Institute for Fiscal Studies

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Working paper
21/40

Price floors and externality correction

Economic and Social Research Council

Price Floors and Externality Correction

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November, 2021

Abstract

We evaluate the impact of a price floor for alcohol introduced in Scotland in 2018, using a difference-in-differences strategy with England as a control group. We show that the policy led to the largest reductions in alcohol units purchased among the heaviest drinkers – the group who, at the margin, are likely to create the largest externalities from drinking. The price floor is well targeted at heavy drinkers because they buy a much greater fraction of their units from cheap products and switched away from these products strongly, with only limited substitution towards more expensive products. We show that if the marginal external cost of drinking is at least moderately higher for heavy than lighter drinkers, then a price floor outperforms an ethanol tax. However, more flexible tax systems can achieve similar reductions in externalities to the price floor, but avoid the large transfers from public funds to the alcohol industry that arise under the floor.

Keywords: externality, corrective taxes, alcohol, price floors
JEL classification: D12, D62, H21, H23
Acknowledgements: The authors gratefully acknowledge financial support from the Economic and Social Research Council (ESRC) under the Centre for the Microeconomic Analysis of Public Policy (CPP), grant number ES/M010147/1, and under the Open Research Area (ORA) grant number ES/VO13513/1. Data supplied by Kantar FMCG Purchase Panel. The use of Kantar FMCG Purchase Panel data in this work does not imply the endorsement of Kantar FMCG Purchase Panel in relation to the interpretation or analysis of the data. All errors and omissions remain the responsibility of the authors.

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1 Introduction

The external costs of alcohol consumption, which include public healthcare costs as well as the effects of drink driving, domestic violence and other crime, are substantial.[1] Many countries tax alcohol, in part to reduce these costs. In a simple textbook setting, a Pigouvian tax levied on the source of an externality can achieve the first-best allocation. However, this is not the case when the marginal externality associated with an extra unit of consumption varies across consumers; for example, if it is higher for heavy than lighter drinkers. Price floors have been advocated as an effective policy to tackle problematic drinking (World Health Organization (2017)), and are being implemented in several countries.[2] They can lower socially costly consumption by raising prices and targeting people who consume cheap alcohol, but, unlike higher taxes, they create windfall gains for firms instead of tax revenue.

In this paper, we study the impact of a price floor for alcohol introduced in Scotland in 2018, which prohibited the sale of alcohol below £0.50 per unit (equivalent to 10ml of ethanol).[3] We use detailed, longitudinal household scanner data on the alcohol purchases made by more than 30,000 households to compare alcohol prices and purchases in Scotland to those in a control group in England. We find that the policy had a large impact on alcohol prices and resulted in big falls in the alcohol purchases of heavy drinkers. We use demand estimates to compare the welfare performance of the price floor with counterfactual tax reforms. When the generation of externalities is sufficiently concentrated among heavy drinkers, a price floor out-performs an ethanol tax. However, we show that a more flexible tax system, with rates that vary across different alcohol types, can achieve similar reductions in externalities to the price floor, whilst avoiding the large transfers from public funds to the alcohol industry that arise under the floor.

Prior to the introduction of the price floor, around 50% of alcohol bought in Scotland was sold at a price below the floor. The policy therefore had a substantial impact on alcohol prices. We show that its main effect was to raise the price of products previously priced below the floor to £0.50 per unit, with little impact on more expensive products. The average price rose by 5%, but some cheap products doubled in price. The price rises led to an average reduction of 11% in alcohol units

[1] The World Health Organization (2014) report that in 2012, 5.9% of global deaths and 5.1% of the global burden of disease and injury were attributable to alcohol consumption. The Centers for Disease Control and Prevention (2016) estimate excessive alcohol consumption cost the US $249 billion in 2010.

[2] We study the floor implemented in Scotland. Ireland has legislated for a similar policy. A number of Canadian provinces also have systems of minimum alcohol prices.

[3] It is thus illegal in Scotland to sell a 1l bottle of 40% ABV spirits for less than £20, or a 0.75l bottle of 13.5% ABV wine for less than £5.12.

purchased per adult per week, with larger than average declines for spirits (13%) and cider (32%), which both experienced relatively large average price rises.

These average treatment effects mask heterogeneity across different groups. We exploit the long panel dimension of our data, using households' historic long-run alcohol purchases to group drinkers from light to heavy, and estimate heterogeneity in treatment effects across these groups. Households in the bottom 70% of the long-run drinking distribution do not show a (statistically or economically) significant change in purchases. However, heavier drinkers exhibit large responses, with those in the top 5% of the long-run drinking distribution reducing their purchases of alcohol by 15%, or 6 units – equivalent to two-thirds of a bottle of wine – per adult per week. The price floor is well targeted at heavy drinkers for two reasons. First, they obtain a disproportionate share of their units from cheap products, which see price rises when the floor is introduced. We show that this is primarily driven by differences in purchase patterns within broad alcohol types (beer, wine, spirits and cider), rather than differences across them. Second, the price floor led heavy drinkers to reduce their purchases of these cheap products considerably, with only limited switching towards more expensive drinks.

The price floor succeeded in reducing the purchases of heavy drinkers, who were explicitly targeted by policymakers due to evidence that they create the largest externalities at the margin (Scottish Government (2018)). Much of the epidemiological evidence suggests that there are "threshold effects" of drinking: the health risk (and associated public cost of health care) is minimal at low levels of alcohol consumption, but rises sharply when consumption exceeds low levels.[4] There is also evidence of convexity in the relationship between alcohol consumption and non-disease related harms: for instance, harmful and hazardous levels of alcohol consumption have been shown to significantly raise the risk of perpetrating domestic violence (World Health Organization (2006)). This evidence is reflected in government guidelines on drinking, e.g., in the UK, people are advised not to consume more than 14 units per adult per week, which, while not regarded as "safe", is termed "low risk" (National Health Service (2018)).

The welfare gains of a price floor depend on the degree of convexity of the external costs from alcohol consumption, i.e., to what extent is the externality from consuming an additional drink higher for heavy than light drinkers, and hence, what share of total externalities do heavy drinkers create. We use a model of demand for alcohol estimated in Griffith, O'Connell, and Smith (2019) to quantify the welfare

[4]For instance, there is evidence of a threshold effect in the relationship between alcohol consumption and the risks of developing liver cirrhosis (Rehm et al. (2010)).

impacts of the price floor and to compare it to counterfactual tax reforms. When externalities are linear in alcohol consumption, a single rate of tax levied in proportion to ethanol content achieves the first best. However, if the 10% of heaviest drinkers, who buy 60% of all ethanol, create more than 80% of the external costs of drinking, the price floor leads to larger welfare gains than a single ethanol tax rate. We show that a more flexible tax system (with rates that vary across the ethanol in different alcohol types) can mimic the pattern of demand reductions achieved by the price floor, thus inducing a similar reduction in external costs. Tax reform has the advantage of raising tax revenue, in contrast to leading to windfall gains to firms that arise under the price floor.

We contribute to the large literature that studies the impact of taxes and regulations in the alcohol market. A number of recent papers study the effects of public policy in US alcohol markets with a particular focus on the strategic pricing response of firms (for example, Seim and Waldfogel (2013), Miravete et al. (2018, 2020), Conlon and Rao (2019, 2020)). We provide direct evidence on how prices changed in response to the introduction of a price floor, highlighting that the price of products that were below the floor pre-reform move to the floor, and the price of other products are largely unaffected. In the Online Appendix we offer some evidence that tax pass-through in the UK context is approximately 100%. A possible driver of these differences is that alcohol sales in the UK are dominated by supermarkets who face little restraint on alcohol pricing (with the exception of the floor), whereas in the US alcohol retailing is highly regulated.

A number of studies assess the public health implications of the alcohol price floors in place in Canada. Although not the explicit aim of policy, several papers find a link between minimum prices and lower alcohol consumption (Stockwell et al. (2012a, 2012b)), and an associated reduction in alcohol-related crime (Stockwell et al. (2017)), hospital admissions (Stockwell et al. (2013)) and morbidity (Zhao et al. (2013), Zhao and Stockwell (2017)). Purshouse et al. (2010) use an epidemiological model to conduct ex-ante evaluations of various alcohol price policies, including a price floor. Holmes et al. (2014) extends this model to assess the potential impact across socioeconomic status and moderate versus harmful drinkers. O'Donnell et al. (2019) also study the impact of the introduction of the price floor in Scotland. Unlike our analysis, they do not account for weeks in which households choose to buy no alcohol, which leads them to significantly overestimate the treatment effect of the price floor on units purchased. We show that the price floor both reduced the probability that households purchase alcohol and led to a reduction in

quantity, conditional on buying. Our work also adds to this literature by comparing the welfare implications of the price floor to alternative tax reforms.

This paper is related to our previous work, Griffith, O'Connell, and Smith (2019), which shows how varying tax rates across product types can create efficiency gains when product-level demands are correlated with marginal externalities. We use the demand model estimated in that paper to show that varying rates across alcohol types can mimic the externality reductions achieved by the price floor, while avoiding the windfall gains to the alcohol industry. While the tax reform uses heavy drinkers' taste for strong alcohol as a tag for socially costly consumption, the price floor instead uses their taste for alcohol that is cheap in per unit terms (Akerlof (1978)). Our work also relates to a literature in environmental economics that focuses on the challenge of designing policy when it is difficult to directly target the source of the externality, and that compares the efficacy of targeting different product features (see, for instance, Grigolon et al. (2018) and Jacobsen et al. (2020)).

The rest of the paper is structured as follows. In the next section, we describe the Scottish price floor and our data. In Section 3 we use a difference-in-differences approach to estimate its impact on prices and quantities. In Section 4 we compare the effects of the price floor with counterfactual tax reforms. A final section summarises and several online appendices provide additional detail.

