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Optimal alcohol taxes for Australia

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Abstract.

Objective: To estimate welfare maximising tax rates for beer, wine, and spirits using a mathematical model that considers both the welfare loss alcohol taxes impose on non-abusive consumers and the welfare gains due to alcohol taxes reducing externality costs.

Results: Optimal per litre of pure alcohol (LAL) tax rates are substantially different to both current alcohol tax rates and the uniform tax rate recommended as part of the 2010 Australian Government Tax Review. Given an individual consumer utility decision model, the best estimate values of the welfare maximising LAL tax rates are: $37 for beer, $11 for wine, $50 for spirits, and $77 for ready-to-drink spirits.

Conclusion: As externality costs and the responsiveness of consumers to price changes are different for each alcohol type, community welfare is maximised by setting beverage specific LAL tax rates.

Key Words: Tax, Alcohol, Externalities

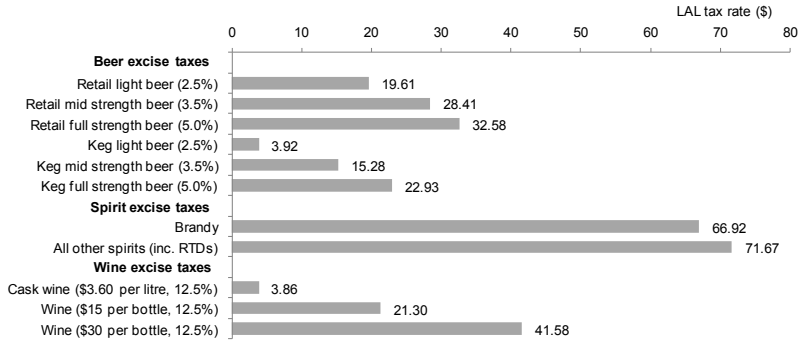
JEL: I18, H23, H21

Introduction

Externality costs, incomplete information about costs, and self-control issues are all potential grounds for government intervention in the alcohol market [1]. National governments have a wide variety of intervention options, but one almost universal policy choice has been to levy alcohol specific taxes [2]. Unfortunately, Australia's current alcohol excise tax regime has been poorly designed and is in need of reform [3].

Figure 1 provides details on Australian excise tax rates in a common format; namely tax per litre of pure alcohol (LAL). For beer there are six different excise tax rates -- three different excise tax classes × two packaging formats, and for spirits there are two different excise tax rates. Wine is taxed on the basis of price not alcohol content, and so for wine three representative cases are shown. To put Australian excise tax rates in perspective, Table 1 provides information on the LAL excise tax rate for beer, wine, and spirits in 29 countries, and the ten largest American states. Notable features of the information in Figure 1 are that: low alcohol beer is lightly taxed; draught beer is taxed more lightly than packaged beer of equivalent alcohol strength; spirits are heavily taxed; cheap wine is lightly taxed; and expensive wine is heavily taxed. Notable features of the information shown in Table 1 are that: countries with a substantial wine industry generally have no wine excise tax or a very low wine tax; spirits are heavily taxed; and current alcohol tax rates in Australia are relatively high.

Figure 1 **Effective alcohol excise tax rates for beer, wine and spirits**



Note: Excise rates are for August 2010, and actual rates are indexed in February and August each year. Beer excise rates are effective excise tax rates that take account of the 1.15 percent excise free component. Wine tax

rates have an adjustment for the impact of the WET producer rebate that exempts the first $500,000 in wholesale sales from tax.

Source: Beer and spirits excise tax www.ato.gov.au wine values based on industry reports.

Table 1 **Alcohol excise taxes per litre of ethanol in 2010 Australian dollars**

Country	Beer LAL $	Wine LAL $	Spirits LAL $	Country	Beer LAL $	Wine LAL $	Spirits LAL $
Australia[a]	32.17	14.90	71.67	Luxembourg	2.93	0.00	15.41
Austria	7.40	0.00	14.80	Malta	2.77	0.00	20.72
Belgium	6.33	5.51	25.93	Michigan[b]	7.95	1.18	1.21
Bulgaria	2.84	0.00	8.32	North Carolina[b]	9.76	5.39	6.05
California	2.40	0.46	1.21	Netherlands	10.06	8.25	22.26
Canada	5.85	5.18	12.37	New York	4.69	0.69	0.85
Cyprus	1.47	0.00	8.85	Ohio[b]	6.59	0.74	1.09
Czech republic	4.66	0.00	16.59	Pennsylvania[b c]	4.77	na	0.49
Denmark	10.12	9.65	29.81	Poland	6.81	4.35	17.29
Estonia	8.03	8.55	20.99	Portugal	5.33	0.00	14.94
Finland	38.47	33.10	58.30	Romania	2.77	0.00	11.10
Florida	4.74	5.18	2.91	Slovakia	6.10	0.00	15.98
France	4.01	0.40	22.39	Slovenia	14.80	0.00	14.80
Georgia[b]	2.76	3.48	6.13	Spain	3.37	0.00	12.29
Germany	2.91	0.00	19.28	Sweden	24.10	24.78	72.82
Greece	9.62	0.00	36.25	Texas	1.75	0.47	1.21
Hungary	8.66	0.00	15.12	United Kingdom	28.13	28.90	38.66
Illinois	6.23	3.20	1.40				
Ireland	23.25	44.51	46.06	Average	8.76	5.87	18.84
Italy	8.69	0.00	11.84	St deviation	8.67	10.31	17.91
Latvia	4.56	7.43	18.59	Min	1.47	0.00	0.49
Lithuania	3.64	6.71	18.93	Max	38.47	44.51	72.82

Note: Beer conversions made for alcohol content of 4.8 percent by volume, and wine conversions made for average alcohol content of 12.65 percent. Conversions to Australian dollars are based on ten year average exchange rates to October 2010.

