ONLINE APPENDIX

Supplementary Material

None for the Road? Stricter Drink Driving Laws and Road Accidents

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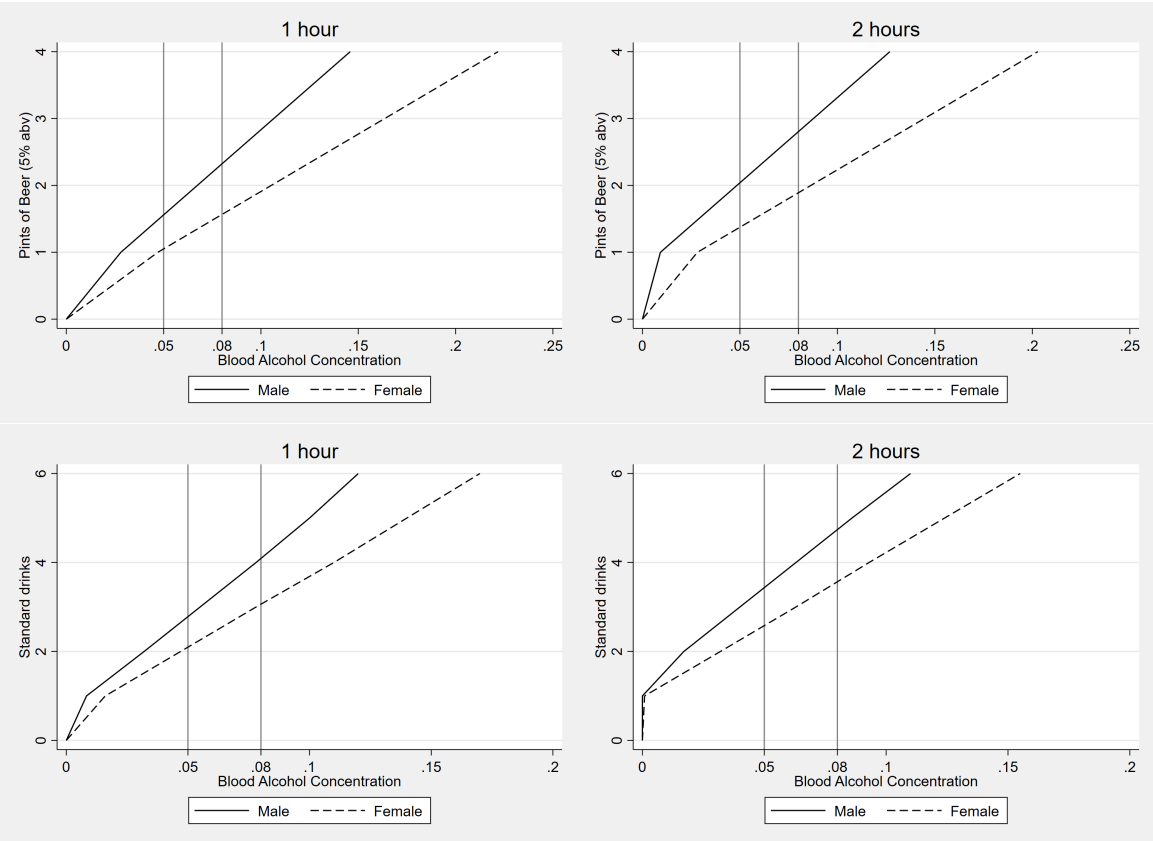
This Appendix reports additional analyses and results discussed in the main text, which could not be included due to space concerns. To locate the material more easily in the context of the paper, in what follows we use the same number and title of the sections used in the text.

2. Background

The Scottish Government's current anti-drink drive website can be found at: <https://roadsafety.scot/topics/drink-driving/>. The website used to be called Don't Risk It.[1] Additional information about the campaign was collated by the European Transport Safety Council (2016).

[1]For an archive copy, see <https://web.archive.org/web/20150501045404/http://dontriskit.info/drink-driving/the-law/>.

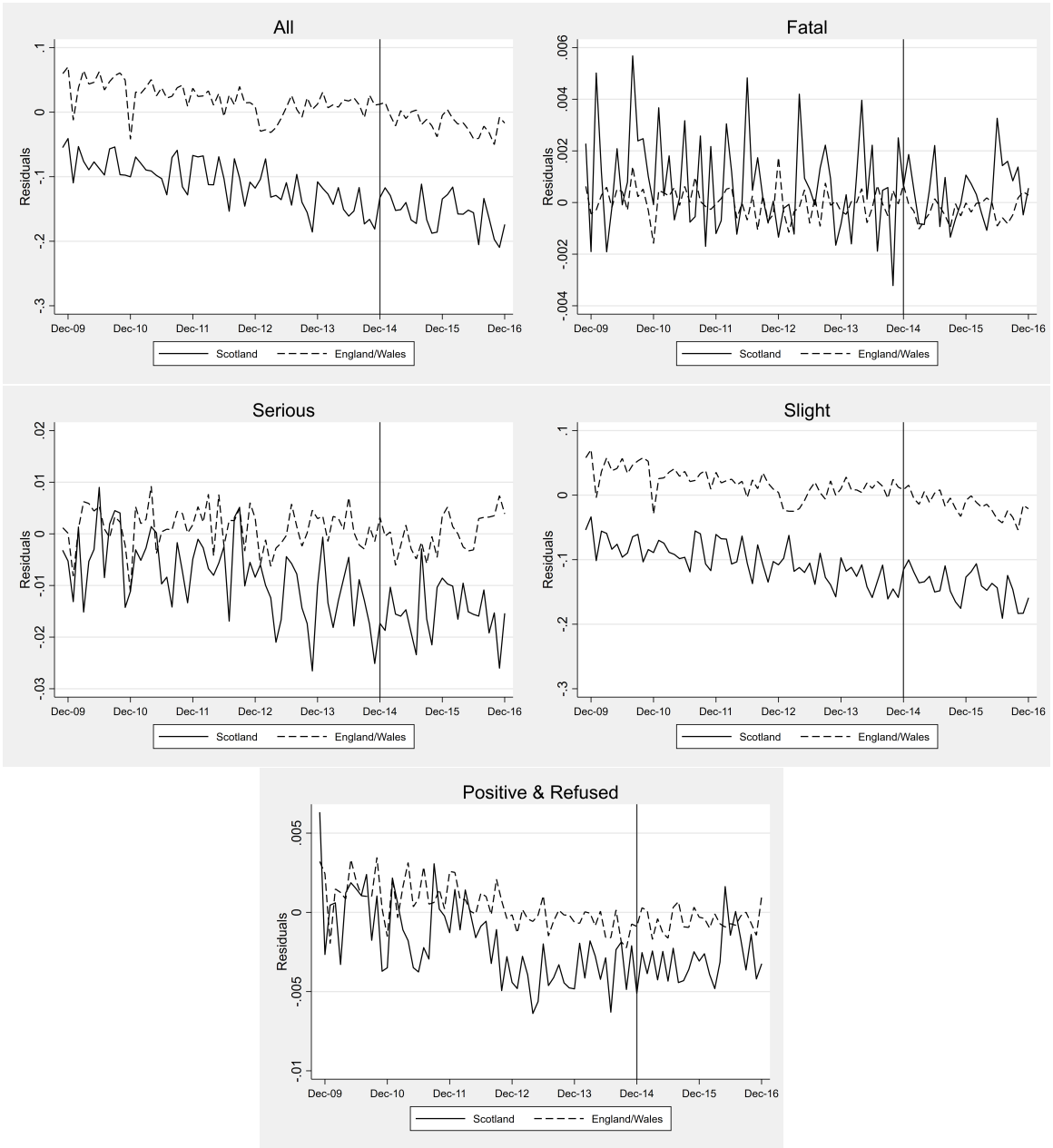
Figure A.1: Relationship between Alcohol Intake and Blood Alcohol Concentration



Source: For BAC based on UK pints: `https://www.drinkdriving.org/bac-calculator.php`
For standard drinks (US): `https://www.calculator.net/bac-calculator.html`
Notes: Blood alcohol concentration (BAC) is expressed in grams of alcohol per deciliter of blood. Estimates are based on an average weight adult man (84kg) and woman (70kg) consuming alcoholic drinks over the space of one hour. Pints are defined as UK pints (or 568ml). Standard drinks are defined as US standard drinks (e.g. a 12 fl oz (US) of beer of 5% ABV). The two vertical lines are drawn in correspondence to the old and new Scottish DDLs, i.e., 0.08 and 0.05 BAC, respectively. Hours indicate the time since first drink.

3. Data and Methods

Figure A.2: Trends in Road Accident Rates Accounting for Seasonality: Scotland versus the Rest of Britain



Sources: Road Accidents Data, Department for Transport, STATS19
Notes: Residuals are obtained from a regression of the road accident rate on a set of month of year dummies.

Methods — Here we describe in more detail the synthetic control method approach that we take. To further contain the scope for omitted variable bias and increase the similarity between treatment and control local councils, the third design follows the synthetic control method introduced by Abadie and Gardeazabal (2003) and Abadie, Diamond, and Hainmueller (2010). With this approach, we weight local authorities in the control group to construct a synthetic counterfactual that replicates the basic predictors of accidents for Scottish local authorities before the 2014 DDL reform (see also Abadie, Diamond, and Hainmueller [2015]).

Adjusting the previous notation to Rubin's (1974) potential outcome framework, we define y^1_{cm} as the accident rate in month m if the local council c is in Scotland and y^0_{cm} the corresponding outcome if the local authority is not in Scotland, so that the treatment effect of the reform is given by $\beta_{cm} = y^1_{cm} - y^0_{cm}$. The synthetic control estimator compares the outcome in the treated region (Scotland) averaged over all local councils, y^1_m, to a weighted average of the outcome over all local authorities in the control group, that is:

$$\widehat{\beta}_m = y^1_m - \sum_{c \in C} \omega_c y^0_{cm}, \tag{1}$$

where $\omega_c \geq 0$ is the weight attached to each local authority c in the control group C. Since treated and control units are observed in different states after the introduction of the reform at month τ (i.e., with and without the 0.05 BAC law, respectively), (3) becomes

$$\widehat{\beta}_m = \beta_m + \Big(y^0_m - \sum_{c \in C} \omega_c y^0_{cm} \Big), \quad \text{for all } m \geq \tau. \tag{2}$$

The accuracy of this approach therefore relies on minimizing the difference in parentheses in (2). A way to achieve this is to minimize the difference between treated and control local councils over the pre-reform period, when none of them was exposed to the reform. As long as the weights reflect features that do not change in the absence of the DDL reduction, the synthetic control approximates the (unobserved) counterfactual evolution of the potential outcome y^0_m from τ onwards.[2] Specifically, let $\mathbf{X}^1_c$ and $\mathbf{X}^0_c$ be the vectors of collision determinants for the treated region (Scotland) and for each of the local authorities c in the control group, respectively. The optimal vector of weights will minimize the square distance $(\mathbf{X}^1_c - \sum_{c \in C} \omega_c \mathbf{X}^0_c)' \mathbf{V} (\mathbf{X}^1_c - \sum_{c \in C} \omega_c \mathbf{X}^0_c)$, where $\mathbf{V}$ is a diagonal matrix with non-

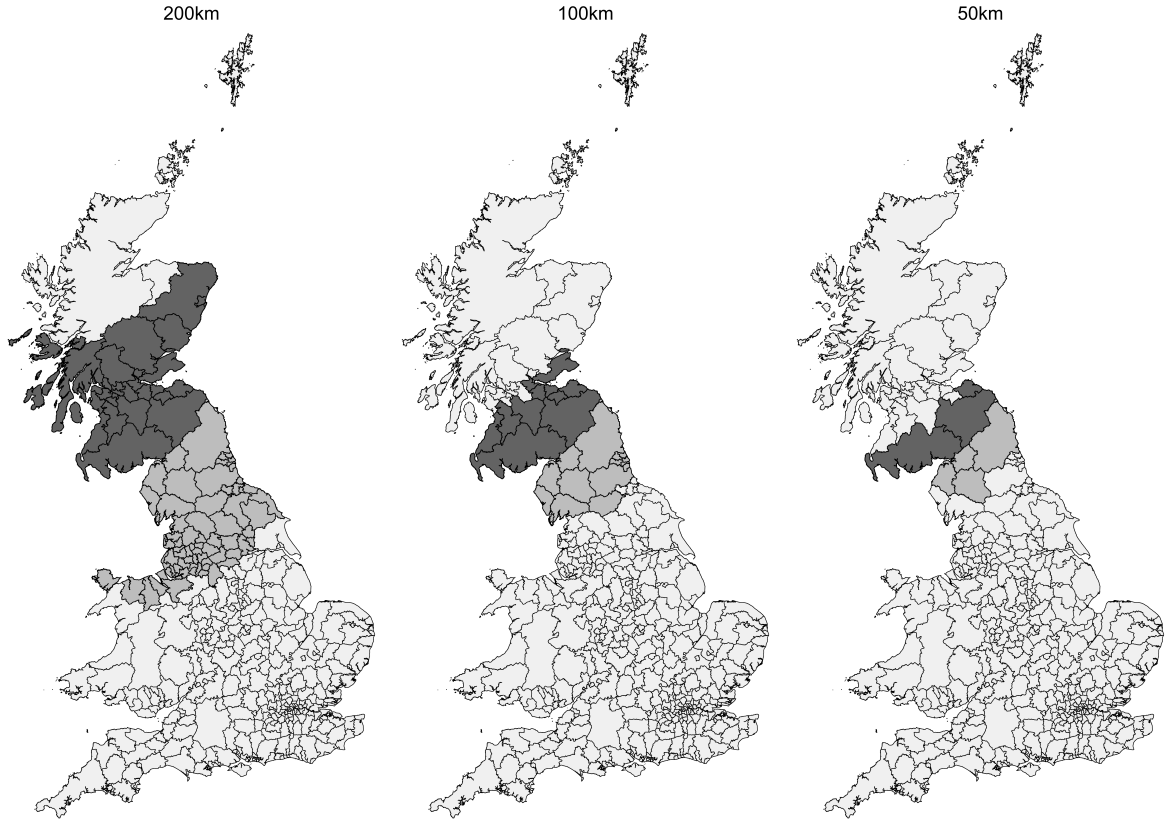
[2] As pointed out by Abadie, Diamond, and Hainmueller (2010), an analogous identifying assumption, namely that unobserved differences between treated and non-treated local authorities are time-invariant, is also imposed by the DD model described above. In fact, the synthetic control method generalizes the DD model by permitting the effect of unobserved confounders to vary over time according to a flexible factor representation of the potential outcomes of the treated local authorities.

negative entries measuring the relative importance of each predictor, $\omega_c \geq 0$, for all $c \in C$, and $\sum_c \omega_c = 1$. In turn, the optimal matrix $\mathbf{V}^*$ is chosen to minimize the mean squared error of outcomes over the pre-reform period, that is, $\frac{1}{m^0} \sum_{m<m^0} (y_m^1 - \sum_{c \in C} \omega_c^* y_{cm}^0)^2$, for $m^0 < \tau$. In the evaluation, the matching is performed over the outcome of interest (i.e., the various accident rates) and the $\mathbf{X}$ vector described above, which includes the key predictors of accidents, namely council-level weather conditions, road congestion, socioeconomic status of the population, and alcohol availability. To compute both the weights and the mean squared prediction error needed in the procedure, we use the entire pre-intervention period from November 2009 to November 2014, 61 months in total, and take the average of y and $\mathbf{X}$ over this period.

4. Results on the Policy Evaluation

A. Benchmark Estimates

Figure A.3: Maps of Great Britain: LAs 200km, 100km, and 50km to/from the Scottish-English Border



Notes: Local authorities (LAs) with their centroid (LA centre point) within 200km (left map), 100km (middle map) and 50km (right map) of the Scottish-English border.

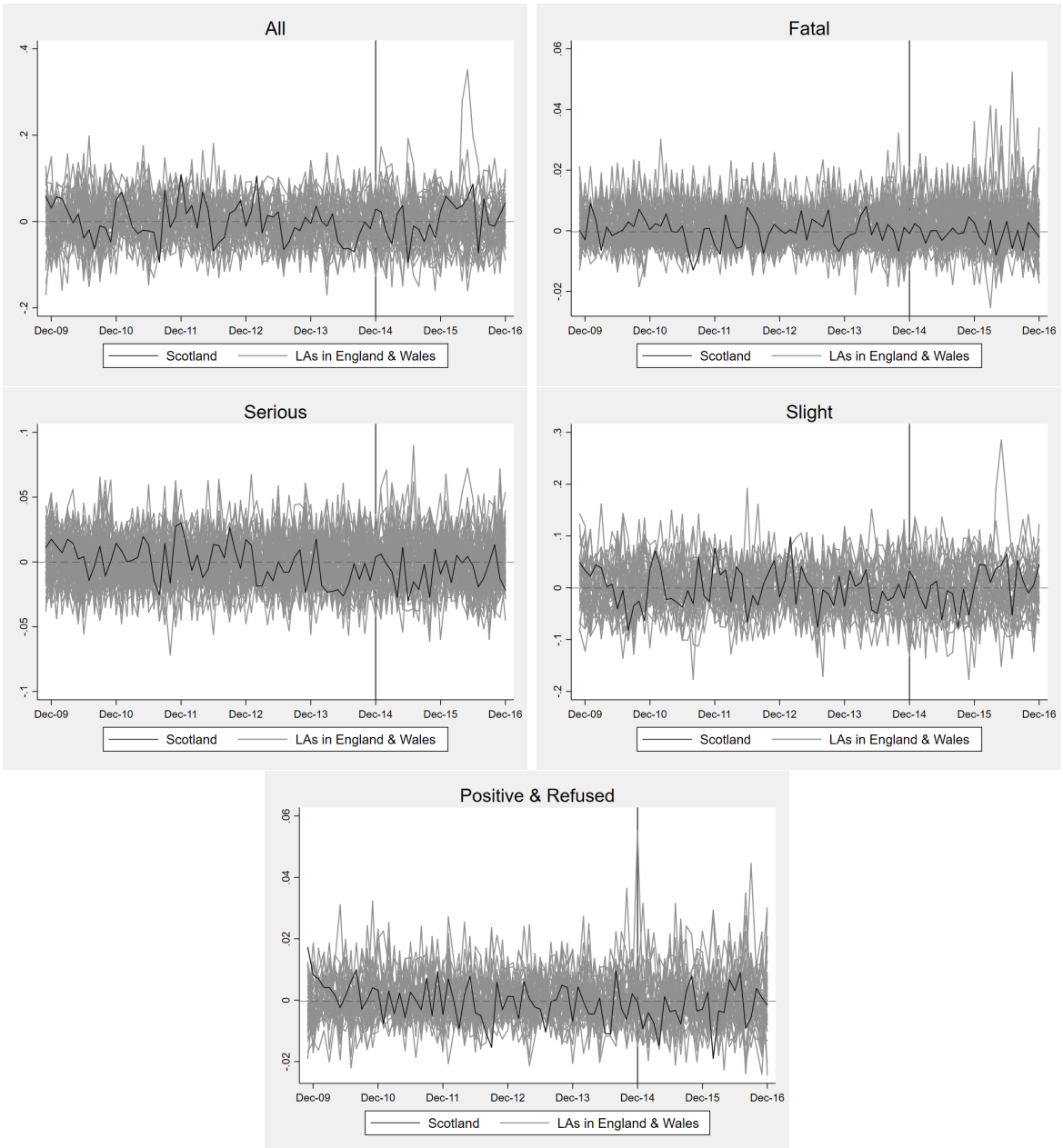
As proposed by Abadie, Diamond, and Hainmueller (2010), appropriate inference can be established by performing a falsification test based on the distribution of the (placebo)

effects estimated for all local authority districts in the control group. The null hypothesis that the effect of the DDL reform is equal to zero is rejected if the effect estimated for the Scottish districts is abnormal relative to the distribution of placebo estimates. If instead the distribution of placebo effects yields effects that are similar to those found for synthetic Scotland, then it is likely that the DDL reduction did not have any impact. We therefore replicate the synthetic control estimates for all possible sets of local authority districts in the control group, pretending that each placebo district experienced the treatment in December 2014. Clearly, it is possible that some of the placebo effects are implausibly large if councils are not well matched in the pre-intervention period. To control for this, we restrict the comparison set of local authority districts to only those that match well and remove all the comparisons with a pre-treatment mean squared prediction error (MSPE) that is more than two times the corresponding MSPE found with the synthetic control.[3]

The results are reported in Figure A.4, which shows the distribution of estimates for the placebo and treated local councils for all collisions together and each type of accident separately. In every panel, the black line is our treatment effect as seen in Figure 3, i.e., the gap in accident rates between Scotland and synthetic Scotland. The gray lines instead represent the gaps associated with each of the runs of the placebo test. In the pre-reform period, the difference between Scotland and synthetic Scotland falls in the middle of the placebo tests. This continues to be the case even after the passing of the new legislation. Evaluated against the distribution of the gaps for the placebo districts, therefore, the gap for Scotland does not appear to be unusual. We thus conclude that the 2014 DDL reform had no effect on accident rates.