2 Policy context and data

2.1 Policy context

A price floor for alcohol – known as a minimum unit price – came into effect in Scotland on 1 May 2018. The policy is motived as a means of tackling externalities from alcohol consumption. The devolved Scottish Government, "*wants to target the price of drinks that are cheap and strong*," as these are "*the alcoholic drinks that tend to be drunk by people who are at more risk of harm due to drinking*", with harms including those associated with health complications (a cost for the public health care system), higher likelihood of committing crime, more absenteeism and those imposed on other family members (Scottish Government (2018)).

The policy made it illegal to sell alcohol products priced below £0.50 per unit of alcohol (10ml of ethanol). The price floor for alcohol was introduced in Scotland, but not in England or other parts of the United Kingdom. Alcohol sold in Scotland

is also subject to taxes that are set by the UK government (and are therefore the same in Scotland and England); see Online Appendix C.1 for details.

2.2 Data

We use data from the Kantar Fast Moving Consumer Goods (FMCG) Purchase Panel, which is a household level scanner dataset collected by the market research firm Kantar UK. A representative sample of UK households record all grocery purchases they make and bring into the home.[5] The dataset covers purchases from supermarkets, convenience and liquor stores. Households record the products that they buy, along with transaction level prices; Kantar also collects information on product and household characteristics. The data are longitudinal, with households typically present in the sample for several years. In this section we describe the key characteristics of these data, providing more detail in Online Appendix A.

Our sample covers the period from May 2016 to January 2020 – 24 months prior to and 20 months following the introduction of the price floor. The data contain information on 2.9 million alcohol transactions made by 2,972 households living in Scotland and 29,496 living in England. We observe each household for an average of 115 weeks over this period, including weeks in which a household reports buying zero alcohol. In total, we have a sample of approximately 4 million household-year-weeks, with alcohol purchased on 32% of these.[6]

Prices

We measure the price per unit paid for alcohol products on each of the 4 million transactions in our data. We observe 13,135 alcohol products (or barcodes), which we index j. Letting ρ_{jt} denote the price paid for product j on transaction t, and z_j the number of units of alcohol in product j, the price per unit of alcohol for product j on transaction t is $p_{jt} = \rho_{jt}/z_j$. The price floor in Scotland made it illegal to sell alcohol at $p_{jt} < £0.50$.

Quantities

The number of alcohol units purchased per adult per week by household i in year-week w is, $\mathcal{Q}_{iw} = \frac{1}{A_i} \sum_j z_j \left(\sum_{t \in T_{iw}} \eta_{jt} \right)$, where η_{jt} is the number of packs of product j bought on transaction t, T_{iw} the set of transactions by household i in year-week

[5] In Online Appendix A.2 we show that the sample is similar along key demographics with the nationally representative consumer spending survey, the Living Costs and Food Survey (LCFS).

[6] Households sometimes buy multiple alcohol products in a week, which is why the number of alcohol transactions is higher than the number of weeks on which alcohol is purchased.

w, and A_i the number of adults in household i. If a household records making any grocery purchases in week w, but does not buy any alcohol, $\mathcal{Q}_{iw} = 0$. On average, households buy 6 units of alcohol per adult per week (i.e., the average of $\mathcal{Q}_{iw}$ is 6).[7] We analogously define units purchased per adult per week from subsets of products, such as those priced above or below the price floor prior to its introduction, and from different alcohol types.

An important limitation of these data is that they do not include information on alcohol bought for consumption out of the home, i.e., in restaurants and bars – known as the "on-trade". Alcohol bought for at-home consumption accounts for around three-quarters of alcohol units consumed in the UK.

As we show below, the price floor had a significant impact on the prices of alcohol bought for at-home consumption. However, as alcohol purchased on-trade is much more expensive (the average price is £1.80 per unit), on-trade prices are not directly affected by the price floor. We present results on the impact of the price floor on alcohol purchased for at-home consumption. One possible margin of response is that people substitute toward on-trade consumption, which might offset changes in at-home consumption. Although we cannot rule out this form of response, we think it is likely to be modest. One reason is that UK competition authorities have repeatedly taken the view that on- and off-trade are separate markets, meaning that substitution between them is low (Office of Fair Trading (2014)). A second reason is that NHS Health Scotland (2019) show that average on-trade consumption evolved similarly in Scotland and England in 2017 and 2018 (when the policy was introduced in Scotland). We provide more details in Online Appendix A.3.

Pre-treatment household attributes

We explore whether there is heterogeneity in the impact of the price floor on alcohol purchases across three dimensions – long-run alcohol purchases, proximity to the Scotland-England border, and equivalised household income. Online Appendix A describes the distributions of these three variables.

We measure a household's long-run average alcohol purchases over the first year of our data. Exploring heterogeneity across this dimension enables us to evaluate whether the price floor is well targeted at people whose marginal consumption is likely to create large externalities. For each household we compute the average units purchased per adult per week over the period May 2016 to April 2017: $\bar{\mathcal{Q}}_i = \frac{1}{N_i} \sum_{w \in [2016m5, 2017m4]} \mathcal{Q}_{iw}$, where N_i denotes the number of weeks household i is

[7] This average excludes abstainers i.e. households that are never observed buying alcohol. Abstaining households account for approximately 15% of all households.

present in the sample during May 2016 to April 2017 (including weeks when they record zero alcohol purchases). Measuring purchases over a whole calendar year allows us to distinguish households that consistently purchase large quantities of alcohol from those that may occasionally make a large purchase. 10% of households consistently buy more than 15 units per adult per week, and 5% buy consistently more than 24 units.

For each household, we observe the postal sector that they live in. We use the straight-line distance from the centre of the postal sector to the Scotland-England border as a measure of proximity to the border. This allow us to assess whether Scottish households travel over the border to circumvent the price floor.

We measure a household's equivalised income by dividing (banded) total household income by the OECD-modified equivalence scale, which sums the equivalence values of each member of the household (the first adult is given a value of 1, additional persons aged over 14 are given a value of 0.5, and children aged under 14 a value of 0.3).

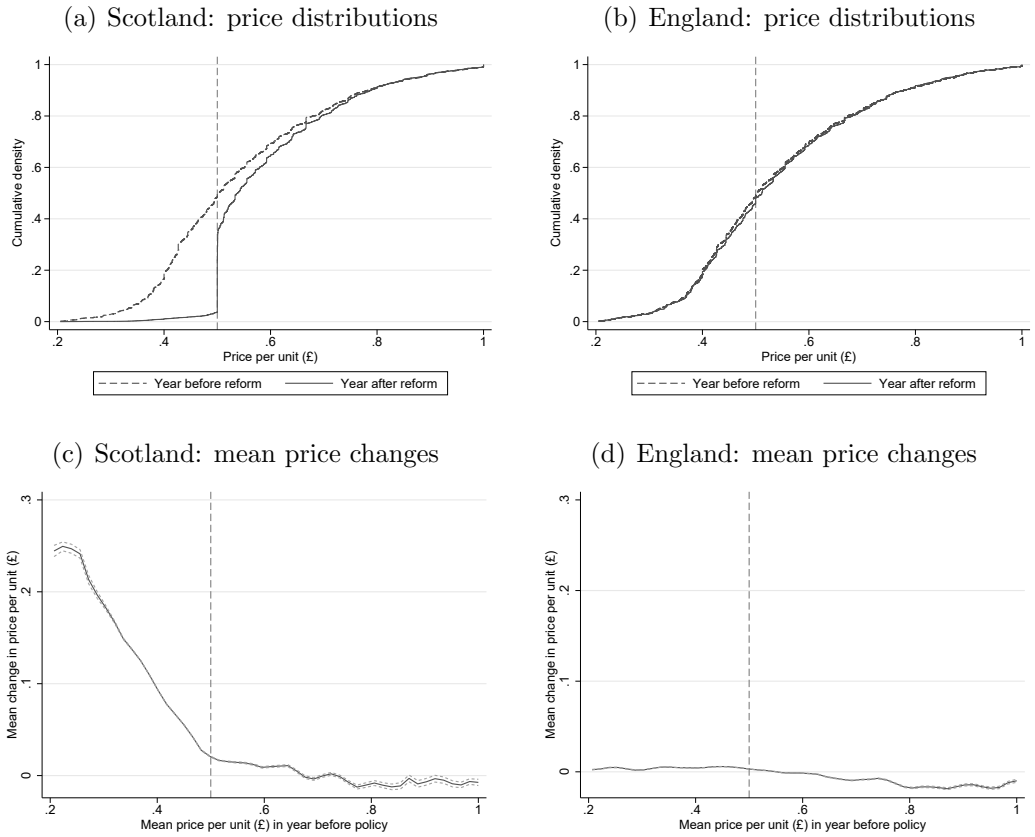
3 Effect of the price floor

3.1 Impact on price distribution

In Figure 1 we show how the distribution of prices changed in Scotland and England from the year before to the year after the introduction of the price floor.

Panel (a) shows that just under 50% of transactions in Scotland were below the floor in the year before the reform; following the reform around 40% of transactions were exactly at the price floor. In comparison, panel (b) shows that in the year prior to the introduction of the policy, the distribution of transaction prices in England was similar to Scotland, with little change in prices in England after the policy was introduced. Panel (c) shows the differential effect of the policy across the price distribution: some previously very cheap products experienced price increases in excess of 100%, while products that were priced above the floor pre-reform exhibit very little change in price. Panel (d) shows that these changes did not occur in England. In Online Appendix B.1 we use a difference-in-differences estimator, with England as a control group, to show that the price floor led to an increase in the average price paid per unit in Scotland of approximately £0.035 per unit. Figure 1 makes clear that this average increase is driven by large price rises for products that were previously priced below the floor and, following the policy's introduction, were priced at the price floor.

