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Research paper

Effects of changes to the taxation of beer on alcohol consumption and government revenue in Australia

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ABSTRACT

Background: In 1988, the Australian government introduced a single nominal rate of tax on all beer products calculated on alcohol content. However, in 2000/01, varying nominal rates of tax were introduced for beer products according to three alcohol content levels (low-/mid-/high-strength) and container type (on-/off-premises). Little is known about the effect of the different tax policies on alcohol consumption and government revenue.

Methods: We undertake time series analysis over 1989–2016 to examine the effect of beer tax policies in two subperiods (before/after 2000/01) on category-level beer consumption per capita and government revenue. We also test if the policy changes in 2000/01 had immediate or long-term effects on total (all beer category) consumption over 1989–2016. Data includes monthly domestic beer sales volumes by category (in litres of alcohol), monthly government revenue from beer tax (AUD$), and inflation-adjusted tax rates (AUD$ per litre of alcohol).

Results: Before 2000/01, the single nominal tax rate had a significant positive effect on revenue, but no significant effect on consumption. After 2000/01, the relatively higher nominal tax rates for two beer categories (mid- and high-strength off-premises) had a significant negative effect on their consumption, and a significant negative effect on revenue in one category (mid-strength off-premises). However, across the full period examined (1989–2016), the level and slope of total beer consumption was not significantly affected by the tax policy changes in 2000/01.

Conclusion: Raising alcohol taxes has the potential to reduce consumption and increase government revenue, but has been underutilised for these public health and public finance objectives in Australia.

Introduction

The net social costs of alcohol use are substantial, equivalent to 1–3% of GDP in several countries (World Health Organization (WHO) (2014)). This reflects the fact that, aside from the value of production and sales, alcohol consumption produces a vast range of externalities, with major impacts on the health and wellbeing of drinkers as well as those around them (Sassi et al., 2015). In Australia, for example, it is estimated there are over 5000 deaths and more than 150,000 hospitalisations attributable to alcohol each year (Gao, Ogeil, & Lloyd, 2014). The combined estimated costs of alcohol to the health system, law enforcement, the criminal justice system, road safety and workforce productivity in Australia exceed AUD$14 billion each year (2010 figures) (Manning, Smith, & Mazerolle, 2013); more than double the annual tax revenue from alcohol collected by government (AUD$6 billion) (Parliamentary Budget Office, 2015).

Levying taxes on alcoholic beverages, and thereby increasing prices, is one of the most widely used, and most cost-effective policy measures used by governments throughout the world to reduce harmful use of alcohol (Chisholm, Moro, & Bertram, 2018; World Health Organization (WHO) (2018)). There is more accumulated evidence showing the health promoting effects of raising alcohol taxes than any other policy intervention aimed at reducing alcohol consumption and harm (Wagenaar, Salois, & Komro, 2009; Wagenaar, Tobler, & Komro, 2010). Alcohol taxes offer governments the potential for delivering a 'trifecta' in public policy by reducing alcohol problems, avoiding costs to the health system, and raising revenue for government (Bray & Babor, 2018). Hence, is it important that changes to alcohol taxation policies are evaluated in terms of both their public health and public finance impacts.

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In this study, we examine the effect of beer taxation policies on alcohol consumption per capita (in beer) and government revenue in Australia. Surprisingly little research has investigated the effects of alcohol taxation policies in an Australian context. Only a small number of empirical studies examine the impact on consumption (Chikritzhs, Stockwell, & Pascal, 2005; Doran & Digiusto, 2011; Gray, Chikritzhs, & Stockwell, 1999) and very few examine the impact on public finances (Byrnes, Petrie, Doran, & Skakeshaft, 2012; Byrnes, Cobiac, & Doran, 2010; Cnossen, 2010; Doran, Byrnes, & Cobiac, 2013; Fogarty, 2012). There have also been a small number of government agency and parliamentary inquiries into alcohol taxation in Australia (see for example, Productivity Commission, 2017; The Senate, 2017). Notably, none of the above examine the consumption and revenue effects of beer tax policies before and after major policy changes in 2000/01.

