Effect of Sunday Alcohol Sales on DUIs and Vehicle-Related Deaths

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1 Abstract

A preliminary nationwide analysis of regulations on Sunday package sales of alcoholic beverages was conducted to investigate their effects on traffic accidents. No evidence was found to suggest that legalizing Sunday alcohol sales increases the number of DUIs or vehicle-related fatalities. However, a comprehensive data collection and analysis is recommended to support legislative changes.

2 Introduction

Motor vehicle accidents is the 11th leading cause of death in the United States in 2010 (1). Driving under the influence (DUI) of alcohol or other drugs is known to contribute to the risk of traffic accidents due to their effects on motor and cognition. One regulation that has been enacted by some states in the United States is to prohibit sales of alcohol on Sundays, with the goal of reducing traffic accidents and vehicle-related deaths. However, the efficacy of such a policy is still undetermined. With Indiana on track to legalize Sunday sales of alcoholic beverages, evidence for or against regulations on Sunday alcohol sales is needed. We conduct an analysis of Sunday alcohol sales regulations and their effects on DUIs and vehicle-related fatalities to answer this important question.

3 Methods

3.1 Log-linear Model

The number of DUIs and vehicle-related fatalities are both important measures of how dangerous driving conditions are and thus the outcomes of interest. To analyze the effect of Sunday alcohol sales regulations on these outcomes, a log-linear regression model was used:

$$\log(y) = \beta_0 + \beta_1^T x_1 + \beta_2 x_2 + \epsilon$$

Here, x_1 is a categorical variable representing the state policy on Sunday alcohol sales (prohibited, limited, or permitted), x_2 is the state population, and y is the outcome of interest (number of DUIs or the number of vehicle-related fatalities).

The null hypothesis is that allowing Sunday alcohol sales (limited or permitted) does not increase the number of DUIs or vehicle-related fatalities ($\beta_1^T = 0$). The regression model adjusts for the state population (x_2), which is a potential confounder due to its high correlation with the outcome variables.

To perform inference with the log-linear regression model, it is assumed that:

1. The observations are independent between states; this is assumed of the data.
2. The residuals are distributed normally; checked with model diagnostics. To better satisfy this assumption, a log transformation was used on the outcome variable y.
3. The residuals exhibit constant variance; checked with model diagnostics.

Table 1: Frequency Table of Sunday Alcohol Sales Regulations

Regulation	Number of States	Percent
Prohibited	11	22.0%
Limited	22	44.0%
Permitted	17	34.0%