Figure 1: *Impact of the price floor on price distributions*



Notes: Panels (a) and (b) show the distributions of price paid per unit across transactions in the year before and the year after the introduction of the price floor in Scotland and England, respectively. Panels (c) and (d) show, for the set of products that are recorded as purchased in the year before and after (which account for 80% of spending across the two years), the average change in price per unit, conditional on the product's average price in the year preceding the reform.

In Online Appendix B.1 we show how price changes resulting from the floor vary across different types of alcohol. Cider and spirits were the most affected alcohol types. 54% of transactions for spirits, and 50% of those for cider, were below £0.50 in the year prior to the introduction of the floor. However, as there were more very cheap cider products than spirits, the increase in the average price of ciders that were priced below the floor was higher than for spirits (£0.12 versus £0.07 per unit). The policy also had a substantial effect on the distribution of beer and wine prices: 44% of beer (and 49% of wine) transactions were below the floor prior to its introduction, and for affected products the policy led to an average price increase of £0.07 per unit for both alcohol types.

Overall, the price floor was a substantial intervention in the market, which led to large price increases for cheap products of all alcohol types. Variation in the propensity of different households to buy affected products plays an important role

in how well targeted the policy is at heavy drinking. We return to this point in Section 3.3.

3.2 Impact on quantities

To determine the impact of the policy on the amount of alcohol purchased we use a difference-in-differences approach, comparing Scottish and English households. We estimate a regression of the form:

$$\mathcal{Q}_{iw} = \beta \times \text{treat}_i \times \text{post}_w + \gamma_{m(w)} + \mu_i + \boldsymbol{\chi}_{s(i)w} + \epsilon_{iw} \tag{3.1}$$

where $\mathcal{Q}_{iw}$ denotes units per adult per week, treat_i is a dummy variable equal to one if household i lives in Scotland, post_w is a dummy variable equal to one if week w is after the introduction of the price floor. $\gamma_{m(w)}$ are year-month effects, μ_i denote a set of household fixed effects, and $\boldsymbol{\chi}_{s(i)w}$ denotes controls for the weeks before Christmas, New Year and Easter, where we allow the effect of these holidays to differ between whether the household is based in Scotland or England (denoted by $s(i)$).

In Figure B.5 in Online Appendix B.2 we plot the time series of mean units per adult per week in Scotland and England. This shows that prior to the introduction of the floor, mean units purchased in Scotland and England evolved similarly and that when the policy was introduced there was a clear decline in units purchased in Scotland. We also formally tests for parallel pre-policy trends by plotting estimates from a dynamic difference-in-difference specification, which replaces $\beta \times \text{treat}_i \times \text{post}_w$ in equation (3.1) with a full set of Scotland specific time dummies, $\text{treat}_i \times \gamma_{m(w)}$. Both the raw data and the formal test provide strong support for parallel pre-policy trends in the two nations, and hence for our identifying assumption that the evolution of purchases in England are a good counterfactual for their evolution in Scotland in the absence of the price floor.

Table 1 reports our estimated $\hat{\beta}$ from equation (3.1), for various dependent variables. Column (1) shows results when the dependent variable is units per adult per week from all alcohol (column (2) shows this when we aggregate to the monthly level); column (3) shows results when we condition on weeks in which households purchase alcohol; column (4) shows results when the dependent variable is an indicator function for purchasing alcohol (i.e., $\mathbb{1}\{\mathcal{Q}_{iw} > 0\}$); in the remaining columns the dependent variable is units from products priced above and below the floor prior to its introduction (columns (5) and (6)), beer, wine, spirits and cider (columns (7) - (10)). We cluster standard errors at the county level, to allow for possible corre-

lation in unobservables across households living in the same area, for example, due to local store coverage or weather shocks.[8]

The price floor led to an average reduction of 0.60 (11.2%) units per adult per week. The policy led both to a reduction in the number of units, conditional on buying (of 7.5%) and a reduction in the probability that households choose to buy alcohol at all (of 3.0%). Units from products previously priced below the floor fell by an average of 0.90, but this reduction was partially offset by substitution towards products previously priced above the floor. Consistent with the impact of the floor on the price distribution of different alcohol types, we find that units from cider exhibit the largest percentage reduction, falling by 31.7%, followed by spirits (13.1%), wine (7.9%) and beer (7.6%).

Heterogeneous treatment effects

Our estimates of the average treatment effects mask variation across households. For the policy to be well targeted it is important that it leads to falls among those most likely to generate high externalities through their marginal consumption. We explore heterogeneity in treatment effects across three pre-treatment household attributes: long-run alcohol purchases (a proxy for the propensity to generate externalities), distance to the border and equivalised household income.

[8]In Online Appendix B.3 we show that our inference remains valid under a random inference approach.

Table 1: *Impact of the price floor on the average quantity of alcohol purchased*

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Total	Total	Conditional on buying	Prob. of buying	Previously below floor	Previously above floor	Beer	Wine	Spirits	Cider
Treatment effect	-0.595	-2.249	-1.314	-0.00877	-0.903	0.259	-0.0796	-0.178	-0.213	-0.124
	(0.126)	(0.502)	(0.279)	(0.003)	(0.102)	(0.057)	(0.026)	(0.106)	(0.065)	(0.040)
Mean of dep. variable	6.0	22.6	18.9	0.3	3.6	2.2	1.1	2.6	1.8	0.4
Percentage change	-11.2	-12.1	-7.5	-3.0	-25.6	14.5	-7.6	-7.9	-13.1	-31.7
R-squared	0.4610	0.7110	0.4965	0.3642	0.4677	0.2733	0.3851	0.4497	0.4050	0.3761
Number of observations	4076771	1075082	1287791	4076786	4076771	4076771	4076771	4076771	4076771	4076771
Level of aggregation	Week	Month	Week	Week	Week	Week	Week	Week	Week	Week
Time effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Household fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: The first row shows the estimated $\hat{\beta}$ from equation (3.1) for different dependent variables. Column (1) shows the results for total units of alcohol purchased per adult per week (p.a.p.w); column (2) for the total units when we aggregate the data to the monthly level; column (3) for the total units purchased p.a.p.w, conditional on buying a positive amount of alcohol; column (4) for a dummy variable if alcohol is purchased; (5) for units p.a.p.w from products priced below the floor pre-reform, (6) for units p.a.p.w from products priced above the floor pre-reform, (7) for units p.a.p.w from beer, (8) for units p.a.p.w from wine, (9) for units p.a.p.w from spirits and (10) for units p.a.p.w from cider. All regressions include household fixed effects, year-month effects and controls for major holidays. Standard errors are clustered at the county level.

For each attribute, we partition households into D groups based on their position in the distribution of the attribute. Denote the set of households belonging to group d by $\mathcal{D}_d$. We estimate a variant of equation (3.1) where we allow the treatment effect to vary across groups:

$$\mathcal{Q}_{iw} = \sum_{d=1}^{D} \beta_d \times \text{treat}_i \times \text{post}_w \times 1[i \in \mathcal{D}_d] + \gamma_{m(w)} + \mu_i + \boldsymbol{\chi}_{iw} + \epsilon_{iw}. \tag{3.2}$$

Figure 2 plots the estimated $\hat{\beta}_d$s in each case, with the red line showing the average treatment effect. Panel (a) shows heterogeneity in treatment effects across the long-run drinking distribution.[9] It show that for households in the bottom 70% of the long-run drinking distribution, the price floor had no statistically significant impact. However, the policy led to large reductions in units purchased at the top of the distribution. Households in the 90-95th percentile reduced their alcohol purchases by 2 units per adult per week, or 10.4%. The top 5% of drinkers (who buy, on average, more than 24 units per adult per week), reduced their purchases by 6 units per adult per week, a fall of 14.8%. Thus the price floor is well targeted at reducing the alcohol purchases of the heaviest drinkers.

In Panel (b) we explore whether there is evidence that households in Scotland engaged in cross-border shopping to avoid the price rises induced by the floor. It shows that for the 5% of households nearest to the border (which equates to less than 52km), the price floor did not lead to a statistically significant reduction in the number of units purchased. This indicates that there was some cross-border shopping in response to the policy. Note, however, that the impact of cross-border shopping on our estimate of the average treatment is negligible,[10] likely due to the low population density around the Scotland-England border.

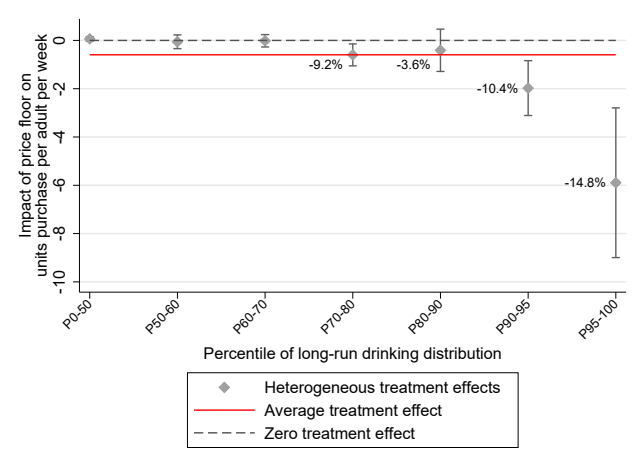
Panel (c) shows heterogeneity in the treatment effect by equivalised household income: there is little variation in the policy's impact on purchases across the income distribution.

[9]Note, since we use the period May 2016 to April 2017 to measure long-run units purchased per adult per week, in this case we estimate equation (3.2) over May 2017 to January 2020.