We aim to fill this gap in knowledge by undertaking time series analysis over 1989–2016 to investigate the effects of beer tax policies on alcohol consumption per capita and government tax revenue in separate sub-periods before and after policy changes in 2000/01. Separate models are necessary because most of the key outcome variables (e.g. beer categories, government revenue) are measured differently in the sub-periods. We also test if the changes to beer tax policy in 2000/01 had immediate or long-term effects on total (all beer category) alcohol consumption over 1989–2016, as this outcome variable is measured consistently over time. The findings have implications for current debates about the reform of alcohol taxation in Australia and elsewhere in the world where alcohol-related harm represents a major population health challenge.

Changes to the taxation of beer in Australia

For several reasons, taxation of beer is of special interest for policy makers. From a public finance perspective, alcohol taxation receipts are an important source of revenue for government. In Australia, the total revenue from alcohol taxation in 2014/15 was around AUD$6 billion (0.4 per cent of GDP), with receipts from beer sales representing the major share (38.5%) of this revenue (Parliamentary Budget Office, 2015). There is also an important public health rationale for taxing beer, as it is disproportionately involved in risky drinking, particularly among young males (Australian Institute of Health and Welfare (AIHW) (2017)), and more closely associated with serious harm (e.g. assault and homicide) than other beverages (Ramstedt, 2011; Stockwell, Masters, & Phillips, 1998). Furthermore, given that beer represents the major share (39.2%) of total alcohol consumption in Australia (Australian Bureau of Statistics (ABS) (2018)), any changes in demand triggered by taxation have the potential to affect total consumption and rates of harm in the population.

Federal government taxation of beer in Australia was established more than a century ago, having commenced within a few months of the formation of the nation in 1901, with the introduction of *The Beer Excise Act* 1901 (Commonwealth of Australia, 1901). For most the twentieth century, taxation of Australian beer was based on litres of beverage. This changed in 1988 when the federal government introduced a single nominal rate of tax on beer based on the portion of its alcohol content above 1.15% alcohol by volume (ABV), adjusted with inflation biannually, plus a federal wholesale sales tax (WST). The changes to federal beer tax policy in 1988 amounted to a substantial reduction in the tax rate on beer. For example, the effective rate of tax on high-strength beer was reduced by 50.3% (James, 1996).

However, in July 2000, the federal government abolished the single nominal rate of tax and the WST on beer. In place of these, the government introduced three new beer tax categories for low-strength (< 3.0% ABV), mid-strength (3.0%–3.5% ABV) and high-strength (> 3.5% ABV) beer, each with a different nominal tax rate. Consistent with beer taxation prior to July 2000, the new tax rates were applied to the portion of alcohol content in beer above 1.15% ABV, and were adjusted with inflation biannually. Also introduced in July 2000 was a new federal 10% *ad valorem* Goods and Services Tax (GST), which was applied to alcohol products at the point of retail sale on top of other taxes. Additionally, in April 2001, the government reduced the nominal rates of tax for beer sold in containers for on-premises consumption (e.g. kegs), while tax rates for beer sold in off-premises containers remained unchanged (e.g. can, bottles). This effectively created six different categories of beer for taxation purposes. Further reductions in the nominal tax rates for mid- and low-strength beer occurred in July 2002. Full details of these and other changes to beer tax policy over 1989–2016 are presented in S1 (see Supplementary data). In our study we also consider the possible effects of State/Territory-level taxes on beer consumption until they were abolished in August 1997, noting however that the impact of these taxes on prices was relatively small compared to the impact of federal taxes (Gabbitas & Eldridge, 1998).