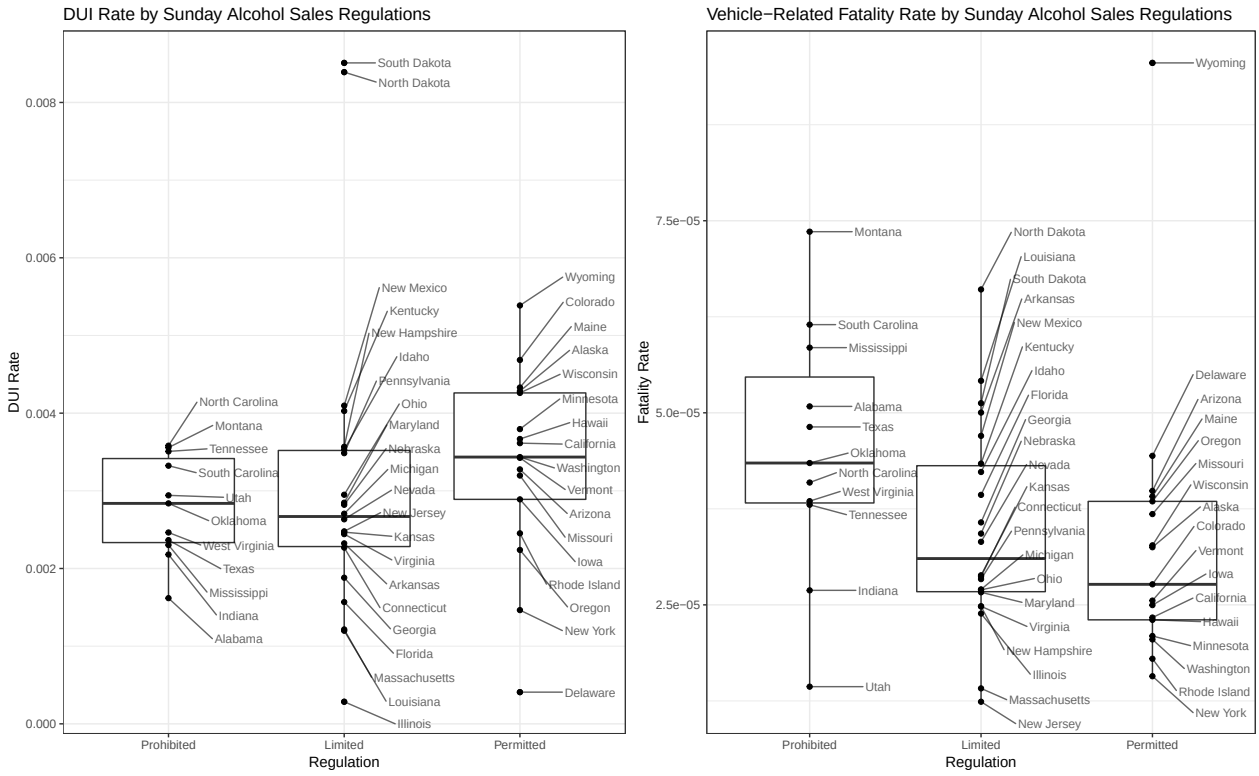

Figure 1: On average, more permissive regulations are associated with a higher DUI rate and a lower fatality rate.

4 Results

4.1 Data Characteristics

The dataset provided contains the number of DUIs, vehicle-related fatalities, regulations on Sunday sales of alcoholic beverages, and populations for the 50 states in the year 2015.

There are three different groups of regulations on Sunday alcohol sales in the data: prohibited, limited, and permitted (Table 1). The limited group consists of states with "restricted" or "local" Sunday alcohol regulations, which are combined because it is unclear whether a "restricted" or "local" regulation is more permissive.

The DUI rate (number of DUIs/state population) and vehicle-related fatality rate (number of fatalities/state population) are plotted by the type of Sunday alcohol sales regulation in Figure 1. The rates are used in the exploratory box plots to account for the strong correlation between state population and both the number of DUIs and fatalities. It appears that more permissive regulations are associated with a slightly higher DUI rate on average and a lower fatality rate on average. There are some notable outliers (e.g. the DUI rate of

Table 2: Log-linear Model for DUIs

Term	Coefficient	Standard error	p value
(Intercept)	8.284	0.142	1.39e-40
Limited	-0.085	0.143	0.722
Permitted	0.047	0.154	0.38
population	2.14e-07	1.78e-08	3.82e-15

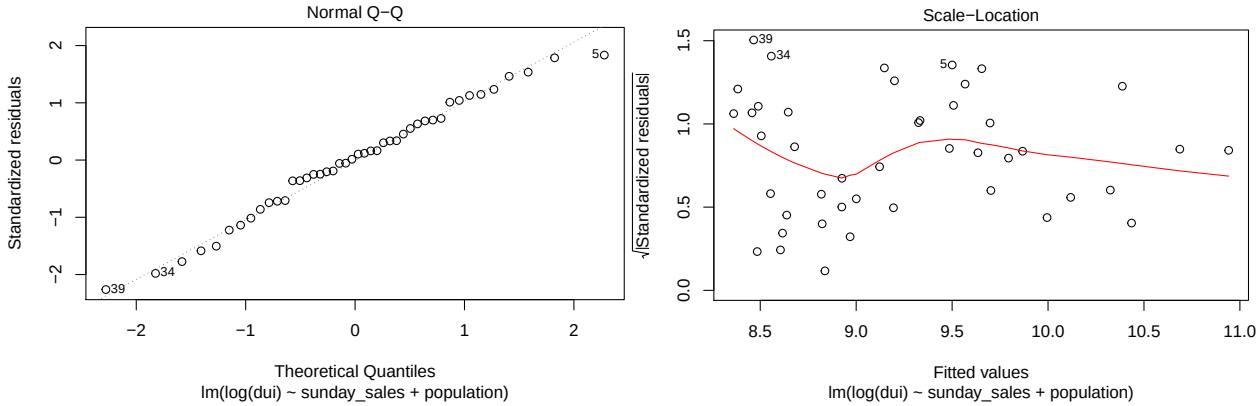

Figure 2: Model diagnostics for log-linear model for DUIs. Left: The normality assumption in the residuals appears reasonable. Right: There is no strong evidence for heteroskedasticity.

North Dakota and South Dakota), suggesting that there are some state-specific or regional circumstances affecting traffic conditions.

4.2 Are There Differences in the Frequency of DUIs Due to Sunday Alcohol Sales?

The null hypothesis is that legalizing Sunday alcohol sales does not lead to higher DUI rates. Based on a log-linear regression model, with the log-transformed DUI count as the outcome, no statistical differences in DUIs with respect to regulations are observed. Relative to the control group, which consists of states that prohibit Sunday alcohol sales, no other groups exhibit a significantly higher number of DUIs (Table 2: p-values of 0.72 and 0.38 respectively for limited and permitted Sunday sales using one-sided t-tests). Therefore, there is no statistical evidence suggesting that permitting sales increases the number of DUIs, keeping state population held constant.