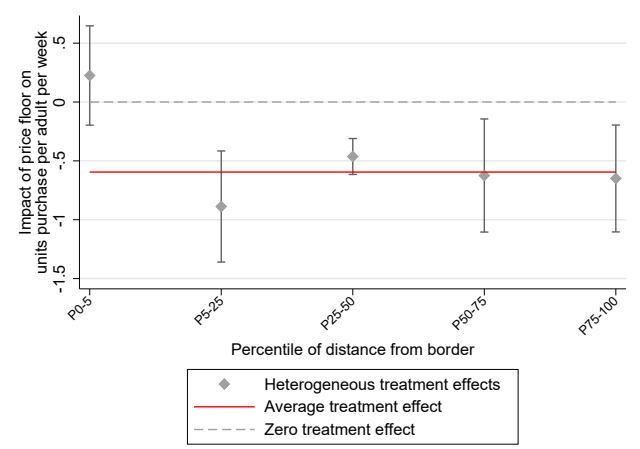
[10]In particular, re-estimating equation (3.1) omitting Scottish households within 52km of the border leads to a very similar estimate.

Figure 2: *Heterogeneity in treatment effects*

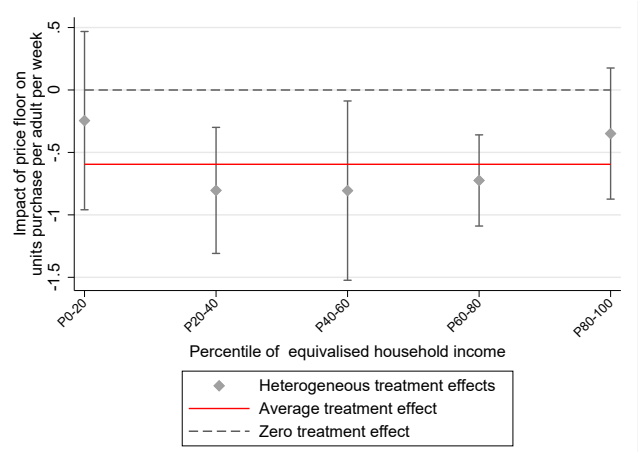
(a) By position in drinking distribution



(b) By distance from border



(c) By equivalised income



Notes: Each panel shows the estimated $\hat{\beta}_d$s from equation (3.2), for a separate household attribute – long-run alcohol purchases (panel (a)), distance to the border (panel (b)) and equivalised household income (panel (c)). In each case we group households based on their percentile in the distribution. See Tables A.2–A.3 in the Online Appendix for percentiles cutoffs. 95% confidence intervals are shown, based on standard errors clustered at the county level.

3.3 Why is the price floor well targeted at heavy drinkers?

The price floor achieves reductions in alcohol units that are larger in percentage (as well as level) terms for heavy drinkers relative to lighter drinkers – it is therefore well targeted at this group. This could reflect differences in the fraction of their basket of alcohol purchases affected by the policy, or how responsive their alcohol purchases are to the resulting prices changes. We explore this in Figure 3.

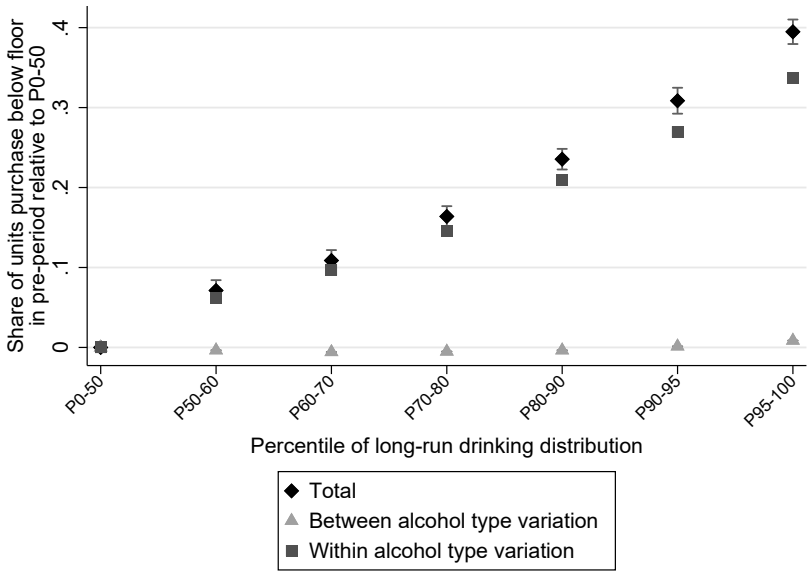
The black markers in panel (a) show how the fraction of units bought below the price floor varies across the distribution of long-term alcohol purchases. It shows that heavy drinkers obtained a much larger fraction of their alcohol from below price floor products – for example, on average, households in the top 5% of the drinking distribution got 40 percentage points more of their units from products priced below the floor, compared with households in the bottom half of the distribution.

The alcohol purchases of heavy and light drinkers vary both in the share they get from different alcohol types and the specific products chosen within these alcohol types. For instance, in the year before the price floor was introduced, those in the top 5% of the drinking distribution obtained 30% of their units from spirits, with 79% of their spirits units priced below the floor. In contrast, those in the bottom half of the drinking distribution obtained 19% of their units from spirits, with 26% of these priced below the floor. Across all alcohol types, heavy drinkers obtained a higher share of their units at prices below the floor (see Table B.2 in Online Appendix B). The red and blue markers in panel (a) show the relative importance of within and between alcohol type variation in driving exposure to the price floor across the long-run alcohol purchase distribution. It makes clear that more of heavy drinkers' alcohol baskets are directly impacted by the price floor because of within (rather than between) alcohol type differences.

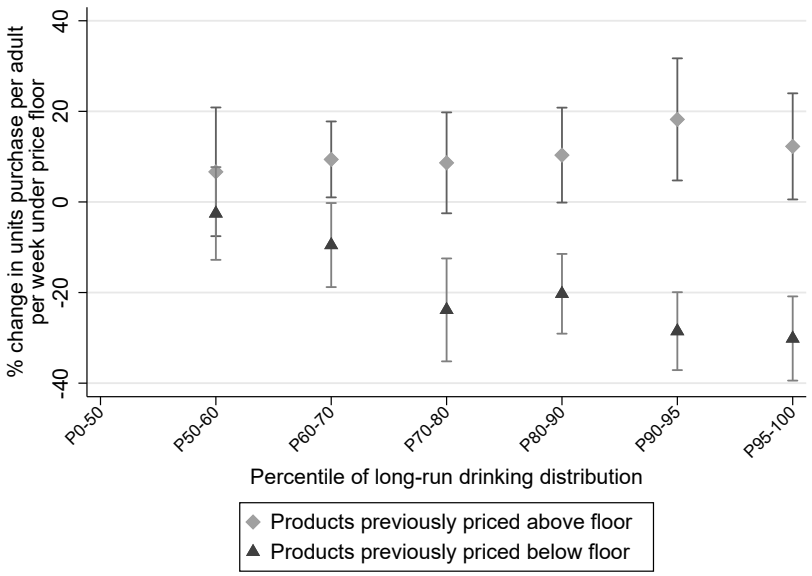
In Panel (b) we show how the percentage changes in units from cheap products (priced below the floor pre-reform) and non-cheap products vary across the long-run drinking distribution. The figure shows that the percentage increase in units that were previously priced above the floor is similar across the drinking distribution, at roughly 10%. In contrast, heavy drinkers reduced their purchases of previously below-floor products by substantially more than lighter drinkers. Those in the top 5% of the drinking distribution reduced units from cheap products by 30%, compared with 10% for those in the 60-70th percentile. The price floor is therefore well targeted at heavy drinkers because (i) they bought a disproportionate share of their units from cheap products pre-reform, and (ii) they reduced their purchases of these products considerably, with only limited switching towards more expensive products.

Figure 3: *Targeting of the price floor at heavy drinkers*

(a) Share of units below floor



(b) Switching patterns



Notes: The top panel shows the share of units purchased below the price floor in the pre-sample period across the drinking distribution, relative to households in percentiles 0–50. The triangle markers show variation when we hold the share of units below the floor within alcohol type (beer, wine, spirits and cider) at the mean, allowing only the alcohol type shares to vary across households. The square markers show variation when we hold the share of units from different alcohol types at the mean, but allow the share of units below the floor within alcohol type to vary across households. The bottom panel shows heterogeneity in the treatment effect (expressed in percentage changes relative to the mean of the variable pre-reform) of the price floor on units from products previously priced below the floor (dark triangles) and those previously priced above the floor (light diamonds). We omit the markers for the P0-50 group because the level changes are not statistically different from zero, and the denominator is also small. 95% confidence intervals are shown, based on standard errors clustered at the county level.

4 Comparison of a price floor with alcohol taxes

In order to compare the performance of a price floor with alcohol taxes we use the model of demand estimated in our earlier work, Griffith, O'Connell, and Smith (2019). In that paper, we model the consumer's decision over whether to buy alcohol, the type of alcohol and how much to buy. Specifically, we estimate choice between purchasing no alcohol or one of 69 varieties (aggregates of underlying products), that vary by alcohol type (e.g., strong premium beer or budget whisky) and by size (e.g., 500ml, 1-2 litres or 2×700ml) – see Table 4.3 of our earlier paper. We allow preference parameters to vary flexibly across five groups of households ordered by their position in the long-run drinking distribution, and we allow for unobserved preference heterogeneity within these groups of households. The model allows us to predict the distribution of units purchased per adult per week across households, including under different counterfactual policy reforms. In Online Appendix C we show that the model does a good job of matching the effect of the price floor across the drinking distribution, when compared with our difference-in-differences results.