Method

Data

As a measure of beer consumption in the population, we use monthly domestic beer sales volumes (litres of alcohol per capita) from July 1989 to June 2016, which is an administrative dataset we obtained from the Australian Tax Office (Australian Tax Office (ATO) (2019), Various years 1989–2016). It is estimated elsewhere that only a very small fraction of alcohol consumed in Australia is produced informally and unrecorded (World Health Organization (WHO) (2014)). Thus, by using data on beer sales administered by the government taxation agency, we generally avoid the problem of measurement error (i.e. under-counting) that may affect this type of research when relying on self-reported consumption measures (Byrnes, Shakeshaft, & Petrie, 2016; Meng, Brennan, & Purshouse, 2014). Because beer has a relatively short shelf life, and is less likely to be stockpiled than expensive alcohol (Robinson, Thorpe, Beeston, & McCartney, 2012), we assume that monthly beer sales are proximal to same-month consumption. We derive estimates of tax revenue from the sales data using the inflation-adjusted tax rates (AUD$ per litre of alcohol) applicable to each type of beer per month, obtained from various historical records of government tax policy (James, 1996; Parliamentary Budget Office, 2015; Webb, 2006). Disaggregation of beer consumption and tax revenue data into low-, mid- and high-strength categories is possible from July 2000 onwards. Further disaggregation of data by container type (on-/off-premises) is possible from April 2001 onwards. We calculate per capita estimates using the Australian estimated resident population aged 15+ years, as at 30 June of each year (Australian Bureau of Statistics (ABS) (2016a)). Prior to analysis we seasonally adjusted the beer consumption and tax revenue series using the *X-13ARIMA-SEATS* program (US Census Bureau, 2016). Table 1 presents summary statistics for the monthly observations of variables before (n = 132) and after (n = 192) the 2000/01 policy changes.

Analytical strategy

Theory suggests that a change in alcohol prices (through changes to alcohol tax) will, ceteris paribus, lead to a change in demand for alcohol (Wagenaar et al., 2009). On this basis we may expect to find that the tax policy changes in 2000/01 affected consumption. However, while the 2000/01 changes added considerable complexity to beer taxation policy, the consumer price index for total beer in Australia indicates minimal change in average beer prices over that period (for details see S2 in Supplementary data). Additionally, the aggregate effect of the 2000/01 policy changes that we investigate is difficult to ascertain a priori because taxes were increased for some beer categories, but lowered for others, and this did not occur uniformly or simultaneously. Hence, it is not possible to calculate an average rate of tax over time with any confidence nor estimate its effects. There is also evidence of a downward slope in beer consumption over time commencing well

Table 1
Summary Statistics: Monthly beer sales, tax rates and government revenue*, Australia, July 1989 – June 2016.
Source: Australian Tax Office (various years 1989–2016).

		Before policy changes	After policy changes						
		Total beer	Total beer	Low strength < 3.0% ABV		Mid strength 3.0-3.5% ABV		High strength > 3.5% ABV	
				On Prem.	Off Prem.	On Prem.	Off Prem.	On Prem.	Off Prem.
	Start Date	Jul 1989	Jul 2000	Apr 2001	Apr 2001	Apr 2001	Apr 2001	Apr 2001	Apr 2001
	End Date	Jun 2000	Jun 2016	Jun 2016	Jun 2016	Jun 2016	Jun 2016	Jun 2016	Jun 2016
	Obs	132	192	177	177	177	177	177	177
Beer sales	Mean	0.466	0.337	0.005	0.016	0.009	0.036	0.064	0.230
(Litres of alcohol per capita)	Std. Dev.	0.086	0.076	0.002	0.008	0.003	0.009	0.014	0.050
	Min.	0.330	0.142	0.001	0.003	0.002	0.012	0.029	0.085
	Max.	0.680	0.585	0.012	0.046	0.015	0.068	0.102	0.363
Beer tax rates	Mean	14.862	–	9.385	36.125	22.272	40.353	22.036	39.704
(A$/litres of alcohol)	Std. Dev.	1.077	–	7.845	4.695	3.997	4.326	3.238	5.051
	Min.	12.580	–	5.690	28.490	17.330	33.220	17.330	30.460
	Max.	16.390	–	44.080	45.460	37.420	47.850	32.220	47.850
Government revenue*	Mean	69.771	151.580	0.362	5.428	2.049	17.118	22.918	103.926
(A$ million)	Std. Dev.	12.181	30.866	0.289	2.410	0.705	6.036	3.169	22.642
	Min.	49.003	85.841	0.077	1.454	0.200	4.745	13.968	57.660
	Max.	111.250	252.873	1.621	14.477	4.728	40.676	35.666	174.941