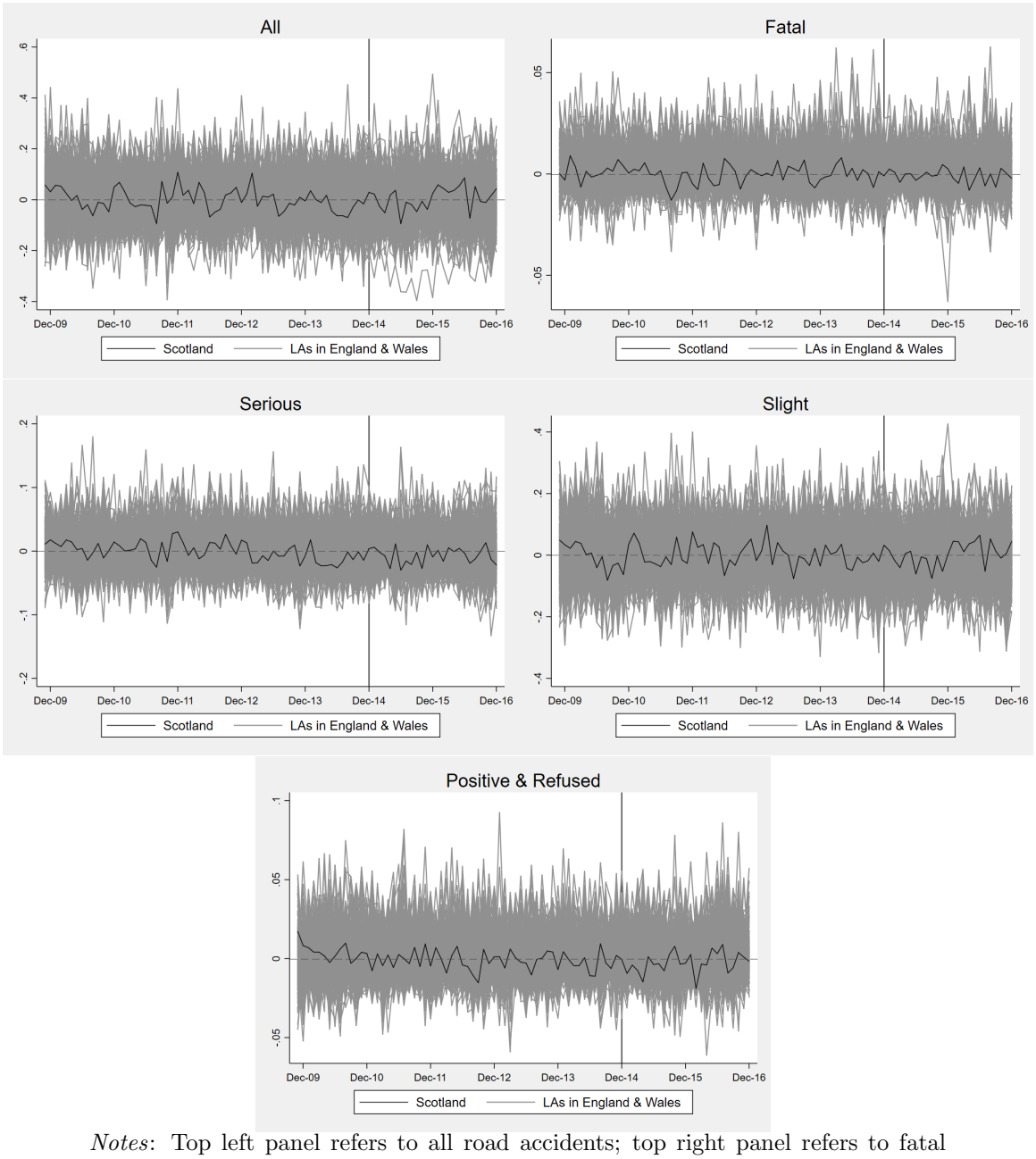
[3]This is a conservative cutoff that discards districts with extreme values of pre-DDL reduction MSPE for which the synthetic control method would be ill-advised. In Appendix Figure A.5 and Appendix Figure A.6, we report the results found when we impose more lenient rules, i.e., when we discard districts with pre-reform MSPE 10 or 5 times higher than synthetic Scotland. The results from those exercises strongly confirm what we have in the text.

Figure A.4: Gaps in Road Accident Rates for Scotland and Synthetic Scotland and for Scotland and Placebos in Control LAs, All Collisions and by Accident Type



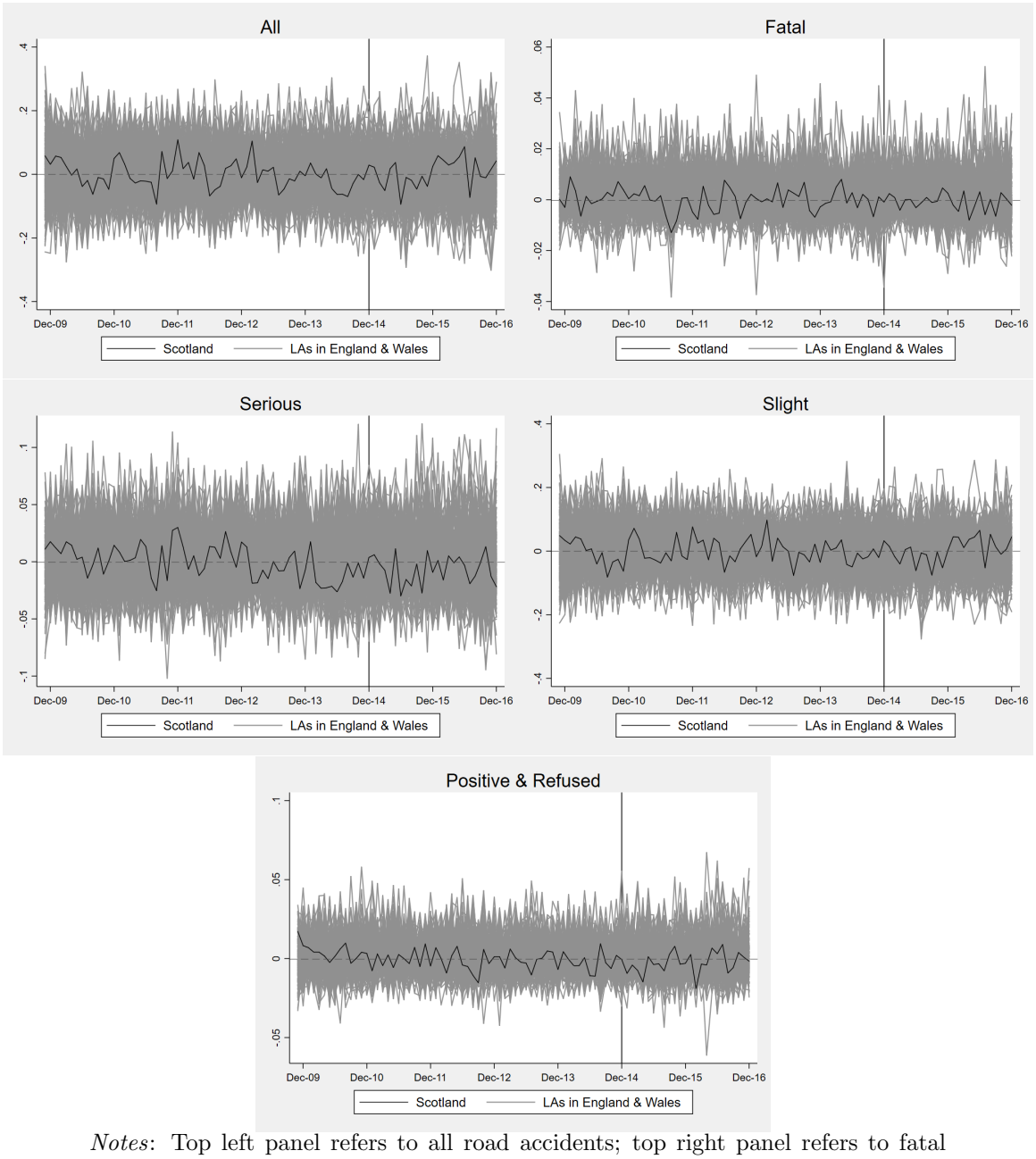
Notes: Top left panel refers to all road accidents; top right panel refers to fatal accidents; middle left panel refers to serious injury accidents; middle right panel refers to slight injury accidents; bottom panel refers to drink drive accidents (those with positive or refused breath test). In all panels, placebo districts with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded. 'LAs' denotes local authorities.

Figure A.5: Gaps in Road Accident Rates for Scotland and Synthetic Scotland and for Scotland and Placebos in Control LAs, 10 MSPE



Notes: Top left panel refers to all road accidents; top right panel refers to fatal accidents; middle left panel refers to serious injury accidents; middle right panel refers to slight injury accidents; bottom panel refers to drink drive accidents (those with positive/refused breath test). In all panels, placebo districts with pre-reform mean squared prediction error (MSPE) that are 10 times higher than Scotland's are excluded.

Figure A.6: Gaps in Road Accident Rates for Scotland and Synthetic Scotland and for Scotland and Placebos in Control LAs, 5 MSPE



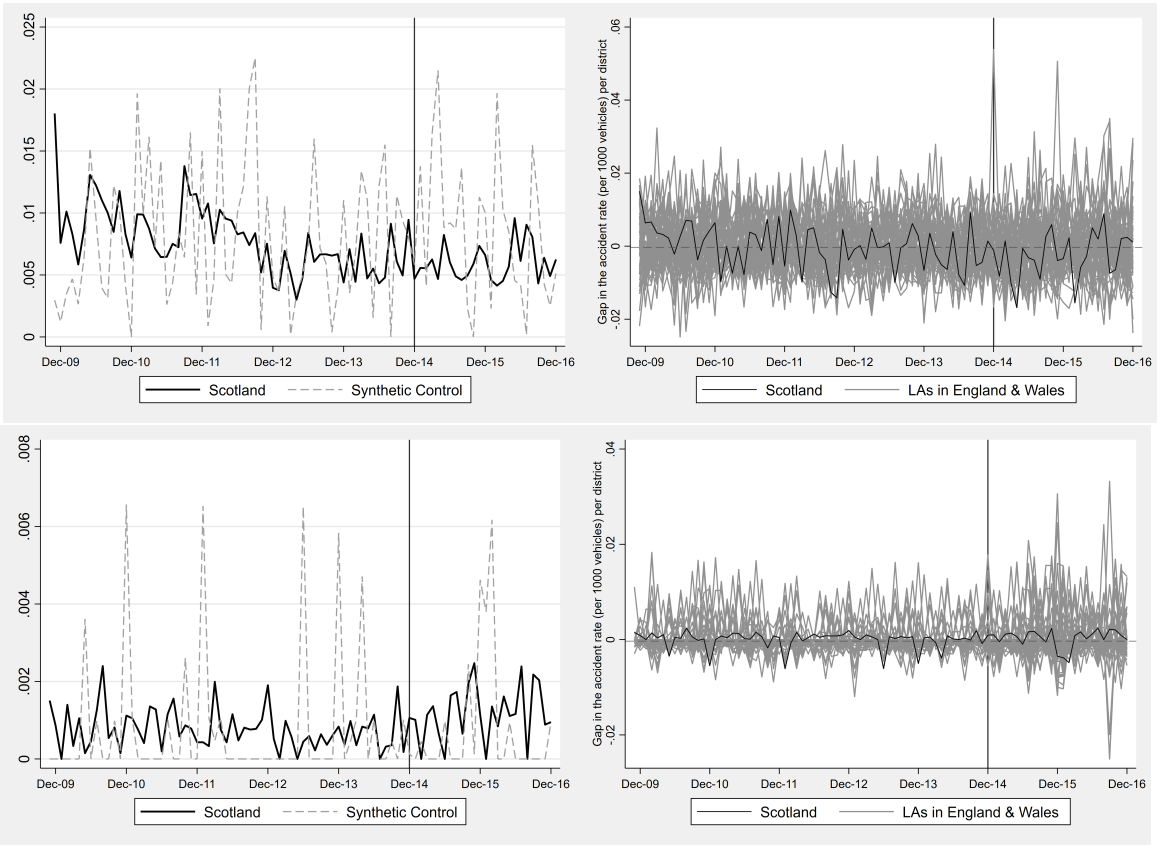
Notes: Top left panel refers to all road accidents; top right panel refers to fatal accidents; middle left panel refers to serious injury accidents; middle right panel refers to slight injury accidents; bottom panel refers to drink drive accidents (those with positive/refused breath test). In all panels, placebo districts with pre-reform mean squared prediction error (MSPE) that are five times higher than Scotland's are excluded.

Table A.1: Effect of the DDL Reform on Postive and Road Accident Rates — Spatial Regression Discontinuity & Synthetic Control Estimates

	RDD <100km	SCM
Positive	0.0004	-0.0026
	(0.0027)	(0.231)
	[0.8904]	
Mean	0.008	0.008
Refused	0.0009	0.0003
	(0.0004)	(0.454)
	[0.0802]	
Mean	0.0007	0.0008
Observations	2,236	
Number of local authorities	26	

Notes: Observations are at the LA-month-year level. The dependent variable is the number of accidents per 1,000 registered vehicles. The sample period goes from November 2009 to December 2016. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. Standard errors in parentheses are clustered at the LA level. Due to the small number of LAs, wild bootstrapped p-values computed using Webb weights (Webb, 2014) and 5,000 replications are in square brackets. Besides the set of controls reported in the notes to Table 2, distance from the Scottish/English border and distance from the border interacted with Scotland (with English distances taking negative values) are also included. RDD regressions are weighted by proximity to the border using a triangular kernel. SCM point estimates are the average treatment effect in the 25 months after the change in the drink drive law. In parenthesis are psuedo standardised p-values. These are the proportion of effects from control units that have a post-treatment RMSPE at least as great as the treated unit scaled by the corresponding pretreatment RMSPE.

Figure A.7: Trends and Gaps in Road Accident Rates for Scotland and Synthetic Scotland for Positive And Refused Breath Test Road Accidents



Notes: The top two panel refer to road accidents where the breath test was positive; the bottom two panels refer to road accidents where the breath test was refused. In the right hand panels, placebo districts with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded. 'LAs' denotes local authorities.

C. Robustness Checks

Alternative specifications — Here we show the effects using different dependent variables and modelling procedures. Specifically we show synthetic control results using the log of accidents (+1), the rate of accidents per miles travelled, and we use weights based on the local authority districts' population size to account for the possibility that the use of disaggregated geographic data be characterized by noise in low-population councils. In each case for the synthetic control results we show the synthetic control treatment effects averaged over the 25 months after the change in the DDL law, with pseudo standardized p-values reported in parentheses. For the count data models we show two models. First is Pseudo Poisson Maximum Likelihood (PPML) (Santos Silva and Tenreyro, 2015) and second is a Zero Inflated Poisson (ZIP). Each of the different models confirms our baseline results.

Event-Study Design — A different concern is that there might be unobservables that

Table A.2: Alternative Specifications of Modelling Procedures

	All	Fatal	Serious	Slight	Pos./refused
Synthetic Control					
log(accidents+1)	-0.040	0.104	-0.022	0.061	0.006
	(0.591)	(0.790)	(0.911)	(0.288)	(0.999)
Rate per million miles travelled	-0.002	0.000	0.000	-0.001	0.000
	(0.290)	(0.925)	(0.872)	(0.359)	(0.302)
Weighted	0.017	0.000	-0.005	0.023	-0.002
	(0.579)	(0.617)	(0.758)	(0.372)	(0.462)
Count Data Models					
Pseudo Poisson Maximum Likelihood (PPML)	-0.0205	-0.00685	-0.0312	-0.0184	0.188
	(0.035)	(0.095)	(0.048)	(0.036)	(0.099)
Zero inflated Poisson (ZIP)	-0.0168	-0.0736	-0.0440	-0.0137	0.150
	(0.015)	(0.137)	(0.037)	(0.016)	(0.125)

Notes: For the synthetic control panel: each point estimate is the average treatment effect in the 25 months after the change in the drink drive law. In parenthesis are psuedo standardised p-values. These are the proportion of effects from control units that have a post-treatment RMSPE at least as great as the treated unit scaled by the corresponding pretreatment RMSPE.

affect accident rates and, possibly, even the enactment of the DDL reform. One of such unobservables is alcohol abuse. In the benchmark DD framework, we account for this possibility by including a large set of controls, while group-specific linear trends and month dummies are meant to capture pre-reform trends and seasonality in collision rates, which could be related to alcohol abuse. The presence of differential pre-reform trends may be taken as evidence against strict exogeneity of the reform, which would justify our approach. But we could fail to detect pre-reform trends not only if they actually do not exist but also if there is not enough statistical power to detect them.

In this exercise, we follow the linear panel event-study design proposed by Freyaldenhoven, Hansen, and Shapiro (2019), in which causal inference is valid even when there are pre-reform trends in the outcome variable. According to this approach, the effect of the lower BAC limit can be estimated by a two-stage least squares (2SLS) regression of the outcome on the reform and observed covariates as in (1), with leads of the policy serving as excluded instruments. Specifically, we assume that the local unemployment rate responds to alcohol abuse among drivers, but plausibly not to legal changes in BAC levels. A large empirical literature documents strong positive effects of ethanol intake on work days lost due to industrial injuries (Ohsfeldt and Morrisey, 1997) and finds that alcohol abuse results in reduced employment and increased unemployment (Terza, 2002; Henkel, 2011).[4] Therefore, instead of using the fraction of working-age individuals in each local authority district claiming Job Seeker's Allowance as a control variable, as we have

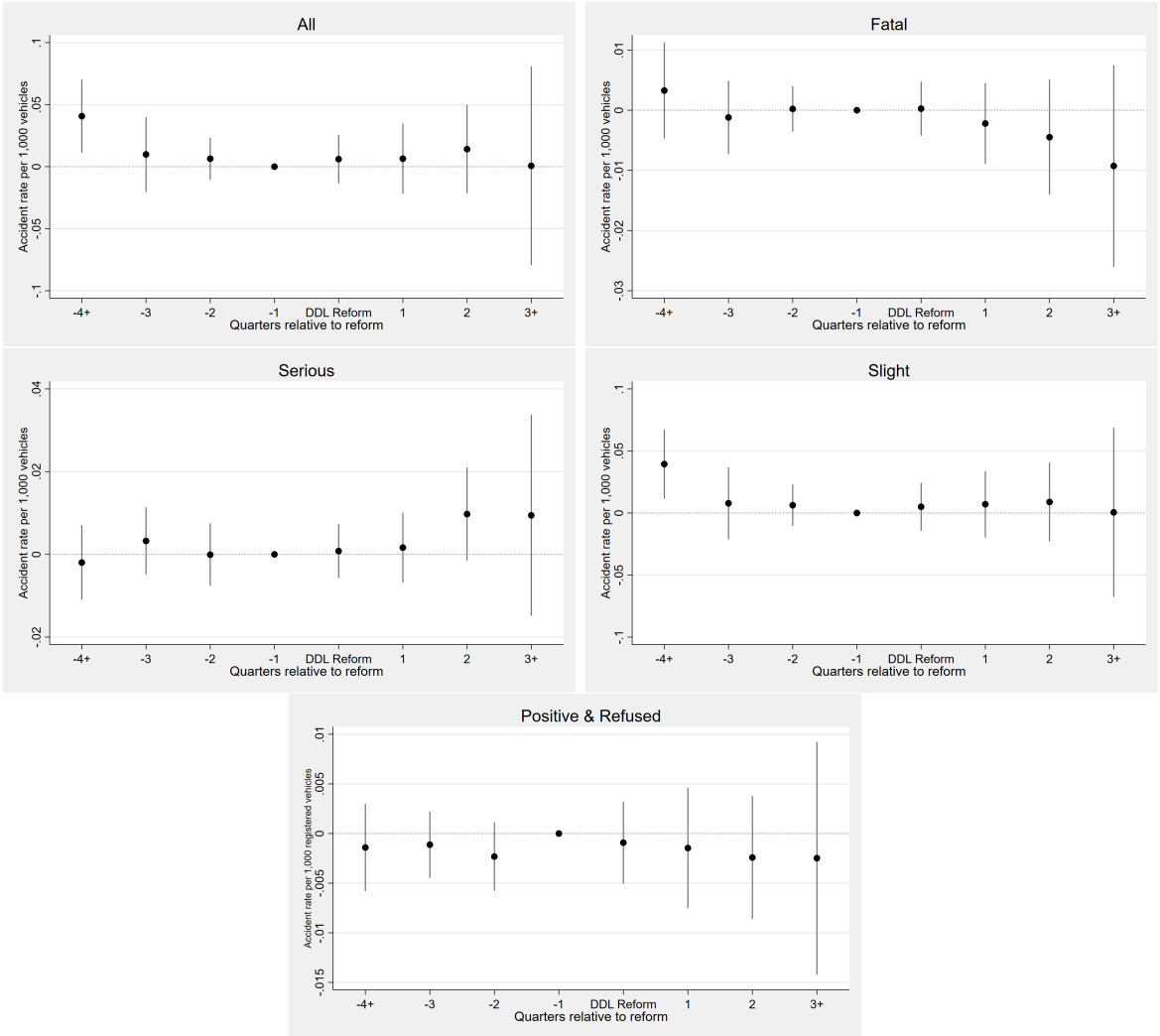
[4]Using published unemployment data on 37 OECD countries in 2018 and WHO data on BAC levels, we find a correlation between unemployment rates and legal drink drive limits of 0.067 (p-value=0.692). We take this as evidence supporting the assumption that unemployment rates do not respond to legal changes in BAC levels.

done in the benchmark analysis, we look at its dynamics around the DDL reduction and use this to infer the dynamics of driving while intoxicated.