We use the model to compare a price floor to two alternative tax reforms – replacing the existing set of alcohol duties with a tax rate per unit of alcohol, and with a system of tax rates applied per unit of alcohol that vary across different types of alcohols.[11] In each case we set the level of tax rates such that they lead to the same reduction in aggregate units as the price floor. For the multi-rate tax system we fix the differences between the tax rates to match those we compute in earlier work, which entail higher rates on stronger alcohol.[12]

Figure 4(a) shows how the change in units per adult per week resulting from each policy varies across the distribution of long-run drinking. The price floor achieves much larger falls in alcohol among heavy drinkers relative to light drinkers than the single ethanol tax rate. However, the multi-rate tax system leads to similar reductions in units purchased across the distribution of drinkers as the price floor. Although the price floor and multi-rate system have similar impacts on *total* units, they target different parts of households' alcohol baskets. The price floor leads to larger falls in cheap units among heavy drinkers than the multi-rate tax system,

[11] The multi-rate tax system entails eight rates, one for each of; beer with ABV<5%, beer with ABV>5%, cider with ABV<5%, cider with ABV>5%, spirits with ABV<20%, spirits with ABV>20%, wine with ABV<14%, wine with ABV>14%. For each reform we account for value added tax, levied on the duty inclusive price.

[12] These are optimal conditional on a particular mapping between units purchased and externalities, and the replacement of VAT with higher alcohol duties. The rates are illustrated in Figure C.1 in Online Appendix C.

while the multi-rate tax system leads to larger falls among their purchases of strong products (those with ABV above 30%) than the price floor.[13]

In Figure 4(b) we show the impact of these alternative policies on the sum of consumer surplus and tax revenue, minus externalities. This comparison depends on how alcohol consumption maps into externalities. We set the total externalities from alcohol consumption (at observed prices) equal to the estimate provided in UK Cabinet Office (2003), and show how results vary with the convexity of consumption externalities. We use a continuous function that maps units purchased per adult per week into a monetary value for externalities. To aid interpretation, we express the convexity of the function in terms of the fraction of total external costs accounted for by the 10% of heaviest drinkers, who buy more than 15 units per adult per week and account for 60% of all alcohol unit purchases.[14] When externalities are linear in consumption (so heavy drinkers account for 60% of externalities), each unit of alcohol consumed is equally costly and a single rate of ethanol tax outperforms the alternative policies (in the sense that it results in a higher value of consumer surplus and tax revenue, net of externality costs).

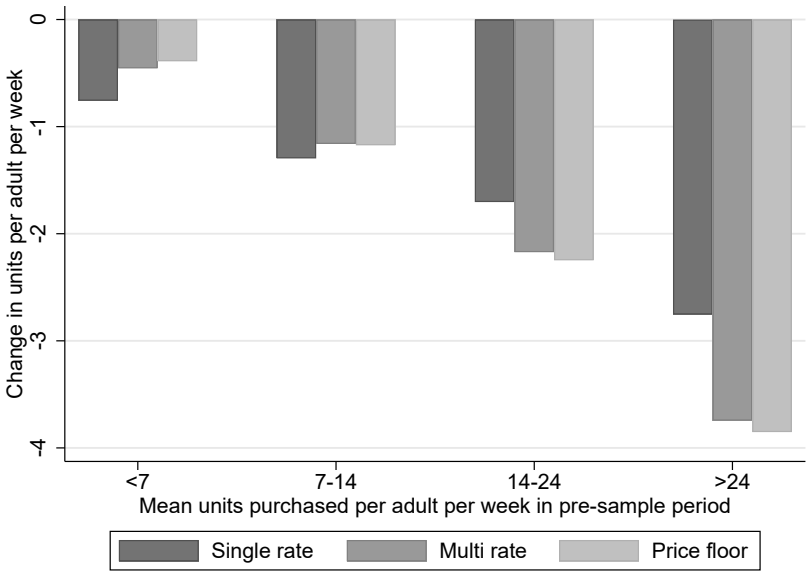
However, if externalities are convex in consumption, there are benefits to targeting policy at heavy drinkers. As long as externalities are at least mildly convex, the multi-rate tax system outperforms the single-rate system. This is because it achieves larger reductions in external costs with smaller reductions in consumer surplus (which offset lower tax revenue raised). For sufficiently convex externalities, the price floor also outperforms the single rate tax, for similar reasons – by raising the price of cheap products, it achieves relatively large falls in consumption among heavy drinkers and hence in externalities, but with smaller losses to consumer surplus. However, independently of the externality convexity, the multi-rate tax system outperforms the price floor. The primary reason for this is that while raising prices through tax policy increases public revenues, a price floor leads to windfall gains for the alcohol industry.

[13] See Table C.1 in Online Appendix C

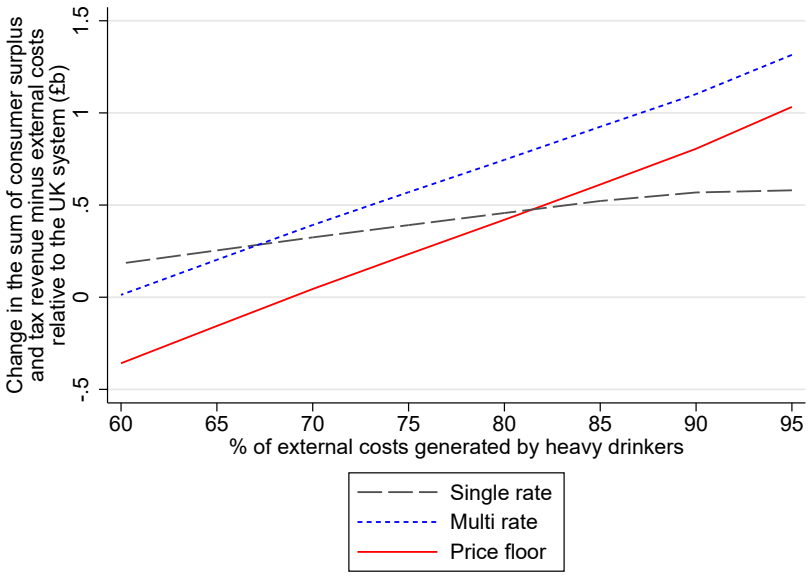
[14] See Online Appendix C.4 for further details.

Figure 4: *Impact of price floor and tax reforms*

(a) Total units



(b) Consumer suplus + tax revenue − externalities



Notes: The top panel shows the impact of the reforms on units across the long-run drinking distribution. The bottom panel shows the change in the sum of consumer surplus and tax revenue minus external costs under the three different reforms, under varying assumptions about the convexity of the externality function.

A government may choose to place weight on the profits that accrue to the alcohol industry. We do not directly measure profits,[15] but we can compute the windfall gains that a price floor confers on sellers of products previously sold below

[15]We do not observe product level marginal costs, and it is beyond the scope of this study to estimate them for the thousands of alcohol products that comprise the UK alcohol market.

the floor,[16] which equals £383 million per year. These gains are enough to offset the differences between the multi-rate tax system and the price floor in consumer surplus plus tax revenue net of externalities, reported in Figure 4(b). Therefore, if the government places equal value on firm profits as it does on consumer surplus and public funds, or if it can claw back alcohol industry windfall gains due to the price floor through taxation, the overall performance of the price floor is similar to the multi-rate tax system (though with markedly different effects for consumers, firms and public revenues).

5 Conclusion

In this paper, we evaluate the impact of a price floor on alcohol prices and purchases. We show that it is well targeted at heavy drinkers, while leaving the alcohol purchases of the bottom 70% of drinkers unaffected. This is because, prior to the reform, heavy drinkers obtained a disproportionate share of their alcohol units from cheap products and the reform led them to switch strongly away from these products. The policy therefore achieves its goal of reducing alcohol consumption among those whose drinking is likely to have the highest social costs. We also show that a simple tax reform is equally well targeted at heavy drinkers but raises more tax revenue than the price floor. This is because a price floor provides windfall gains to the alcohol industry, rather than raising tax revenue. If a price floor is used alongside a levy on these windfall gains its overall welfare performance is similar to the simple tax reform we consider.

One reason why Scotland implemented a price floor is that it does not have the constitutional powers to vary alcohol tax rates. In addition, in 2018, when the policy was adopted, the UK was highly constrained by European law in the tax reforms that were legally permissible. However, this is no longer the case and means the UK has the flexibility to rationalise alcohol taxation. An interesting avenue for future research is to explore whether there are complementarities in jointly setting tax policy and a price floor to combat the social harms for externality generating goods such as alcohol.

[16] Let $\tilde{\mathbf{p}}^1$ and $\tilde{\mathbf{p}}^0$ denote the vector of tax-exclusive post- and pre-reform prices, $\mathbf{p}^1$ and $\mathbf{p}^0$ denote the corresponding tax-inclusive prices and $\mathbf{q}(\mathbf{p})$ denote the vector of demands. We define windfall industry gains as $(\tilde{\mathbf{p}}^1 - \tilde{\mathbf{p}}^0)\mathbf{q}(\mathbf{p}^1)$. This corresponds to the change in firm profits under perfect competition and marginal cost pricing.

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Online Appendix

Price Floors and Externality Correction

Rachel Griffith, Martin O'Connell and Kate Smith

A Data on prices and quantities purchased

A.1 Kantar FMCG Purchase Panel

Households in the Kantar FMCG Purchase Panel record purchases that they make and bring into the home using a handheld scanner. The data contain information on the transaction price, pack size and other product attributes, including alcohol-by-volume (ABV). For around 0.5% of the alcohol products, ABV is not reported. In this case, we use an average computed by alcohol type (of which there are seven) and brand. We calculate the number of alcohol units in a product as the product volume in litres multiplied by ABV. For instance, a 1 litre bottle of vodka with 40% ABV has 0.4 litres of ethanol and hence 40 units of alcohol (1 unit of alcohol = 10ml of ethanol).

