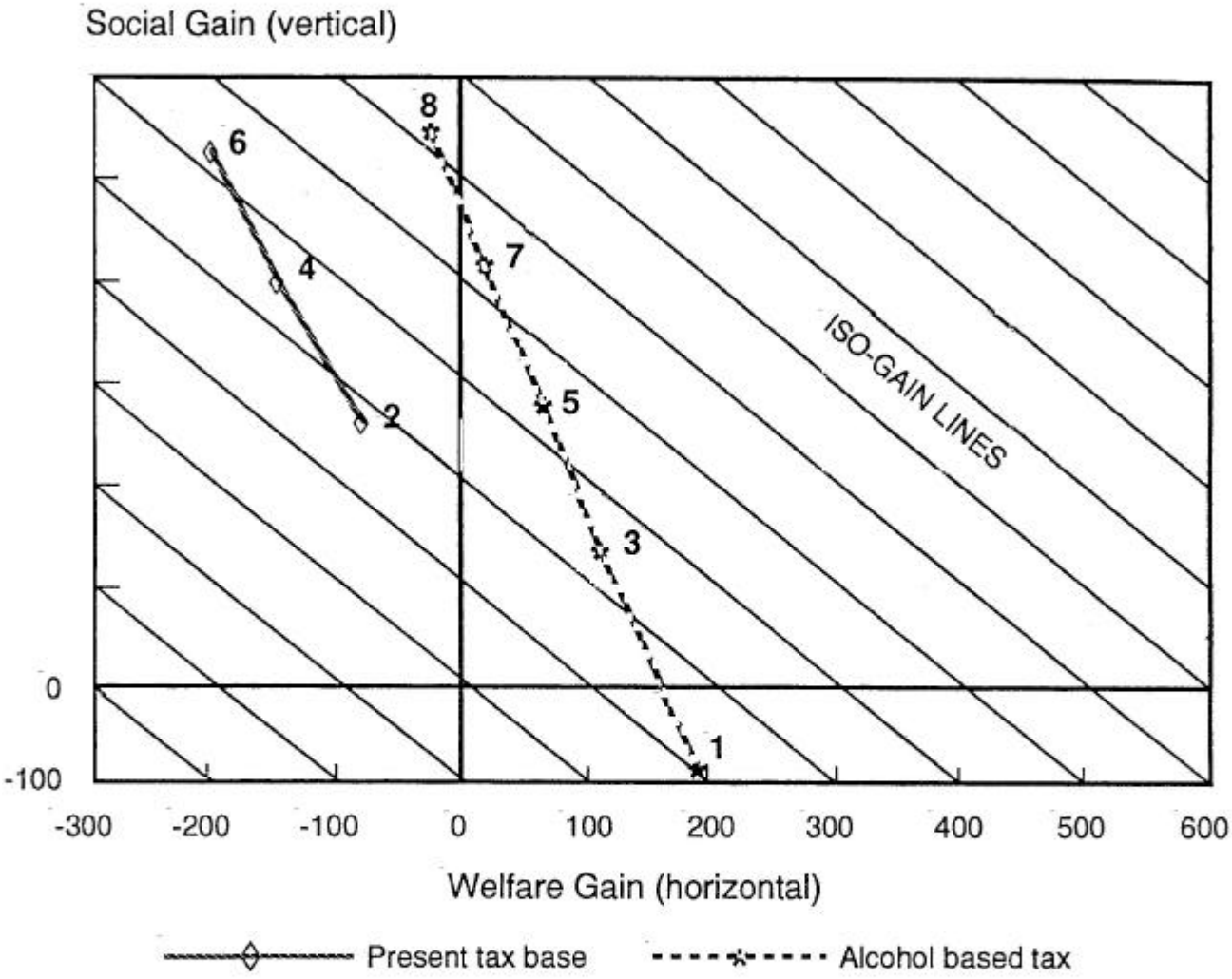


FIGURE 2: THE ECONOMIC BENEFITS OF ALCOHOL TAXATION



Key:

Alcohol based tax		Present tax base	
1	(196, -91)	2	(-95, 267)
3	(111, 160)	4	(-150, 394)
5	(75, 284)	6	(-208, 536)
7	(22, 415)		
8	(-23, 534)		