We summarize the 2SLS results in Figure A.8, where monthly level information is aggregated at the quarterly level for graphical convenience.[5] Four or more quarters before the reform, Scotland had a higher motor vehicle collision rate than the rest of Britain, driven exclusively by slight injury accidents. But in the last three quarters pre-reform, the difference was small and statistically insignificant. After the new legislation, we continue to find no differential in car crash rates, regardless of the type of accident or the time horizon. These results bolster the zero-effect evidence from the benchmark estimates. The results from further sensitivity analysis, in which we exclude or include local unemployment rate as a proxy for alcohol involvement, are in Appendix Figures A.9 and A.10 and reiterate these findings.

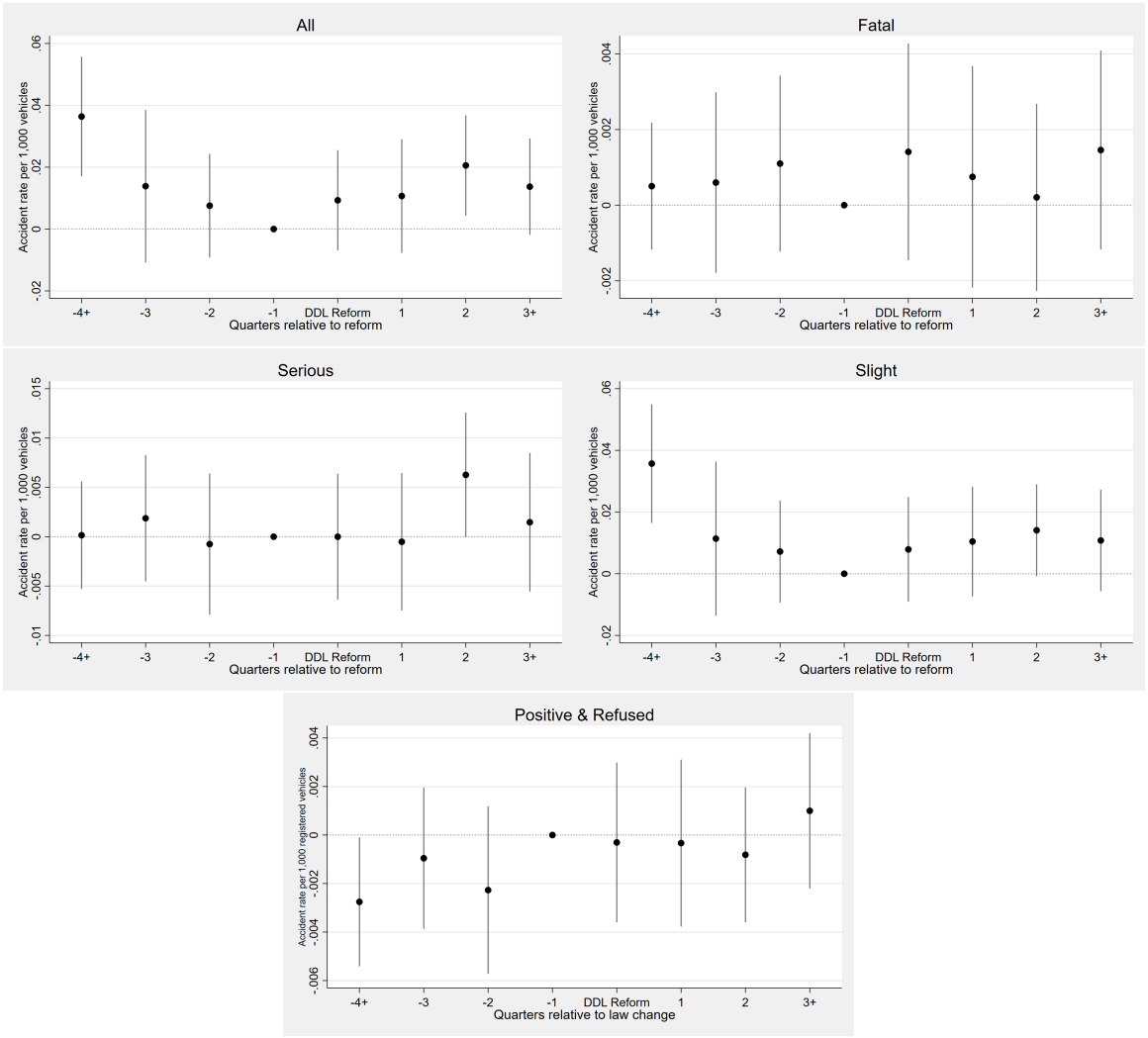
[5]The estimates found using monthly data are qualitatively identical and thus not shown.

Figure A.8: Effect of the DDL Reform on Road Accident Rates at Quarters Around the Reform — 2SLS Estimates



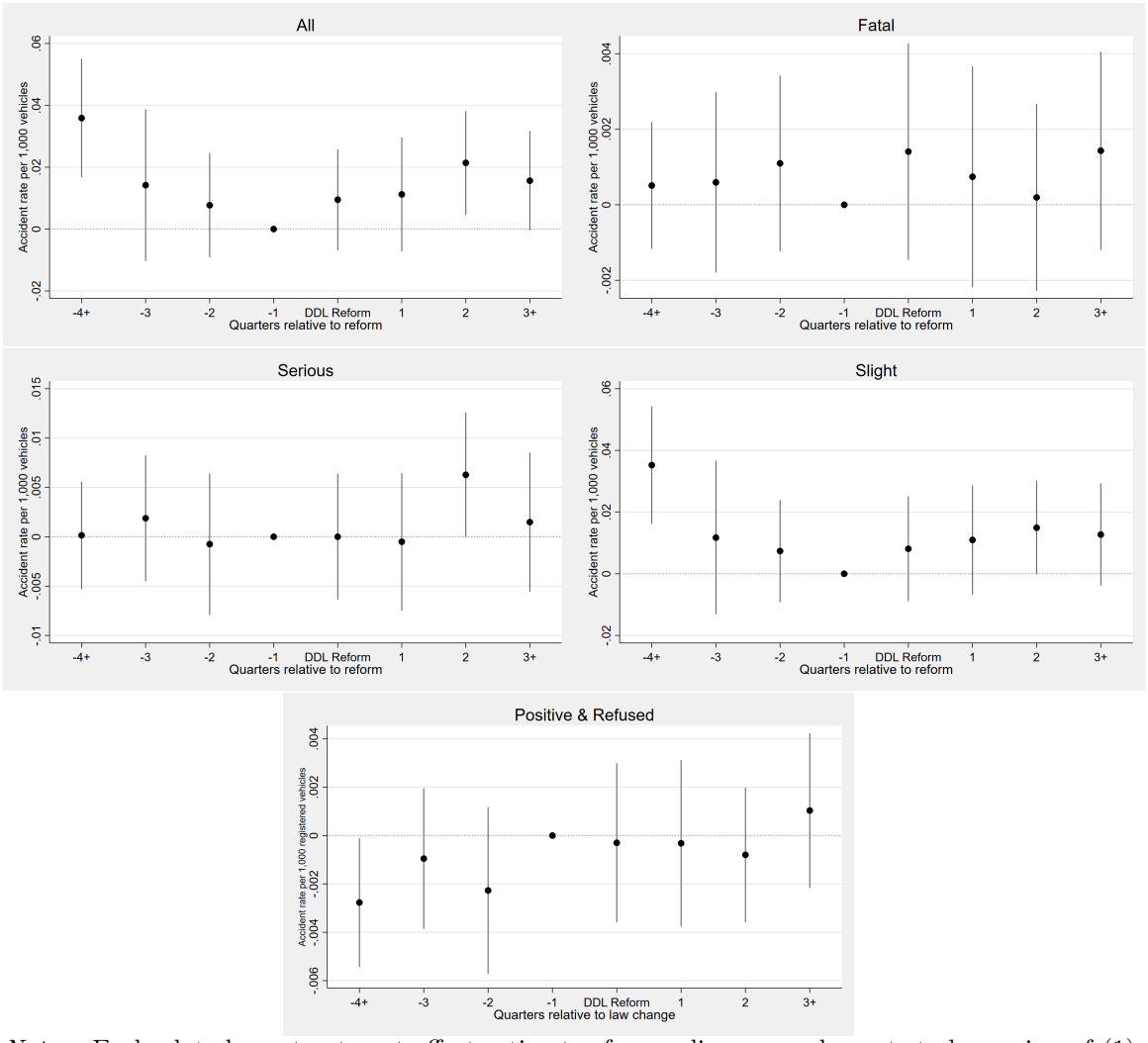
Notes: Each plot shows treatment estimates from a linear panel event-study version of (1), according to the procedure proposed by Freyaldenhoven, Hansen, and Shapiro (2019). One lead of the reform is used as excluded instrument for local unemployment rate (measured by the local Job Seekers' Allowance rate), our proxy for alcohol abuse (for a more detailed explanation, see the text). The vertical bars around each estimate are the 95% confidence intervals. Standard errors are clustered at the local authority level.

Figure A.9: Effect of the DDL Reform on Road Accident Rates at Quarters Around the Reform — Event-Study Estimates Without Controlling for Local Unemployment Rate



Notes: Each plot shows treatment effect estimates from a linear panel event-study version of (1), following the procedure proposed by Freyaldenhoven, Hansen, and Shapiro (2019). The vertical bars around each estimate are the 95% confidence intervals. Standard errors are clustered at the local authority level.

Figure A.10: Effect of the DDL Reform on Road Accident Rates at Quarters Around the Reform — Event-Study Estimates Controlling for Local Unemployment Rate



Notes: Each plot shows treatment effect estimates from a linear panel event-study version of (1), following the procedure proposed by Freyaldenhoven, Hansen, and Shapiro (2019). The vertical bars around each estimate are the 95% confidence intervals. Standard errors are clustered at the local authority level.

Alternative Definition of Drink Drive Accidents — The previous exercise emphasizes the importance of alcohol abuse. As mentioned in Section 3, the information on alcohol involvement in the RAD records is incomplete, since police officers may not always breathalyze all drivers at the roadside (e.g., those who died) and some drivers may depart the accident scene before the arrival of the police in hit-and-run cases. To address this issue, we use new data compiled by the DfT and, like RAD records, derived in part from STATS19 forms. These are supplemented with detailed information on hit-and-run accidents and toxicology data on fatalities from coroners in England and Wales and public prosecutors (or procurators fiscal) in Scotland.[6] These new drink drive data, however, are coarser than those used in the benchmark analysis in two important dimensions: they come at an annual frequency from 2009 to 2016 (not permitting us to define accident rates at the monthly level) and at a less granular geographic detail (i.e., instead of 378 local councils, we only have nine English regions, the whole of Wales and the whole of Scotland). This means we cannot rely on spatial RD models or synthetic control methods.

We then estimate DD models that follow as closely as possible the baseline specification, accounting for differences in annual regional average temperature range, population density, road length, proportion of residents with no qualification, proportion of individuals with bad or very bad general health, median hours worked per week, Job Seeker's Allowance rate, and the number of licensed alcohol premises. We find a small and negative overall impact of the reform on all drink drive related accidents. The point estimate relative to the mean is around 2% and is not statistically significant. As in the benchmark analysis, when group-specific linear trends are included, the estimates change sign and remain statistically insignificant. Serious and slight injury accidents follow the same pattern. Contrary to theory, the estimates for fatal drink drive collisions are wrong-signed (positive) and significant, even when controls are included, but become statistically indistinguishable from zero when we account for differential trends.

[6] In this new data, the definition of a drink drive accident not only is based, as before, on reporting a positive roadside breath test or refusing to give a breath test when requested by the police, but also includes cases of individuals who died and, within 12 hours of the accident, were found to be above the legal limits.

Table A.3: Effect of the DDL Reform on Drink Drive Accident Rates — Difference-in-Difference Estimates Based on an Alternative Definition of Drink Driving Accidents

	Mean	(a)	(b)	(c)	(d)	(e)	(f)
		A. All					
β	0.157	-0.004	-0.006	0.030	0.025	0.033	0.034
		(0.018)	(0.016)	(0.022)	(0.025)	(0.027)	(0.027)
		B. Fatal					
β	0.006	0.004*	0.004*	0.005	0.006	0.004	0.005
		(0.002)	(0.002)	(0.003)	(0.004)	(0.003)	(0.004)
		C. Serious					
β	0.025	-0.003	-0.003	0.006	0.006	0.006	0.008
		(0.004)	(0.003)	(0.004)	(0.005)	(0.004)	(0.005)
		D. Slight					
β	0.126	-0.006	-0.008	0.023	0.017	0.026	0.025
		(0.016)	(0.015)	(0.021)	(0.023)	(0.025)	(0.027)
Observations		77	77	77	77	77	77
Controls		N	Y	Y	Y	Y	Y
Linear annual trend		N	N	Y	N	Y	N
Linear annual × Scotland		N	N	Y	N	Y	N
Linear annual × region		N	N	N	Y	N	Y
Region fixed effects		N	N	N	N	Y	Y

Notes: Observations are at the region-year level. The sample period goes from 2009 until 2016. Robust standard errors are in parentheses. The control regions are: North East, North West, Yorkshire and the Humber, East Midlands, West Midlands, East, South East, London, South West, Wales. Controls are: monthly regional average temperature range, population density, road length, proportion of residents with no qualification, proportion of residents with bad or very bad general health, median hours worked per week, Job Seeker's Allowance rate, and the number of alcohol premises. The definition of a drink-drive accident is a reported incident on a public road in which someone is killed or injured, where at least one of the motor vehicle drivers or riders involved met one of the following criteria: (i) failed a roadside breath test by registering above 35 μg/100 ml of breath (England and Wales) or 22μg/100 ml (Scotland) after December 2014; (ii) refused to give a breath test specimen when requested by the police, other than when incapable of doing so for medical reasons; (iii) died, within 12 hours of the accident, and was subsequently found to have more than 80mg of alcohol per 100ml of blood (England and Wales) or 50mg (Scotland).
* $p < 0.05$.

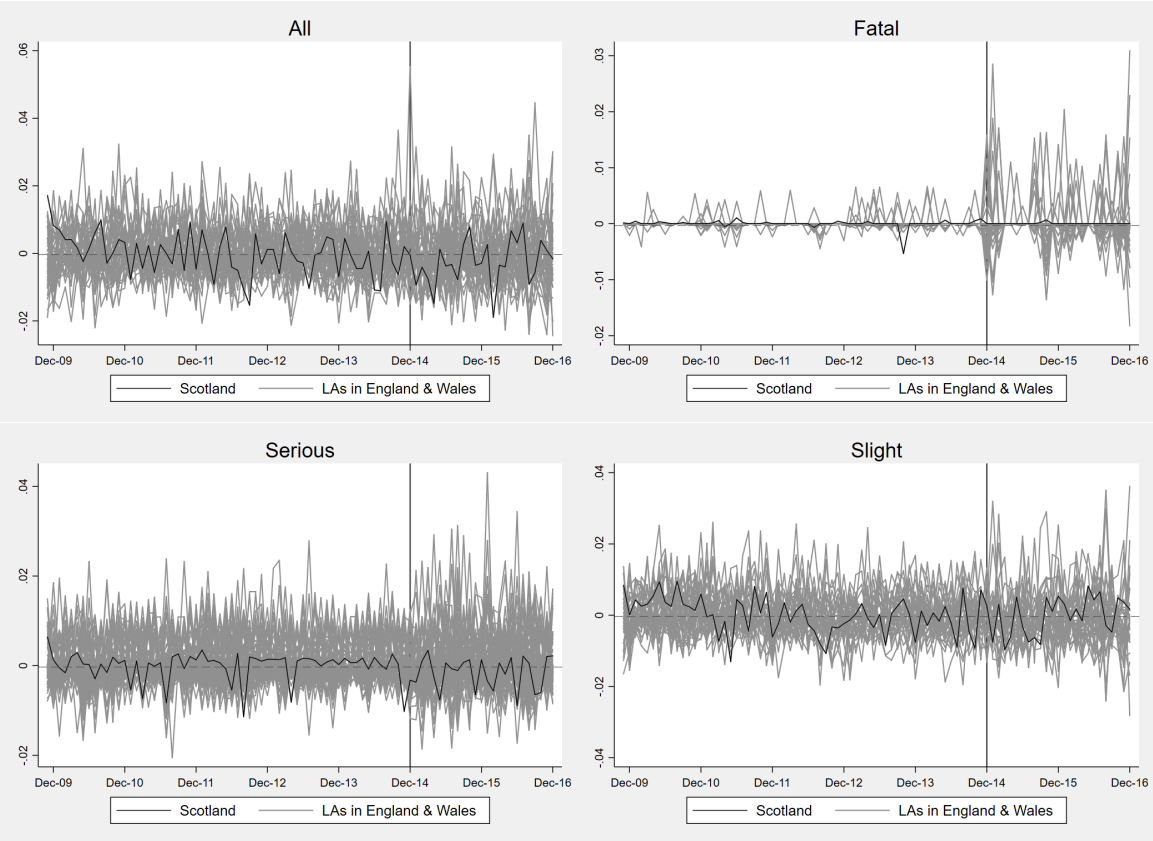
Accidents with Positive Breath Testing Only — Another related check is to repeat the benchmark analysis but only on motor vehicle crashes in which at least one of the drivers tested positive (i.e., above the legal limit) or refused to be tested by accident type. Irrespective of accident severity and estimation method, we always find no evidence of an impact of the stricter limit.

Table A.4: Effect of the DDL Reform on Road Accident Rates with Positive/Refused Breath Test — Difference-in-Difference and Spatial Regression Discontinuity Estimates

	Mean	(a)	(b)	(c)	(d)	(e)	(f) <200km	(g) <100km	(h) <50km
					A. Fatal				
β	0.00011	-0.00008	-0.00008	-0.00008	-0.00005	-0.00005	0.000107	0.000200	0.000219
		(0.00005)	(0.00005)	(0.000102)	(0.000101)	(0.000101)	(0.000117)	(0.000119)	(0.000326)
							[0.548]	[0.113]	[0.548]
					B. Serious				
β	0.00169	0.00006	0.00006	0.000475	0.000408	0.000408	0.000717*	-0.000318	-0.000171
		(0.000243)	(0.000243)	(0.000287)	(0.000311)	(0.000311)	(0.000390)	(0.000595)	(0.000682)
							[0.839]	[0.604]	[0.839]
					C. Slight				
β	0.00688	-0.000438	-0.000438	0.00101	0.00116	0.00116	0.00170	0.00173	0.00176
		(0.000534)	(0.000534)	(0.000806)	(0.000802)	(0.000802)	(0.000933)	(0.00174)	(0.00512)
							[0.738]	[0.348]	[0.738]
Obersvations		32,164	32,164	32,164	32,164	32,164	8,170	2,236	602
Controls		N	Y	Y	Y	Y	Y	Y	Y
Monthly trend		N	N	Y	Y	Y	Y	Y	Y
Monthly trend × Scotland		N	N	Y	Y	Y	Y	Y	Y
Month of year dummies		N	N	N	Y	Y	Y	Y	Y
Month of year × Scotland		N	N	N	Y	Y	Y	Y	Y
LA fixed effects		N	N	N	N	Y	Y	Y	Y

Notes: Observations are at the LA-month-year level. The dependent variable is the number of accidents with a positive or refused breath test per 1,000 registered vehicles. The sample period goes from November 2009 to December 2016. Standard errors clustered at the LA level are in parentheses. For the spatial regression discontinuity results, due to the small number of LAs, wild bootstrapped p-values computed using Webb weights (Webb, 2014) and 5,000 replications are in square brackets. For completeness, however, these are shown also for large bandwidths. 'LAs' denotes local authorities. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. 'Controls' are monthly averages of temperature range (at the UK Met Office climate region), population density, proportion of residents aged 16 or more with no educational qualification, proportion of residents with bad or very bad health, median total hours worked, median gross pay, Job Seeker's Allowance rate, alcohol licensed premises, and total road length.