Table A.1 shows the summary statistics for households in our sample. In our analysis we include all weeks in which the household records positive grocery spending. If they do not buy alcohol, then we record this as a zero alcohol purchase. We drop households who never record buying alcohol across our entire sample period. No alcohol is purchased on 68% of the approximately 4 million household-year-weeks in our sample. Table A.1 shows that households in Scotland and England are broadly similar in terms of the number of adults in the household, age of main shopper, equivalised income and spending on groceries and alcohol.

Figure A.1 shows the distribution of long-run average alcohol purchases. For each household in our sample, we compute the mean number of units purchased per adult per week in the year from May 2016 to April 2017. The figure shows that the distributions for England and Scotland are broadly similar, although the

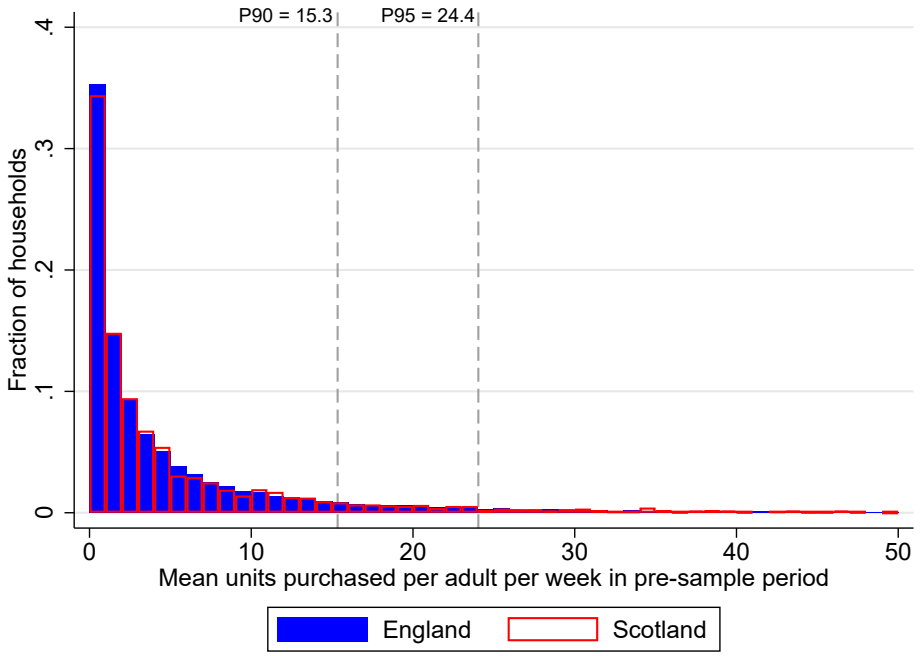
average is slightly higher in Scotland. We control for household fixed effects in our empirical analysis, which means we use only differential within-household variation in purchases across England and Scotland to identify the impact of the price floor. Tables A.2–A.3 show the distribution of three variables, along which we investigate heterogeneity in the treatment effect of the price floor.

Table A.1: *Household characteristics*

	England		Scotland	
	May 2016-April 2018	May 2018-Jan 2020	May 2016-April 2018	May 2018-Jan 2020
Number of households	26928	25572	2720	2580
Number of adults per hh	2.04	2.04	1.96	1.97
Age of main shopper	52.6	53.6	53.3	54.2
Equivalised household income	20197.7	20380.0	20051.7	20233.3
Mean weekly grocery expenditure	61.8	63.1	59.9	60.8
Mean weekly alcohol expenditure	5.4	5.7	6.0	6.4

Notes: The first row of the table show the number of households in our sample in England and Scotland before and after the introduction of the price floor. The remaining rows show the mean values of variables listed in the first column in England and Scotland before and after the introduction of the price floor. Equivalised household income is expressed in £ per year.

Figure A.1: *Distribution of long-run average drinking*



Notes: For each household we compute the mean number of units purchased per adult per week in the year from May 2016 to April 2017. The figure shows the distribution of this variable separately by England and Scotland. The vertical lines show the 90th and 95th percentiles (across both countries).

Table A.2: *Distribution of long-run average drinking*

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Mean units p.a.p.w		No. hh		% hh		Mean units p.a.p.w	
Percentile band	Range	England	Scotland	England	Scotland	England	Scotland
P0-50	0-2.0	12482	1165	50.1	49.4	0.8	0.9
P50-60	2.0-3.2	2503	227	10.0	9.6	2.7	2.7
P60-70	3.2-5.0	2484	246	10.0	10.4	4.0	4.1
P70-80	5.0-8.3	2508	221	10.1	9.4	6.4	6.6
P80-90	8.3-15.3	2500	230	10.0	9.8	11.2	11.3
P90-95	15.3-24.4	1241	124	5.0	5.3	19.1	19.2
P95-100	24.4+	1219	145	4.9	6.1	40.6	42.5

Notes: Column (1) lists the percentile bands into which we group households based on their mean units purchased per adult per week in May 2016 – April 2017; column (2) shows the range of mean units within each band. Columns (3) and (4) show the number of households in each band in England and Scotland, and columns (5) and (6) show the percentage of households. The final two columns show the mean units purchased per adult per week across all households and weeks in each band prior to the introduction of the price floor.

Table A.3: *Distance from the border*

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Distance from border		No. hh		% hh		Mean units p.a.p.w	
Percentile band	Range	England	Scotland	England	Scotland	England	Scotland
P0-5	0-52km	–	150	–	5.2	–	7.9
P5-25	52-102km	–	544	–	20.0	–	7.1
P25-50	101-120km	–	658	–	25.0	–	6.1
P50-75	120-137km	–	691	–	24.7	–	6.6
P75-100	137km+	–	677	–	25.1	–	7.0

Notes: Column (1) lists the percentile bands into which we group Scottish households based on their distance from the Scotland-England border; column (2) shows the range of distances within each band. Column (4) shows the number of households in each band in Scotland, and column (6) shows the percentage of households. The final column show the mean units purchased per adult per week across all households and weeks in each band prior to the introduction of the price floor.

Table A.4: *Distribution of equivalised household income*

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Equivalised household income		No. hh		% hh		Mean units p.a.p.w	
Percentile band	Range	England	Scotland	England	Scotland	England	Scotland
P0-20	0-10.7k	4585	473	17.1	17.3	5.2	5.8
P20-40	10.7-15.8k	4492	482	16.7	17.9	5.6	6.9
P40-60	15.8-21.7k	4636	447	17.2	16.5	5.8	6.8
P60-80	21.7-29.2k	4555	458	16.8	16.5	6.3	6.4
P80-100	29.2k+	4520	451	16.9	16.9	6.7	7.9
Unknown	Unknown	4140	409	15.3	15.0	5.7	6.6

Notes: Column (1) lists the percentile bands into which we group households based on their equivalised household income (using the OECD-modified equivalence scale); column (2) shows the range of mean equivalised income (£/year) within each band. Columns (3) and (4) show the number of households in each band in England and Scotland, and columns (5) and (6) show the percentage of households. The final two columns show the mean units purchased per adult per week across all households and weeks in each band prior to the introduction of the price floor.

A.2 Comparison of Kantar with LCFS

The main consumer expenditure survey in the UK is the Living Cost and Food Survey (LCFS).[1] Table A.5 shows that our sample of households is similar along key demographics with those in the LCFS. It also shows that, conditional on making an alcohol purchase over a two-week period, households in the Kantar data report buying a similar quantity of units per adult per week to those in the Living Costs and Food Survey. In making this comparison, we condition on buying alcohol in order to make the measurement comparable across the two datasets: the LCFS records household spending using a two-week diary, which means that we cannot compute long-run measures of household alcohol purchases in the LCFS. We also compare the share of households who record never buying alcohol in the Kantar data to share who report not drinking in the past twelve months in the Health Survey for England; both record approximately 15%.

[1]Previously called the Expenditure and Food Survey (EFS) and before that the Food and Expenditure Survey (FES).

Table A.5: *Household characteristics*

	Kantar	LCFS
Region		
England - North	27.9	26.1
	[27.3, 28.5]	[24.7, 27.5]
England - Midlands	18.0	17.0
	[17.5, 18.5]	[15.9, 18.2]
England - South and East	45.1	47.1
	[44.5, 45.7]	[45.6, 48.7]
Scotland	9.0	9.7
	[8.7, 9.4]	[8.9, 10.5]
Employment status of household head		
Full time	41.7	42.7
	[41.1, 42.3]	[41.2, 44.2]
Part time	21.3	10.6
	[20.8, 21.8]	[9.7, 11.5]
Self-employed*		8.7
	[., .]	[7.9, 9.6]
Unemployed	1.8	1.6
	[1.6, 2.0]	[1.2, 2.0]
Retired or not working	35.2	36.4
	[34.6, 35.8]	[34.9, 37.9]
Socioeconomic status		
Highly skilled	22.1	22.5
	[21.5, 22.7]	[20.9, 24.1]
Semi skilled	59.5	58.0
	[58.7, 60.2]	[56.1, 59.9]
Unskilled	18.1	19.5
	[17.6, 18.7]	[17.9, 21.0]
Alcohol purchases		
Average weekly units, conditional on buying	13.1	14.1
	[12.8, 13.4]	[13.5, 14.8]
Share of units consumed at-home		76.2
	[., .]	[75.2, 77.3]
Share of alcohol spending at-home		51.9
	[., .]	[50.6, 53.1]

*Notes: Table shows the share of households in the Kantar FMCG Purchase Panel and Living Costs and Food Survey (LCFS) in various demographic groups. Numbers are shown for May 2017 – April 2018 (i.e. the year before the floor was introduced) in both datasets. * The self-employed are not distinguished from employees in the Kantar data. Socioeconomic status is based on the occupation of the head of the household and is shown for the set of non-pensioner households. Average weekly units are measured per adult, are for at-home consumption only, and are conditional on the household buying alcohol across the two week measurement period. The bottom two rows shows the share of aggregate units and expenditure for at-home alcohol consumption in the LCFS data. 95% confidence intervals are shown below each share.*

A.3 Purchases out-of-home: the "on-trade"

Our data covers alcohol consumed at home, which makes up around three-quarters of units consumed in the UK. Out-of-home consumption in pubs and restaurants – often referred to as the "on-trade" – makes up the remaining 25% of units consumed. These calculations use the LCFS; see above for a description of these data. It is important to note that the share of expenditure on alcohol consumed outside of the home is higher, at 48%. This is because alcohol consumed out-of-home is more expensive than that bought in supermarkets and other stores.

