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Colin P. Green, John S. Heywood and Maria Navarro

The Department of Economics
Lancaster University Management School
Lancaster LA1 4YX
UK

LUMS home page: http://www.lums.lancs.ac.uk/

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Colin P. Green[1], John. S. Heywood[2,1] and Maria Navarro[1]

[1]*Lancaster University*
[2] *University of Wisconsin - Milwaukee*

Abstract

Legal bar closing times in England and Wales have historically been early and uniform. Recent legislation liberalised closing times with the object of reducing social problems thought associated with drinking to "beat the clock." Indeed, we show that one consequence of this liberalization was a ***decrease*** *in traffic accidents. This decrease is concentrated heavily among younger drivers. Moreover, we provide evidence that the effect was most pronounced in the hours of the week directly affected by the liberalization; late nights and early mornings on weekends. This evidence survives a series of robustness checks and suggests at least one socially positive consequence of expanding bar hours.*

Corresponding Author:

Colin Green
Economics Department
Lancaster University
Lancaster, LA1 4YT

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1. Introduction

Excessive alcohol consumption is responsible for tens of thousands of deaths annually and billions of dollars of economic costs in both the US and the UK (Hahn et al. 2010; NICHE 2010). Across developed countries, alcohol ranks third among twenty-six risk factors in terms of contributions to disease, disability and mortality (WHO 2002). At the same time alcohol consumption is viewed by many as an individual right and is associated with entrenched economic interests. As a consequence, the regulation of alcohol consumption remains a highly contentious area of public policy that has generated large literatures in both public health and economics (see Anderson et al, 2009 and Carpenter and Dobkin, 2011 for recent reviews). The forms of governmental regulation are numerous (Anderson et al 2009 set out the range of interventions) and so are the outcomes of concern including disease, death, lost worker productivity and crime. We add to this literature by using the recent liberalisation in England and Wales to examine the influence of bar closing hours on traffic accidents.

In late 2005 new legislation allowed much later serving hours as part of a government push to liberalise drinking regulations. The previous restrictions typically required closing by 11 pm and were considered by the government a *source* of social problems. The initial government White Paper, *Time for Reform* (UK Home Office, 2000), contended that the uniform and early closing hour meant "that large numbers of drinkers come out onto the streets late at night at the same time causing disorder." It also contended that early closing caused a "beat the clock" game that encouraged binge drinking. Famously, MP Jane Griffiths is quoted claiming that "The effect of compulsory

closure has been for people to drink 'against the clock', with whole generations of young people learning to drink as much as possible in a short space of time ..., Most of these young people are drunker than they would be if they drank at their own pace (IAS 2007 p. 3)." The government claimed that deregulated closing times could create a more European-style cafe culture that spread out peak dispersal time and resulted in reductions in both binge drinking and in drinking related legal offences.

This paper examines how liberalization in on-premise alcohol availability influences one particular source of concern, and concerted government effort, road traffic accidents. We use administrative data to examine the effect of the dramatic extension of licensed on-premise drinking hours on traffic accidents. The hypothesised influence of the policy is theoretically ambiguous. At its base, the policy change increased access to alcohol with an anticipated increase in the underlying risk of motor vehicle casualties. Yet, if the government is right, less homogenous closing times could reduce accidents by reducing roads congested by intoxicated drivers (Levitt and Porter, 2001) and by shifting such drivers to later at night when fewer other vehicles are on the road. Similarly, it remains possible that reductions in binge drinking also cut against the longer hours and could result in fewer accidents. Finally, it seems possible that the policy reduced the amount of driving as there would be less driving from the pub which closed early to either late night illegal pubs or home parties. In a range of estimates, we show that the policy change led to a decrease on the order of 3.9 accidents for each of 384 local jurisdictions per month in England and Wales. This proves robust to a range of tests and alternative specifications. We demonstrate that this reduction is concentrated almost entirely among the group likely

to be most affected by the policy, young people. Likewise, the magnitude of this effect is substantially larger during late nights and early mornings on the weekend.

In what follows, we briefly review the literature on the consequences of alcohol regulation paying particular attention to their consequences on traffic accidents. We then describe in detail the changes created by the liberalization policy and outline our data. We follow this with a description of our methodology and the key results. We present a series of tests for treatment heterogeneity, and make robustness checks including the adoption of a synthetic cohort approach as per Abadie and Gardeazabal (2003). We conclude with suggestions for further research.

2. Setting the Stage

Governments act as the chief regulator of alcohol, helping set its availability, price (through taxes) and terms of sale (such as age of the buyer). This availability is set by conditions associated with issuing alcohol licenses. Thus, the number of outlets can be regulated, the permissible days of the week for selling can be set (for instance Blue Laws in some US states), and the times during the day for selling can be set. In the latter case, typical on-premises licenses include mandatory closing hours that eliminate legal access during late nights and early mornings. A range of jurisdictions have liberalised these closing hours. For instance, in the UK an earlier 9:30pm closing time was eventually made 11:00pm, restrictions on Sunday trading were loosened and required `afternoon breaks' were eventually abolished in the Licensing Act of 1988.[1] Over this same post war

[1] Until this act all pubs had to close between lunch and evening for at least two and a half hours.

period, there has been increased effort to mitigate the negative consequences of alcohol consumption many of which happen on the road.