[a] Wine calculation based on average price of wine sold in Australia.

[b] State government controls all spirit sales and the implied excise tax rate is calculated using the Distilled Spirits Council of the United States methodology.

[c] All wine sales are through state-run stores.

Source: European Commission Excise Duty Tables July 2010; Canada www.cra-arc.gc.ca; and US www.taxfoundation.org

Attempts to estimate optimal alcohol taxes for Australia in the 1980s suffered from significant data uncertainty, but were nevertheless able to show that moving to a regime where tax rates are set based on externality cost information could generate an overall welfare gain [4]. The following discussion further develops a methodology for calculating alcohol taxes noted in the 2010 Australian Government tax review as appropriate, but not used, and then calculates optimal alcohol taxes rates for beer, wine, spirits, and ready-to-drink spirits (RTDs) under different assumptions.

Method

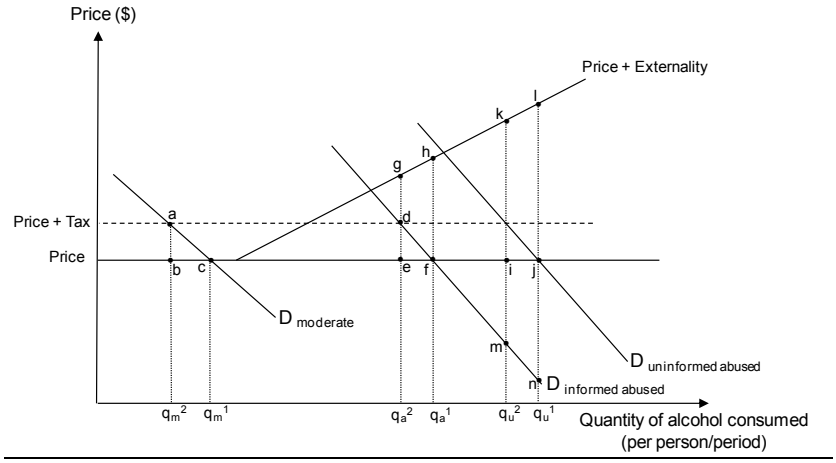
The model [5] [6] assumes there are three types of alcohol consumer: moderate drinkers, informed abusers, and uninformed abusers. Consumption by moderate drinkers results in no externality

costs, but consumption by abusers does. The difference between informed abusers and uninformed abusers is that informed abusers recognise the full range of private costs associated with abusive consumption, whereas uninformed abusers do not. The uninformed abuser group would include young and underage drinkers. The model also assumes that: (i) the alcoholic beverage industry is a competitive industry where price equals long run marginal cost and any tax change is fully passed through to the consumer;[1] (ii) alcohol tax revenue is cycled back to consumers; and (iii) due to the small budget share for each beverage type the income compensated demand curve and the uncompensated demand curve are approximately equal.

Abstracting from the issue of different beverage types to illustrate, the problem faced by the policy maker trying to set the optimal alcohol tax can be understood by considering Figure 2. Prior to the introduction of the tax moderate drinkers consume at the point q_m^1 and impose no externality costs on society. Informed abusers take complete account of the negative impacts of excessive alcohol consumption on themselves, and prior to the introduction of the tax consume at the point q_a^1. The dollar value of the marginal externality cost imposed on society with consumption of q_a^1 is equal to the vertical distance *fh*. Uninformed abusers fail to recognise some of the private costs of excessive alcohol consumption and so consume more than informed abusers. Specifically, prior to the tax uninformed abusers consume at the point q_u^1, and at this point the marginal benefit to the individual consumer is less than the marginal cost by the distance *nj*, with the marginal externality cost imposed on society equal to the distance *jl*.

[1] If it is made clear at the outset that the desired policy outcome is to raise prices by a fixed amount and that if prices do not increase by this amount the tax rate will be increased further, there is little reason to think that 100 percent of the tax will not be passed through to consumers.

Figure 2 **Optimal alcohol taxation welfare losses and gains**



Note: Figure draws on [5] [6].

Following the introduction of the tax consumption by moderate consumers falls to q_m^2, consumption by informed abusers falls to q_a^2, and consumption by uninformed abusers falls to q_u^2. The welfare implications of these changes are as follows: moderate consumers suffer a welfare loss equal to the area *abc*; informed abusers suffer a welfare loss equal to the area *def*, but society gains the area *efgh* due to lower externality costs; uninformed abusers enjoy a welfare gain equal to the area *ijmn*, and society gains the area *ijkl* from the reduction in externality costs. A formal mathematical representation of Figure 2, along with the implied optimal tax formula is given in the appendix.

With the basic framework established, it is now possible to return to the issue of beverage specific taxes. There is strong evidence that externality costs vary with beverage type [8-13], and that the own-price elasticity of demand is different across beer, wine, and spirits [14]. This means the optimal tax will be different for each beverage type. The task of calculating optimal beverage specific taxes is however simplified as there is evidence that at an aggregate level cross beverage substitution impacts can be ignored [15].