These figures from the LCFS are in line with those produced by the Scottish government using market research data, obtained from Nielsen and CGA Strategy for 1994, 1995 and 2000–2018. The following summarises some of the key points from these data, taken from NHS Health Scotland (2019).

> *"In 2018, a total of 44.7 million litres of pure alcohol were sold in Scotland. ... 73% of all alcohol sold in Scotland was sold through the off-trade (supermarkets and other off-licences) compared with 27% sold through the on-trade (such as pubs, clubs and restaurants)." (NHS Health Scotland (2019), page 6).*

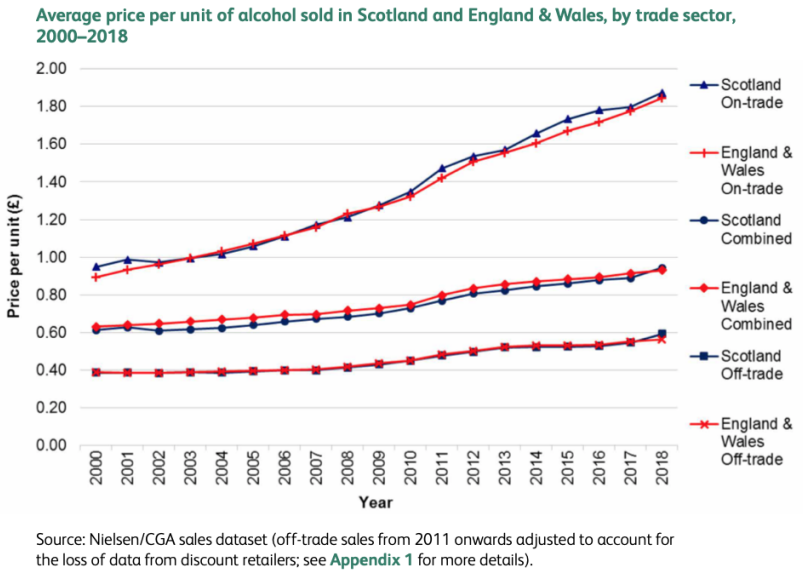
We use the National Health and Nutrition Examination Survey (NHANES) to compare these figures with those in the US. We find that 31% of units are consumed out of the home in the US – this is a little higher than the UK, but not markedly out of line. NHANES does not have information on spending, so we cannot use it to compare the expenditure shares with the UK.

In this section, we address three potential concerns relating to our focus on at-home consumption. First, we argue that the price floor is unlikely to directly affect out-of-home consumption because prices are much higher in this sector. Second, we discuss whether the price floor may lead to substitution from at-home to out-of-home consumption. Third, we discuss the implications for our comparison of the price floor and tax reform.

Impact of the price floor on out-of-home consumption

Prices of alcohol purchased in the on-trade sector are substantially higher than those bought off-trade. Figure A.2 shows that unit prices for the on-trade have risen considerably over the last few decades, while prices in the off-trade are much lower (£0.60 per unit compared to £1.80 per unit) and have remained low. The much higher price level on-trade means the floor does not directly affect the prices in this segment.

Figure A.2: *Change in relative prices of on- and off-trade*



Notes: Reproduced from NHS Health Scotland (2019) p9.

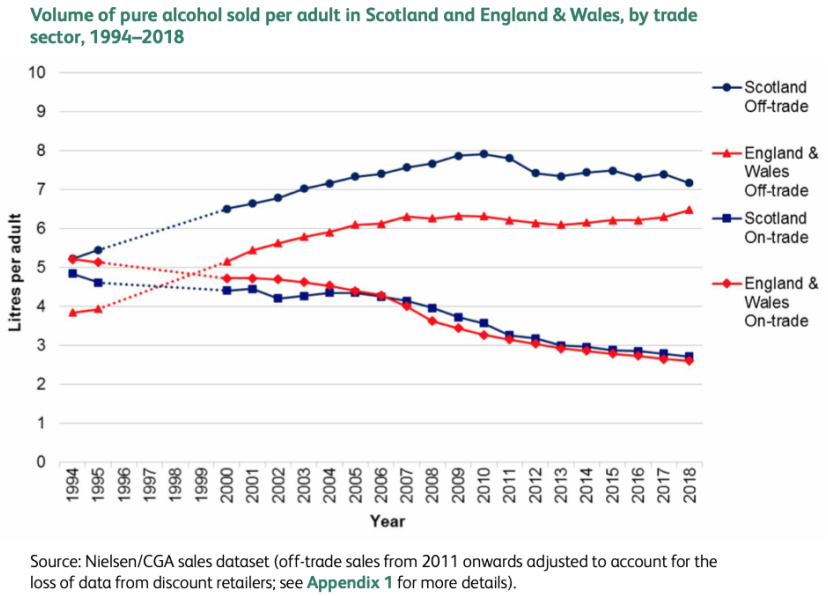
Substitution between at-home and out-of-home consumption

It is possible that households substitute between consumption at-home and out-of-home in response to policy reforms. However, we think this effect is likely to be relatively small.

The view taken by the Office of Fair Trading (OFT), formerly the UK regulator for consumer protection and competition law, in several merger and competition investigations in the alcohol market is that the on-trade and off-trade constitute separate markets. Thus, changes in prices in one would not be expected to materially affect behaviour in the other. See, for example, the discussion in paragraph 36 in the OFT's decision about the merger between Diego PLC and United Spirits Ltd, two whisky distillers (Office of Fair Trading (2014)). The report concludes, "*As noted above, the parties supply to both on-trade and off-trade customers. The Commission has considered each to be distinct markets in relation to the supply of whisky in a recent decision (footnote Pernod Ricard/V&S) 13 and noted the distinction in others (Guinness/Grand Metropolitan, Pernod Ricard/Diageo/Seagram Spirits)*".

Figure A.3 shows that, over the last few decades, the size of the off-trade in terms of volume of pure alcohol sold has grown relative to the on-trade. It also shows that there was no difference in the change from 2017 to 2018 in aggregate on-trade purchases of alcohol between Scotland and England. This suggests that the price floor did not affect on-trade alcohol purchases.

Figure A.3: *Purchases of alcohol in the off-trade relative to on-trade*



Notes: Reproduced from NHS Health Scotland (2019) p7.

Out-of-home consumption and policy comparison

In Section 4 of the paper we compare the effects of a price floor to that of tax reforms. Alcohol taxes apply to both off-trade and on-trade alcohol, therefore tax reforms would affect on-trade prices, and potentially consumption in this segment. On-trade responses are not covered by our analysis. Note, however, that because prices on-trade are much higher than off-trade (three times higher on average) the impact of tax reforms we consider (per-unit specific taxes) on on-trade prices will be much smaller in percentage terms than off-trade price, and consequently it is likely consumption responses will be too.

B Additional difference-in-differences results

B.1 Prices

Figure B.1 shows the mean price paid per unit (across transactions) in England and Scotland before and after the introduction of the price floor. Prior to its introduction, prices moved similarly. We use a difference-in-differences approach to assess the impact of the introduction of the price floor in Scotland, by comparing

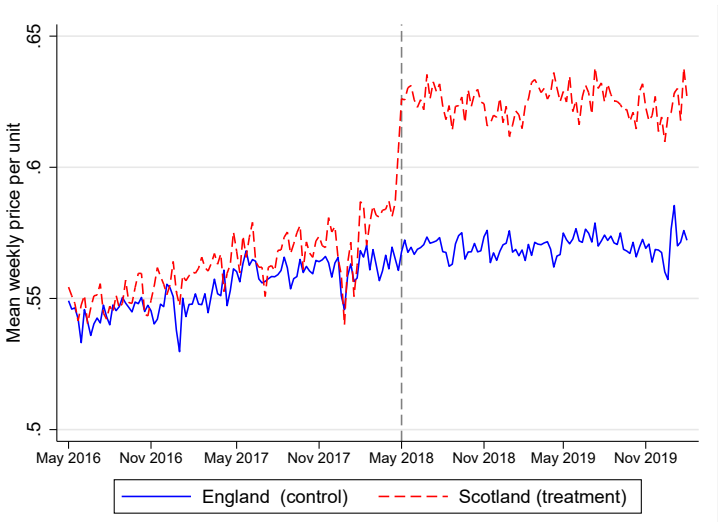
to price changes in England. We estimate (across all alcohol products in our data):

$$p_{jt} = \sum_{m=1}^{45} (\beta_{m(t)} \times \text{treat}_t + \gamma_{m(t)}) + \zeta_j + \mu_{i(t)} + \boldsymbol{\chi}_t + \epsilon_{jt} \tag{B.1}$$

where m indexes year-months, treat_t is a dummy variable equal to one if transaction t was made by a household that lives in Scotland, $\gamma_{m(t)}$ are year-month effects, ζ_j denote product fixed effects, $\mu_{i(t)}$ are household fixed effects, and $\boldsymbol{\chi}_t$ are controls for the weeks before Christmas, New Year and Easter, where we allow the effect of these holidays to differ between Scotland and England.[2]

Figure B.2 plots the $\hat{\beta}_m$s. Prior to the introduction of the policy, the coefficients are not statistically different from zero, indicating that prices satisfy parallel pre-trends. Once the policy came into force, there was a sharp £0.035 /unit increase in mean price in Scotland relative to England. This corresponds to a mean price increase of roughly 5%, although, as shown in Figure 1, this mean effect consists of a mix of large price increases for cheap (per unit of alcohol) products and no changes for more expensive (per unit of alcohol) products. Figure B.3 and Table B.1 show the change in the price distribution across alcohol types.