In seminal work, Levitt and Porter (2001) estimate the effects of drinking on traffic fatalities and quantify the negative externalities imposed by drunk drivers. Drivers with alcohol in their blood are seven times more likely to cause a fatal crash and legally drunk drivers are thirteen times more likely to cause a fatal crash than sober drivers. Most of the literature on drinking and driving investigates the influence of public policies, including regulating alcohol availability, on traffic accidents. These policies include those targeted directly at detection and deterrence of drunk driving and those that influence the level or timing of alcohol consumption. The former include mandatory jail time for Driving under the Influence (DUI), random roadside breath tests and zero tolerance laws. The latter includes taxation and day, time and age restrictions on availability.

Empirical evidence is mixed, but there certainly exist studies that find more restrictive alcohol laws reduce traffic accidents. Ruhm (1996) finds a significant effect of beer taxes, but not of DUI policies on motor vehicle fatality rates. Ruhm also demonstrates that higher drinking ages are strongly related with reduced fatalities among those 18 to 20 years old. Dee (1999) finds that beer taxes have a relatively small and insignificant impact on teenage drinking. Yet, the higher drinking age reduces teen drinking by at least 8% and traffic fatalities by at least 9%. Carpenter and Dobkin (2009, 2011) find that a higher drinking age reduces traffic mortality. Carpenter (2004) finds that Zero Tolerance

laws reduce binge drinking among underage males by 13% but fails to find a robust effect on either drinking participation or drunk driving.[2]

A literature related to our examination studies legislation regarding the sale of alcohol off-premise on Sundays in the US (so called 'blue laws'). The evidence from this literature again appears mixed. For instance, Lowenheim and Steefel (2011) show only a modest negative effect of the introduction of Sunday blue laws on motor vehicle fatalities in US states. McMillan and Lapham (2006) demonstrate a positive effect of repealing blue laws on traffic fatalities in New Mexico. However, in a multi-state study Stehr (2010) demonstrates that New Mexico is the only case where this is true claiming it reflects uniquely larger increases in alcohol consumption due to the repeal and more frequent and longer distance driving in this state. Finally, Heaton (2012) finds no effect of these laws on arrests for driving under the influence.

Somewhat further afield, interesting work has examined the relationship between the nature of leisure time regulation that influences drinking behaviour and traffic accidents. Thus, Adams et al., (2012) argue that minimum wage increases give more earnings to those youth who work but also potentially more leisure to teenagers in general due to negative employment effects. They follow this line of logic with evidence that increases in the minimum wage in the US generate increased alcohol-related traffic fatalities among teens. In earlier work, Adams and Cotti (2008) argue that local jurisdiction bans

2 Dee and Evans (2001) and Eisenberg (2003) find that Zero Tolerance laws reduce teenage traffic fatalities.

on smoking in bars will cause more driving to other jurisdictions to drink. Their evidence shows that such local bans also generate increased alcohol-related traffic fatalities.

The specific form of regulation that we examine is on-premise licensing hours. While, Green and Navarro (2012) have shown that the longer hours in the UK are associated with greater on-premise expenditure on alcohol[3], there exists only a modest body of evidence on the health effects of this specific form of legislation. In an exhaustive review of the public health literature, Hahn *et al*. (2010) identify a total of 16 studies that examine the relationship between hours of sale and alcohol consumption and its related harms. Of these studies, only a minority study motor vehicle accidents. The others focus on measures of consumption, hospital admissions, arrests for violence and crime.[4] Moreover, among the few that do examine traffic accidents they all make simple before and after comparisons without a suitable control. As illustrations, Vingilis *et al*. (2005) examine an increase in licensing hours in Ontario (1am to 2am), and using trauma admissions data show no effect on injury admissions due to motor vehicle accidents. Smith (1990) in earlier work examines an increase in Sunday opening hours in the Australian state of Victoria and demonstrates an increase in motor vehicle accidents in the period directly after the expanded hours.

Thus, in focusing on the influence of bar serving hours on traffic accidents we focus on an aspect of availability that deserves more scrutiny and contribute to a growing literature

[3] Other research has demonstrated a link between off-premise availability and alcohol consumption, see for instance Carpenter and Eisenberg (2007, 2009), Norstrom and Skog (2003, 2005) and Olsson (1982).
[4] For recent evidence on the link between hours of sale and crime see Biderman *et al*, (2010) and Gronqvist and Niknami (2011).

on the legislative determinants of traffic accidents. We do so in a framework that provides a reasonable control with the object of getting closer to causation.

We take for granted the extremely tight positive link between driving after drinking and the resulting accidents. Thus, we see the influence of extending bar hours on traffic accidents potentially working through at least two channels. First, extended hours may influence the intensity of drinking (the number of impaired bar patrons). Thus, if patrons spend longer at the bar and drink the same total amount as before the longer hours, the intensity could decline as they no longer drink to beat the clock. Alternatively, the longer period could allow a larger share of drinkers to become impaired and so intensity could increase. The second influence works through the amount and timing of driving among the impaired patrons. As we've suggested, the later closing hour may reduce the driving to illegal pubs or home parties as patrons stay in the pub. Moreover, if the bar no longer goes instantly from full to empty at the early closing hour, there may be fewer impaired drivers simultaneously on the road, even if the total number of impaired drivers is the same. In addition, the impaired drivers may now drive later in the night when fewer other drivers are on the road. While these influences may suggest fewer accidents, it could be the case that those who leave the bar very late have less access to public transit and are more likely to drive. In the end, we find the arguments each way at least plausible and view the direction of the influence as an empirical issue.