APPENDIX 1: EXPENDITURE PRICE AND QUANTITY, ALCOHOLIC PRODUCTS IN AUSTRALIA, 1988/89

	BEER	WINE	SPIRITS	TOTAL ALCOHOL
1. Household Expenditure per Week ($ 1988)	9.74	3.30	3.34	16.34
2. Proportion of Total	0.60	0.20	0.20	1.00
3. Estimated National Expenditure 1988/89	4771.2	1,561.3	1,552.5	7,885.0
($M 1988/89)	(60.5%)	(19.8%)	(19.7%)	
4. Quantity Beverage Consumed 1988/89	1,885,857	317,981	53,720	2,257,558
('000 litres)	(59.0%)	(25.9%)	(15.1%)	
5. Quantity Absolute Alcohol Consumed 1988/89 ('000 litres)	83,962	36,912	21,488	143,362
6. Price/unit Volume ($ 1988/89)	2.53	4.91	28.90	3.49
7. Total Tax ($M 1988/89)	884.67	140.35	737.27	1762.29
8. Tax/litre Beverage	0.47	0.44	13.72	0.78
9. Tax per litre alcohol	10.54	3.80	34.31	12.38
10. Expenditure — tax = cost	3886.53	1420.95	813.57	6121.05
11. Cost per litre alcohol	46.29	38.50	37.86	43.00
12. Tax/cost %	22.77	9.87	90.62	28.79

Sources:

Row 1. ABS Household Expenditure Survey, Australia. Detailed Expenditure Items, 1988/89 cat. No. 6535.0

Row 2. From Row 1.

Row 3. ABS National Accounts: National Income and Expenditure 1988/89, Table 47 Cat. No. 5206.0. Information is available from retail surveys for total alcohol expenditure. Disaggregated data is available for 1985/86 published in a Special Issue of the above ABS publication (1988). To obtain the 1988/89 estimates for the individual alcohol beverages 1985/86 expenditures were adjusted by the appropriate index in the CPI alcohol sub-group. This results in total estimated National Expenditure being slightly less than that cited in the ABS National Accounts 1988/89.

Row 4. ABS Apparent Consumption of Foodstuffs and Nutrients, preliminary report, 1988/89, Table 1, Cat. No. 4306.0.

Row 5. Ibid., The estimated litres alcohol consumption for spirits has been calculated by assuming that average

alcohol content of spirits is 40% vol/vol.

Row 6. Row 3 ÷ Row 4.

Row 7. Information obtained from the Commonwealth Department of Health, Statistical Services Section. Excludes state licence fees and taxes as data is only available for total alcohol group.

Row 8. Row 7 ÷ Row 4.

Row 9. Row 7 ÷ Row 5.

Row 10. Row 3 ÷ Row 7.

Row 11. Row 10 ÷ Row 5.

Row 12. Row 7 ÷ Row 10.

APPENDIX 2: ESTIMATES OF VALUING LIFE USING WILLINGNESS TO PAY (WTP) METHODOLOGY

AUTHOR (COUNTRY)	ESTIMATE 1991 ($A MIL) PER LIFE	METHOD	COMMENTS
Arnould & Nichols (U.S.A., 1983)	1.14	Compensating wage differential approach	Based on occupational risk and actuarial estimates from insurance data
Blomquist (U.S.A., 19)	1.2 - 20.5	Contingent valuation method	Based on a survey of other authors studies which employ questionnaires relating to air travel
	0.8 - 5.5	Compensating wage differential approach	Estimates based on range of studies
Miller (U.S.A., 1989)	1.6 - 5.0	Mix of WTP approaches	Assessed 49 value of the value of life based on WTP. Estimates are based on 29 of these which are deemed to be methodology sound
	1.6 - 4.8	Compensating wage differential approach	Of the above 29 studies, 15 are based on this method.
Jones - Lee et al. (1985)	2.5 - 6.9	Contingent valuation approach	Questionnaires based upon wtp to reduce the risk of serious motor vehicle accidents
Dardis (1980)	0.6 - 0.9	Contingent valuation approach	Based on the demand for residential smoke detectors
Lapsley and Collins 1991, (Aust)	$10,000/ life year		Reviewed published studies and applied low estimate