Notes:
*Government revenue is not directly comparable between the periods before and after the 2000/01 policy changes because the values for the pre-2000/01 period includes revenue exclusive of federal wholesale sales tax and state tax revenues, and the post-2000/01 period includes revenue exclusive of the federal Goods and Services Tax (GST) revenue. Values shown are nominal dollars (i.e. not adjusted for inflation).
A$: Australian dollars.
ABV: Alcohol By Volume.
On Premises: packaged in containers > 48 litres (e.g. kegs) notionally for on-premises consumption.
Off Premises: packaged in containers < 48 litres (e.g. cans, bottles) notionally for off premises consumption.

before the start of the 2000/01 policy changes, which may potentially bias estimates if not controlled for. To address these issues, our main analysis is two-fold and is summarised in brief below.

First, we estimate autoregressive integrated moving average (ARIMA) models for the consumption and revenue effects of the different beer tax policies, separately for the sub-periods before and after the 2000/01 policy changes. We follow the standard Box-Jenkins method for fitting ARIMA models to our data, involving an iterative three-step cycle of model specification, estimation and diagnostic checking, with the ultimate objective of achieving the best possible fit and most parsimonious model (Box & Jenkins, 1976). To determine optimal lag lengths in the models, we give consideration to theory, findings of other relevant studies, and formal tests. Theoretically, we can expect changes in alcohol prices, resulting from a change to the taxation of alcohol, to have an almost immediate effect on per capita consumption (i.e. within a period of 1–6 months), assuming taxes are fully passed through to prices and depending on demand and supply considerations. Empirical studies in other countries indicate that the effect of changes in alcohol taxes on prices is close to immediate (Henkel, 2005; Makela & Osterberg, 2009). Formal tests for selecting the optimal lag lengths in our models involved consideration of five selection criteria including the sequential modified likelihood ratio test statistic (LR), final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ). The identified lag length for each model is presented in the results. We also control for macroeconomic conditions, by including the monthly national unemployment rate (Australian Bureau of Statistics (ABS) (2016b)). For the ARIMA modelling, all variables are taken in logs.

Second, we treat the 2000/01 policy changes as a natural experiment and test whether this affected total (all beer category) consumption per capita over 1989–2016, using interrupted time series (ITS) analysis. ITS is considered the strongest, quasi-experimental design to evaluate longitudinal effects of time-delimited interventions (Kontopantelis, Doran, & Buchan, 2015). Many researchers have used ITS designs to estimate the effects of changes to alcohol tax policy (see Nelson and McNall (2016) for a recent review). This is largely because evaluating the effect of a change in alcohol taxation in the population is not amenable to using randomised controlled trials (RCTs), and because we only have aggregated data. Natural experiments such as a tax policy change, though rare, provide a practical real-world alternative to RCTs for examining large-scale before-and-after effects of such interventions (Craig, Katikireddi, & Layland, 2017). Furthermore, investigating natural experiments using ITS methods is considered useful for estimating not only the effect of a new tax or a tax increase, but also the effect of full or partial removal of an existing tax (Craig, Gibson, & Campbell, 2018).

A methodological challenge we face is the lack of a comparison group, because the 2000/01 policy changes were implemented nationally. However, ITS analysis is well suited for these single-group situations, as it projects the pre-intervention trend into the treatment period as the counterfactual (Kontopantelis et al., 2015). Furthermore, our long pre-intervention period (n = 132 monthly observations) significantly increases the power of the ITS model in detecting secular trends (Ramsey, Matowe, & Grilli, 2003). For our ITS analysis we take monthly total (all beer category) alcohol consumption per capita as the main outcome variable because it is measured consistently over the 1989–2016 period, whereas other variables (e.g. beer categories, government revenue) are measured differently before and after the 2000/01 policy changes.