The information required to calculate the optimal tax for each beverage type is the pre-tax price; the average alcohol content; the average externality cost for abusive consumption in the relevant range; the average uninternalised private cost for uninformed abusers; the own-price

elasticity of demand for moderate drinkers, informed abusers, and uninformed abusers; and the consumption share for moderate consumers, informed abusers, and uninformed abusers. Additionally, for spirits and RTDs cross-price elasticity values are required. The best estimate values for each of the above parameters are shown in Table 2.

Details of how the values in Table 2 were calculated are contained in the supplementary material, but the pre-tax price information has been derived from unpublished industry data; the elasticity information is taken from economic studies [14] [16]; the externality cost estimates are from a comprehensive study on the social costs of alcohol and drug use [7], with beverage specific cost shares informed by analysis of Australian National Drug Strategy Household Survey data [11] and other relevant information; the specific cost items included as externality costs are consistent with those considered in a recent alcohol tax paper [17]; the alcohol content calculations are based on industry data, but are consistent with the values reported in a recently revised alcohol consumption series [18], and the uninternalised private cost was inferred from available demand information.

Table 2 **Model parameter values used to calculate optimal Australian alcohol taxes**

Model parameters	Beer	Wine	RTDs	Spirits
Key beverage details				
Average pre-tax price $ LAL	99	76	78	46
Consumption LAL (M litres)	73.9	65.0	18.1	17.1
Average alcohol content (%)	4.24	12.65	5.15	36.27
Consumption shares				
Moderate consumption share of total consumption (%)[a]	56	72	43	52
Informed abuser share of total consumption (%)	35	25	40	35
Uninformed abuser share of total consumption (%)[b]	9	3	17	13
Price elasticity values				
Overall beverage price elasticity	-.37	-.40	-.67	-.96
Best estimate consumer type price elasticities				
Moderate consumers	-.50	-.47	-1.00	-1.33
Informed and uninformed abusive consumers	-.21	-.19	-.41	-.55
Low variation in consumer type price elasticities				
Moderate consumers	-.46	-.45	-.87	-1.20
Informed and uninformed abusive consumers	-.27	-.26	-.51	-.70
High variation in consumer type price elasticities				
Moderate consumers	-.55	-.50	-1.13	-1.46
Informed and uninformed abusive consumers	-.15	-.13	-.31	-.40
Spirits-RTDs cross-price elasticity values[c]				
Moderate consumers	-	-	.29	.33
Informed abusive consumers	-	-	.08	.07
Uninformed abusive consumers	-	-	.08	.06
Externality costs				
Family utility model				
Externality cost informed abusers $ per LAL	71	43	80	89
Externality cost uninformed abusers $ per LAL	78	47	88	98
Individual utility model				
Externality cost informed abusers $ per LAL	125	75	151	141
Externality cost uninformed abusers $ per LAL	137	82	166	155
Uninternalised private costs				
Uninformed abuser uninternalised private $ per LAL[d]	66	56	41	40

Note: [a] Total moderate consumption share set at 60 percent of total ethanol consumption. [b] Total uninformed abuser ethanol share set at 20 percent of total abuser ethanol intake. [c] The value in the RTD column gives percentage change in RTD consumption following a one percent change in the price of spirits, and the value in the spirits column gives the percentage change in spirit consumption following a one percent change in the price of RTDs. [d] These values depend in part on the assumed elasticity value, and the values shown are those consistent with the best estimate elasticity values.

Results

The first set of results in Table 3 are estimates of the optimal alcohol tax for each beverage where the decision unit is assumed to be the family so that any negative impacts felt by family members due to abusive consumption are not considered. The second set of results in Table 3 are estimates of the optimal tax where the decision unit is assumed to be the individual so that the negative impacts on family members due to abusive alcohol consumption are considered. For the purposes

of discussion, the results based on considering the individual as the appropriate decision unit are used.

For beer, the estimated optimal tax rate involves a small increase in the effective full strength packaged beer tax, and a 60 percent increase in the current effective full strength draught beer tax. Excise tax is a relatively small part of the overall draught beer retail price, and as such, an increase in the draught beer tax rate of 60 percent implies a retail price increase of only six percent. The beer industry is therefore unlikely to be impacted dramatically by the change in taxation suggested by the optimal tax formula.

As the current wine tax is based on price not alcohol content, the implications of applying an LAL tax rate of $11.22 are difficult to calculate, but several broad points can be made. First, if the current tax revenue collected from wine was converted to an LAL equivalent the implied tax rate would be around $13-$14. So, overall the total tax burden on the wine industry would fall. Second, the excise tax on wine retailing for less than around $10-11 per bottle would rise and the excise on wine retailing for more than around $10-11 per bottle would fall. Third, the effective tax on cask wine would increase by almost 300 percent; implying an increase in retail price of around 25 percent. So, although the optimal wine tax is relatively low, shifting to a volumetric tax of $11.22 would have a noticeable impact on the relative price of different wine products.

For spirit drinkers the results suggest the tax on RTDs should be increased slightly, and that the tax on bottled spirits should be reduced by around 30 percent. The implied retail price increase for RTDs would be around 4-5 percent, while the implied retail price fall for bottled spirits would be around 17 percent. The model accounts for substitution between bottled spirits and RTDs. If cross beverage substitution effects within the spirits market were ignored, the implied optimal LAL tax rates would be lower. Specifically, for the individual utility model the optimal tax rates would be $66 for RTDs and $47 for spirits.