To verify that the statistical tests are valid, diagnostics of model assumptions was run. Six identified outliers that contributed to lack of normality or homoskedasticity were removed from the regression model. Model diagnostics are displayed for the final regression model and the assumptions seem reasonable (Figure 2).

4.3 Are There Differences in the Frequency of Vehicle-Related Fatalities Due to Sunday Alcohol Sales?

The null hypothesis is that legalizing Sunday alcohol sales does not lead to higher vehicle-related fatality rates. Based on a log-linear regression model with the log-transformed fatalities as the outcome variable, no statistical differences in the number of vehicle-related fatalities with respect to Sunday alcohol sales regulations are observed. Relative to the control group, which consists of states that prohibit Sunday alcohol

Table 3: Log-linear Model for Fatalities

Term	Coefficient	Standard error	p value
(Intercept)	4.186	0.179	4.89e-26
Limited	-0.389	0.183	0.98
Permitted	-0.529	0.195	0.995
population	1.91e-07	2.14e-08	1.46e-11

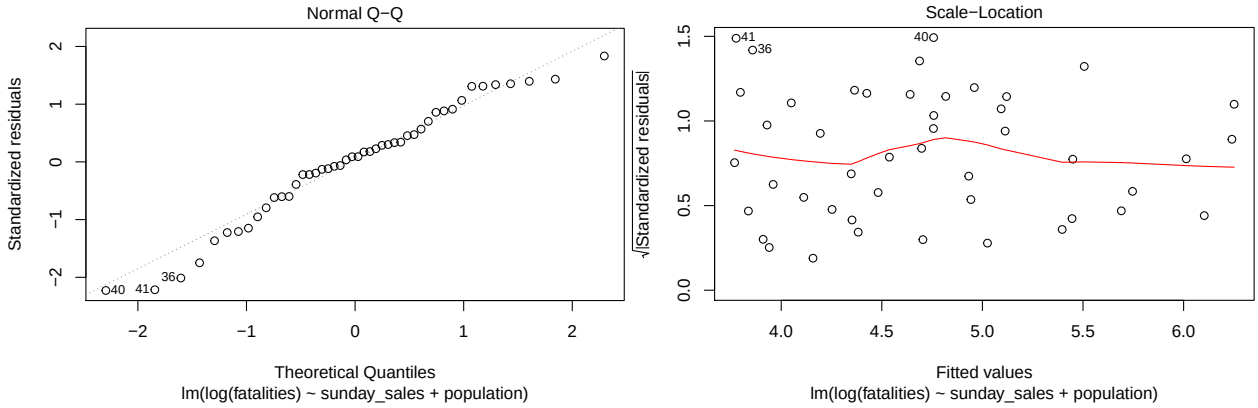

Figure 3: Model diagnostics for fatalities log-linear model. Left: There is some minor deviance from the normality assumption of the residuals. Right: The residuals appear to have reasonably constant variance with respect to the fitted values.

sales, no other groups exhibit a significantly higher number of fatalities (Table 3: p-values of 0.98 and >0.99 respectively for limited and permitted Sunday sales using one-sided t-tests). Thus, there is no statistical evidence that allowing Sunday alcohol sales is associated with higher numbers of vehicle-related fatalities.

To verify that the statistical tests are valid, diagnostics of model assumptions was run. Four identified outliers that contributed to lack of normality or homoskedasticity were removed from the regression model. Model diagnostics are displayed for the final regression model and the assumptions do not appear to be severely violated (Figure 3).

5 Discussion

The evidence is consistent with the hypothesis that permitting Sunday alcohol sales does not significantly raise the number of DUIs and vehicle-related fatalities. However, the analysis comes with several caveats that prevent a causal conclusion. The data was not adjusted for any confounding factors other than the state population. Possible confounding factors such as the quality of roads and traffic signs, the climate, and the stringency of police enforcement may be correlated with both state regulations on Sunday alcohol sales as well as DUI and vehicle-related fatalities. For instance, states with more permissive policies regarding alcohol sales may have better traffic conditions in general, which reduce traffic fatalities. This will result in an apparent association between permissive regulations for Sunday alcohol sales and lower vehicle-related fatalities, but the association is not causal.

Further analysis is recommended to provide evidence for legislative changes. Data on additional confounding factors should be collected and used in the analysis. Investigations on whether and how DUIs and vehicle-related fatalities change before and after alcohol regulation changes would also provide stronger causal evidence for the effect of Sunday alcohol sales.

6 References

1. Heron, Melonie P. “Deaths : Leading Causes for 2010.” National Vital Statistics Reports, edited by National Center for Health Statistics (U.S.) and National Vital Statistics System (U.S.), vol. 62, no. 6, https://stacks.cdc.gov/view/cdc/21434.