There is a likelihood of time-lags between the start of the tax policy changes in 2000/01 and changes to consumption if, for example, there is not an immediate full pass-through of taxes to prices (Bergman & Hansen, 2010). Our ITS model selection therefore involved fitting the model with different lag lengths and selecting the best fit following the Cumby-Huizinga test for autocorrelation in the error distribution, using the "actest" command in STATA developed by Baum and Schaffer (2013). In our ITS model, any time-varying unmeasured confounders are assumed to be slowly changing and therefore distinguishable from the sudden change in the intervention dummies (Linden, 2015).

Notwithstanding this, for robustness checks we include pseudo start times of the interventions (e.g. 6 and 12 months before and after the real policy change dates). Further details of our ITS analysis are provided in S3 (see Supplementary data). Additionally, using quarterly time series datasets, we check the robustness of our main analysis by examining the effect of price changes in other beverage categories (wine and spirits), with controls for real income (i.e. quarterly real GDP per capita), economic conditions (i.e. quarterly unemployment rates), major economic events (i.e. the global financial crisis), seasonal effects (i.e. quarterly dummies), and changes to beer tax policy (i.e. dummy variable starting July 2000). We also control for other tax changes (e.g. the one-off alcopops tax increase in April 2008).

Results

Effect of tax policy before 2000/01

For the sub-period before the 2000/01 policy changes (July 1989 – June 2000) we model the effects of the single nominal rate of tax on beer. This tax rate did not change during this sub-period, apart from biannual inflation-adjustments. The results indicate that the tax did not have a significant effect on consumption, but did have a large and significant positive effect on tax revenue (see Table 2). In other words, before the 2000/01 policy change, beer tax was only effective as a means of raising revenue, not reducing average beer intake in the population. However, the results indicate that beer consumption was affected by macroeconomic conditions, with an increase in the national unemployment rate contributing to a significant reduction in beer consumption over this period.

Effect of tax policy after 2000/01

In the sub-period following the 2000/01 policy changes, the results indicate that the relatively higher nominal tax rates for mid- and high-strength beer sold in off-premises containers had significant negative effects on their consumption (see Table 3). However, the relatively lower tax rates for beer in on-premises containers and low-strength beer had no significant effects on consumption. The effect of the taxes on government revenue are mostly non-significant across beer categories, with the exception of tax revenue from mid-strength beer sold in off-premises containers, which was negatively affected by the tax rates. Unemployment rates had no significant effect on consumption or revenue in the period after the 2000/01 policy changes.

A robustness check accounting for changes in the price of other beverage categories (wine, spirits) over time, real income, economic conditions, seasonality and other events did not alter our main findings (refer to S5 in Supplementary data).

Immediate and long-term effects of the 2000/01 policy change

Visual inspection of a plot of actual monthly total beer consumption per capita over 1989–2016 shows a downward slope over time, with no obvious change in the level or slope around the time of the 2000/01 policy changes (see Fig. 1). The results of ITS analysis confirm this preliminary view, indicating that consumption decreased by a small but significant amount (0.001 litres per capita) each month prior to the tax policy changes starting in July 2000, but that the policy changes had no significant immediate effects (i.e. no change in level) and no significant long-term effects (i.e. no change in slope) on total beer consumption. Results of the ITS analysis are presented in S4 (see Supplementary data), and the predicted values are also plotted in Fig. 1.

Robustness checks, which included adding pseudo start times for the policy changes to the ITS model (e.g. 6 and 12 months before and after the real dates of the policy change) and dummies corresponding to other events (e.g. other tax policy changes), did not alter the main findings of our ITS analysis. An additional robustness check accounting for the removal of State/Territory-level alcohol taxes in 1997 did not alter our main findings (refer to S6 in Supplementary data).

Discussion

This study has examined the effect of different beer tax policies on alcohol consumption and government revenue in Australia. Theory and previous empirical research suggest that raising alcohol taxes can reduce consumption and increase government revenue. However, we find beer tax policies in Australia have underutilised these opportunities for improving public health and public finance outcomes. Our findings have implications for current debates about the reform of alcohol taxation in Australia, and elsewhere in the world, where alcohol-related harm places a large burden on the health system, where alcohol taxes are at historically low levels, and where addressing budget shortfalls is a constant challenge for governments.