All parameter values were varied within what where thought reasonable ranges, and the key model assumption was found to be the assumption about the relative price responsiveness of abusive and moderate consumers. If abusers are assumed to be more insensitive to price changes than in the default case optimal taxes fall by around 30 percent (lower bound estimates in Table 3). If abusers are assumed to be more sensitive to price changes than in the default case optimal taxes increase by around one third (upper bound estimates in Table 3).

Table 3 **Optimal Australian alcohol taxes**

Beverage Category	Family utility model			Individual utility model		
	Best estimate	Lower bound	Upper bound	Best estimate	Lower bound	Upper bound
Wine tax $ per LAL	9.13	4.96	8.85	11.26	8.07	14.85
Beer tax $ per LAL	29.81	17.07	28.23	36.95	27.46	46.99
RTDs tax $ per LAL	47.36	32.15	65.31	76.79	52.35	104.60
Spirits tax $ per LAL	29.82	19.04	41.78	49.80	32.19	68.92

Discussion

The analysis presented here has shown that the alcohol tax rates that maximise overall community welfare -- in that they balance the costs imposed on moderate drinkers against the gains made from lowering externality cost -- vary substantially with beverage type, and so the default position taken in the 2010 Australian Government tax review of a uniform LAL tax rate equal to the current packaged beer tax rate will not maximise overall community welfare.

In addition to raising overall community welfare, using the approach outlined here to set alcohol taxes has a number of additional benefits, the most important of which is that the approach aligns the interests of alcoholic beverage manufactures with those of the broader community. The alignment of interests occurs because with alcohol taxes set based on the formulas given in the appendix, the optimal alcohol tax falls if either the share of abusive consumption falls or the share of uniformed consumers falls. In the specific case of wine, moving to a volumetric tax of $11.22 would have the additional effect of raising the minimum standard drink price in Australia by around 25 percent.

Appendix

The situation described by Figure 2 in the main text can be formally developed as a model for calculating the optimal alcohol tax as follows. First, note that for the purposes of calculating optimal taxes the markets for beer, wine, and spirits can be treated separately. This means that for beer and wine the change in welfare following the introduction of the tax can be written, respectively, as:

$$W = \frac{1}{2}T_b(\Delta q_b^m)N_b^m + \frac{1}{2}T_b(\Delta q_b^a)N_b^a - E_b^a(\Delta q_b^a)N_b^a - E_b^u(\Delta q_b^u)N_b^u - H_b^u(\Delta q_b^u)N_b^u, \text{ and} \tag{1}$$

$$W = \frac{1}{2}T_w(\Delta q_w^m)N_w^m + \frac{1}{2}T_b(\Delta q_w^a)N_w^a - E_w^a(\Delta q_w^a)N_w^a - E_w^u(\Delta q_w^u)N_w^u - H_w^u(\Delta q_w^u)N_w^u. \tag{2}$$

For the spirits market it is necessary to consider the interaction between bottled spirits consumption and RTD consumption, and so the change in welfare following the introduction of a tax can be written as:

$$\begin{aligned} W = {} & \frac{1}{2}T_s(\Delta q_s^m)N_s^m + \frac{1}{2}T_s(\Delta q_s^a)N_s^a - E_s^a(\Delta q_s^a)N_s^a - E_s^u(\Delta q_w^u)N_w^u - H_s^u(\Delta q_s^u)N_s^u \\ & + \frac{1}{2}T_r(\Delta q_r^m)N_r^m + \frac{1}{2}T_r(\Delta q_r^a)N_r^a - E_r^a(\Delta q_r^a)N_r^a - E_r^u(\Delta q_r^u)N_r^u - H_r^u(\Delta q_r^u)N_r^u. \end{aligned} \tag{3}$$

In the above T_i denotes the tax for beverage type *i* (*i* = beer, wine, spirits, RTDs); Δq_i^j denotes the change in consumption of consumers of type *j* (*j* = moderate, informed abuser, uninformed abusers) in beverage category *i*; N_i^j denotes the number of consumers of type *j* of beverage type *i*; E_i^j denotes the marginal externality cost associated with consumers of type *j* of beverage type *i* averaged over the relevant range of consumption; and H_i^j denotes the marginal uninternalised private cost for consumer type *j* of beverage type *i*, averaged over the relevant range. With this notation it can be seen that in equations (1) and (2) the first term captures the fall in welfare of moderate consumers following the introduction of the tax, and the second term captures the fall in

welfare of informed abusers. The third and fourth terms capture the gain to society from the reduction in externality costs associated with the reduced consumption of informed abusers and uninformed abusers, respectively, and the final term captures the private benefits to uninformed abusers following a reduction in their consumption. For the spirits market it is necessary to consider both what happens to RTD consumption and what happens to bottled spirit consumption, so equation (3) has double the terms of equation (1) and (2).

