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Title: Minimum Alcohol Pricing and Motor Vehicle Collisions in Scotland

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Running Head: Alcohol Pricing and Motor Vehicle Collisions

Key words: Alcohol; minimum price; motor vehicle collisions; Scotland

Abstract

On 1 May 2018, Scotland introduced a minimum price of 50 pence per unit of alcohol, which led to a reduction in alcohol consumption. As drink-driving is an important motor vehicle collision risk factor, we examined whether this was followed by a decrease in collisions. We took advantage of a case where the minimum price was introduced to one population during the study period (Scotland), while another population that served as the control group did not experience this intervention (England and Wales). We used data on the daily number of motor vehicle collisions resulting in death or injury in 2018 and used a differences-in-differences econometric approach, comparing trends before and after the introduction of the minimum price. Controlling for seasonality, we found a small relative decrease in collisions in Scotland compared to England and Wales [diff-in-diff interaction coef: -0.35; p-value = 0.03; 95%CI: -0.65 to -0.04]. Our results suggest that there were on average between 1.52 and 1.90 fewer daily collisions in Scotland in the first months after the introduction of the policy. Further research is needed to understand any long-term impacts of minimum alcohol pricing.

Keywords: Alcohol; minimum price; motor vehicle collisions; Scotland

1. Background

Drink-driving is a major motor vehicle collision risk factor.[1-3] According to the World Health Organization, 20% of fatally injured drivers in high-income countries had excess alcohol in their blood,[4] and 5-35% of all collision fatalities globally are alcohol related.[5] The UK Department for Transport estimates that there were 240 fatalities in the UK in 2017 in collisions linked to alcohol.[6] Apart from collisions, alcohol may contribute to other health problems, including cancers, cardiovascular disease, poisoning and liver damage, and may also trigger violence.[7] There were 7697 alcohol-specific deaths in the United Kingdom in 2017, of which 1120 occurred in Scotland.[8]

In light of this evidence, Scotland introduced a minimum alcohol price on 1 May 2018, in order to reduce consumption, while England, Wales and Northern Ireland are yet to adopt such a policy. The minimum price per unit of alcohol was set at 50 pence per unit, which targeted alcohol bought in stores. According to the policy, the minimum price for a 40% alcohol volume 70cl bottle of whisky is £14, and that of a 75cl bottle of 12.5% volume red wine is £4.69.[9] Before the introduction of the price floor, the recommended limit of 14 units a week could be bought for £2.50, which increased to a minimum of £7.50 from 1 May 2018.[10] The measure was unlikely to affect pubs, bars and restaurants, as they typically sell alcohol above the minimum price. At the time of the introduction of the new policy, the Scottish government claimed that it would help save 58 lives and prevent 1300 hospital admissions in the first year.[11]

A recent study suggests that the introduction of the policy was associated with an average increase in the price of alcohol by 0.64p per gram and led to a reduction in consumption by 9.5 grams of alcohol on average per adult in each household (or 1.2 units) – which constitutes a 7.6% decrease.[12] Based on these findings, the policy seems to have achieved its goal in the short run. Reductions in consumption were also previously reported in Canadian provinces, following the introduction of a similar policy.[13-14]

According to previous research, alcohol prices and availability, as well as alcohol-related policies such as taxes and minimum drinking age, have helped reduce the number of motor vehicle collisions,[15-21] emergency department visits,[22] hospital admissions,[23] morbidity,[24] excessive alcohol consumption and other alcohol-related harms.[25] Another study found that an increase in alcohol prices following a partial privatization of off-premise sales was associated with a reduction in alcohol-related traffic violations, crimes against persons and total crime rates.[26] Changes in per capita consumption have also been linked to changes in motor vehicle collision rates in Europe, the USA and Canada.[27-29]

The objective of this paper was to examine whether the introduction of the minimum alcohol price in Scotland had an impact on motor vehicle collisions. We used England and Wales as a control group, as they have not adopted similar policies.

2. Data and Methods

We used data from the Road Safety Database, which is provided by the UK Department for Transport[30]. We collected data on the daily number of collisions that resulted in death or injury in Scotland, and in England and Wales in 2018, and used the annual population estimates from the Office of National Statistics[31] to calculate the number of collisions per one million people. The data source does not report collisions by cause, so we did not have information on the number of alcohol-related collisions. Nevertheless, an increase in alcohol-related collisions would lead to a deviation from the baseline, even when considering the total number of collisions. Previous studies examining the impact of alcohol policies on collisions often considered their total number as an outcome.[15,19,20,22] Figure 1 shows the trends in collisions per one million people. It is hard to reach any conclusions on any changes in trends from a visual inspection of the graph, so we conducted a multivariate regression analysis at the daily level.