3. The Policy Change and the Data

The identification strategy in this paper follows from a legislative change that extended the legal closing hours in two constituent parts of Great Britain, England and Wales. We compare outcomes in these jurisdictions to the remaining part of Britain, Scotland, which had no change in legal closing hours at this time. Prior to the legislative change pubs in England and Wales were not allowed to stay open (and serve alcohol) after 11:00 pm.[5] Following the Licensing Act of 2003, licensed venues could apply to remain open for longer up to a maximum of 5:00 am. This came into effect in all of England and Wales as of the 24th of November 2005. By April 1, 2006 (the first available official statistics) some 50,114 venues had been granted these licenses. Four years later in 2010 this had increased to 78,879 venues. This is out of total of approximately 130,000 premises licensed to sell alcohol in England and Wales. Hence, most venues increased hours, and the majority of these increases occurred just after the legislation took force. According to survey data collected by the UK Department for Culture, Media and Sport (DCMS), of those venues that increased their hours 50% increased their licensed hours to 12am, another 30% went to 1am and the remainder went to later hours (DCMS, 2006).[6] According to the same survey, the variation in the density of extended hours licences by region appears to be very modest. As a rough estimate, we used the adult population per region to compute the number of licenses per thousand people. This ranged only between 0.94 licenses per thousand people and 1.47 per thousand people.

[5] There were modest exceptions with a few pubs and nightclubs holding special licences allowing opening later hours on specific nights.

[6] Although these are typically much larger than average premises.

We use road accident data from the Department of the Environment, Transport and the Regions (DETR) that contain all motor vehicle accidents reported to the police from 2002 to 2008 for all 416 local jurisdictions in the three parts of Britain.[7] We know the type of accident (whether it caused either serious injury or a death), the date and time of the accident, location of the accident and the age of the driver of any vehicle involved in the accident. Critically, the data allow us to accurately assign accidents to the pre and post policy period. We then match this data to population data from the Key Population and Vital Statistics and Area from the UK Standard Area Measurements (SAM) both available from the Office of National Statistics (ONS).

During our period of analysis, traffic accidents and fatalities have generally been declining in Great Britain (Department of Transport, 2012). In the year 2000 just over 41,000 individuals were killed or seriously injured in motor vehicle accidents in Great Britain, by 2005 just prior to the opening hours change it was approximately 32,000. This overall trend continued but less dramatically in the following years. As a result, part of the empirical challenge in this paper is to identify the policy effect, if any, in a time period with a clearly decreasing trend.

INSERT FIGURE 1

Figure 1 plots average monthly traffic accidents per local jurisdiction, grouped by treatment (England and Wales) and comparison group (Scotland). The accident data is quite noisy with substantial monthly fluctuations in accident numbers. To aid with presentation we use a five month moving average to smooth the data. These reinforce the

[7] Available from the Economic and Social Data Service (www.esds.org.uk)

view that there has been a clear general reduction in traffic accidents across the period for both treatment and control groups. It also makes clear that the initial trend of decline is far greater in Scotland than in England and Wales. Thus, we are immediately concerned that failure to recognise this difference could generate spurious associations with the timing of the liberalization. Finally, it is also evident that there is substantial cyclical variation.

INSERT FIGURE 2

In Figure 2 we present average accidents per month (dots) for pre and post policy periods for England/Wales and Scotland separately. This data is then fitted using simple regression to fit the data before and after the policy was implemented for the treatment and control groups. This initial graphical evidence confirms the downward trend in traffic accidents and shows that the trend differs in a way that would predict a widening gap between the treatment and control in the absence of the intervention. It also shows a drop associated with the policy change for England and Wales but little or no drop associated with the policy for the control of Scotland. We now move to statistical testing.

4. Methodology

To more formally examine the influence of longer hours we estimate various difference-in-differences specifications in which the difference between the number of accidents before and after the legislation in England/Wales is contrasted with that same difference in Scotland. Our main estimating equation is a flexible difference in difference model

that allows for different time trends between the treatment areas (England/Wales) and comparison area (Scotland):

$$Acc_{it} = \phi + \delta LongerHours_t + \gamma England/Wales_i + \beta LongerHours * England/Wales_{i_t} + \alpha X_{it} + \tau T_t + \lambda T_t * England/Wales_i + \varepsilon_{it}$$

where Acc_{it} corresponds to the number of motor vehicle accidents occurring in local government area *i* in period *t*. $LongerHours_t$ equals one for time after the extension of drinking hours (24th of November 2005), 0 otherwise. $England/Wales$ is an indicator variable that equals 1 if a regional authority is in England or Wales and 0 if it is in Scotland. The key policy parameter is the interaction of these two variables such that β provides the Difference-in-Differences estimator. Thus, β estimates the change in motor vehicle accidents associated with longer opening hours in England/Wales compared to the change in Scotland over the same period. We include both a continuous monthly time trend (*T*) and the interaction between this and the treatment indicator. [8]

The initial time period we examine brackets the legislation enforcement in 2005 running from the beginning of 2002 to the end of 2008. We take the unit of observation to be the monthly accidents in each local jurisdiction. We discuss robustness exercises regarding the use of monthly data, adding relevant controls and controlling for cyclical variation.