Now, let $N_i^j q_i^j = Q_i^j$, so that Q_i^j denotes the total amount of consumption associated with consumer type *j* for beverage *i*. The price elasticity is defined as $\eta_{ik}^j = \frac{\Delta Q_i^j / Q_i^j}{\Delta P_k \ / P_k}$, and gives the ratio of the percentage change in the consumption of beverage type *i* in consumer category *j* divided by the percentage change in the price of beverage *k*, where $\Delta P_k \ = T_k$ and here price refers to the pre-tax price. Given each market is treated separately, and using the above relationships, it is possible to write the total change in consumption for beer, wine, bottled spirits, and RTDs following the introduction of a tax, as, respectively: $\Delta Q_b^j = \frac{T_b}{P_b}. \eta_{bb}^j. Q_b^j$, $\Delta Q_w^j = \frac{T_w}{P_w}. \eta_{ww}^j. Q_w^j$, $\Delta Q_s^j = \frac{T_s}{P_s}. \eta_{ss}^j. Q_s^j + \frac{T_r}{P_r}. \eta_{sr}^j. Q_s^j$, and $\Delta Q_r^j = \frac{T_r}{P_r}. \eta_{rr}^j. Q_r^j + \frac{T_s}{P_s}. \eta_{rs}^j. Q_r^j$, and these relationships can then be substituted into equations (1), (2), and (3).

Following these substitutions the optimal beer and wine taxes are found by differentiating equations (1) and (2) to find $\frac{\partial W}{\partial T_b}$ and $\frac{\partial W}{\partial T_w}$, which are then set to zero and solved for T_b and T_w. Following simplification this process gives:

$$\frac{T_b}{P_b} = t_b = \frac{E_b^a}{P_b}\left(\frac{1}{\frac{\eta_{bb}^m. Q_b^m}{\eta_{bb}^a. Q_b^a} + 1}\right) + \frac{E_b^u + E_b^h}{P_b}\left(\frac{1}{\frac{\eta_{bb}^m. Q_b^m}{\eta_{bb}^u. Q_b^u} + \frac{\eta_{bb}^a. Q_b^a}{\eta_{bb}^u. Q_b^u}}\right), \text{and} \tag{4}$$

$$\frac{T_w}{P_w} = t_w = \frac{E_w^a}{P_w}\left(\frac{1}{\frac{\eta_{ww}^m . Q_w^m}{\eta_{ww}^a . Q_w^a} + 1}\right) + \frac{E_w^u + E_w^h}{P_w}\left(\frac{1}{\frac{\eta_{ww}^m . Q_w^m}{\eta_{ww}^u . Q_w^u} + \frac{\eta_{ww}^a . Q_b^a}{\eta_{ww}^u . Q_w^u}}\right), \quad (5)$$

where the optimal LAL tax rate can then be calculated by multiplying the ad valorem rate by price and dividing by average alcohol content [5] [6].

For the spirits market the optimal spirits and RTD tax rates are found as follows. First, equation (3) is differentiated to find $\frac{\partial W}{\partial T_s}$ and $\frac{\partial W}{\partial T_r}$. These equations are then set to zero and expressed in terms of T_s and T_r. This in turn results in a system of two equations with two unknowns that can be solved simultaneously [19]. Although the demand symmetry restriction can be used to achieve a degree of simplification, the optimal tax expressions for spirits and RTDs remain relatively complex. As such, the approach taken was to use Mathematica to solve the expressions and calculate the optimal tax rates.

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Supplementary information

The following information explains how the key values in Table 2 of the main paper were determined.

Key beverage parameters. The average pre-tax price, consumption, and alcohol content information were taken from a detailed database constructed from unpublished industry reports, WFA-Deloitte wine industry surveys, and ABS data [1]. Summary information on the nature of the database is shown in Table A1, and the way the average pre-tax and retail prices were calculated can be understood as follows. If p_{cj} and $\bar{p}_{cj}$ are used to denote, respectively, the retail and pre-tax price for consumption category *c,* within beverage type *j*, and q_{cj} is used to denote the associated quantity of consumption, then $\sum_c p_{cj} q_{cj} = RE_j$ and $\sum_c \bar{p}_{cj} q_{cj} = TFE_j$ denote, respectively, total retail expenditure and total tax free expenditure on beverage type *j*. If a_{cj} denotes the alcohol content of consumption category *c* within beverage type *j*, then $\sum_c a_{cj} q_{cj} = A_j$ denotes total ethanol consumption for beverage type *j*, and $RE_j/A_j = P_j$ denotes the average per litre of pure alcohol (LAL) retail price for beverage *j*, and $TFE_j/A_j = \bar{P}_j$ denotes the average LAL pre-tax price for beverage *j*.

Table A1 **Elements of the alcohol consumption database**

	Beverage Groupings	Retail price	Tax free price	Alcohol	Volume
		$/Litre	$/LAL	%	'000 (L)
Wine	4 and 5 litre casks	3.14	2.36	12.65	129,776
	2 litre casks	6.24	4.80	12.65	55,618
	Less than $7/bottle	6.65	5.15	12.65	65,292
	$7-$15 bottle	12.65	9.90	12.65	113,218
	$15-$20 bottle	21.92	17.46	12.65	68,557
	$20-$30 bottle	31.31	25.53	12.65	23,893
	More than $30 bottle	52.98	40.48	12.65	7,132
Beer	Light packaged beer	3.32	2.46	2.68	142,647
	Mid packaged beer	3.63	2.32	3.48	231,681
	Regular packaged beer	4.54	2.69	4.56	871,179
	Premium packaged beer	7.08	4.72	5.20	105,479
	Light keg beer	8.79	7.88	2.68	39,099
	Mid keg beer	9.50	8.11	3.48	48,085
	Regular keg beer	11.05	9.03	4.56	274,915
	Premium keg beer	17.94	15.10	5.20	29,194
Spirits	Spirits	46.13	16.70	36.27	47,161
	RTD Light	9.06	4.40	5.51	102,395
	RTD Dark	8.09	3.88	5.00	249,425