Our analysis of the effect of beer taxes in sub-periods before and after policy changes in 2000/01 found mixed results for alcohol consumption and government revenue. In the sub-period before the policy changes, taxes had no significant effect on consumption, but they did have a significant positive effect on government revenue. A possible explanation for why the beer tax did not affect consumption during this sub-period is because the nominal rate of tax had been set at a relatively low level in 1988, having been reduced to around half of its level from the previous year (James, 1996). Additionally, the real value of the tax rate did not change over time during this sub-period, as it was subject to only small biannual adjustments made in line with the official rate of inflation.

In the sub-period after the 2000/01 policy changes, the relatively higher nominal tax rates for two beer categories (mid- and high-strength beer sold in off-premises containers) had a significant negative effect on their consumption, and a significant negative effect on revenue in one category (mid-strength sold in off-premises containers). These findings, in part, align with the literature on the price elasticity of demand for alcohol, which shows that when the relative price/tax for alcohol increases, there is a modest decrease in demand (Wagenaar

Table 2
Estimated consumption and revenue effects before the policy changes, July 1989 – June 2000.

	Alcohol consumption				Government revenue			
	Lags	Coef.	S.E.	*p*-value	Lags	Coef.	S.E.	*p*-value
Tax rate	5	0.005	0.039	0.271	6	1.497	0.729	0.042
Unemployment rate	3	−0.122	0.071	0.090	4	−0.230	0.212	0.282
ARIMA term[*]		(2,1,1)				(2,1,1)		
Q-10 lag †		9.783, $p = 0.281$				10.696, $p = 0.152$		

Notes:
[*] ARIMA: autoregressive integrated moving average.
† Ljung-Box Q-statistics at 10 lags diagnostic check that each model is correctly specified.
All variables are taken in logs.

Table 3
Estimated consumption and revenue effects after the policy changes, July 2000 – June 2016.

	Alcohol consumption				Government revenue			
	Low-strength beer < 3.0% ABV							
	Lags	Coef.	S.E.	*p*-value	Lags	Coef.	S.E.	*p*-value
Tax rate: low-strength, on-premises	4	0.038	0.039	0.329	4	0.051	0.054	0.345
Tax rate: low-strength, off-premises	4	−0.111	0.119	0.350	4	−0.095	0.168	0.573
Unemployment rate	3	0.112	0.085	0.189	4	−0.129	0.120	0.283
ARIMA term[*]		(3,1,1)				(1,1,3)		
Q-10 lag †		12.322, $p=0.090$				12.697, $p = 0.080$		
	Alcohol consumption				Government revenue			
	Mid-strength beer 3.0-3.5% ABV							
	Lags	Coef.	S.E.	*p*-value	Lags	Coef.	S.E.	*p*-value
Tax rate: mid-strength, on-premises	3	0.107	0.076	0.161	0	0.140	0.092	0.128
Tax rate: mid-strength, off-premises	3	−0.718	0.300	0.018	0	−1.087	0.350	0.002
Unemployment rate	3	0.126	0.112	0.263	3	0.088	0.128	0.494
ARIMA term[*]		(1,1,3)				(2,1,1)		
Q-10 lag †		6.503, $p=0.369$				4.541, $p = 0474$		
	Alcohol consumption				Government revenue			
	High-strength beer > 3.5% ABV							
	Lags	Coef.	S.E.	*p*-value	Lags	Coef.	S.E.	*p*-value
Tax rate: high-strength, on-premises	0	−0.233	0.299	0.174	0	−0.037	0.146	0.802
Tax rate: high-strength, off-premises	6	−2.264	0.960	0.020	6	−0.398	0.509	0.436
Unemployment rate	0	0.115	0.104	0.271	0	0.096	0.095	0.313
*ARIMA term**		(3,1,1)				(0,1,3)		
Q-10 lag †		11.003, $p=0.202$				10.921, $p = 0.281$		

Notes:
[*] ARIMA: autoregressive integrated moving average. † Ljung-Box Q-statistics at 10 lags diagnostic check that each model is correctly specified.
ABV: Alcohol By Volume.
On Premises: packaged in containers > 48 litres (e.g. kegs) notionally for on-premises consumption.
Off Premises: packaged in containers < 48 litres (e.g. cans, bottles) notionally for off premises consumption.
All variables are taken in logs.