[8] In robustness checks we will vary our treatment of trends by dropping the differential trends and matching on a synthetic cohort that has a similar trend to England/Wales.

An important extension of this methodology recognises that the liberalization should have different treatment intensity for different hours of the week. Thus, we focus attention on Friday and Saturday evenings on the suggestion that these evenings are when the policy influence should be greatest. In addition, we recognise that alcohol related accidents are concentrated among younger people (see NHTSA 2012) and that part of the original rationale of extending hours was aimed at changing the behaviour of younger patrons. Thus we examine treatment heterogeneity across age groups. While much of the analysis focuses on the determinants of all traffic accidents, we use the same approach to focus on traffic accidents that result in very serious injury or death. Not only might these serious accidents be of more interest as their social costs are greater, but they may also be more accurately reported and so serve as an important accuracy check.

Finally, in discussing the results we recognise a number of potential threats to identification and seek to address these. These include, but are not limited to, inference based on biased standard errors in panel data difference-in-difference models and the underlying count nature of the data. Importantly, we demonstrate that our key results are robust to a range of approaches that seek to address these and other key concerns.

5. Initial Results

Table 1 reports initial results from the difference-in-difference estimator. They provide the change in motor vehicle accidents that occurred in the local jurisdictions in England/Wales after the extension of on-premise drinking hours relative to the comparison group of authorities in Scotland. The first column reports an initial

specification with a monthly time trend and this monthly time trend interacted with England/Wales. In addition it is assumed that the error term is IID. This reveals a decrease of 3.95 accidents per month, per local jurisdiction as a result of longer opening hours, albeit an effect that is statistically significant at only the 10% level. As there are 416 local jurisdictions in England and Wales, this equates to an overall decrease in monthly accidents of 1,643. Viewed another way, there is a pre-reform period average of 30.7 accidents per jurisdiction in England and Wales so this initial estimate would suggest that the reform is associated with a 12.8% decrease in accidents.

In the second column more structure is imposed on the error term by clustering at the local jurisdiction level. This is motivated by a concern that the error term may be correlated within local jurisdictions across monthly observations with the result that the standard errors in column one are incorrect (Bertrand et al, 2004). The second column generates a more precise estimate with the policy influence now statistically significant at the 1% level. The estimate reported in column 3 adds controls for the population and physical size of each local jurisdiction. These controls seem likely to influence accidents as proxies for the amount of driving (the land area) and the traffic density (the population holding the land area constant). The data from which these controls are generated is, in a very few cases (11 of 416), not perfectly matched to the local jurisdiction. In those cases, we simply drop the local jurisdictions from the estimation. Both control variables positively influence the number of accidents as anticipated but their inclusion does not fundamentally change the key policy estimate.

Insert Table 1

The estimate in column 4 adds quarterly dummies to capture the evident cyclical pattern seen in the raw data. In a pattern often noted in the UK data, the fourth quarter is found to have the highest number of accidents (the last three months of each calendar year) but including these controls does little to change the magnitude of the policy influence. This estimate is further augmented by interacting the quarterly dummies with the treated group, England/Wales and the result is summarised in the column 5. The interactions are significant and indicate wider swings in England/Wales but, again, even their inclusion only modestly alters the policy influence. Indeed, we have repeated the exercise with monthly dummies and their interactions and a policy influence of very similar magnitude remains and it retains high significance.

We next return to the full set of local jurisdictions in order to test a variety of alternative specifications. We begin by replacing the jurisdiction level controls with jurisdiction fixed effect estimates. The result is an estimate based only on the within local jurisdiction variation in accidents that occurred with the policy implementation. This estimate is shown in the first column of Table 2. The difference in difference estimate remains as in the early estimates of Table 1 with a large and statistically significant coefficient at the 1% level. We then add the quarterly dummies and then their interaction with the treated jurisdictions. As shown in columns 2 and 3, there is only very modest movement in the estimated policy influence. Again, replacing the quarterly dummies with monthly dummies does not change the pattern of results and significance. We also note that returning the annual population measure and losing a few jurisdictions in doing so, does

not meaningfully change the fixed effect estimate. Thus, we suggest that the original result is largely robust to fixed effects at the jurisdictional level.

Insert Table 2

The fourth column in Table 2 addresses the assumption of continuity in our dependent variable when it may properly be viewed as count data. We estimate a Poisson regression. For ease of interpretation we report incident rate ratios (IRR) that in this context provide the percentage change in accidents. As the IRR is .902, this implies the policy is associated with a 9.8% decrease in the number of accidents per jurisdiction. The negative and statistically significant effect of the policy change on motor vehicle casualties in England and Wales relative to Scotland is robust to controlling for time invariant characteristics at the jurisdiction level in this count data estimate.

While only 8.2% of the monthly jurisdictional observations have zero crashes, it may be the case that the estimate suffers from zero inflation. Indeed, the Vuong test returns a statistic of 52.6 which gives a p-value of essentially zero and allows us to reject the hypothesis of no zero inflation. As a consequence, we estimate the Zero Inflated Poisson (ZIP) analogue of our main model. This estimate of the IRR is .920 and implies the policy is associated with a statistically significant 8.0% decrease in accidents. In order to provide easy interpretation of magnitudes, we revert to estimation by OLS for testing for treatment heterogeneity. Yet, we stress that the qualitative results (sign, significance and rough size) are robust to count data estimation.