Figure A.11: Gaps in Road Accident Rates with Positive/Refused Breath Test for Scotland and Synthetic Scotland and for Scotland and Placebos in Control LAs

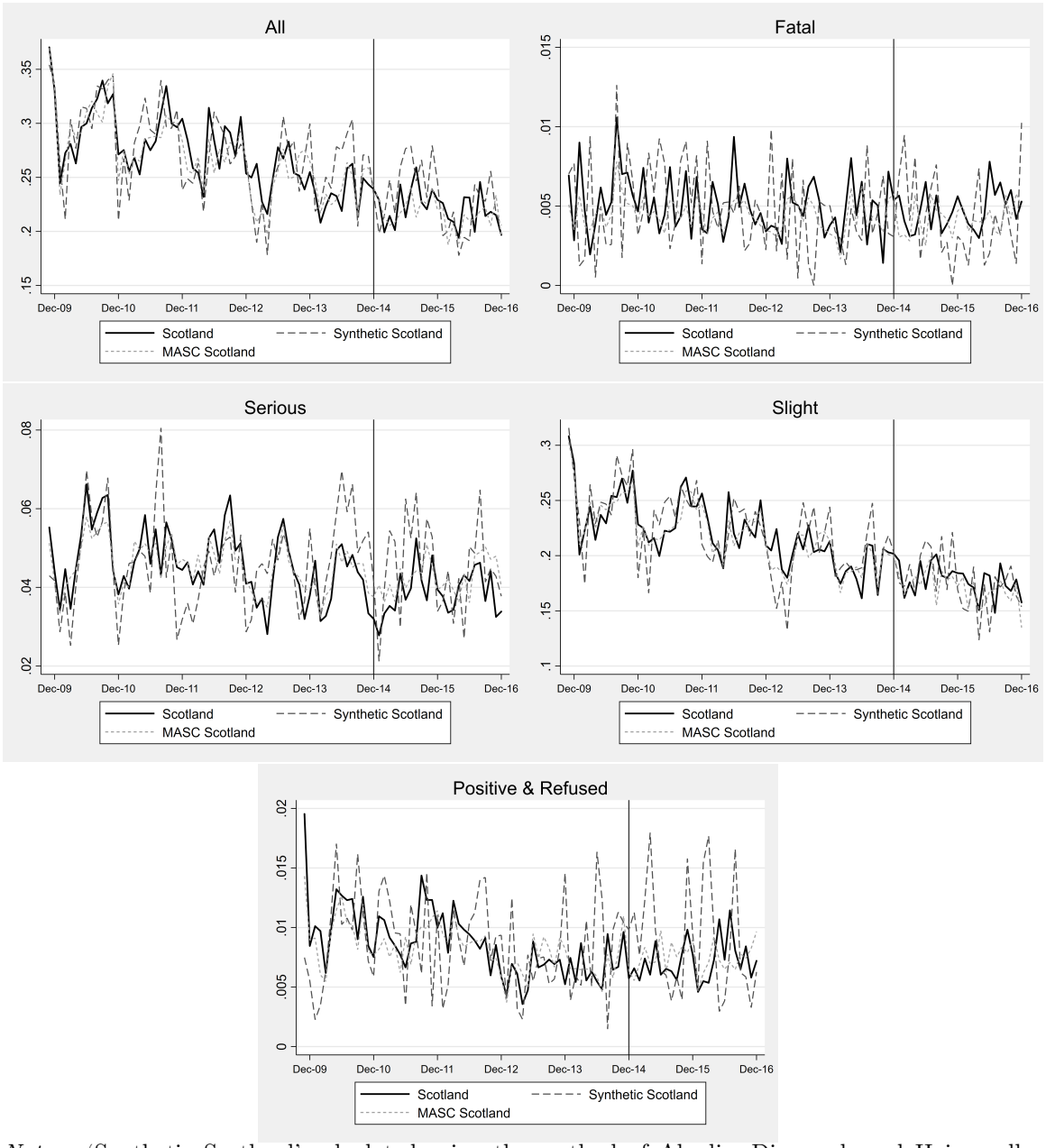


Notes: In all panels, placebo districts with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded. All panels show results for accident rates with a positive or refused breath test. The panels are all accidents (top left), fatal accidents (top right), serious accidents (bottom left), and slight accidents (bottom right).

Matching and Synthetic Control (MASC) Approach — To deal with the potential interpolation bias induced by the synthetic control method mentioned in Section 3, we estimate MASC models as formulated by Kellogg et al. (2019). Together with the estimates shown in Figures 3, Appendix Figure A.12 adds the district-specific accident rates found for MASC Scotland. Across all five crash types, the MASC estimates track Scotland's accident rate trajectories extremely well over the entire pre-intervention period.

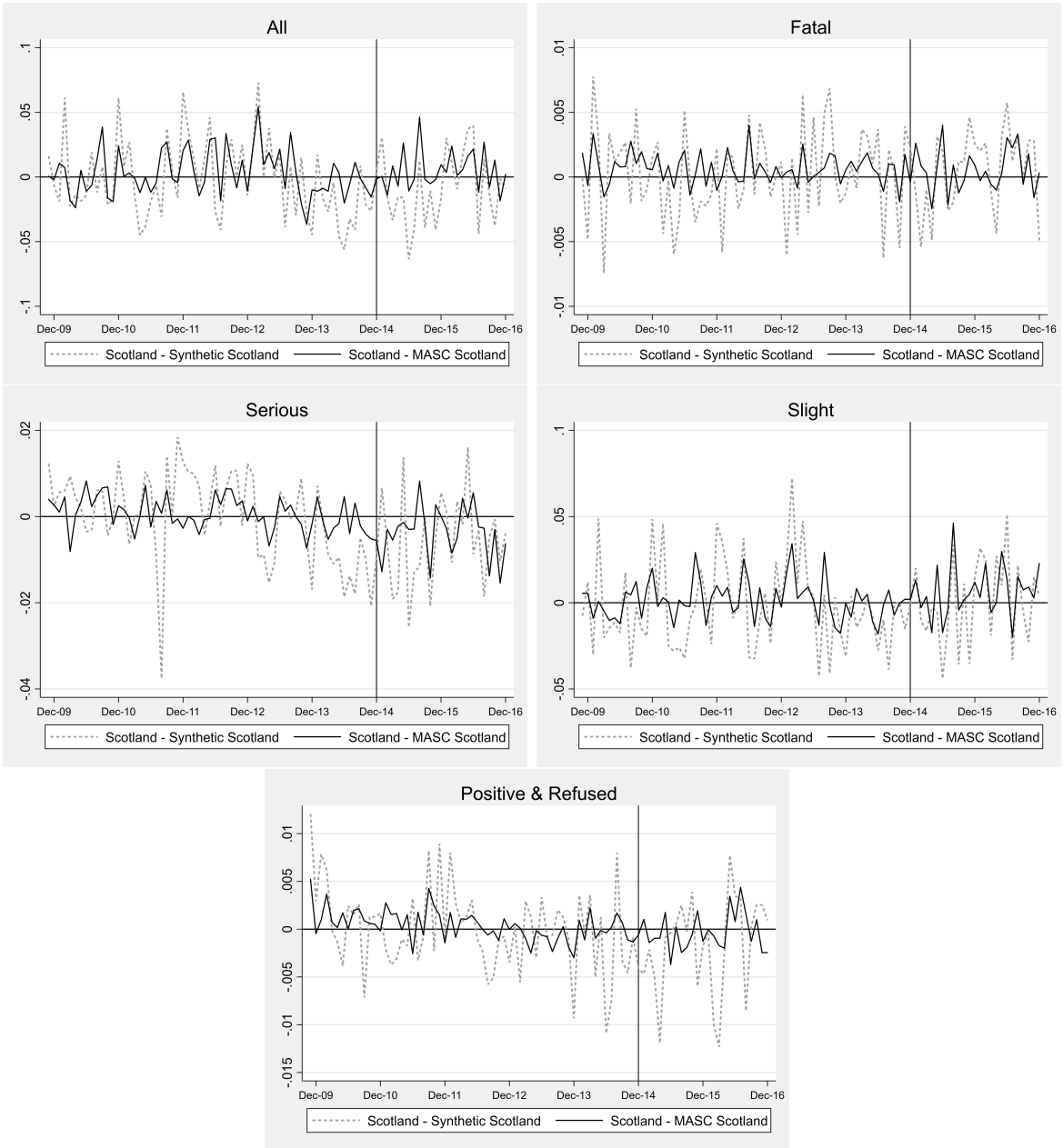
In line with the synthetic control results, the MASC Scotland estimates also confirm that the stricter Scottish DDL had no impact on road traffic collisions. This is clearly illustrated in Figure A.13, where we plot the difference between Scotland and synthetic Scotland, as in Figure A.4, as well as the difference between Scotland and MASC Scotland for each accident type. The figure reveals that the two estimators not only perform equally well in replicating Scotland's pre-reform crash rates, but are also broadly equivalent in what they capture after the enactment of the new legislation.

Figure A.12: Trends in Road Accident Rates, by Type: Scotland vs Synthetic Scotland vs MASC Scotland



Notes: 'Synthetic Scotland' calculated using the method of Abadie, Diamond, and Hainmueller (2010). 'MASC Scotland' calculated using the matching and synthetic control approach proposed by Kellogg et al. (2019).

Figure A.13: Gaps in Road Accident Rates for Scotland and Synthetic Scotland and for Scotland and MASC Scotland, All Collisions and by Type



Notes: The gap (Scotland – Synthetic Scotland) shows the difference between the average road accident rate in Scotland and that produced by the synthetic control method of Abadie, Diamond, and Hainmueller (2010). The gap (Scotland – MASC Scotland) shows the difference between the average road accident rate in Scotland and that produced by the matching and synthetic control (MASC) approach proposed by Kellogg et al. (2019).

6. Channels: Why Was the DDL Reform Ineffective?

Taxi Availability

Table A.5: Effect of the DDL Reform on Taxi Licence Rates — Difference-in-Difference Estimates

	Mean	(a)	(b)	(c)	(d)	(e)
		A. Driver licences per 10,000 heads of population				
β	64.8	-5.893*	-5.474*	-6.010*	-1.659	-2.018
		(1.474)	(1.490)	(1.492)	(2.172)	(2.231)
		B. Vehicle licences per 10,000 heads of population				
β	35.7	-2.465*	-2.480*	-2.662*	0.414	0.154
		(0.818)	(0.889)	(0.842)	(0.952)	(0.933)
Observations		1,374	1,374	1,374	1,374	1,374
Controls		N	Y	Y	Y	Y
Biennial trend		N	N	N	Y	Y
Biennial trend × Scotland		N	N	N	Y	Y
LAs fixed effects		N	N	Y	N	Y

Sources: Department for Transport, Taxi Statistics – Table TAXI0104; Office for National Statistics.
Notes: Observations are at the LA-year level. The sample period goes from 2009 to 2015 (biennially). Standard errors in parentheses are clustered at the LA level. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. 'Controls' are LA yearly averages of temperature range, population density, proportion of residents aged 16 or more with no educational qualification, proportion of residents with bad or very bad health, median total hours worked, median gross pay, Job Seekers' Allowance rate, alcohol licensed premises, and total road length (see the notes to Table 1 for more details). 'LAs' denotes local authorities.
* $p < 0.05$.

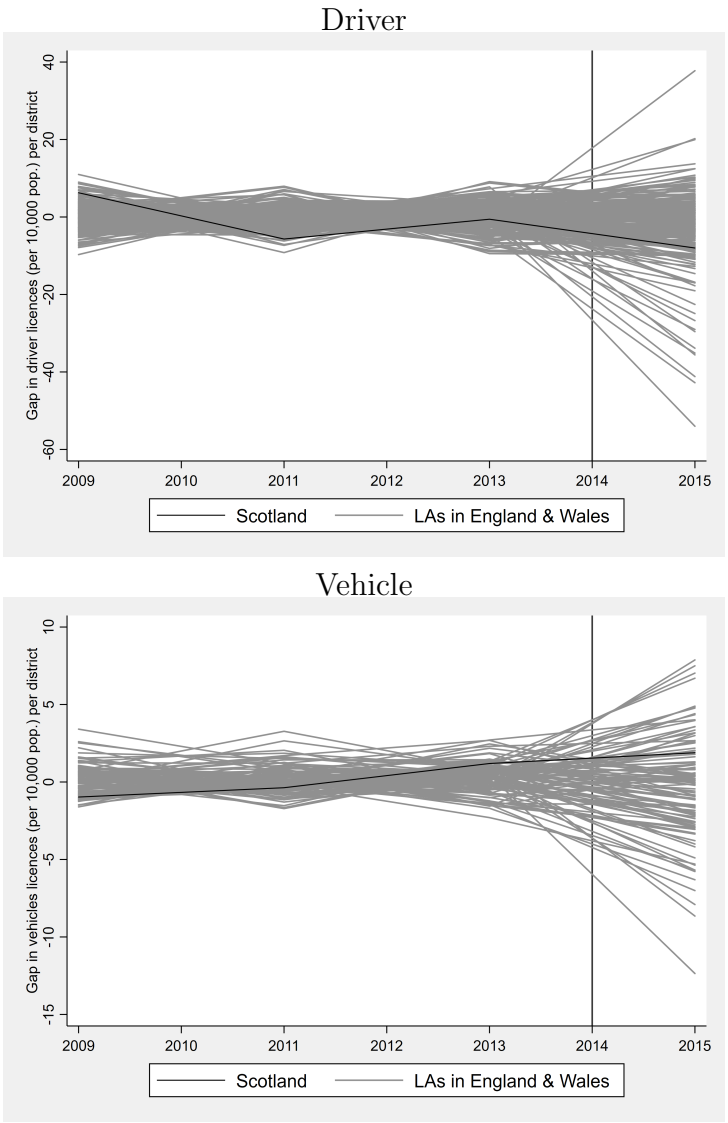
Table A.6: Effect of the DDL Reform on Taxi Licence Rates — Spatial Regression Discontinuity Estimates

	(a) <200 km	(b) <100 km	(c) <50 km
	A. Driver Licences per 10,000 Pop.		
β	-4.465	-0.739	-3.535
	(4.511)	(3.068)	(7.094)
	[0.373]	[0.819]	[0.609]
Mean	62.4	57.7	41.9
	B. Vehicle Licences per 10,000 Pop.		
β	-1.963	1.278	1.073
	(2.703)	(1.935)	(5.183)
	[0.652]	[0.539]	[0.871]
Mean	36.0	31.5	26.3
Observations	384	104	28
Number of LAs	96	26	7

Sources: Department for Transport, Taxi Statistics – Table TAXI0104; Office for National Statistics.

Notes: Observations at the LA-year level. The sample period goes from 2009 to 2015 (biennially). Standard errors are clustered at the LA level. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. 'Controls' are LA monthly averages of temperature range, population density, proportion of residents aged 16 or more with no educational qualification, proportion of residents with bad or very bad health, median total hours worked, median gross pay, Job Seeker's Allowance rate, alcohol licensed premises, and total road length. Due to the small number of LAs, wild bootstrapped p-values computed using Webb weights (Webb, 2014) and 5,000 replications are in square brackets. For completeness, however, these are shown also for large bandwidths. 'LAs' denotes local authorities.

Figure A.14: Gaps in Taxi Licence Rates for Scotland and Synthetic Scotland and for Scotland and Placebos in Control LAs, by Type of License



Notes: In both panels, placebo districts with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded.

Taxi Tariffs

Table A.7: Effect of the DDL Reform on Taxi Tariffs — Difference-in-Difference and Spatial Regression Discontinuity Estimates

	Mean	(a)	(b)	(c)	(d)	(e)	(f) <200km	(g) <100km	(h) <50km
β	5.07	0.115*	0.131*	0.101	0.090	0.085	0.084	0.084	0.324
		(0.049)	(0.048)	(0.052)	(0.053)	(0.050)	(0.054)	(0.103)	(0.166)
							[0.152]	[0.439]	[0.081]
Observations		30,616	30,616	30,616	30,616	30,616	7,826	2,150	516
Controls		N	Y	Y	Y	Y	Y	Y	Y
Month-year trend		N	N	Y	Y	Y	Y	Y	Y
Month-year trend × Scotland		N	N	Y	Y	Y	Y	Y	Y
Month FEs		N	N	N	Y	Y	Y	Y	Y
Month FEs × Scotland		N	N	N	Y	Y	Y	Y	Y
LAs fixed effects		N	N	N	N	Y	Y	Y	Y

Source: Private Hire and Taxi Monthly available at: <https://www.phtm.co.uk/taxi-fares-league-tables>.

Notes: Observations are at the LA-month-year level. The sample period goes from November 2009 to December 2016. The dependent variable is the taxi tariff in pounds sterling. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. Standard errors in parentheses are clustered at the LA level. Due to the small number of LAs in the spatial RD regressions, wild bootstrapped p-values computed using Webb weights (Webb, 2014) and 5,000 replications are in square brackets. For completeness, however, these are shown also for large bandwidths. 'Controls' are yearly averages of temperature range, population density, proportion of residents aged 16 or more with no educational qualification, proportion of residents with bad or very bad health, median total hours worked, and median gross pay, Job Seekers' Allowance rate, alcohol licensed premises, and total road length (see the notes to Table 1 for more details). 'LAs' denotes local authorities, 'FEs' denotes fixed effects.

* $p < 0.05$.

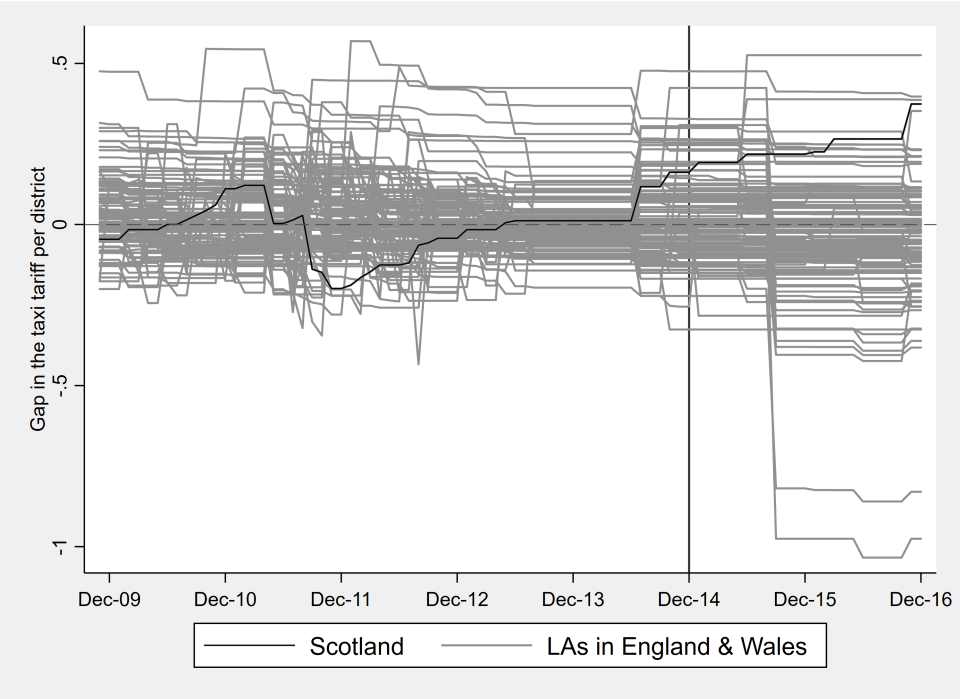
Table A.8: Effect of the DDL Reform on Taxi Tariffs — Difference-in-Difference Estimates

	Mean	(a)	(b)	(c)	(d)
		A. Tariff 1			
Flag	2.54	0.016	-0.017	-0.018	-0.016
		(0.019)	(0.016)	(0.016)	(0.016)
1 mile	3.28	0.023	-0.011	-0.014	-0.011
		(0.024)	(0.020)	(0.021)	(0.020)
10-mile	18.02	0.113	-0.043	0.066	0.132
		(0.135)	(0.127)	(0.126)	(0.122)
Running	1.63	0.022	0.0002	0.010	0.011
		(0.016)	(0.015)	(0.015)	(0.014)
		B. Tariff 2			
Flag	3.24	0.018	-0.019	-0.005	-0.001
		(0.025)	(0.023)	(0.024)	(0.023)
1 mile	4.11	0.042	0.0002	0.016	0.017
		(0.030)	(0.026)	(0.027)	(0.026)
10-mile	20.60	0.173	-0.013	0.091	0.122
		(0.148)	(0.134)	(0.134)	(0.130)
Running	1.82	0.027	0.008	0.010	0.013
		(0.016)	(0.013)	(0.013)	(0.013)
Observations		658	658	658	658
Month-year trend		N	Y	Y	Y
Month-year trend × Scotland		N	Y	Y	Y
Month FEs		N	N	Y	Y
Month FEs × Scotland		N	N	Y	Y
Region fixed effects		N	N	N	Y

Source: Private Hire and Taxi Monthly, <`https://www.phtm.co.uk/taxi-fares-league-tables`>.

Notes: Observations are at the region-month-year level. The sample period goes from January 2009 to October 2016. All regressions include regional indicators, where the regions are: East Anglia, Midlands, North, South, South West, and Wales. Panel-corrected standard errors are calculated using a Prais-Winsten regression, where a region-specific AR(1) process is assumed. This also allows the error terms to be region specific, heteroskedastic, and contemporaneously correlated across regions. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. 'FEs' denotes fixed effects. For other definitions, see the notes to Figure **??**.