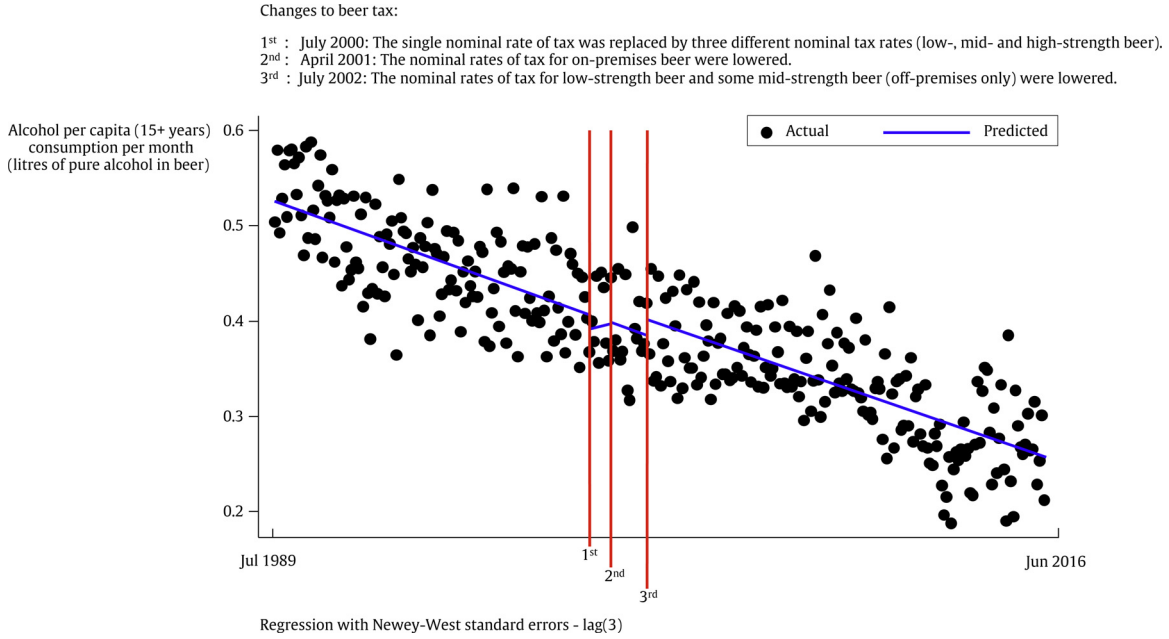

Fig. 1. Estimated effect of changes to beer tax on alcohol per capita (15+ years) consumption, Australia, 1989–2016.

et al., 2009). For example, while the relatively high tax for mid- and high-strength beer sold in off-premises containers contributed to significant reductions in consumption of these beer categories, the relatively low rate of tax for low-strength beer and beer sold in on-premises containers has been insufficient to significantly affect alcohol consumption within these categories.

The inconsistent effect of the tax policy since 2000/01 across the beer categories is possibly explained by the differential impact of volumetric (content-based) alcohol taxes on product prices. For example, the relatively higher value of beer sold on-premises (i.e. reflecting differences in product quality, value and the labour costs of serving) means that taxes represent a relatively smaller component of on-premises beer prices compared to off-premises beer. Other studies have also found that demand for on-premises alcohol is generally more price inelastic than off-premises alcohol (Jiang, Livingston, Room, & Callinan, 2016; Meng et al., 2014).