Consumption ratio. Earlier studies of US alcohol demand used approximately 40 percent of total consumption as the abusive consumption share [2] [3]. The range of values suggested for Australia is between 30 percent and 50 percent [4]. As such, the total ethanol share attributed to abusive consumption was set at 40 percent. Information on occasional and heavy binge drinking that showed binge drinking to be most commonly associated with RTDs, followed by spirits, then beer, and lastly wine [5] was then used to adjust the shares in each beverage category with the global constraint that the share of total ethanol consumption attributable to abusive consumption was 40 percent. Formally, let A_j denote total ethanol consumption for beverage type j (j = beer, wine, spirits, RTDs) so that $\sum_j A_j = A$ denotes total ethanol consumption. Let m_j, where $0 < m_j < 1$, denote the share of abusive ethanol consumption associated with beverage type j so that $m_j A_j = \bar{A}_j$ denotes total abusive ethanol consumption for beverage type j, $\sum_j \bar{A}_j = \bar{A}$ and $\bar{A}/A = .40$. The specific values used for m_j were: .44 for beer, .28 for wine, .48 for spirits, and .57 for RTDs.

The share of total uninformed consumption out of total abusive consumption was set at 20 percent so that the total ethanol shares across moderate consumers, informed abusers, and uninformed abusers are 60 percent, 32 percent, and 8 percent. Based on the idea that it will be the young that are overrepresented in the uninformed consumer category, the beverage specific uninformed consumer share was then adjusted to reflect information on the underage participation rate by beverage type that showed underage participation to be highest for RTDs, followed by spirits, then beer, and finally wine [5]. Formally, let s_j, where $0 < s_j < 1$, denote the share of uninformed abusive consumption out of total abusive ethanol consumption associated with beverage type j so that $s_j\bar{A}_j = \bar{Y}_j$ denotes total uninformed abusive ethanol consumption for beverage type j, $\sum_j \bar{Y}_j = \bar{Y}$ denotes total uninformed abusive consumption, and $\bar{Y}/\bar{A} = .20$. The specific values used for s_j were: .20 for beer, .11 for wine, .27 for spirits, and .29 for RTDs.

Elasticity values. The overall own-price elasticity estimates for beer, wine, and spirits represent the average of the unconditional compensated price elasticity values reported for Australia in a recent meta-analysis of alcohol demand [6]. Information on the own-price elasticity of demand for RTDs was not available and the value used is the average of the spirits and beer own-price elasticity values. To determine the moderate and abuser price elasticity values additional information on the ratio of the own-price elasticity of demand for the median drinker, -1.19, standard error .25, to that of a heavy drinker, -.49 standard error .26, where a heavy drinker is classified as a drinker at the 90th percentile of consumption was used [7]. Specifically, the own-price elasticity values used are the values consistent with the elasticity ratio of -1.19/-.49 = 2.4 that satisfy the additional constraint that the consumption share weighted own-price elasticity values equal the overall beverage specific own-price elasticity. For example, in the case of wine, the overall own-price elasticity estimate is -.40, the abusive share of consumption estimate is 28 percent, and the non-abusive share of consumption estimate is 72 percent. As (-.19 × .28) + (-.47 × .72) = -.40, and -.47/-.19 = 2.4, for wine, the abusive elasticity estimate is -.19 and the non-abusive elasticity estimate is -.47. For the

low variation in consumer type scenario an elasticity ratio of 1.7 was used, and for the high variation in consumer type scenario an elasticity ratio of 3.6 was used. These two elasticity ratios represent, respectively, the case where the above cited median and heavy drinker price elasticity estimates are each one half a standard error closer together, and each one half a standard error further apart.

Cross-price effects. In setting the cross-price elasticity values for spirits and RTDs the requirement that the conditional budget share weighted cross-price elasticity values are equal was imposed for each consumer type. To establish a reference cross-price effect, for each consumer group the spirits-RTD cross-price effect was set at the spirits own-price elasticity multiplied by -.20.

Externality costs. Social cost data was obtained for the period 2004-05 [4] and these values were then converted to current dollar values using the CPI. The range of costs considered in the analysis varies depending on whether an individual utility model is used or a family utility model is used [8]. The specific allocation of costs for the family utility model and the individual utility model largely follow an existing allocation structure [8] and can be understood as follows. For the case where the family is chosen as the appropriate decision unit: 100 percent of estimated crime costs are deemed an externality; 50 percent of estimated road trauma costs are deemed external to abusers; 80 percent of estimated additional health costs are assumed to be external to abusers; and lost tax revenue is calculated as 30 percent of estimated lost labour income. For the case where the individual is chosen as the appropriate decision unit all of the costs associated with the family unit model are included, plus: 70 percent of lost disposable income, and 30 percent of the intangible cost of higher morbidity and mortality. For each cost category the raw social cost estimate, and the share of costs deemed to be an externality for each model are shown in Table A2.