6. Heterogeneity in Treatment Effect

A key feature of the legislative change is the potential to change the timing of alcohol consumption. The influence of this feature should be particularly noticeable during the hours of the week when most on-premises alcohol is consumed. Put differently, those treated are heavily concentrated in weekend evenings and one might anticipate a fundamentally stronger influence at this time. The estimates in Table 3 divide the observations into those during the day, 8:00 in the morning till 8:00 at night, and those in the night, 8:00 at night till 8:00 in the morning. The influence of the longer hours policy as measured by the difference in difference with jurisdiction fixed effects is statistically significant for both periods but that in the day, when most of the accidents occur, is a decrease of slightly more than 12%. When we look at night hours the decrease is slightly higher at 14%. These night hours can be further divided into those on the weekends and during the weekdays. The weekday decrease is 12% as shown in row 3 while the Friday and Saturday decrease is 18% as shown in row 4. This larger reduction on Friday and Saturday nights suggests, as anticipated, that the hours with the largest number of treated patrons is where the reduction in accidents is concentrated. The estimated change in the actual number of accidents is smaller during these hours but this is because only a relatively small number of all accidents happen on Friday and Saturday nights. This decrease is 50% higher than the decrease during day time hours.

Insert Table 3

We focus on even finer divisions of the hours of Friday and Saturday night. We next examine the hours of 9:00 at night to 3:00 in the morning on Friday and Saturday nights.

As shown in the fourth row of Table 3, the estimated decline remains statistically significant and represents a 23% decline. Similarly, an even narrower window of 11:00 at night to 3:00 in the morning on Friday and Saturday nights shows a nearly 24% decline in accidents. Thus, at the very hours when one might anticipate patrons would otherwise be simultaneously streaming out of bars and into cars, the new legislation allows them to remain in the bar and spreads out their dispersal with a large apparent decline in traffic accidents.

We next imagine that drinking and risk taking behaviour vary markedly by age and test whether or not the treatment effect displays heterogeneity across age groups. It is generally noted that younger drinkers tend to take more risks and given our earlier suggestion that liberalization was actually associated with fewer accidents, it could be that it was younger drinkers who were previously drinking to beat the clock and/or more willing to drive after doing so. Table 4 presents estimates that focus on the crucial weekend night hours and splits the observed accidents into three age groups. After presenting the results for all ages combined, the second column estimates all accidents in which at least one driver is between 18 and 25 years old. The fourth column estimates all accidents in which no driver involved is under age 45. The third column estimates the mutually exclusive group which we label 26-44 and includes accidents in which all drivers are older than 25 and at least one driver is under age 45. All of the estimates presented are those with local jurisdiction fixed effects.

The estimates reveal that the decrease in accidents associated with longer hours is concentrated almost entirely among young drivers. In the top panel we focus on all reported accidents and disaggregate the -.473 coefficient for all ages. The coefficient for the youngest drivers is -.380, the vast majority of the decline, and is statistically significant. As a percentage decrease, a drop of .380 represents a 32.5% decrease for younger drivers on Friday and Saturday nights. While the coefficient is negative for middle age drivers, it is not statistically different from zero. The coefficient for older drivers is not significant, vanishingly small and actually positive. Thus, the clear pattern is that the age group most influenced by the policy change is the youngest drivers. Again, we take this to be the group potentially most likely to have their behaviour changed (to be treated) by the extension in hours.

Insert Table 4

The link between longer hour's legislation and serious injuries and fatalities merits separate attention.[9] As the social costs are larger, these outcomes may simply be of greater policy interest. In addition, these outcomes also provide a robustness test as there should be less measurement error in the reporting of serious injuries and fatalities than accidents in general. The middle panel of Table 4 repeats the estimates but is limited to the count of accidents with serious injuries or fatalities per local authority, per month. These estimates demonstrate a decrease in serious and fatal accidents that is again concentrated almost entirely in accidents involving young drivers. The bottom panel takes this further and looks at fatalities only. Here there is some suggestion of a decrease

[9] In our data, fatalities are those who die immediately or die within 30 days of the accident as a result of their injuries. Serious injuries are those that require hospital admission.

overall but our models suffer from a loss of precision, which might result from traffic fatalities being a much less common occurrence. Nonetheless, our results suggest that the policy effect remains concentrated among the youngest drivers with a weakly significant decline in fatalities among the 18 – 25 year olds. Thus, across all three measures of type of accident, it seems fair to say that heterogeneity by age has been identified and that the influence of the policy change is most evident and largest among the youngest drivers.

7. Robustness and Threats to Identification

In this section we provide further checks aimed at examining the robustness of our results. First, we estimate a simple placebo test. We estimate the fixed effects (at local jurisdiction level) model of the policy effect for Scotland only. This identifies the within local jurisdiction variation in accidents associated with the policy implementation in our comparison group. The point estimate of -0.446 [0.639] indicates no statistically significant change in accident levels in Scotland coinciding with the policy implementation in England and Wales.

There exists the potential for bias associated with the introduction of a smoking ban in bars in Scotland on March 26th 2006. Adda *et al.* (2012) show this ban had a significant impact on bar sales in Scotland. If this caused a change in traffic accidents in Scotland in the post policy period, it could bias our policy estimates. We re-estimated our models over a much shorter time frame and one that ends the day before the introduction of the Scottish smoking ban. Our estimates remain essentially unchanged suggesting that the

ban does not drive the results. The fixed effect estimate suggested a decline of -3.207 accidents per jurisdiction that was statistically significant at the 1% level.