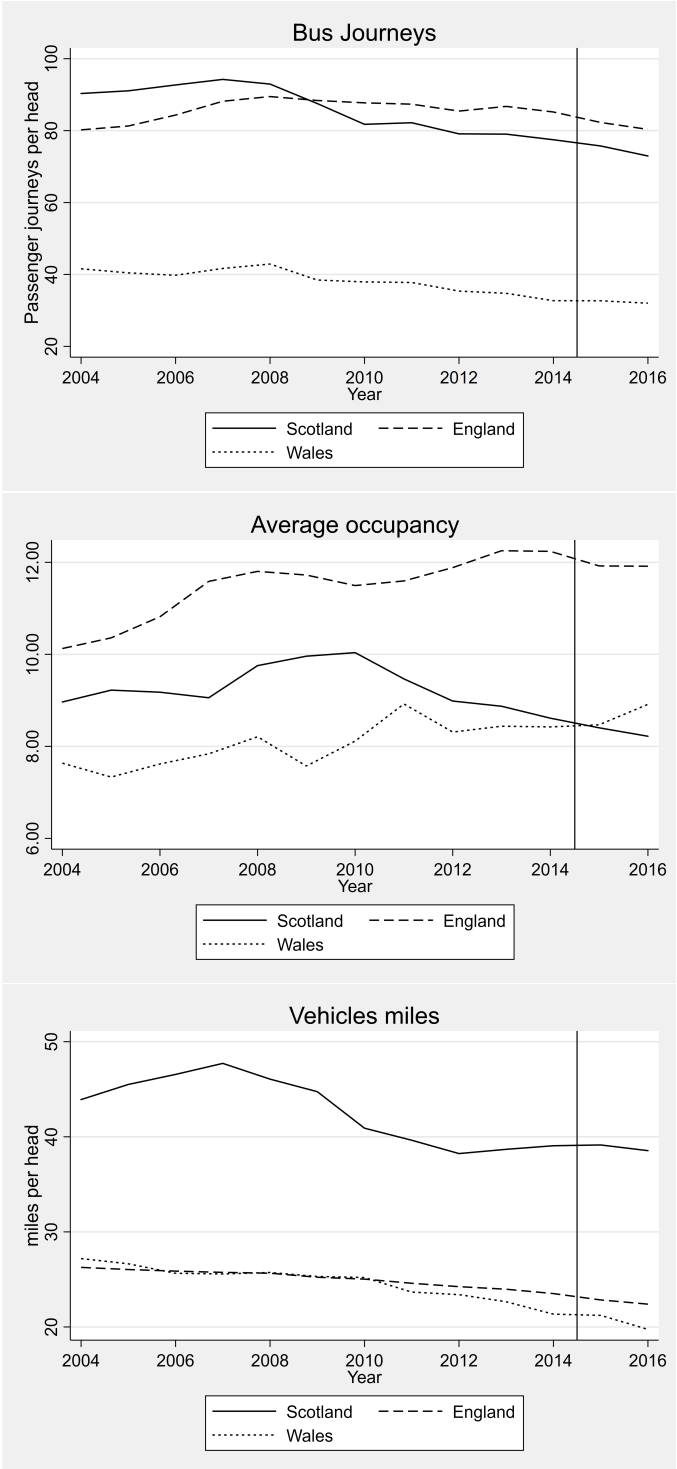
Figure A.15: Gaps in Taxi Tariffs for Scotland and Synthetic Scotland and for Scotland and Placebos in Control LAs



Notes: Placebo districts with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded. 'LAs' denotes local authorities.

Bus Availability and Bus Fares

Figure A.16: Trends in Bus Availability, by Measure of Bus Usage



Source: Department for Transport Bus Statistics (Tables BUS0108, BUS0206, BUS0304).

Table A.9: Effect of the DDL Reform on Bus Journeys — Difference-in-Difference Estimates

	(a)	(b)	(c)	(d)
	2014/2015		2015/2016	
	A. Per Capita Bus Journeys			
β	-7.109	3.996	-6.898	3.552
	(15.02)	(24.69)	(16.58)	(24.03)
Mean	87.1		86.2	
	B. Average Bus Occupancy			
β	-0.712	-0.481	-0.468	-0.123
	(0.404)	(0.341)	(0.428)	(0.460)
Mean	9.35		9.28	
	C. Per Capita Bus Miles			
β	1.349	1.439	1.077	0.982
	(1.366)	(1.585)	(1.414)	(1.599)
Mean	224.9		223.5	
Observations	39	39	39	39
Linear annual Trend	N	Y	N	Y
Linear annual Trend × Scotland	N	Y	N	Y

Source: Department for Transport Bus Statistics (Tables BUS0108, BUS0206, BUS0304).
Notes: Observations are at the country-year-level. The sample period goes from 2004/05 to 2016/17. Control countries are England and Wales (separately). The dependent variables are: average passenger journeys on local bus services by region per head of population, annual from 1991/92 (panel A); average bus occupancy on local bus services (panel B); vehicle kilometres per head on local bus services (panel C). Panel-corrected standard errors are calculated using a Prais-Winsten regression, where a region-specific AR(1) process is assumed. This also allows the error terms to be region specific, heteroskedastic, and contemporaneously correlated across regions. 'Mean' refers to the Scottish pre-reform mean of the dependent variable.

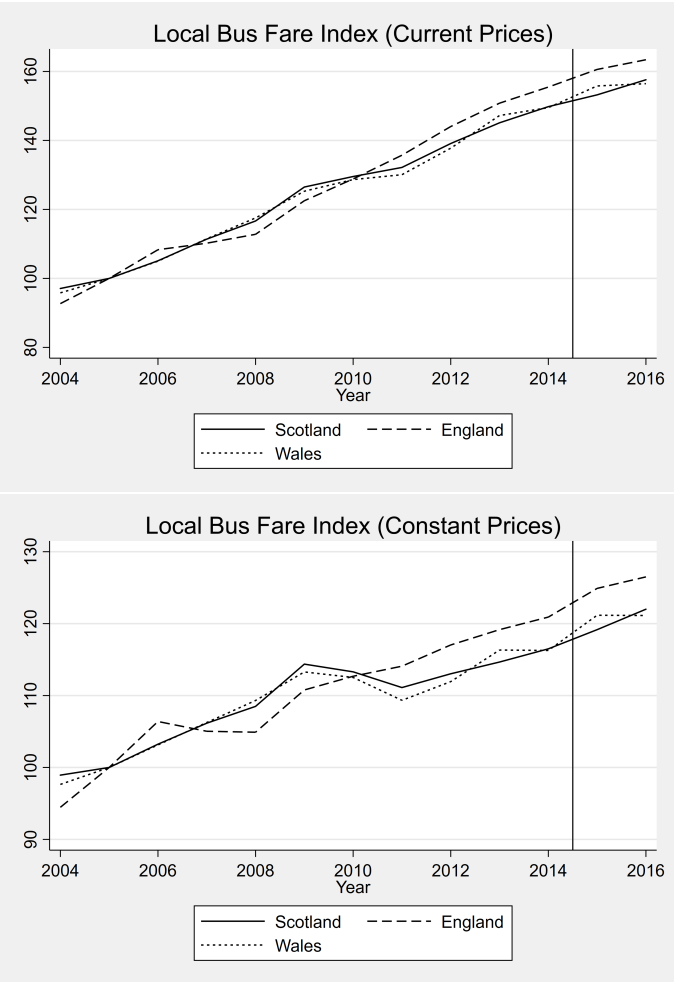
Table A.10: Effect of the DDL Reform on Bus Fares — Difference-in-Difference Estimates

	(a)	(b)	(c)	(d)
	2014/2015		2015/2016	
	A. Current Prices			
β	-2.401	-1.230	-2.450	-1.875
	(1.819)	(1.416)	(1.567)	(1.599)
Mean	120.3		123.0	
	B. Constant Prices			
β	-2.148	-0.737	-2.092	-0.661
	(1.438)	(1.910)	(1.388)	(1.508)
Mean	108.3		109.1	
Observations	39	39	39	39
Linear annual Trend	N	Y	N	Y
Linear annual Trend × Scotland	N	Y	N	Y

Source: Department for Transport Bus Statistics (Tables BUS0108, BUS0206, BUS0304).

Notes: Observations are at the country-year-level. The sample period goes from 2004/05 to 2016/17. Control countries are England and Wales (separately). The dependent variables are: local bus fares at current prices (panel A); local bus fares at constant prices (panel B). Panel-corrected standard errors are calculated using a Prais-Winsten regression, where a region-specific AR(1) process is assumed. This also allows the error terms to be region specific, heteroskedastic, and contemporaneously correlated across regions.

Figure A.17: Trends in Bus Fares



Source: Department for Transport Bus Statistics (Tables BUS0405a, BUS0405b).
Notes: Fare figures are in pence. The constant price fares are expressed in 2005 prices.

Car Sharing as a Passenger

Table A.11: Effect of the DDL Reform on Time Spent as a passenger in a car — Difference-in- Difference Estimates

	All days			Friday, Saturday and Sundays		
β	-0.133	-0.113	-0.316	0.027	0.038	0.003
	(0.213)	(0.215)	(0.344)	(0.191)	(0.192)	(0.250)
Observations	14,203	14,203	14,203	13,921	13,921	13,921
Controls	N	Y	Y	N	Y	Y
Monthy Trend	N	N	Y	N	N	Y
Monthy Trend x Scotland	N	N	Y	N	N	Y

Sources: UK-TUS, 2014–2015.
Notes: Dependent variable is the number of minutes as a passenger in a car. Fieldwork was conducted between April 2014 and December 2015. Controls include age, and indicators for: having left school at age 17 or more, gender, presence of at least one child aged 0-14 in the household, full-time employment, self-employment. Standard errors are clustered at the household level.

Table A.12: Effect of the DDL Reform on on road accidents with single or two or more casualties — Synthetic Control Estimates

	All	Fatal	Serious	Slight	Pos./refused
One Casualty	-0.010	-0.001	-0.005	-0.008	-0.001
	(0.340)	(0.715)	(0.591)	(0.236)	(0.173)
Two+ casualities	0.006	-0.001	-0.003	0.006	-0.001
	(0.706)	(0.568)	(0.118)	(0.349)	(0.280)

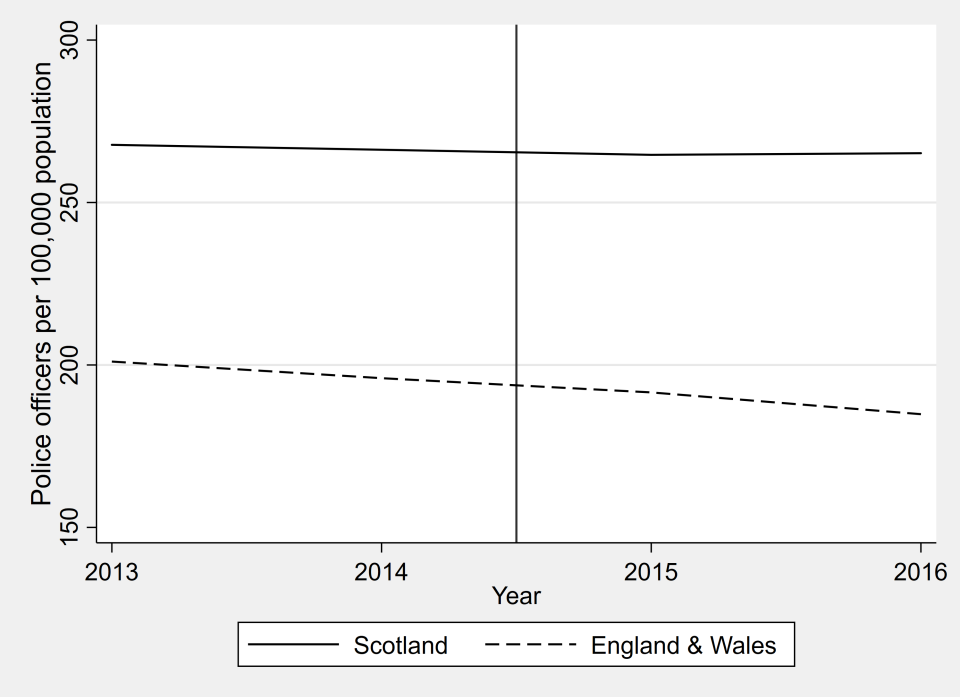
Notes: Each point estimate is the average treatment effect in the 25 months after the change in the drink drive law. In parenthesis are psuedo standardised p-values. These are the proportion of effects from control units that have a post-treatment RMSPE at least as great as the treated unit scaled by the corresponding pretreatment RMSPE.

B. Enforcement of the New Limit

Police Numbers — Due to restructuring of the police force in Scotland and to changes in recording police officer activities in both Scotland and the rest of Britain around the 2014 BAC reform, we can only examine police numbers overall and not the number of police officers deployed in specific activities, such as traffic duties. Police Scotland was formed in April 2013. There were originally 14 divisions: Aberdeen City, Aberdeenshire and Moray, Tayside, Highland and Islands, Forth Valley, Edinburgh, The Lothians and Scottish Borders, Fife, Glasgow, Ayrshire, Lanarkshire, Argyll and West Dunbartonshire, Renfrewshire and Inverclyde, and Dumfries and Galloway. By March 2016 there were 13 as Aberdeen City and Aberdeenshire and Moray had merged into North East. Police Scotland stopped reporting the number of police officers assigned to the road policing unit

in quarter ending on 31 March 2014. Local police officer resources are the core compliment of officers under the direction of the local commander and include community policing, response policing, and divisional road policing teams. In addition, in England and Wales in 2016 the Home Office changed the definitions of different officer duties making the comparison with earlier years difficult.

Figure A.18: Trends in Police Numbers: Scotland versus the Rest of Britain



Sources: Police Officer Quarterly Strength Statistics (Scotland); Home Office Police workforce (England and Wales).

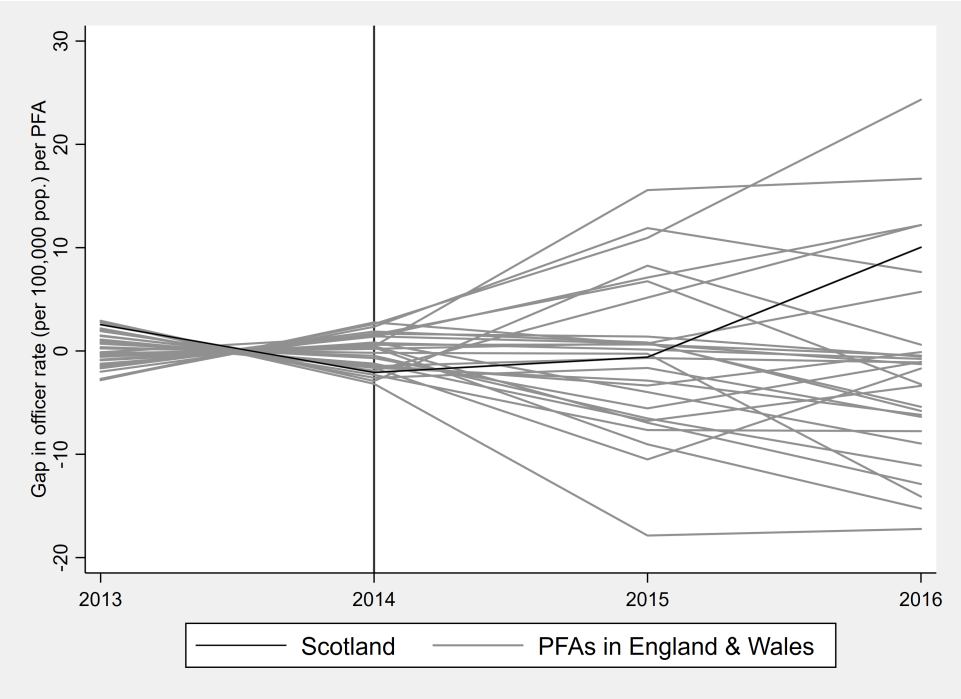
Table A.13: Effect of the DDL Reform on Police Numbers — Difference-in-Difference Estimates

	Mean	(a)	(b)	(c)	(d)
β	267.0	8.226*	18.93	3.227	-3.032
		(1.950)	(10.21)	(12.73)	(3.381)
Observations		220	220	220	220
Controls		N	Y	Y	Y
Linear annual trend		N	N	Y	Y
Linear annual trend × Scotland		N	N	Y	Y
PFAs fixed effects		N	N	N	Y

Sources: Police Officer Quarterly Strength Statistics (Scotland); Home Office Police workforce (England and Wales).

Notes: Observations are at the PFA-year level. There are 42 PFAs in England and Wales, and 13 regional PFAs in Scotland. The sample period goes from 2013 to 2016. The dependent variables is the number of police officers per 100,000 of the population. Standard errors in parentheses are clustered at the PFA level. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. 'Controls' are yearly averages of temperature range, population density, proportion of residents aged 16 or more with no educational qualification, proportion of residents with bad or very bad health, median total hours worked, and median gross pay, Job Seekers' Allowance rate, alcohol licensed premises, and total road length (see the notes to Table 1 for more details). 'PFAs' denotes police force areas. *** $p < 0.05$.

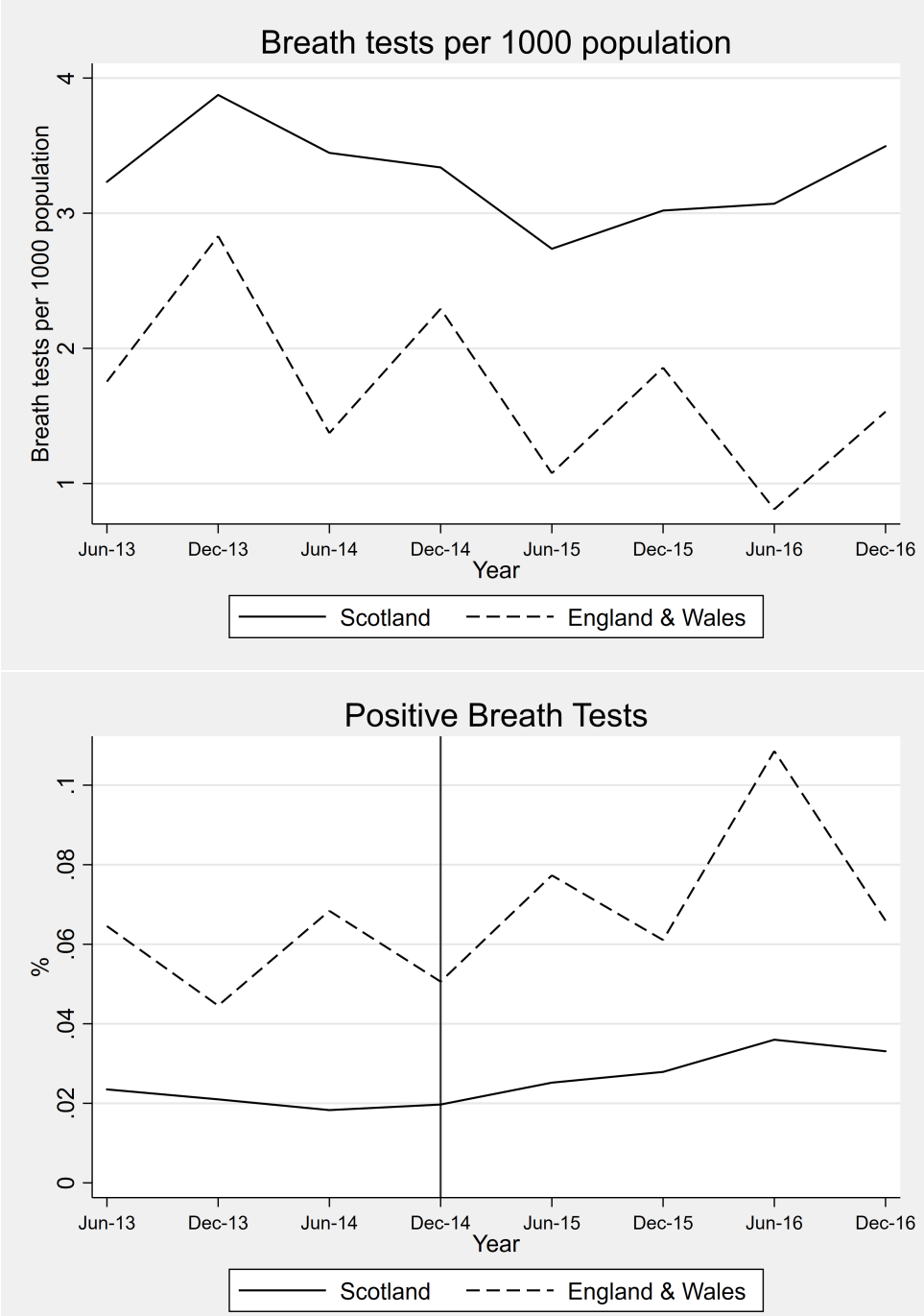
Figure A.19: Gaps in Police Numbers for Scotland and Synthetic Scotland and for Scotland and Placebos in Control PFAs



Notes: Placebo districts with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded.

Breath Testing —

Figure A.20: Trends in Breath Testing: Scotland versus the Rest of Britain



Sources: Scotland: Parliamentary Advisory Council for Transport Safety (PACTS), <www.tinyurl.com/pacts-breath>. England and Wales: Home Office Breath test statistics: Police Powers and Procedures.