Table A2 **Translation of raw social cost estimates to externality costs**

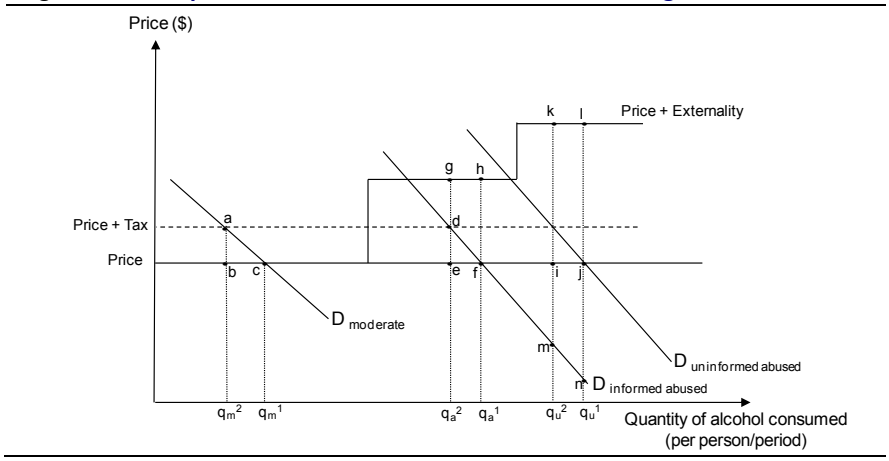
Externality cost category	Social cost estimate ($)	Family decision model ($)	Individual decision model ($)
Traffic costs	2,202	1,101	1,101
Health costs	1,977	1,582	1,582
Crime costs	1,424	1,424	1,424
Lost tax revenue	1,061	1,061	1,061
Loss disposable income to family	2,477	-	1,734
Intangible costs of morbidity and mortality	4,489	-	1,347
Total cost in 2004-05 dollars	13,630	5,168	8,248
Total cost in current dollars	15,807	5,993	9,566

Note: Raw social cost data [4] Allocation methodology [8], specific share allocation for lost disposable income and intangible cost author estimates.

The model requires an estimate of externality costs per LAL across abusive consumption for each beverage type. Total abusive consumption was established as described above, and total externality costs allocated are as per Table A2. The way these costs were allocated across beverages can be understood as follows. If C_i denotes the total externality cost associated with cost category i (i = health, crime, road trauma, lost tax revenue, lost disposable income, and intangible costs of morbidity and mortality), then $\sum_i C_i = T$ is the total alcohol related externality cost. Let w_{ij} denote the unadjusted externality cost weight for beverage type j applicable to externality cost category i, where $w_{ij} = \bar{A}_j/\bar{A}$, and $\sum_j w_{ij} = 1$. With this notation $w_{ij}C_i$ represents the externality cost allocation to beverage type j for externality cost category i under the assumption that externality costs do not vary across beverage types. Let each w_{ij} then be subjectively adjusted based on available information to reflect the extent to which externality cost type i varies across the j beverage types so that the adjusted weight $\overline{w}_{ij}$ is greater than w_{ij} if there is evidence beverage type j is overrepresented in externality cost category i, and less than w_{ij} if there is evidence beverage type j is underrepresented in externality cost category i, with the overall constraint that the $\overline{w}_{ij}$ must be positive and $\sum_j \overline{w}_{ij} = 1$. Although the reweighting is subjective, it reflects a genuine attempt to incorporate available information on traffic costs [5] [9-10], health costs [5] [11-13], crime costs [5] [13-14], and labour productivity costs [5].

Total externality costs for each beverage were then allocated across informed and uninformed abusive consumption with the additional assumption that externality costs are 10 percent higher for uninformed abusers. This assumption effectively gives a step-wise price plus externality cost curve so that Figure 2 in the main paper looks like Figure A1 below. Evidence to support the adjustments made to the raw externality weights, along with the specific weights used are set out below.

Figure A1 **Optimal alcohol taxation welfare losses and gains**



Traffic costs details. A study using data from Western Australia found: (i) no impact from wine sales at licensed premises to drink driving incidents; (ii) higher spirit sales at licensed premises were associated with more drunk driving but not accidents; and (iii) higher beer sales at licensed premises were associated with more accident and non-accident drink driving [9]. A Canadian study found a one litre increase in beer ethanol consumption results in a 23 percent increase road fatalities, and no association for spirits and wine [10]. The same study also cites many similar findings for the over representation of beer in drink driving incidents. Analysis of Australian National Drug Strategy Household Survey data also shows beer drinkers are most likely to have driven a car while under the influence of alcohol, followed by RTD drinkers, spirit drinkers, and lastly wine drinkers [5]. Combined this information provides the basis for increasing the weight for beer, slightly increasing the weight to RTDs, holding the weight to spirits constant, and decreasing the weight to wine.

Health costs details. Self-reported health status measures in the Australian National Drug Strategy Household Survey data suggests fair or poor health is most common for beer drinkers, followed by spirits drinkers, and then wine drinkers [5]. A meta analysis found evidence to support the idea that moderate wine consumption confers greater benefits than moderate beer consumption in relation to cardio vascular disease [12], where the working hypothesis regarding the additional protection of wine is that it is due to the phenolic acids and polyphenols contained in wine. Support for this view can be found in evidence the benefits of wine consumption relative to other alcoholic beverages are greater in populations that do not have a diet high in fruit and vegetables which contain phenolic acids and polyphenols [11]

The relationship between alcohol consumption and accident mortality in 14 European countries has also been investigated [13]. Countries were identified as either beer drinking (Austria, Belgium, Denmark, Germany, Ireland, the Netherlands, and the UK), wine drinking (France, Portugal, Italy, and Spain), or spirit drinking (Finland, Norway, and Sweden), and it was found that the impact of a one litre increase in pure alcohol consumption had the most pronounced impact on accident mortality in the spirit drinking countries, followed by the beer drinking countries, and then the wine drinking countries. In Australia, risky behaviour such as swimming while drunk etc., is generally more common with RTD drinkers, followed by full strength beer drinkers, and finally wine drinkers [5]. Synthesising this information suggests that adjusted externality cost weights should not vary radically from their unadjusted weights, but that relative to the unadjusted weights the adjusted weight for wine should be reduced, the weight to beer left approximately unchanged, and the weight to spirits and RTDs increased.