In order to conduct a multivariate analysis, we collected data on additional variables. The monthly unemployment rates for Scotland as well as for England and Wales were obtained from Nomis, the official labour market statistics, provided by the Office for National Statistics.[32] This was used as drinking patterns are associated with unemployment,[33] but also because previous research has showed that the risk of vehicle collisions is affected by recessions, unemployment and economic uncertainty.[34-40] Weekly unleaded petrol prices were provided by the Department for Business, Energy and Industrial Strategy.[41] Petrol prices affect the affordability of driving, and therefore traffic volume, which means fewer vehicles on the road that can be involved in collisions. However, less congestion may also allow more speeding – an important risk factor. Summary statistics are presented in Table 1, and further information, including percentiles, are reported in Web Table 1 in the Web Appendix.

We followed a differences-in-differences (DID) econometric approach, using an OLS estimator, with the daily number of motor vehicle collisions involving death or injury as dependent variable. We treat the occurrence of this intervention as a quasi-experimental setting where one group is affected while the other is not. The setting is quasi-experimental in the sense that we did not allocate individuals in treatment and control groups, as this allocation occurs naturally in the field. In this setting, Scotland (the treatment group) is affected, while England and Wales (the control group) are not. There is no plausible way that the other group could have been affected by the intervention. This methodology has been used extensively in the literature for the purpose of causal inference.[42-45]

The difference-in-differences approach allows us to filter out any secular trends that might affect the outcome variable, by employing a control group, as opposed to a before-after analysis which could reveal changes in the outcome due to any other factor. For example, collisions increase during summer months in the UK anyway – so our analysis would need to take this into account, and a control group together with adjustment for seasonality is a common way to address this. The treatment in this case is the introduction of the minimum alcohol price that took place on 1 May 2018.

In the UK, England, Northern Ireland, Scotland and Wales are comparable in many aspects, but different laws lead to within-state variation, which allows the use of control groups when different policies apply. Previous studies have also compared different areas within the United Kingdom as treatment and control groups when examining the impact of certain interventions.[44,46] Data on collisions for Scotland, England and Wales are all included in the same Road Safety Database, which makes them directly comparable. However, data on collisions in Northern Ireland are available from a different source and are reported at a different level, which is why this area was not included in the analysis.

The main coefficient of interest is the interaction of the treatment period (from 1 May 2018 onwards) and the treatment group (Scotland). The econometric model thus includes a dummy variable for Scotland; a dummy variable for the treatment period; and the interaction of the two. The coefficient of the interaction term between the treatment group and the treatment period will show whether the policy change was associated with any *relative* change in collisions in Scotland compared to the control group.

Control variables include the monthly unemployment rate and the weekly unleaded petrol price. We also used dummy variables for the first seven days following daylight saving time changes in Spring and Autumn, as previous research suggests that sleep deprivation or light conditions following the time switch may affect collisions.[47-48] In addition, we used time dummies for the day of the week and the calendar month. These allow us to control for different commuting and drinking patterns depending on the day of the week, and seasonality, relating to traffic volume and weather conditions. We used robust standard errors in all estimations. The following Equation shows the empirical model:

$$MVC = \beta_0 + \beta_1 Scotland + \beta_2 mayonwards + \beta_3 Scotland * mayonwards + \beta_4 unemployment + \beta_5 petrol + \beta_6 DSTspring + \beta_7 DSTautumn + \sum_{m=8}^{13} \beta_m day \sum_{k=14}^{24} \beta_k month + \varepsilon$$

Scotland is a dummy variable that takes the value of 1 for observations on Scotland and zero otherwise; *mayonwards* is a dummy variable that denotes the treatment period (from 1 May 2018 onwards); *unemployment* denotes the unemployment rate; *petrol* is the petrol price; and *DSTspring* and *DSTautumn* denote the first seven days following daylight saving time changes in Spring and Autumn, respectively. *day* denotes a set of dummy variables for the day of the week, and *month* denotes month dummies.

We used three main specifications. The first one includes all control variables. The second one includes only unemployment and day/month dummies; and the third one includes only petrol prices and day/month dummies.

A visual inspection of Figure 1 shows that the common trend assumption prior to the treatment appears to be satisfied. However, we also tested the common trend assumption formally, with a series of regressions. We thus restricted the sample to the period prior to the policy change (1 May 2018) and performed a number of falsification tests. In particular, we estimated regressions for placebo "interventions" in February, March and April 2018, in order to see whether there were any differences in trends between the two groups prior to the actual implementation date. A similar test of the common trend assumption has been used in the literature.[44-45] As discussed later in Section 3, in all three regressions, the interaction between the false "intervention" and the treatment group (Scotland) had high *p*-values (between 0.772 and 0.962), suggesting that there was no difference in trends between Scotland and England and Wales before May 2018.