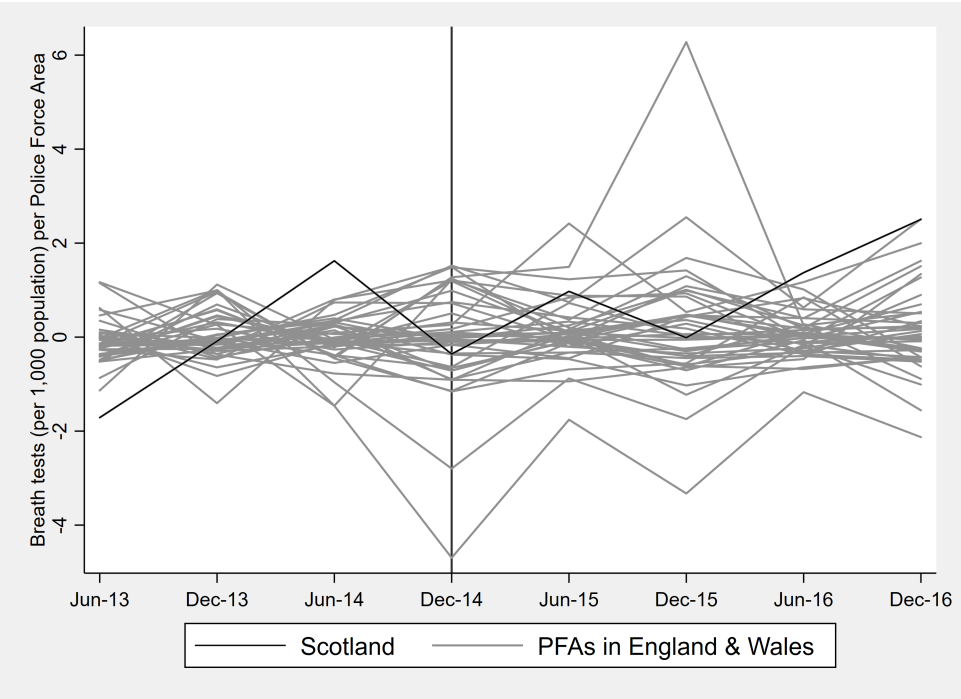
Notes: Observations are at the country-(4-week)-year level. There are two four-week periods per year corresponding to the when Police Scotland undertake their drink driving campaigns. The Scottish campaigns were: Summer 2013 (June, 4 weeks), Festive 2013 (December, 4 weeks), Summer 2014 (June, 2 weeks), Festive 2014 (December, 4 weeks), Summer 2015 (June, 2 weeks), Festive 2015 (December, 4 weeks), Summer 2016 (June, 2 weeks), Festive 2016 (December, 4 weeks). Two week campaigns are scaled up to their four-week equivalent. English and Welch police force data are combined and scaled down to four weeks (28 days) to be comparable to the Scottish data. The sample period goes from 2013 to 2016.

Table A.14: Effect of the DDL Reform on Breath Testing — Difference-in-Difference Estimates

	Mean	(a)	(b)	(c)	(d)	(e)
		A. Breath Tests Administered per 1,000 Population				
β	3.52	0.598	0.890	-0.783*	-0.828*	-0.759*
		(0.412)	(0.465)	(0.206)	(0.251)	(0.351)
		B. % Positive Breath Tests				
β	0.021	-0.007	-0.013	-0.005	-0.007	0.0004
		(0.006)	(0.007)	(0.006)	(0.007)	(0.011)
Observations		352	352	352	352	352
Controls		N	Y	Y	Y	Y
Linear time trend		N	N	Y	Y	Y
Linear time trend × Scotland		N	N	Y	Y	Y
June		N	N	N	Y	Y
June × Scotland		N	N	N	Y	Y
PFAs fixed effects		N	N	N	N	Y

Source: Parliamentary Advisory Council for Transport Safety (PACTS), <www.tinyurl.com/pacts-breath> (Scotland); Home Office Breath Test Statistics: Police Powers and Procedures (England and Wales).
Notes: Observations are at the country-(4-week)-year level. There are two four-week periods per year corresponding to the when Police Scotland undertake their drink driving campaigns. The Scottish campaigns were: Summer 2013 (June, 4 weeks), Festive 2013 (December, 4 weeks), Summer 2014 (June, 2 weeks), Festive 2014 (December, 4 weeks), Summer 2015 (June, 2 weeks), Festive 2015 (December, 4 weeks), Summer 2016 (June, 2 weeks), Festive 2016 (December, 4 weeks). Two week campaigns are scaled up to their four-week equivalent. England and Wales combined are the control country. English and Welch police force data are combined and scaled down to four weeks (28 days) to be comparable to the Scottish data. The sample period goes from 2013 to 2016. The dependent variables are the number of breath tests administered per 1,000 heads of population (panel A) and the proportion (in percent) of tests that are positive (panel B). 'Mean' refers to the Scottish pre-reform mean of the dependent variable. Robust standard errors in parentheses. 'PFAs' denotes police force areas.
* $p < 0.05$.

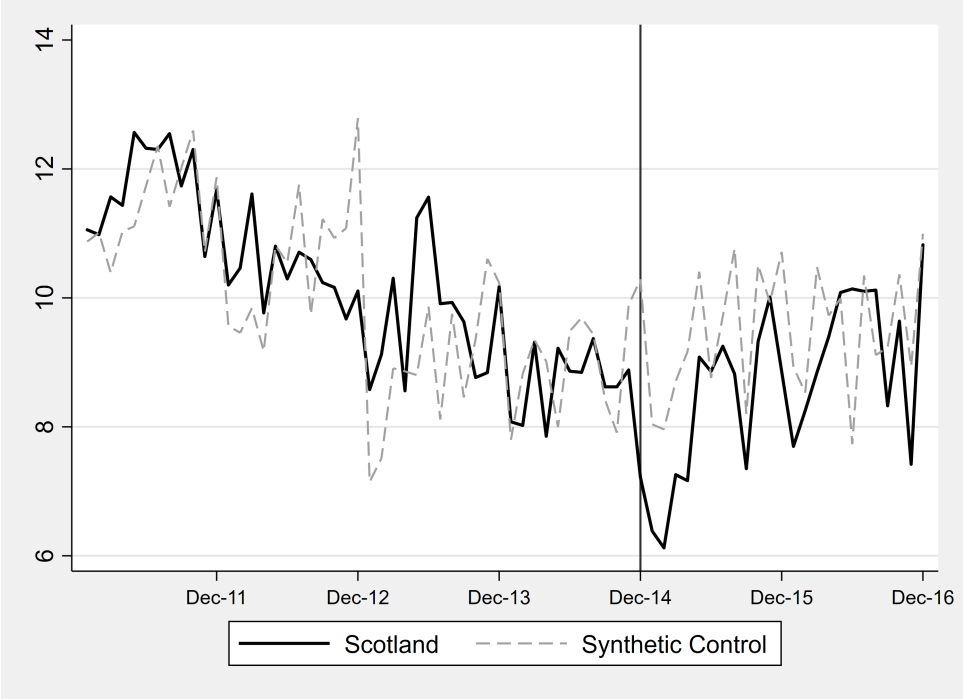
Figure A.21: Gaps in Breath Testing for Scotland and Synthetic Scotland and for Scotland and Placebos in Control PFAs



Note: Placebo districts with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded.

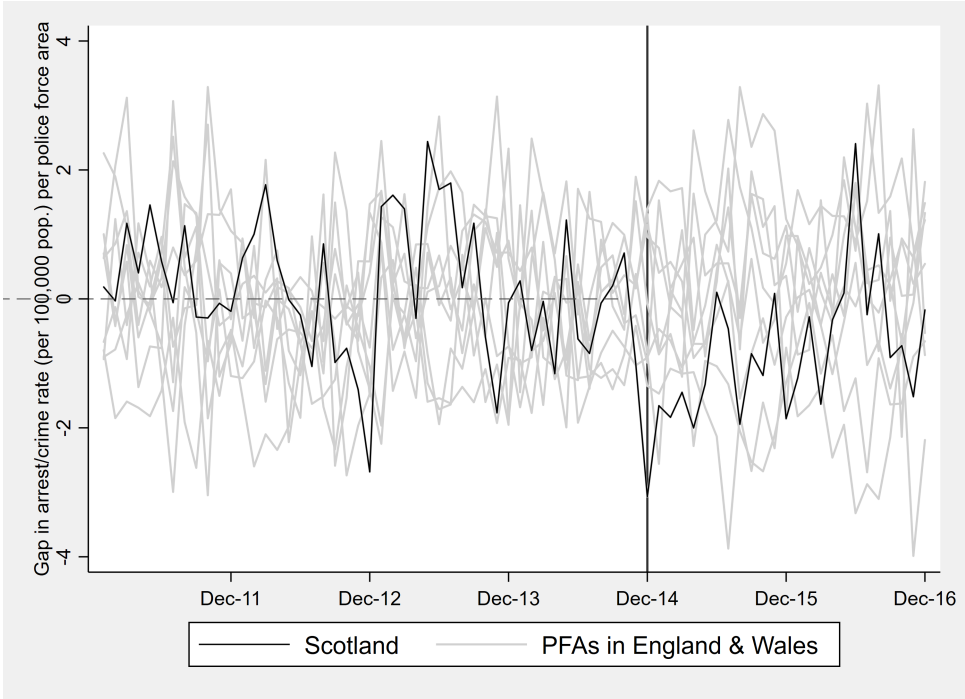
Drink Drive Arrests Unrelated to Road Accidents —

Figure A.22: Trends in Drink Drive Arrest Rates: Scotland versus Synthetic Scotland



Notes: The sample period goes from January 2011 to December 2016.

Figure A.23: Gaps in Drink Drive Arrest Rates for Scotland and Synthetic Scotland and for Scotland and Placebos in Control PFAs



Notes: Placebo districts with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded. 'PFAs' denotes police force areas.

Figure A.24: Police Scotland's Response to the Request Regarding Drink Drive Arrests

Our Ref: IM-FOI-2019-1654
Date: 10th July 2019

POLICE SCOTLAND
Keeping people safe
POILEAS ALBA

FREEDOM OF INFORMATION (SCOTLAND) ACT 2002

I refer to your recent request for information which has been handled in accordance with the Freedom of Information (Scotland) Act 2002.

For ease of reference, your request is replicated below together with the response.

How many arrests were there for suspicion of drink driving by month from January 2010 to December 2017?

How many of the above were:

a. Released without charge
b. Charged?

Firstly, I must advise you that Police in Scotland have the power to arrest an individual where there is sufficient evidence to support a charge against them - either for a common law offence or for a statutory offence where the statute empowers the police to arrest any person contravening its provisions.

There is however no mandatory recording process in relation to arrests as not all offenders are routinely arrested when they commit offences and some may be subject of a report to the Procurator Fiscal without ever having been arrested

As such, in terms of Section 17 of the Freedom of Information (Scotland) Act 2002 I can confirm that the information you seek is not held by Police Scotland.

Police Scotland do however record the number of reported and detected crimes and statistics regarding drink driving offences are publicly available on the Police Scotland website:-

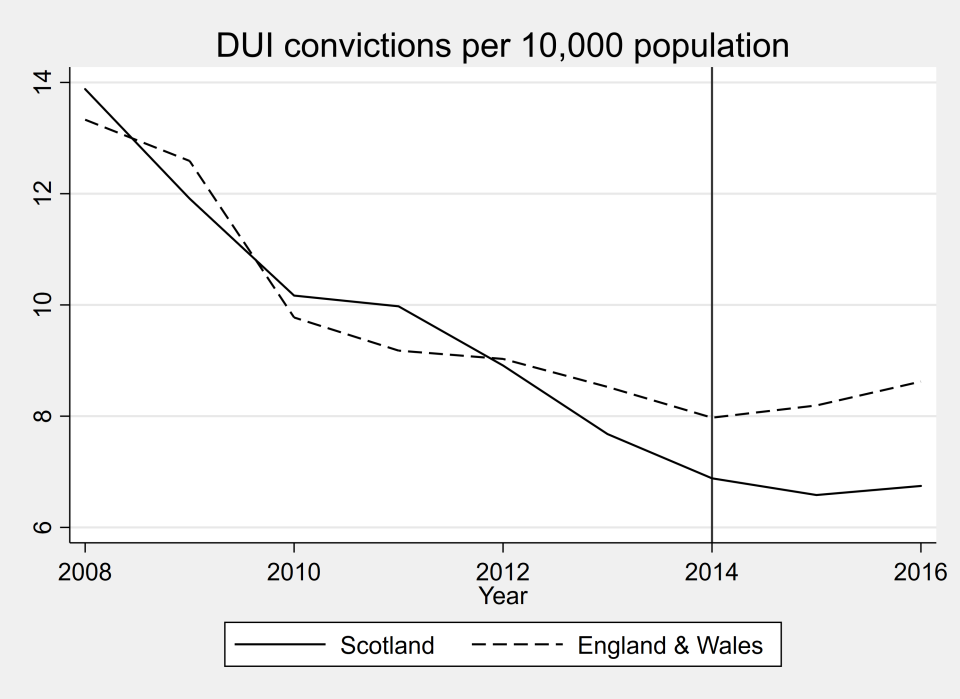
https://www.scotland.police.uk/assets/pdf/138327/232757/Police-Scotland-Recorded-and-Detected-Crime-Data

Should you require any further assistance please contact Information Management - Dundee on 01382 596657 quoting the reference number given.

If you are dissatisfied with the way in which Police Scotland has dealt with your request, you are entitled, in the first instance, to request a review of our actions and decisions.
Your request must specify the matter which gives rise to your dissatisfaction and it must be submitted within 40 working days of receiving this response - either by email to foi@scotland.pnn.police.uk or by post to Information Management (Disclosure), Police Scotland, Clyde Gateway, 2 French Street, Dalmarnock, G40 4EH.

Drink Drive Convictions Unrelated to Road Accidents —

Figure A.25: Trends in Drink Drive Conviction Rates: Scotland versus the Rest of Britain



Sources: Criminal Proceedings in Scotland (Scotland). Ministry of Justice (England and Wales). *Notes*: Figures for Scotland cover convictions for drink driving which refers to: (i) driving or in charge of motor vehicle while unfit through drink or drugs; (ii) blood alcohol content above the limit; and (iii) failing to provide breath, blood or urine specimens. Figures for England cover convictions for the following: (i) driving with alcohol in the blood above the prescribed limit; (ii) drive a motor vehicle with the proportion of specified controlled drug above specified limit; (iii) driving and failing to provide specimen for analysis (breath, blood or urine); (iv) in charge of motor vehicle with alcohol in the blood above the prescribed limit; (v) in charge of a motor vehicle with the proportion of specified controlled drug above specified limit; (vi) in charge of motor vehicle while unfit through drink or drugs (impairment); (vii) in charge of motor vehicle and failing to provide specimen for analysis (breath, blood, or urine); (viii) in charge of a vehicle whilst unfit to drive through drink or drugs (impairment); (ix) driving or attempting to drive a vehicle/motor vehicle whilst unfit to drive through drink or drugs; (x) failing to provide specimen for initial breath test; (xi) Failing to allow specimens of blood to be subjected to laboratory test.

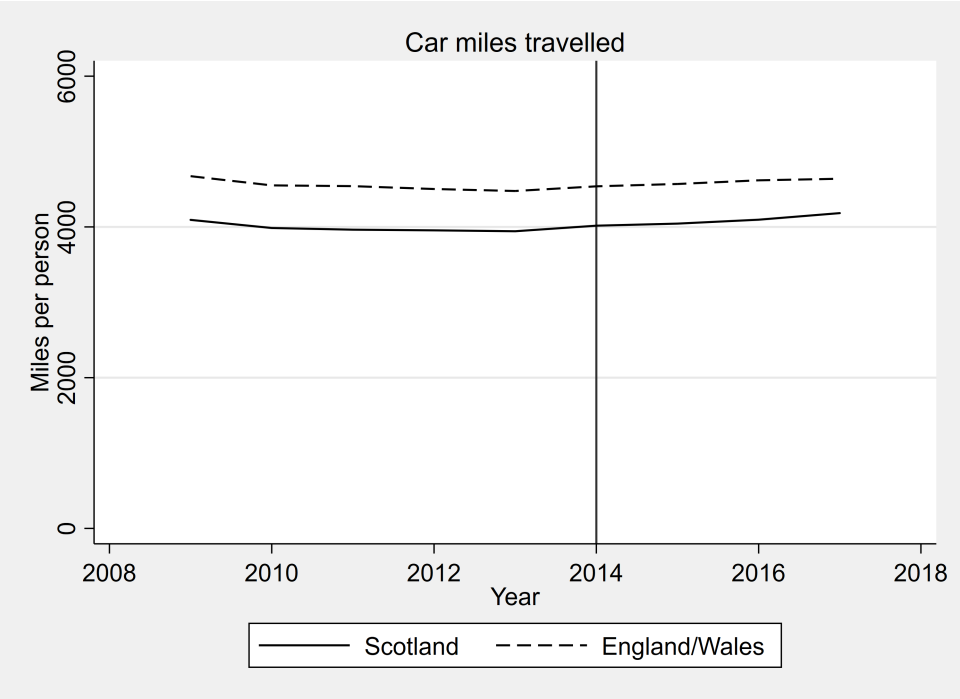
Table A.15: Effect of the DDL Reform on Drink Drive Conviction Rates — Difference-in-Difference Estimates

	Mean	(a)	(b)
β	10.95	-1.968*	-0.629
		(0.784)	(0.658)
Linear annual trend		N	Y
Linear annual × Scotland		N	Y
Observations		18	18

Sources: Criminal Proceedings in Scotland (Scotland); Ministry of Justice (England).
Note: Observations are at the country-year-level. The dependent variable is the number of drink drive convictions per 10,000 population. The sample period goes from 2008 to 2016. Panel-corrected standard errors are calculated using a Prais-Winsten regression, where an AR(1) process is assumed. For the different definitions of conviction in Scotland and England/Wales, see the notes to Figure A.25.
* $p < 0.05$.

7. Unintended Consequences and Spillover Effects

Figure A.26: Trends in Annual Car Miles Travelled Per Person: Scotland versus the Rest of Britain



Source: Department for Transport Statistics (Table TRA8902).

Table A.16: Effect of the DDL Reform on Vehicle Miles Travelled — Difference-in-Difference Estimates

	Mean	(a)	(b)	(c)
β	3,992.8	30.38	52.34	-16.55
		(18.27)	(59.06)	(22.06)
Observations		2,976	2,976	2,976
Controls		N	Y	Y
Linear annual trend		N	N	Y
Linear annual trend × Scotland		N	N	Y
LAs fixed effects		N	N	Y

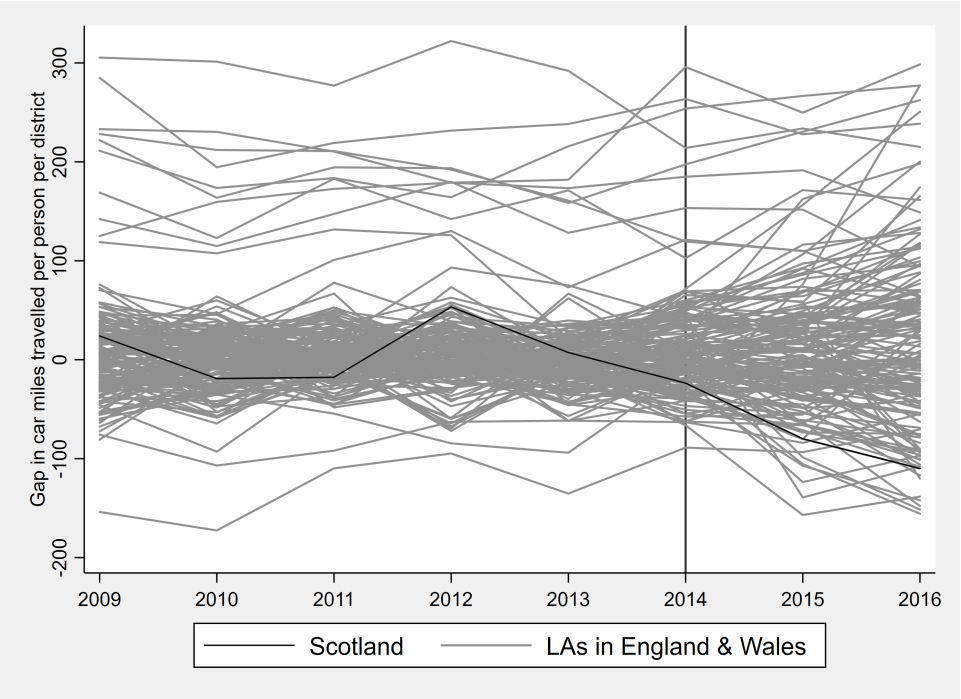
Source: Department for Transport Statistics (Table TRA8902).
Note: Observations are at the LA-year level. The sample period goes from 2009 to 2016. The dependent variable is the LA average number of car miles travelled per person per year. Standard errors are clustered at the LA level. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. 'Controls' are yearly averages of temperature range, population density, proportion of residents aged 16 or more with no educational qualification, proportion of residents with bad or very bad health, median total hours worked, and median gross pay, Job Seekers' Allowance rate, alcohol licensed premises, and total road length. 'LAs' denotes local authorities.

Table A.17: Effect of the DDL Reform on Vehicle Miles Travelled — Spatial Regression Discontinuity Estimates

	(a) <200 km	(b) <100 km	(c) <50 km
β	2.550	-15.82	67.28
	(29.93)	(55.61)	(59.02)
	[0.934]	[0.824]	[0.421]
Mean	4007.0	4143.0	4858.4
Observations	736	184	48
Number of LAs	92	23	6

Notes: Standard errors in parentheses are clustered at the LA level. Due to the small number of LAs, wild bootstrapped p-values computed using Webb weights (Webb, 2014) and 5,000 replications are in square brackets. For completeness, however, these are shown also for large bandwidths. For all other details, see the note to Table A.16.

Figure A.27: Gaps in Car Miles Travelled for Scotland and Synthetic Scotland and for Scotland and Placebos in Control LAs



Notes: Placebo districts with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded.