Crime cost details. RTD drinkers are the most likely to admit they have damaged public property, created a public disturbance, or physically abused someone [5]. International evidence suggests that violent crime has a tendency to be associated with spirit consumption [14] and those likely to engage in the types of risky behaviour associated with property crime tend to consume beer

[15]. With greater weight placed on Australian evidence over international evidence, it was thought appropriate to decrease the weight to wine, increase the weight to beer and spirits slightly, and increase the weight to RTDs.

Lost tax revenue details. Information on self-reported days absent from work or study due to alcohol consumption was used to adjusted the weights. The available information indicated there was a substantial difference between wine and other beverages, and that the problem of missing work or study due to alcohol consumption was greatest with RTD consumption. Specifically, the average days absent from work/study each year reported were: .066 for wine drinkers, .135 for beer drinkers, .163 for bottled spirits drinkers, and between .166 and .190 for RTD drinkers [5]. Based on this information the weight to wine was reduced, the weight to beer increased slightly, and the weight to spirits and RTDs increased.

Lost income to family members. The weights used for lost income to family members are equal to the weights used for lost tax revenue.

Intangible costs of morbidity and mortality. The weights used to allocate the intangible costs of morbidity and mortality are equal to the arithmetic mean of the weights for health and traffic costs.

Table A3 **Externality weights and per LAL externality costs by beverage type**

Externality cost details	Beer	Wine	RTDs	Spirits
Ave externality cost across abusive consumption: Family utility model $ per LAL	103	59	119	99
Ave externality cost across abusive consumption: Individual utility model $ per LAL	170	92	196	166
Unadjusted externality weight for each beverage	.47	.26	.15	.12
Adjusted externality weight – road trauma	.56	.18	.16	.12
Adjusted externality weight – health care	.48	.18	.15	.19
Adjusted externality weight – crime	.48	.13	.24	.15
Adjusted externality weight – lost tax revenue	.50	.15	.20	.15
Adjusted externality weight – lost income to family members	.50	.15	.20	.15
Adjusted externality weight – Intangible costs of morbidity and mortality	.52	.18	.17	.13

Uninternalised private costs. In each beverage category uninformed abusers are assumed to consume 12.5 percent more than informed abusers. With this assumption the implied uninternalised private cost was calculated as follows. First, beverage specific own-price elasticity values for abusive and non-abusive consumption were estimated as described above. The abusive own-price elasticity estimate was then used to calculate the implied slope of a linear demand curve around the point of current estimated per capita abusive consumption using the estimated current average LAL retail price. It can however be noted that given the fixed percentage assumption used for the difference between informed and uninformed abusive consumption, an accurate estimate of current per capita abusive consumption is not required.

Given the slope of the demand curve for the informed abusive consumer and the uninformed abusive consumer is the same, it is then possible to calculate the size of the vertical distance between the uninformed and informed abuser demand curves. For example, assume the average informed wine abuser consumes 10 litres of pure alcohol from wine each year. Given the assumption made about uninformed abusive consumption relative to informed abusive consumption, uninformed abusers consume 11.25 litres of pure alcohol from wine per year. The assumed abuser own-price elasticity is -.19, and the average LAL retail price for wine is \$89.54. The slope of both the informed abuser and uninformed abuser demand curve is then $\frac{\Delta P}{\Delta Q} = \frac{1}{\eta} \times \frac{P}{Q} = \frac{1}{-.19} \times \frac{96.75}{10} = -51.67$. The difference in the assumed level of consumption multiplied by the slope of the demand curve 1.25 × \$57.16 = \$64.59 then gives the vertical distance between the two demand curves, which is the raw estimate of the uninternalised private cost, and for beverage j this value is denoted $\ddot{U}_j$. Given the number of assumptions used to calculate each uninternalised private cost estimate an adjustment was then made to draw each estimate closer to the mean uninternalised private cost estimate as follows. Let $\frac{1}{4}\sum_{j=1}^{4} \ddot{U}_j = \bar{U}$, so that the adjusted uninternalised cost estimate for beverage j, denoted U_j is found as $\theta\ddot{U}_j + (1-\theta)\bar{U}$, where the default value for θ is .5.

As the formula used to calculate the uninternalised private cost relies on the own-price elasticity estimate, for the scenarios that consider abusers as either more responsive or less responsive the estimated uninternalised private cost was recalculated. The specific uninternalised private cost values used for each scenario are shown in Table A4.

Table A4 **Uninternalised private cost estimates**

Externality cost details	Beer	Wine	RTDs	Spirits
Best estimate values $ per LAL	66	56	41	40
Abusers more responsive $ per LAL	56	45	37	34
Abusers less responsive $ per LAL	101	84	59	52

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