While the policy came into effect in late 2005 and there appeared to be an early wave of license provisions, there may have been a period of adjustment where bars slowly changed or experimented with opening hours and where patrons changed bar attendance patterns. This behaviour could have occurred in a range of ways, including slow adjustment to later hours of drinking or alternatively a short novelty period of late drinking followed by a reversion to earlier habits. In either case this may undermine our approach that relies on the date of implementation to identify the policy switch. We examine this by excluding the first year of policy implementation (November 25th 2005 to November 25th 2006) and re-estimating the model. This leads to a policy estimate that is actually larger in magnitude, -7.007[1.356] in fixed effect model from Table 2. This suggests that the influence of the policy was not only short-term and behaviour may have continued to evolve such that the policy influence grew over time.

A more fundamental concern is that Scottish jurisdictions simply may not provide good counterfactuals for traffic accidents in England and Wales. While we control for obvious observable differences, such as population and size, there may be other underlying features which make the sum of Scottish districts unsuitable as a comparison. Abadie and Gardeazabal (2003) suggest implementing a matching protocol to create a synthetic control by optimally weighting a set of jurisdictions among those in the counterfactual, Scotland in our case. The chosen weights create the synthetic control that best matches

the traffic accidents in England and Wales before the passage of the Licensing Act. This control is then compared to the average across the treated jurisdictions, England /Wales, in a straightforward difference in difference. Thus, there emerges one observation per period for both the treatment and synthetic control.

Using the protocol of Abadie and Gardeazabal, we match England on the number of accidents, the jurisdictional trend in accidents, population and area. This generates a weighted average of four Scottish jurisdictions as the best match for the English average. These jurisdictions and their weights in the synthetic cohort are as follows: Aberdeen City (.436), Dumfries and Galloway (.142), Fife (.038) and Stirling (.384). The matching process minimises the mean squared prediction error (the average number of accidents per jurisdiction in England/Wales minus that in synthetic Scotland) for the pre-policy periods. The resulting mean squared error is 3.74 and can be compared with the otherwise similar mean squared error using the actual data before matching of 107.6. Thus, the fit between the synthetic cohort and England/Wales is obviously much tighter.

The accident series data from the synthetic cohort is shown in Figure 3 and compares the English/Wales average in a fashion analogous to that in Figure 1. The pattern shows a very close match between England/Wales and Scotland in the pre policy period as would be anticipated from the protocol. It is also apparent that the pattern in the post-policy period shows substantial divergence with the series for synthetic Scotland continuing roughly along trend but that for England/Wales falling well below.

Insert Figure 3

The difference in difference estimate confirms what Figure 3 shows visually. Neither the coefficients for the policy period nor for England/Wales are statistically different from zero yet the interaction emerges with a coefficient of -4.76 with a standard error of 1.237. Thus, this methodology confirms our earlier estimates with a large estimated decline in traffic accidents for England/Wales associated with the advent of longer drinking hours. This correspondence to our earlier estimates that used differentiated trends supports the suggestion that the decline following the policy is genuine.

8. Conclusion

At the time of passage, it was hoped that reforming closing hours would be part of changing attitudes and behaviour toward alcohol. Supporters felt that eliminating early and uniform closing hours would reduce alcohol related social problems. While we have examined only one of those problems, our evidence does suggest that later closing hours are associated with decreases in automobile accidents. This decrease has been concentrated among the young, those most likely to be influenced, and within the hours of the week where behaviour is most likely to be influenced. We emphasise that we are not advocating for greater access to alcohol in all circumstances and have presented evidence on only one of potentially many social costs. It could easily be the case that even if the policy eliminated the simultaneous release of many drunken drivers onto the road, it increases the total consumption of alcohol and so increases the associated costs related to worse health, poorer family relations and greater absenteeism.

Recognizing that driving impairment is not the only social problem associated with alcohol, future work might provide a more complete evaluation of liberalizing the drinking hours. These could include examinations of lost worker productivity, increased sickness and greater violence and crime. In addition, future work might retain the focus on driving but explore whether districts that had particularly large increases in the proportion of venues seeking late hours had particularly large decreases in accidents. Obviously, care would need to go into an identification strategy as the districts most likely to have venues increase hours might well be those that have increasing demand for alcohol independent of the legislation. Nonetheless, this might allow both identifying another dimension of treatment heterogeneity and potentially finding even more dramatic influences in some jurisdictions.

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Table 1: The Influence of the Licensing Act on traffic accidents in the UK (2002-08)

	(1)	(2)	(3)	(4)	(5)
Longer Hours in England/Wales	-3.951	-3.951	-4.123	-4.153	-3.640
	(2.183)*	(1.027)***	(1.073)***	(1.073)***	(1.062)***
Policy Period	-0.446	-0.446	-0.540	1.053	0.579
	(2.097)	(0.706)	(0.730)	(0.731)	(0.713)
England/Wales	0.994	0.994	7.956	7.950	10.054
	(2.269)	(4.726)	(2.355)***	(2.355)***	(2.645)***
Population			0.180	0.180	0.180
			(0.019)***	(0.019)***	(0.019)***
			0.016	0.016	0.016
Area			(0.005)***	(0.005)***	(0.005)***
Monthly Trend	Yes	Yes	Yes	Yes	Yes
Monthly Trend x England/Wales	Yes	Yes	Yes	Yes	Yes
Clustered Errors	No	Yes	Yes	Yes	Yes
Quarterly Dummies	No	No	No	Yes	Yes
Quarterly Dummies X England/Wales	No	No	No	No	Yes
Observations	34944	34944	33300	33300	33300
R-squared	0.02	0.02	0.42	0.42	0.42
Number of local jurisdictions	416	416	405	405	405