Table A.18: Effect of the DDL Reform on Time Spent in the Pub — Difference-in-Difference Estimates

	(a)	(b)	(c)	(d)	(e)	(f)
	A. All		B. Male		C. Female	
β	-2.070	-0.191	0.206	0.0139	-4.072*	-0.367
	(1.580)	(0.159)	(1.787)	(0.179)	(2.067)	(0.206)
Mean	8.55		7.35		9.60	
Observations	8,752	8,752	4,163	4,163	4,589	4,589
	D. Aged 18-30		E. Aged 31-49		F. Aged 50+	
β	-0.972	-0.0651	-1.980	-0.146	-2.077	-0.224
	(2.209)	(0.225)	(3.108)	(0.308)	(2.429)	(0.242)
Mean	8.13		9.35		8.39	
Observations	1,790	1,790	2,711	2,711	3,901	3,901
	G. Monday - Thursday		H. Friday, Saturday, Sunday		I. Saturday, Sunday	
β	-0.728	-0.0623	-1.900	-0.154	-2.530	-0.211
	(1.154)	(0.116)	(1.216)	(0.123)	(1.354)	(0.136)
Mean	3.71		4.64		4.72	
Observations	5,670	5,670	8,603	8,603	7,131	7,131
Controls	N	Y	N	Y	N	Y

Sources: UK-TUS, 2014–2015.

Notes: Dependent variable is the number of minutes in a pub, restaurant or cafe. Fieldwork was conducted between April 2014 and December 2015. Controls include age, and indicators for: having left school at age 17 or more, gender, presence of at least one child aged 0-14 in the household, full-time employment, self-employment. Standard errors are clustered at the household level.

* $p < 0.05$.

Table A.19: Effect of the DDL Reform on Smoking and Eating — Difference-in-Difference Estimates

	(a)	(b)	(c)	(d)	(e)	(f)
	A. Cigarettes Per Day			B. Currently Smoking		
β	-0.302*	-0.276*	-0.013	-0.013*	-0.010	0.003
	(0.089)	(0.086)	(0.127)	(0.006)	(0.005)	(0.008)
Mean		3.25			0.235	
Observations	129,235	129,235	129,235	129,612	129,612	129,612
	C. At Least One Portion of F&V			D. 5+ Portions of F&V		
β	-0.002	-0.003	-0.005	-0.015*	-0.014*	-0.008
	(0.004)	(0.004)	(0.006)	(0.005)	(0.005)	(0.009)
Mean		0.914			0.205	
Observations	148,981	144,248	144,248	148,981	144,248	144,248
Controls	N	Y	Y	N	Y	Y
Linear annual trend	N	N	Y	N	N	Y
Linear annual trend × Scotland	N	N	Y	N	N	Y

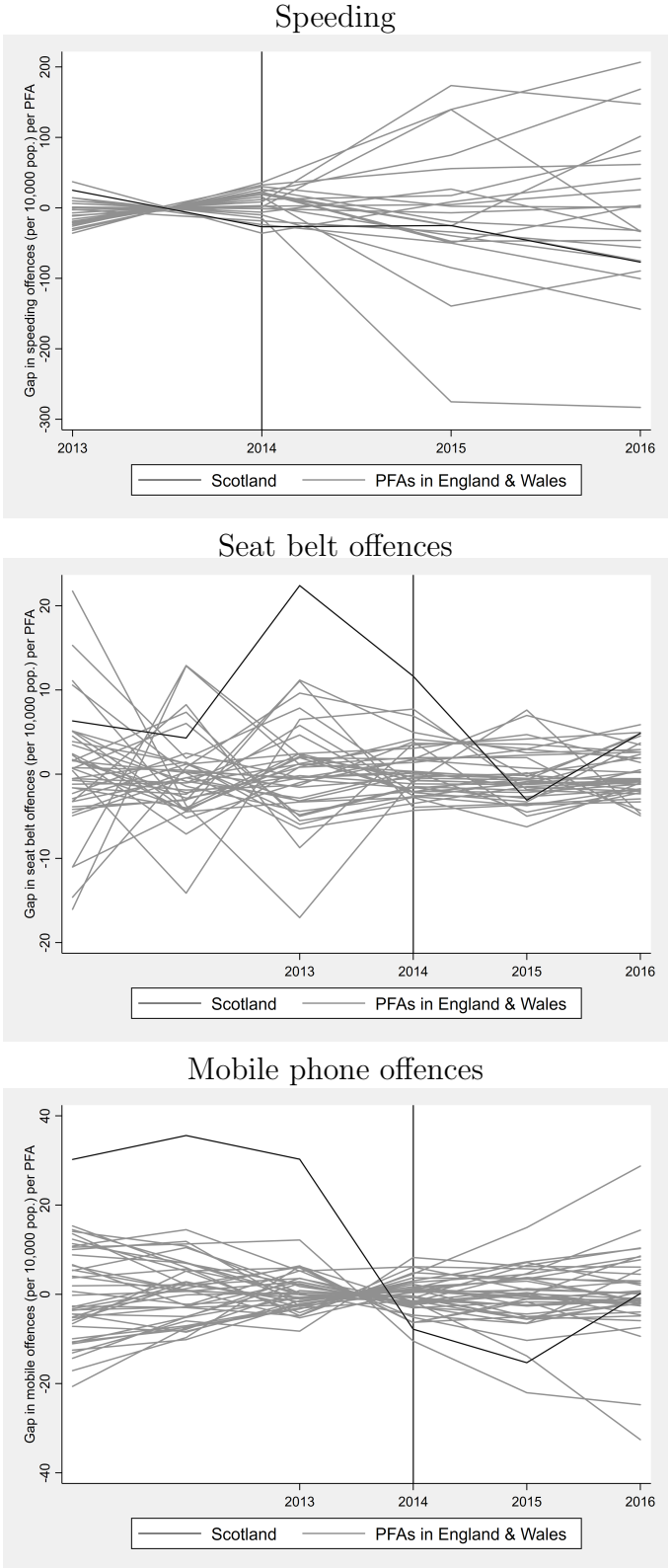
Sources: Health Survey of England (England) and Scottish Health Surveys (Scotland), 2008–2016.
Notes: Observations correspond to the number of individuals over the sample period. The dependent variables are: the number of cigarettes usually smoked in a day (panel A); an indicator variable that equals 1 if the individual smokes at the time of the survey, and 0 otherwise (panel B); an indicator variable that equals 1 if the individual eats at least one portion of fruit and vegetables (F&V) per day, and 0 otherwise (panel C); an indicator variable that equals 1 if the individual eats five or more portions of fruit and vegetables (F&V) per day, and 0 otherwise (panel D). 'Mean' refers to the Scottish pre-reform mean of the dependent variable. Robust standard errors are in parentheses. In all panels, 'controls' are: indicators of sex, marital status (married/cohabiting), ethnic minority (White, Black, or Asian, with others as the base category), education (leaving school at age 17 or after), and age (15 3-year age band groups).
* $p < 0.05$.

Table A.20: Effect of the DDL Reform on Speeding and Other Motor Vehicle Offenses — Difference-in-Difference Estimates

	Mean	(a)	(2)	(c)
		A. Speeding		
β	134.3	-89.00*	-73.85*	1.494
		(15.10)	(34.70)	(27.81)
Observations		164	164	164
		B. Seat Belt		
β	55.5	-30.89*	-27.64*	-23.06*
		(1.228)	(5.057)	(2.084)
Observations		246	246	246
		C. Mobile Phone		
β	50.4	-30.13*	-31.46*	-25.42*
		(1.123)	(3.481)	(1.950)
Observations		246	246	246
Linear annual trend		N	N	Y
Linear annual trend × Scotland		N	N	Y
PFAs fixed effects		N	Y	Y

Sources: Recorded Crime in Scotland (Scotland); Fixed Penalty Notices for Motoring Offences Statistics Data Tables: Police Powers and Procedures, Home office (England and Wales).
Notes: Observations are at the PFA-year level. The dependent variable is the number of crimes/offences per 10,000 heads of population. For panel A, the sample period goes from 2013 to 2016. For panel B and C, the sample period goes from 2011 to 2016. Standard errors in parentheses are clustered at the PFA level. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. All regressions include, as controls, yearly averages of temperature range, population density, proportion of residents aged 16 or more with no educational qualification, proportion of residents with bad or very bad health, median total hours worked, and median gross pay, Job Seekers' Allowance rate, alcohol licensed premises, and total road length. 'PFAs' denotes police force areas.
* $p < 0.05$.

Figure A.28: Gaps in Speeding and Other Motor Vehicle Offenses for Scotland and Synthetic Scotland and for Scotland and Placebos in Control PFAs



Notes: In all panels, placebo police force areas with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded.

Other Types of Crime — Here we define each of the four crime types analyzed in the text, namely drug, attempted murder and serious assault, robbery, and sexual crime for Scotland and England and Wales separately.

Drug crime — In Scotland, drug crime is defined by the following activities: illegal importation of drugs, illegal cultivation of drugs, possession of drugs with intent to supply, possession of drugs, and "Drugs, other offenses, money laundering". For England and Wales, instead, it is defined by: other drug offenses, possession of controlled drugs (cannabis), possession of controlled drugs (excluding cannabis), and trafficking in controlled drugs.

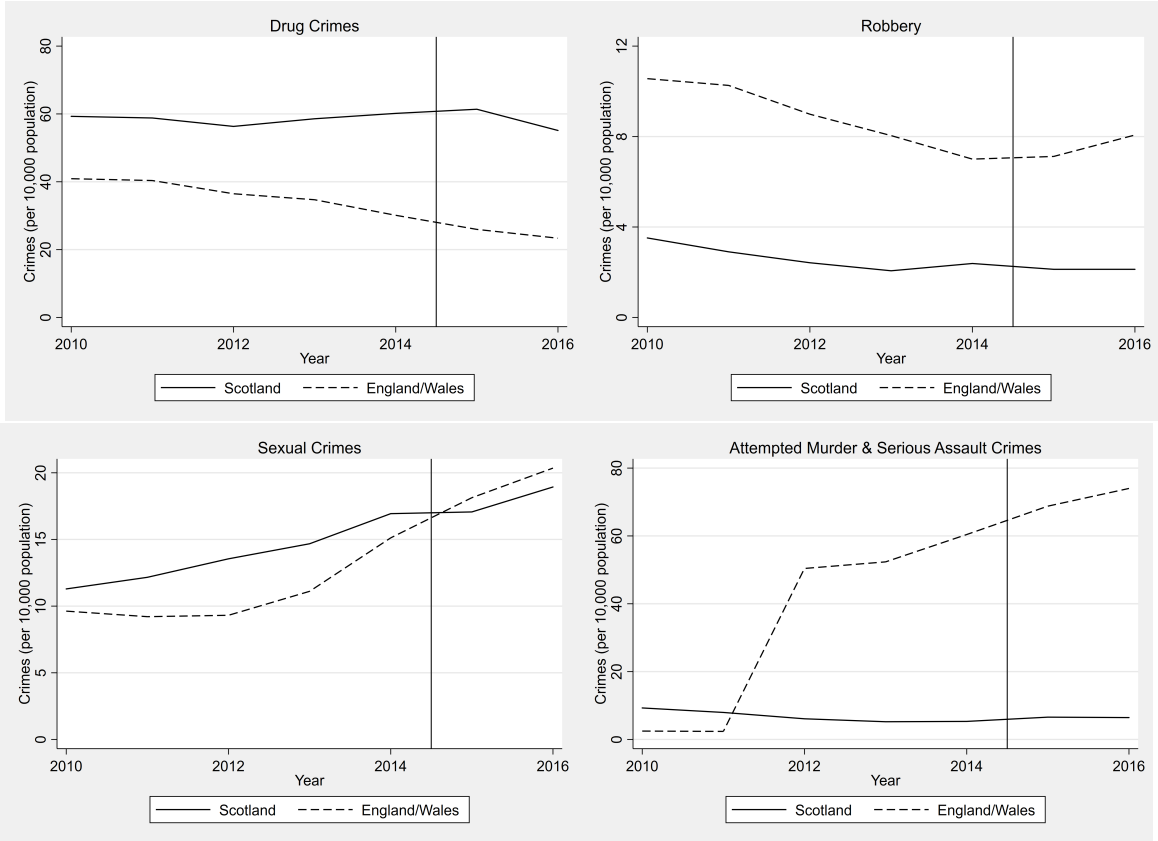
Attempted murder and serious assault — In Scotland, the crime comprising attempted murder and serious assault is defined by the following activities: attempted murder and serious assault. For England and Wales, instead, it is defined by: attempted murder, assault with injury, assault without injury, inflicting grievous bodily harm without intent.

Robbery — In Scotland, robbery is defined by one of the following activities: robbery or robbery and assault with intent to rob. For England and Wales, instead, robbery is defined as: robbery of personal property and robbery of business property.

Sexual crime — In Scotland, this is defined by the following offenses: rape, attempted rape, contact sexual assault (13–15 year old or adult 16+), sexually coercive conduct (on 13–15 year old child or adult aged 16+), sexual crimes against children under 13 years of age, lewd and libidinous practices, crimes relating to prostitution, soliciting services of person engaged in prostitution, brothel keeping, immoral traffic, procuration, other sexually coercive conduct, other sexual crimes involving 13-15 year old children, taking, distribution, possession etc. of indecent photos of children, incest, unnatural crimes, public indecency, sexual exposure, threatening to disclose and intimate image, disclosure of an intimate image communications Act 2003 (sexual), other sexual crimes. For England and Wales, instead, sexual crime is defined as: abuse of children through prostitution and pornography, abuse of children through prostitution and pornography, abuse of children through prostitution and pornography, abuse of children through prostitution and pornography, exploitation of prostitution, exploitation of prostitution, incest or familial sexual offences, other miscellaneous sexual offences, rape of a female aged 16 and over, rape of a female child under 13, rape of a female child under 16, rape of a male aged 16 and over, rape of a male child under 13, rape of a male child under 16, sexual activity etc with a person with a mental disorder, sexual activity involving a child under 13, sexual activity involving a child under 13, sexual assault on a female aged 13 and over, sexual assault on a female child under 13, sexual assault on a male aged 13 and over, sexual

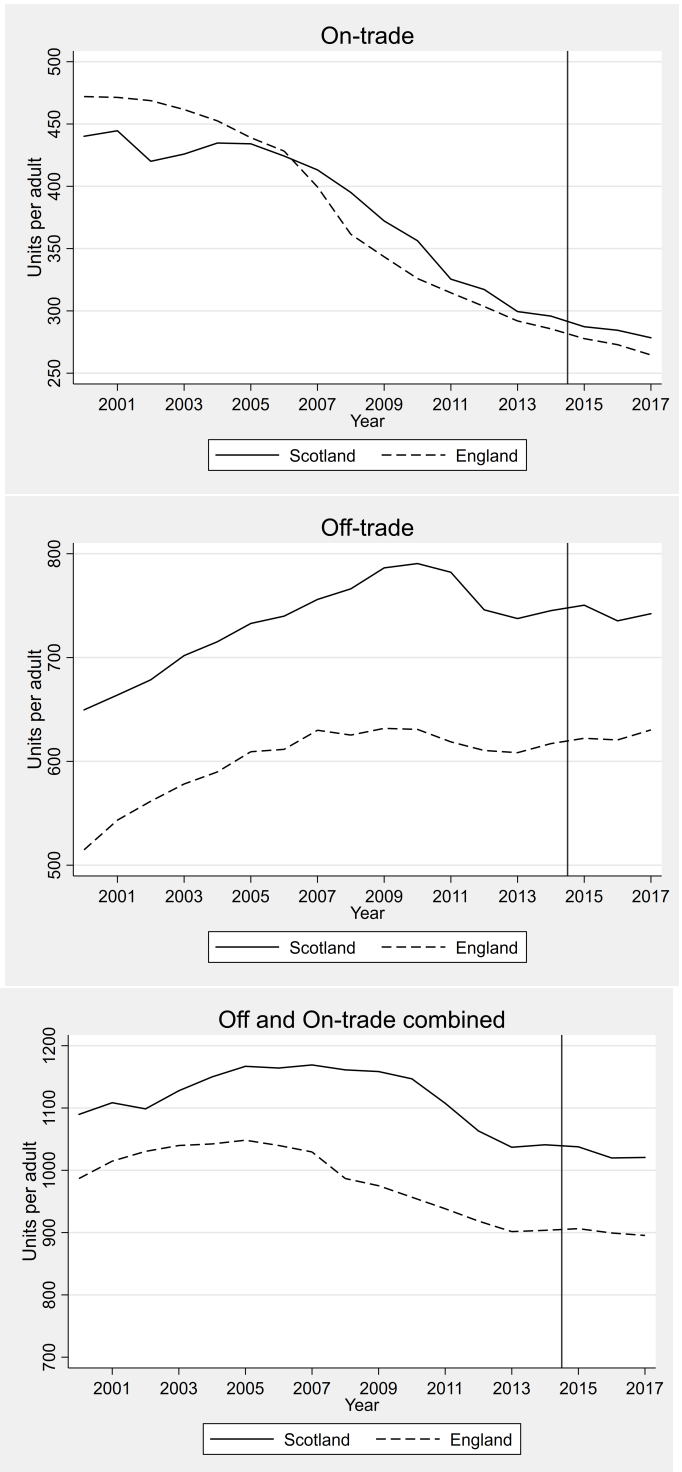
assault on a male child under 13 years of age, sexual grooming, soliciting for the purposes of prostitution, trafficking for sexual exploitation, unnatural sexual offences.

Figure A.29: Trends in Other Crimes and Offences: Scotland versus the Rest of Britain



Sources: Recorded Crime in Scotland, 2010–2016 (Scotland); Recorded crime data at the community safety partnership and local authority level (ONS), 2010–2016 (England).
Notes: Each outcome is the number of crimes/offences per 10,000 heads of population. The sample period goes from 2010 to 2016. The panels are: drug crimes (top left), robbery (top right), sexual offenses (bottom left) and attempted murder & serious assault (bottom right).

Figure A.30: Trends in Aggregate Alcohol Sales: Scotland versus the Rest of Britain



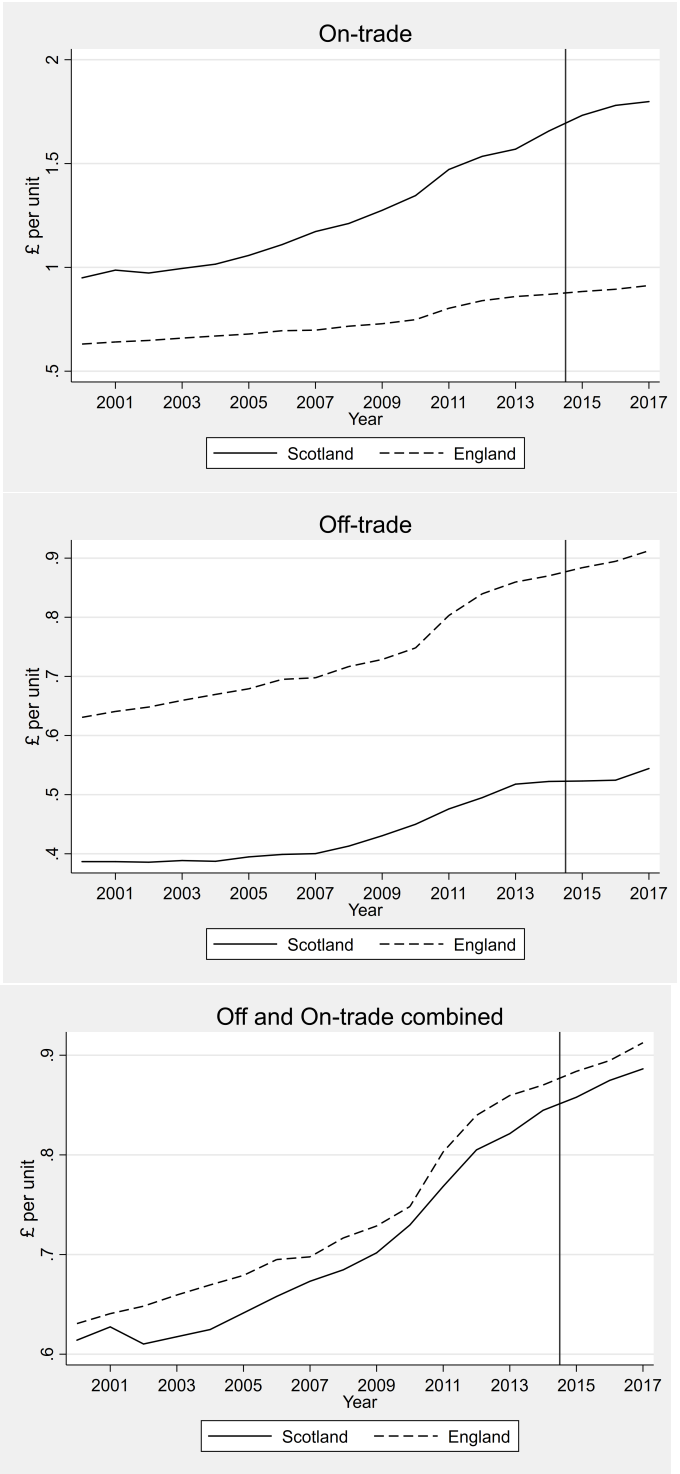
Source: Nielsen/CGA 2018:
<`www.tinyurl.com/2018MESASSAS`>.
Note: The figures refer to units of pure alcohol sold per adult (aged 16 or more).