From an initial visual inspection of the graphs (Figure 1), the time series do not appear to be trended, thus offering informal evidence of stationarity. For a more formal investigation, we also checked for stationarity using an augmented dickey fuller test for both the control and treatment groups. The null hypothesis of non-stationarity is rejected, meaning that the data are stationary at their levels.

3. Results

The study sample includes daily observations on the number of motor vehicle collisions in 2018. The average number of collisions per million people was 3.23 in Scotland and 5.39 in England and Wales, while the standard deviation was 0.96 and 1.05 respectively. Summary statistics for all variables in each area are presented in Table 1.

Web Figure 1 in the Web Appendix shows the difference in collisions in Scotland and England and Wales between the period before and after the introduction of minimum pricing, as often presented in studies with a similar design.[43] Motor vehicle collisions increased in both areas, due to seasonality. However, when comparing the period from January to April with the period from May to December, the increase in Scotland (0.31 daily collisions per 1 million people, or 10.3%) was smaller than the increase in England and Wales (0.60 daily collisions per 1 million people, or 12%). The difference in the increases in the two areas was 0.29 daily collisions per 1 million people – or 1.6 percentage points (Web Table 2 in the Web Appendix). Limiting the comparison to only one month before and one month after the introduction of the policy demonstrates similar patterns (Web Table 3 in the Web Appendix). The difference in the changes between the two areas was 0.45 daily collisions per 1 million people, or 2.7 percentage points.

Results of the baseline econometric model can be found in Table 2. Column 1 presents the model with all explanatory variables. The coefficient of the differences-in-differences interaction term is negative [coef: -0.35; *p*-value = 0.03; 95%CI: -0.65 to -0.04], indicating that there was a relative decrease in motor vehicle collisions in Scotland compared to the control group, following the introduction of the minimum price. The coefficient of the petrol price is positive [coef: 0.11; *p*-value<0.01; 95%CI: 0.04 to 0.18], but the coefficients of the unemployment rate (*p*-value= 0.37) and daylight-saving time changes in both spring (*p*-value=0.95) and autumn (*p*-value=0.50) do not seem to affect collisions. Column 2 presents the results of the model when excluding the petrol and daylight-saving time variables. The coefficient of the difference-in-differences interaction term is again negative [coef: -0.35; *p*-value=0.02; 95%CI: -0.65 to -0.04]. Results are similar when excluding the unemployment rate and daylight-saving time variables, as presented in Column 3 [Difference-in-Differences coef: -0.29; *p*-value=0.04; 95%CI: -0.56 to -0.01]. We repeated the same analysis excluding the top and bottom 1 percent outliers. Results, which are very close to those of the baseline model and hold the same interpretation, are reported in Web Table 4 in the Web Appendix.

Figure 1 shows that the trends in collisions in the treatment and control populations prior to the introduction of the policy were parallel. However, in order to formally test the common trend assumption, we conducted falsification tests, as explained in the methods section.[44-45] The results of these regressions are presented in Web Table 5 in the Web Appendix. The interaction coefficients of a false date of implementation of an "intervention" have a *p*-value of 0.77; 0.96; and 0.77 in all three cases – whether considering 1 February, 1 March or 1 May, respectively, as a false "intervention" date.

4. Discussion

This paper examined the short-term impact of the introduction of a minimum alcohol price on motor vehicle collisions in Scotland, using England and Wales as a control group. Using a differences-in-differences econometric approach, we found evidence of a small reduction in collisions in relative terms. On a random day in Scotland there were on average

0.28-0.35 fewer collisions per million people resulting in death or injury, compared to the pre-treatment period and the control group – or 1.52-1.90 fewer daily collisions.

This study shows that the minimum price in Scotland appears to have helped improve at least one public health outcome in the first months after its introduction. It follows previous studies that showed that there was a relative reduction in alcohol consumption following the introduction of the policy in Scotland[12] and Canadian provinces.[13,14] Our findings add to a body of literature that suggests that changes in alcohol prices and availability and alcohol-related policies can lead to better health outcomes[23] and fewer motor vehicle collisions and other alcohol-related injuries.[15-19,25] In Scotland, a minimum price rather than a tax on alcohol was introduced, as the Scottish government does not have the power to introduce such taxes – and the UK government has yet to make any such decision. Any tax on consumption would end up funding the government budget – and possibly to help fight alcohol-related diseases. A minimum price, however, means that producers may end up having higher profits (assuming that demand is inelastic), because the price floor would prevent them from competing by undercutting each other's price.