Our analysis also finds that although beer consumption in Australia has declined over 1989–2016, the tax policy changes in 2000/01 had no significant immediate or long-term effects on consumption. That is, it appears that the Australian government adopted a 'consumption neutral' approach when making changes to beer tax policies in 2000/01. Our finding that beer taxes in Australia have failed to affect total consumption over time may be explained by the small magnitude of the price variation resulting from taxes, as indicated in the consumer price index (CPI) for total beer over the study period (see Fig. S2 in Supplementary data). On average, the CPI for total beer increased by only 1.0% per quarter over the study period. Furthermore, while nominal rates of tax on beer have been adjusted biannually in line with the official rate of inflation, the affordability of beer has generally increased because average incomes in Australia have grown faster than real beer taxes and average beer prices. For example, over 1994–2016, the CPI for beer increased by 120%, whereas average weekly earnings increased by 141% (Australian Bureau of Statistics (ABS) (2017)). In robustness checks of our main analysis, we estimate that while prices had no significant effect on beer consumption over time, real income had a significant positive effect. This aligns with findings from previous Australian research showing that the increasing affordability of beer over time (i.e. real prices relative to incomes) has had a positive effect on per capita beer consumption in Australia (Jiang et al., 2016). International research also shows there has been an increase in the affordability of beer as income growth has outpaced increases in taxes and real prices of beer in most high-income countries (Blecher, Liber, Van Walbeek, & Rossouw, 2018).

Another possible explanation for the 2000/01 policy change having no effect is that the largest tax changes were too narrowly applied (i.e. on certain beer categories only) to affect total beer consumption. A further possible explanation for some of our findings is the extent of 'saturation', with tax effects possibly offset by long-standing situational and cultural norms that influence alcohol consumption in the population (Room, Osterberg, Ramstedt, & Rehm, 2009). Broader economic factors, besides taxation, may also be influential. For example, we found that in the sub-period before 2000/01, which included a major recession in the early 1990s, the unemployment rate had a significant negative effect on beer consumption. Such effects were not found in the sub-period after 2000/01, during which there were no recessions in Australia. In part, these findings align with other studies that show alcohol consumption is affected pro-cyclically by macroeconomic conditions (Ruhm, 1995).

Overall, our findings provide further empirical evidence, in an Australian context, that raising alcohol taxes may have the potential to reduce per capita consumption and increase government revenue, but that these outcomes have not been consistently achieved over time. Our study has important implications for strengthening alcohol taxation policy, from both a public health and public finance perspective. First, it appears that the differential tax rates for low-, mid-, and high-strength beer may need to be further widened by government in order to more effectively encourage the consumption of beer with low alcohol content. This could address the call internationally by health experts for countries to do more to facilitate consumption of lower alcohol content beverages among current drinkers (Rehm, Lachenmeier, & Llopis, 2016). Second, increasing the nominal tax rates for on-premises beer appears to be warranted, given that demand for these beverages is known to be more price inelastic. Third, to maintain revenue for government, even when consumption drops, general increases in nominal tax rates across all beer categories may be appropriate. Further, it may be appropriate to adjust beer tax rates according to changes in average weekly earnings, which have risen faster than the CPI in Australia, in order to better restrict the affordability of beer.

The amount of tax revenue collected from alcohol sales is especially important when considered in relation to the social costs of alcohol related harm. For example, Australian research estimates that 65 cents of every alcohol tax dollar collected by government is absorbed by alcohol's costs to publicly funded healthcare and law enforcement (Collins & Lapsley, 2008). There is scope for government to earmark (hypothecate) a portion of alcohol tax revenue to fund programs aimed at preventing harmful use of alcohol (Cnossen, 2010), as has been demonstrated in several countries in the region, including the Philippines, Mongolia and Thailand. Policy makers in Australia should be encouraged by surveys showing that a growing percentage of the population support higher alcohol taxes, on the condition that some revenue be used to pay for health, education, and alcohol treatment programs (Australian Institute of Health and Welfare (AIHW) (2017)).

A limitation of our study is the lack of control groups for the ITS analysis, other than the pre-intervention period where beer tax policy remained unchanged. Also, while we show that government revenue from beer tax is declining in Australia, it is possible that tax revenue from other beverages (e.g. wine, spirits) is stable or increasing. A further limitation is that we do not distinguish the effects of tax changes on different categories of consumers, such as heavy drinkers compared to light drinkers, nor have we estimated the effects of tax changes on rates of alcohol related harm. These limitations represent opportunities for further research into the public health and economic impacts of alcohol taxation.

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Declarations of competing interest

None

Appendix A. Supplementary data

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