Table A.21: Effect of the DDL Reform on Alcohol Sales — Difference-in-Difference Estimates

	(a)	(b)	(c)	(d)	(e)	(f)
	Total volume of pure alcohol (units) sold per adult (aged 16+ years)					
	On-trade		Off-trade		On and off trade	
β	1.807	-11.10	-8.403	-5.926	-14.13	-14.05
	(12.03)	(10.89)	(10.07)	(10.76)	(18.70)	(15.98)
Mean	387		733		1119	
Observations	35	35	35	35	35	35
Linear annual trend	N	Y	N	Y	N	Y
Linear annual trend × Scotland	N	Y	N	Y	N	Y

Source: Nielsen/CGA 2018, available at:
<www.tinyurl.com/2018MESASSAS>.
Notes: Observations are at the country-year level. The sample period goes from 2000 to 2016. England and Wales combined are the control country. Panel-corrected standard errors are calculated using a Prais-Winsten regression, where a region-specific AR(1) process is assumed. This also allows the error terms to be region specific, heteroskedastic, and contemporaneously correlated across regions.

Figure A.31: Trends in Aggregate Alcohol Prices: Scotland versus the Rest of Britain



Source: Monitoring and Evaluating Scotland's Alcohol Strategy, Monitoring Report 2018; available at: <www.tinyurl.com/2018MESASSAS>

Note: The figures refer the average price per unit of alcohol.

Table A.22: Effect of the DDL Reform on Alcohol Prices — Difference-in-Difference Estimates

	(a)	(b)	(c)	(d)	(e)	(f)
	Average price per unit of alcohol sold					
	On-trade		Off-trade		On and off trade	
β	-0.015	0.019	-0.007	-0.002	-0.008	0.003
	(0.025)	(0.022)	(0.004)	(0.003)	(0.010)	(0.009)
Observations	35		35		35	
Mean	0.43		0.489		0.695	
Linear annual trend	N	Y	N	Y	N	Y
Linear annual trend × Scotland	N	Y	N	Y	N	Y

Source: Monitoring and Evaluating Scotland's Alcohol Strategy, Monitoring Report 2018; available at: <www.tinyurl.com/2018MESASSAS>

Notes: Observations are at the country-year level. The sample period goes from 2000 to 2016. England and Wales combined are the control country. Panel-corrected standard errors are calculated using a Prais-Winsten regression, where a region-specific AR(1) process is assumed. This also allows the error terms to be region specific, heteroskedastic, and contemporaneously correlated across regions.

Table A.23: Effect of the DDL Reform on the Pub Industry — Difference-in-Difference Estimates

	Mean	(a)	(b)	(c)	(d)
		A. Pubs per 1,000 Population			
β	0.567	0.0273*	0.0245*	0.00537	-0.0103
		(0.0133)	(0.0111)	(0.0367)	(0.0243)
Observations		3,008	3,008	3,008	3,008
		B. Pub Jobs per 1,000 Population			
β	4.80	-0.412*	-0.493*	0.172	-0.194
		(0.122)	(0.237)	(0.555)	(0.329)
Observations		3,008	3,008	3,008	3,008
Controls		N	Y	Y	Y
Linear annual trend		N	N	Y	Y
Linear annual trend × Scotland		N	N	Y	Y
LAs fixed effects		N	N	N	Y

Source: "Economies of Ale: Changes in the UK Pubs and Bars Sector, 2001 to 2019", ONS; available at: <https://www.tinyurl.com/econale2020>

Notes: Observations are at the LA-year level. The sample period goes from 2009 to 2016. The dependent variables are the number of pubs per 1,000 heads of population (panel A) and the number of pub jobs per 1,000 heads of population (panel B). Standard errors in parentheses are clustered at the LA level. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. 'Controls' are LA annual averages of temperature range, population density, proportion of residents aged 16 or more with no educational qualification, proportion of residents with bad or very bad health, median total hours worked, median gross pay, Job Seekers' Allowance rate, alcohol licensed premises, and total road length. 'LAs' denotes local authorities.

* $p < 0.05$.

Table A.24: Effect of the DDL Reform on the Pub Industry — Spatial Regression Discontinuity Estimates

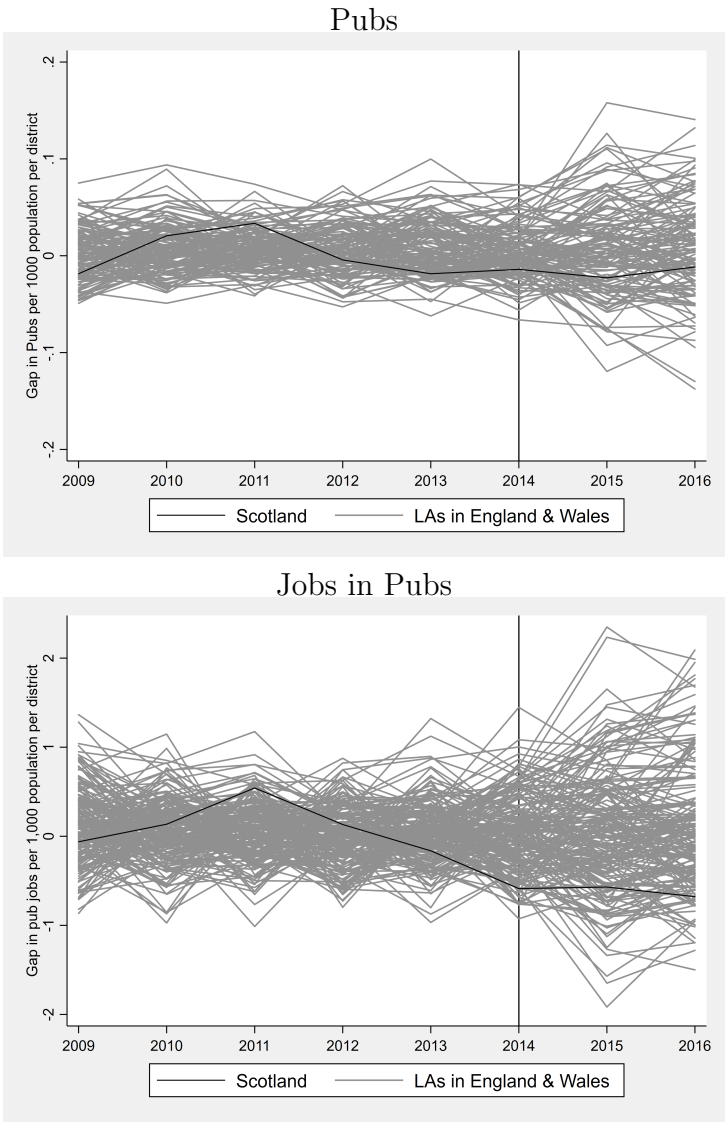
	(a) <200 km	(b) <100 km	(c) <50 km
	A. Pubs per 1,000 Population		
β	-0.043*	-0.066*	-0.139
	(0.014)	(0.026)	(0.088)
	[0.004]	[0.017]	[0.164]
Mean	0.579	0.612	0.618
	B. Pub Jobs per 1,000 population		
β	-0.700*	-0.951*	-2.194
	(0.156)	(0.344)	(1.130)
	[0.000]	[0.006]	[0.084]
Mean	4.821	4.865	4.222
Observations	752	200	56
Number of local authorities	94	25	7
Linear annual trend	N	Y	Y
Linear annual trend × Scotland	N	Y	Y
LA fixed effects	N	N	Y

Source: "Economies of Ale: Changes in the UK Pubs and Bars Sector, 2001 to 2019", ONS; available at: <www.tinyurl.com/econale2020>

Note: Observations are at the LA-year level. The sample period goes from 2009 to 2016. The dependent variables are the number of pubs per 1,000 heads of population (panel A) and the number of pub jobs per 1,000 heads of population (panel B). Standard errors in parentheses are clustered at the LA level. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. All regressions are estimated with all controls as in Table A.23. Due to the small number of LAs, wild bootstrapped p-values computed using Webb weights (Webb, 2014) and 5,000 replications are in square brackets. For completeness, however, these are shown also for large bandwidths. All regressions control for distance from the Scottish/English border and distance from the border interacted with Scotland (with English distances taking negative values) are also included. 'LAs' denotes local authorities.

* $p < 0.05$.

Figure A.32: Gaps in Pubs and Pub Jobs per 1,000 Population for Scotland and Synthetic Scotland and for Scotland and Placebos in Control LAs



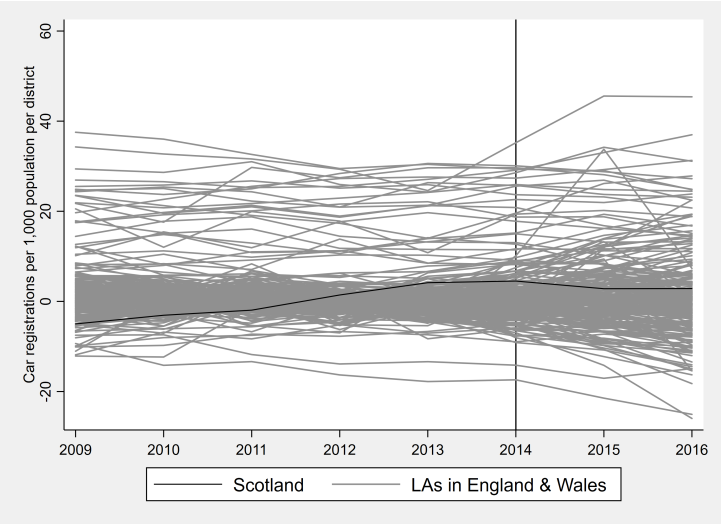
Notes: In all panels, placebo LAs with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded.

Table A.25: Effect of the DDL Reform on Car Registrations — Difference-in-Difference Estimates

	Mean	(a)	(b)	(c)
β	450.7	4.391	6.995	-0.075
		(4.033)	(5.282)	(3.772)
Observations		3,024	3,024	3,024
Controls		N	Y	Y
Linear annual trend		N	N	Y
Linear annual trend × Scotland		N	N	Y
LA fixed effects		N	N	Y

Notes: Observations are at the LA-year level. The sample period goes from November 2009 to December 2016. The dependent variable is the number of registered cars at the LA level. Standard errors in parentheses are clustered at the LA level. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. 'Controls' are LA annual averages of temperature range, population density, proportion of residents aged 16 or more with no educational qualification, proportion of residents with bad or very bad health, median total hours worked, median gross pay, Job Seekers' Allowance rate, alcohol licensed premises, and total road length. 'LA' denotes local authority.

Figure A.33: Gaps in Car Registration Rates for Scotland and Synthetic Scotland and for Scotland and Placebos in Control LAs



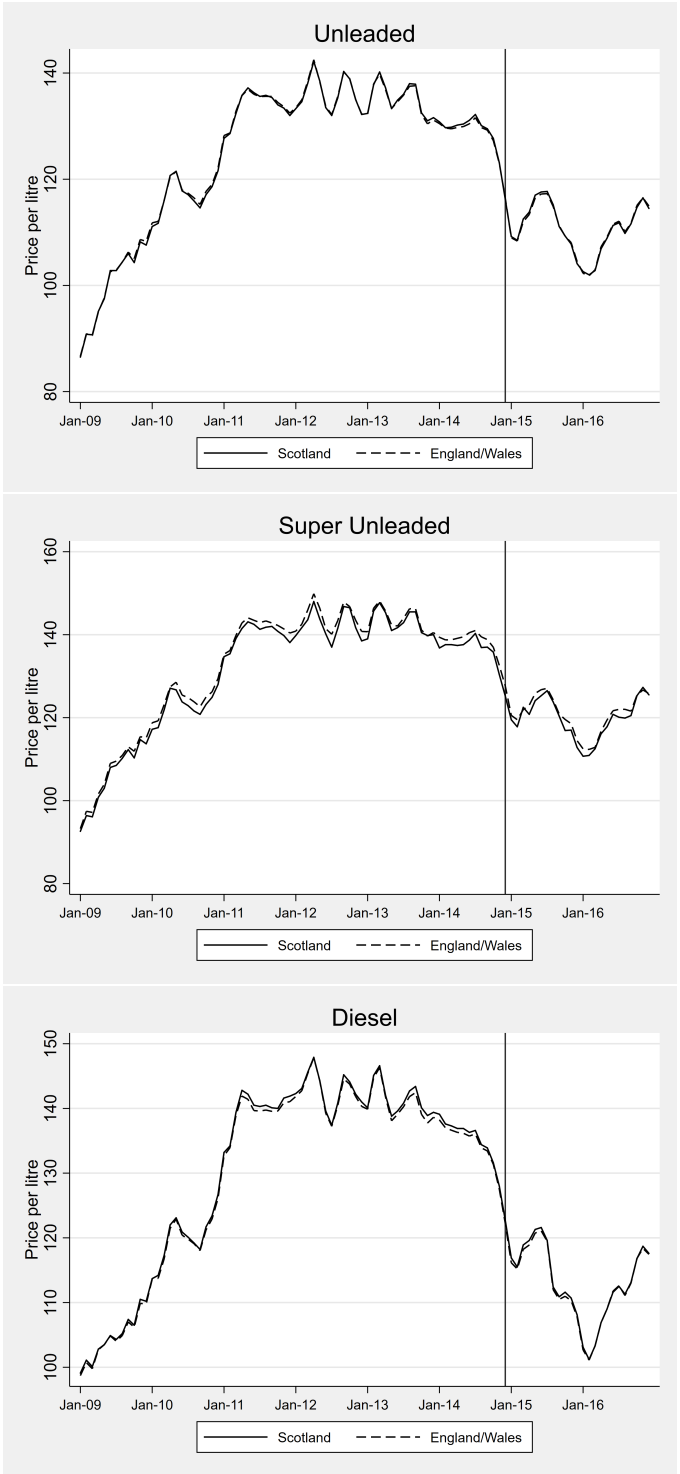
Notes: In all panels, placebo LAs with pre-reform mean squared prediction error (MSPE) that are two times higher than Scotland's are excluded. 'LAs' denotes local authorities.

Table A.26: Effect of the DDL Reform on Car Registrations — Spatial Regression Discontinuity Estimates

	(a) <200 km	(b) <100 km	(c) <50 km
β	-2.056	-3.156*	-3.965
	(3.535)	(1.510)	(2.526)
	[0.624]	[0.042]	[0.137]
Mean	447.3	441.2	482.5
Observations	768	208	56
Number of local authorities	96	26	7
Linear annual trend	N	Y	Y
Linear annual trend × Scotland	N	Y	Y
LAs fixed effects	N	N	Y

Note: Observations are at the LA-year level. The sample period goes from 2009 to 2016. The dependent variables are the number of pubs per 1,000 heads of population (panel A) and the number of pub jobs per 1,000 heads of population (panel B). Standard errors in parentheses are clustered at the LA level. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. All regressions are estimated with all controls as in Table A.25. Due to the small number of LAs, wild bootstrapped p-values computed using Webb weights (Webb, 2014) and 5,000 replications are in square brackets. For completeness, however, these are shown also for large bandwidths. All regressions control for distance from the Scottish/English border and distance from the border interacted with Scotland (with English distances taking negative values) are also included. 'LAs' denotes local authorities.
* $p < 0.05$.

Figure A.34: Trends in Average Petrol Prices: Scotland versus the Rest of Britain



Source: Automobile Association (The AA) Fuel Price Reports, January 2009–December 2016; available at: <www.tinyurl.com/AAfuelprices>

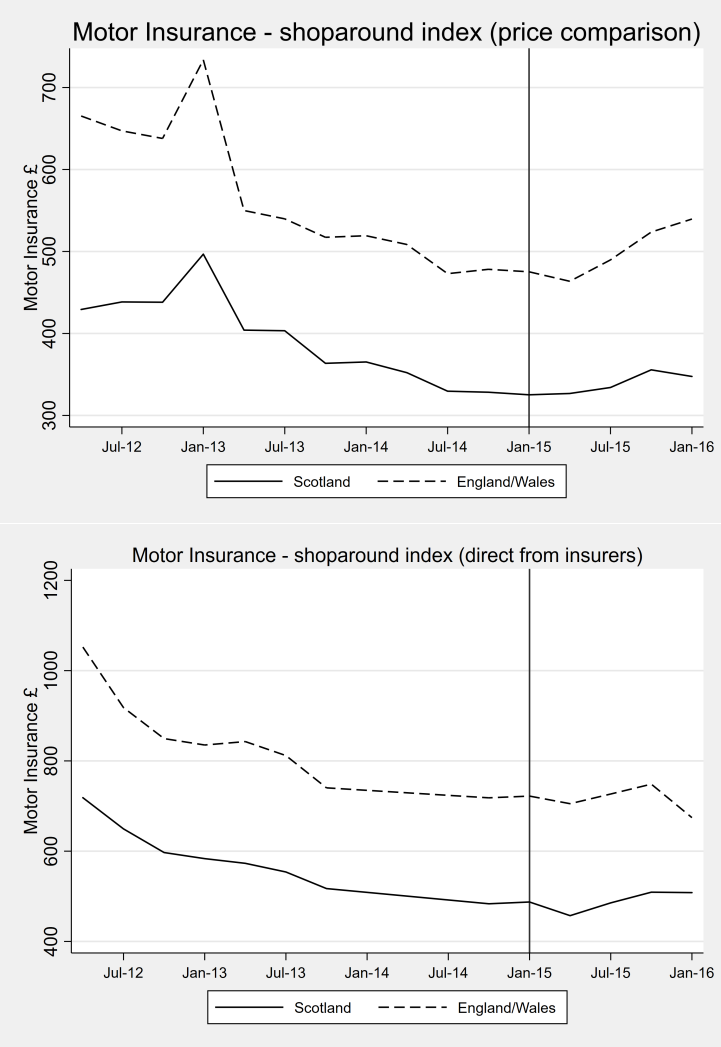
Table A.27: Effect of the DDL Reform on Petrol Prices — Difference-in-Difference Estimates

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)
	Pence per litre								
	A. Unleaded			B. Super Unleaded			C. Diesel		
β	-0.299	-0.586*	-0.461*	-0.116	-0.302	0.033	0.020	-0.108	-0.058
	(0.246)	(0.245)	(0.243)	(0.813)	(0.793)	(0.806)	(0.205)	(0.202)	(0.210)
Mean		125.2			131.7			130.6	
Observations	1,045	1,045	1,045	1,045	1,045	1,045	1,045	1,045	1,045
Month-year trend	N	Y	Y	N	Y	Y	N	Y	Y
Month-year trend × Scotland	N	Y	Y	N	Y	Y	N	Y	Y
Month FEs	N	N	Y	N	N	Y	N	N	Y
Month FEs × Scotland	N	N	Y	N	N	Y	N	N	Y

Source: Automobile Association (The AA) Fuel Price Reports, January 2009–December 2016; available at: <www.tinyurl.com/AAfuelprices>
Notes: Observations are at the region-month-year level. The sample period goes from January 2009 to December 2016, except London which runs from January 2009 to January 2016. Control regions are: London, South West, South East, East Anglia, East Midlands, West Midlands, Yorkshire and Humberside, North West, North Wales. The dependent variable is the price (pence) per litre of petrol. 'Mean' refers to the Scottish pre-reform mean of the dependent variable. 'FEs' denotes fixed effects. Panel-corrected standard errors are calculated using a Prais-Winsten regression, where a region-specific AR(1) process is assumed. This also allows the error terms to be region specific, heteroskedastic, and contemporaneously correlated across regions.
* $p < 0.05$.

Automobile Insurance Premiums — The Automobile Association (AA) publishes a variety of motor insurance indexes, which are widely used in the automobile industry. The most consistent time series is on the price comparison "shoparound" premium index (also known as aggregator). The data go from April 2012 to January 2016 and are collected quarterly. The shoparound premium is a combined average of the five cheapest quotes from both the price comparison site market and from the direct and broker market. There is also a shoparound direct series (i.e., directly from insurers). The data for this index cover the same time period as the price comparison index, except there is missing information for the three quarters from January 2014 to September 2014. The data are regional (TV regions), with the following breakdown: Anglia, Border Tyne Tees, Central, Granada, London, South, Wales, West and Yorkshire, and Scotland.

Figure A.35: Trends in Car Insurance Premiums: Scotland versus the Rest of Britain



Source: The Automobile Association.

Table A.28: Effect of the DDL Reform on Shoparound Automobile Insurance Premium Indices — Difference-in-Difference Estimates

	Mean	(a)	(b)	(c)
		A. Premium		
β	395.4	-9.039	8.079	-28.84
		(29.56)	(40.84)	(25.27)
Observations		160	160	160
		B. Direct Premium		
β	584.5	-14.54	-3.369	-40.69
		(32.55)	(33.34)	(26.34)
Observations		160	160	160
Linear quarterly trend		N	Y	Y
Linear quarterly trend × Scotland		N	Y	Y
TV region fixed effects		N	N	Y

Notes: Observations are at the TV region-quarter-year level. The sample period goes from April 2012 to January 2016 for panel A, and the same period except the three quarters from January 2014 to September 2014 for which there is missing information for panel B. The dependent variable is the region specific average price of the car insurance premium (see the description above for an explanation of the two indexes). 'Mean' refers to the Scottish pre-reform mean of the dependent variable. The regions are: Anglia, Border Tyne Tees, Central, Granada, London, South, Wales, West and Yorkshire, and Scotland. Panel-corrected standard errors are calculated using a Prais-Winsten regression, where a region-specific AR(1) process is assumed. This also allows the error terms to be region specific, heteroskedastic, and contemporaneously correlated across regions.

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