The minimum alcohol policy has not affected prices in pubs and restaurants, where prices normally already exceeded the minimum alcohol price, so any change is likely to have been driven by drinking at home – as documented by an increase in alcohol purchases.[11] However, the latter might mean that people may go to the pub after having (more) drinks at home, or drinking more when paying a visit to friends' homes.

As the unit of analysis is the daily number of collisions per country, a limitation of the study was that it was not possible to control for individual factors such as weather, light conditions and drivers' age. Furthermore, we used the total number of collisions instead of alcohol-related collisions, due to data availability. It is also worth noting that collisions that do not result in injury or death are not recorded in the Road Safety Database, and that the association between the policy introduction and collisions does not necessarily confirm a causal relationship. In any case, this study focuses on the short-term consequences of the minimum price, as the policy is relatively new. Future research can investigate any long-term impact, as people might adapt to the new prices. The study by O'Donnell et al[12] perhaps shows some elements of adaptation via a gradual increase in alcohol sales in Scotland, following the initial drop in consumption.

The implications for poorer socioeconomic groups should not be ignored, as any price increase may have affected their budget. However, as this policy is likely to affect low-income, heavier drinkers, it might also help reduce health inequalities,[49] depending on substitution patterns in the consumption of different goods when relative prices change. Low-income individuals may be at higher risk of fatal motor vehicle collisions, possibly because additional safety features are available on newer, more expensive vehicles, but also because of different drinking patterns. Furthermore, low-income individuals are also more price-sensitive and hence more likely to reduce consumption as a result of a price hike.[12] Therefore, the policy may have helped reduce socioeconomic inequalities in motor vehicle collisions. Our study thus highlights a possible immediate positive impact of the new minimum price on alcohol in Scotland.

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Table 1 – Summary Statistics (mean and standard deviation) of variables used in the empirical analysis

Variables	Total (*n* = 730)	Scotland (*n* =365)	England & Wales (*n* = 365)
	Mean (SD)	Mean (SD)	Mean (SD)
Crashes per 1m people	4.31 (1.48)	3.23 (0.96)	5.39 (1.05)
Scotland	0.50 (0.50)	1.00 (0.00)	0.00 (0.00)
Policy introduction	0.67 (0.47)	0.67 (0.47)	0.67 (0.47)
Unemployment rate	4.09 (0.24)	3.98 (0.29)	4.21 (0.08)
Petrol price (pence)	125.11 (4.09)	125.11 (4.09)	125.11 (4.09)
Daylight saving time, spring	0.02 (0.14)	0.02 (0.14)	0.02 (0.14)
Daylight saving time, autumn	0.02 (0.14)	0.02 (0.14)	0.02 (0.14)

Table 2. Differences-in-differences regressions on the relationship between the introduction of the minimum price policy in Scotland and motor vehicle collisions, where England and Wales form the control group.

Variables	Model 1[a]		Model 2[a]		Model 3[a]	
	Coefficient	95% CI	Coefficient	95% CI	Coefficient	95% CI
Scotland x policy introduction[b]	-0.35	-0.65, -0.04	-0.35	-0.65, -0.04	-0.29	-0.56, -0.01
Scotland[c]	-1.98	-2.21, -1.75	-1.98	-2.21, -1.75	-1.97	-2.194, -1.743
Policy introduction[d]	-0.11	-0.58, 0.35	0.04	-0.43, 0.50	-0.06	-0.48, 0.37
Unemployment rate	-0.24	-0.76, 0.29	-0.24	-0.76, 0.29		
Petrol price	0.11	0.04, 0.18			0.11	0.04, 0.19
Daylight saving time, spring[e]	-0.01	-0.41, 0.38				
Daylight saving time, autumn[e]	0.16	-0.31, 0.63				
Day of week[e]	yes		yes		yes	
Month[e]	yes		yes		yes	
Constant term	-8.05	-16.82, 0.73	5.36	3.08, 7.63	-9.47	-18.24, -0.69
R-squared	0.672		0.667		0.672	
F-statistic	73.65		82.92		83.8	

CI: confidence interval.
[a] Number of observations: 730.
[b] Difference-in-difference interaction term
[c] Treatment group dummy
[d] Treatment period dummy
[e] Dummy variable

Figures

Figure 1 – Number of monthly collisions resulting in injury or death (as defined and provided by the UK Department for Transport) per 1 million people, Scotland and England & Wales, 2018.[a]

[a]The number of collisions per 1 million people was calculated by dividing by the population of Scotland and England and Wales in 2018, as provided by the Office for National Statistics. The vertical dotted line indicates the introduction of minimum pricing on 1 May 2018.