Notes: England/Wales corresponds to the treatment group where the comparison group are local jurisdictions in Scotland. Policy Period is the policy variable that takes value 1 after the 24th November 2005 and 0 otherwise. Longer Hours in England Wales is the interaction between the policy period and the treatment group (England/Wales). Observations: 416 different local jurisdictions during 84 months (7 years).

*, **, and *** indicate statistical significance at the 10%, the 5%, and the 1% levels, respectively.

Table 2: Alternative Specification of the Licensing Act on traffic accidents in the UK (all se are clustered at a local jurisdiction level)

	(1)	(2)	(3)	Poisson	ZIP
Longer Hours in England/Wales	-3.951 (1.027)***	-3.951 (1.027)***	-3.464 (1.016)***	-0.103 (0.039)*** [0.902]	-0.084 (0.039)** [0.920]
Policy Period	-0.446 (0.706)	1.072 (0.707)	0.623 (0.690)	-0.049 (0.029)* [0.953]	-0.044 (0.029) [0.957]
England/Wales				-0.049 (0.177) [0.952]	0.105 (0.175) [1.111]
Monthly trend	Yes	Yes	Yes	Yes	Yes
Monthly trend × England/Wales	Yes	Yes	Yes	Yes	Yes
Jurisdiction Fixed Effect	Yes	Yes	Yes	No	No
Quarterly Dummies	No	Yes	Yes	No	No
Quarterly Dummies X England/Wales	No	No	Yes	No	No
Observations	34944	34944	34944	34944	34944
R-squared	0.02	0.05	0.05		
Number of local authority	416	416	416	416	416

Notes: England/Wales corresponds to the treatment group where the comparison group are local jurisdictions in Scotland. Policy Period is the policy variable that takes value 1 after the 24th November 2005 and 0 otherwise. Longer Hours in England Wales is the interaction between the policy period and the treatment group (England/Wales). Observations: 416 different local jurisdictions during 84 months (7 years).

*, **, and *** indicate statistical significance at the 10%, the 5%, and the 1% levels, respectively.

Table 3. Extending Drinking Hours and Accident Heterogeneity by Time, 2002-2008.

	Longer Hours in England/Wales	**Mean Accidents England/Wales Pre-Policy**	**% Change**
All Days 8:00-20:00	-3.069 (0.860)***	24.71	12.4%
All Nights 20:00 - 8:00	-1.312 (0.329)***	9.36	14.0%
Nights Except Friday and Saturday	-0.839 (0.253)***	6.78	12.4%
Friday and Saturday, 20:00-8:00	-0.473 (0.109)***	2.59	18.3%
Friday and Saturday, 21:00-3:00	-0.398 (0.089)***	1.72	23.1%
Friday and Saturday, 23:00-3:00	-0.262 (0.069)***	1.11	23.6%

*** indicates statistical significance at the 1% level. Robust standard errors in parentheses. All rows are the difference in difference estimate from separate models that include local jurisdiction fixed effects, year and quarter dummies and all controls as per model (3) in Table 2.

Table 4: Age Heterogeneity in DiD Estimates for Friday and Saturday Nights (FE estimates)

All Accidents

	All ages	18-25years	26 to 44 years	45 years +
Longer Hours in England/Wales	-0.473 (0.109)***	-0.380 (0.092)***	-0.102 (0.069)	0.010 (0.057)
Monthly trend	Yes	Yes	Yes	Yes
Monthly trendx England/Wales	Yes	Yes	Yes	Yes
Observations	34944			

Serious and Fatal Accidents

	All ages	18-25years	26 to 44 years	45 years +
Longer Hours in England/Wales	-0.202 (0.050)***	-0.133 (0.045)***	-0.058 (0.022)***	-0.011 (0.023)
Monthly trend	Yes	Yes	Yes	Yes
Monthly trendx England/Wales	Yes	Yes	Yes	Yes
Observations	34944			

Fatalities

	All ages	18-25years	26 to 44 years	45 years +
Longer Hours in England/Wales	-0.027 (0.018)	-0.026 (0.014)*	-0.005 (0.009)	0.003 (0.010)
Monthly trend	Yes	Yes	Yes	Yes
Monthly trendx England/Wales	Yes	Yes	Yes	Yes
Observations	34944			

***, ** and * indicates statistical significance at the 1%, 5% AND 10% level, respectively. Robust standard errors are in parentheses.

Figure 1: Average Monthly Traffic Accidents per Local Jurisdiction, Scotland and England/Wales. These are 5 month moving averages and time 0 refers to introduction of licensing act.

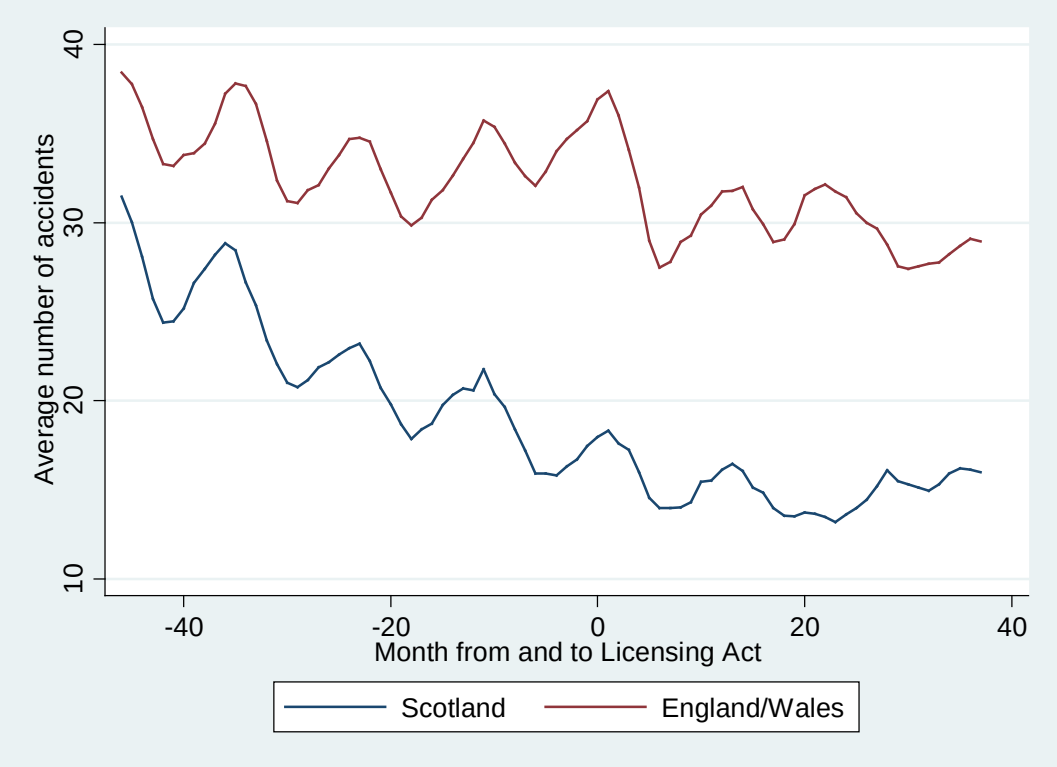

Figure 2: Estimated Average Monthly Traffic Accidents per Local Jurisdiction, Pre and Post Drinking Hours Extension. Scotland and England/Wales.

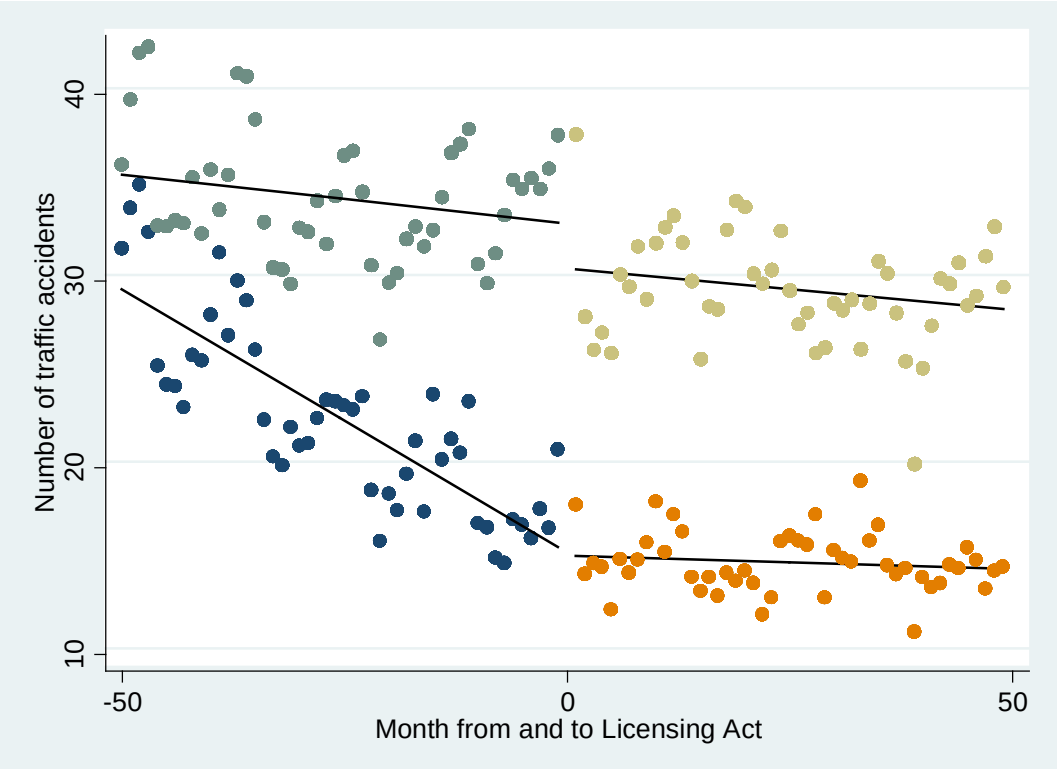

Figure 3: Comparing Average Traffic Accidents per Jurisdiction in England/Wales with that from the Synthetic Scottish Control (2002 – 2008). These are 5 month moving averages and time 0 refers to introduction of licensing act.