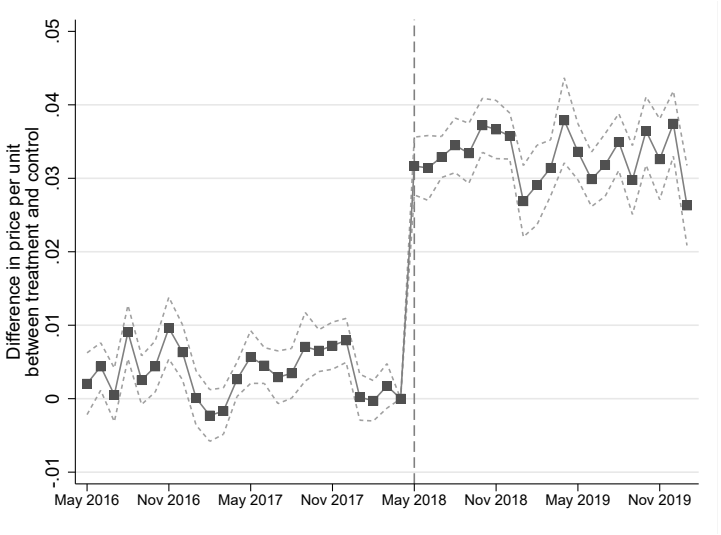
Figure B.1: *Average price per unit of alcohol in England and Scotland, 2016-20*



Notes: The figure shows the mean price paid per unit of alcohol in England and Scotland in each week from May 2016 to January 2020. The dashed vertical line shows the introduction of the Scottish price floor on 1 May 2018.

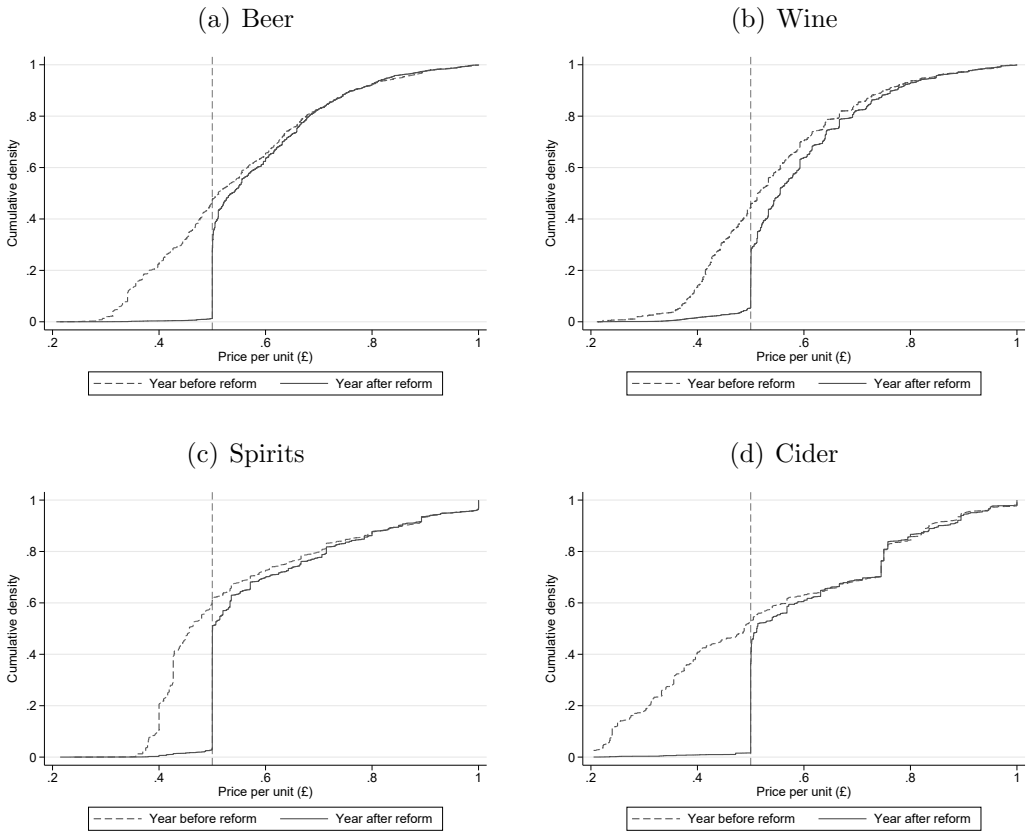
[2]For instance, the tradition of celebrating "Hogmanay" – the last day of the year – in Scotland means considerably more alcohol per person is purchased there than in England.

Figure B.2: *Dynamic event study: mean price paid per unit*



Notes: Figure plots the estimated $\hat{\beta}_m$s from equation (B.1), where we omit the year-month just prior to the introduction of the price floor in May 2018 (shown by the vertical dashed line). 95% confidence intervals are shown, with standard errors clustered at the county level.

Figure B.3: *Impact of the price floor on the alcohol price distributions, by alcohol type*



Notes: Each panel shows the distributions of price paid per unit across transactions in the year before and the year after the introduction of the price floor in the Scotland, for different alcohol types.

Table B.1: *Impact of the price floor across alcohol types*

	% trans. below floor in year prior	Mean p_{jt} in year prior		Change in p_{jt} in Scotland for below floor products
		All	Below floor	
Beer	44.1	0.557	0.409	0.072
Wine	48.6	0.554	0.422	0.066
Spirits	53.7	0.603	0.421	0.071
Cider	49.7	0.572	0.334	0.123

Notes: The first column shows the percentage of transactions (in Scotland and England) below the 50p price floor in the year prior to its introduction for different alcohol types. The second and third columns show the mean price per unit for all products and those price below the floor in the year prior, respectively, for different alcohol types. The final column shows the mean change in price per unit for those products previously priced below the floor.

B.2 Quantities

Mean effect

Figure B.4 shows the mean units purchased per adult per week in Scotland and England before and after the introduction of the price floor. Prior to its introduction, alcohol purchases were higher in Scotland than England. In May 2018, when the price floor was introduced, there was a drop in units purchased in Scotland, but no change in England.

As above, we estimate the impact of the price floor using a dynamic difference-in-differences approach. We estimate:

$$\mathcal{Q}_{iw} = \sum_{m=1}^{45} (\beta_{m(w)} \times \text{treat}_i + \gamma_{m(w)}) + \mu_i + \boldsymbol{\chi}_{iw} + \epsilon_{iw} \tag{B.2}$$

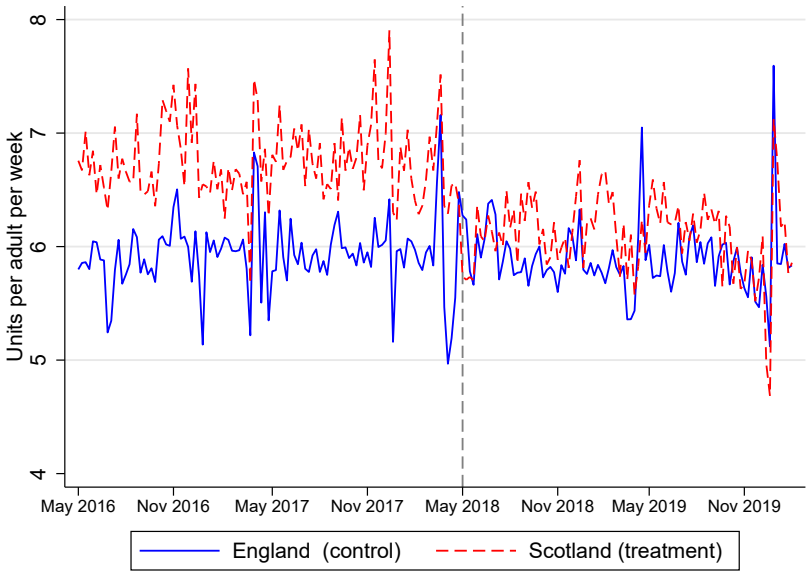
where m indexes year-months, treat_i is a dummy variable equal to one if household i lives in Scotland, $\gamma_m(w)$ are year-month effects, μ_i are household fixed effects, and $\boldsymbol{\chi}_{iw}$ are controls for the weeks before Christmas, New Year and Easter, where we allow the effect of these holidays to differ between Scotland and England.

Figure B.5 plots the $\hat{\beta}_m$, which are the estimated differences in the quantity of alcohol purchased (mean units per adult per week) between households in Scotland and England in the months before and after the introduction of the price floor. We omit the month immediately prior to the introduction of the price floor.

Before the introduction of the price floor, the profile of coefficients is flat, with the exception of an increase one month immediately prior to its adoption. This indicates that units purchased evolved similarly in Scotland and England prior to the policy's introduction, except in April 2018 when units purchased by Scottish households increased relative to purchases by English households. This is consistent

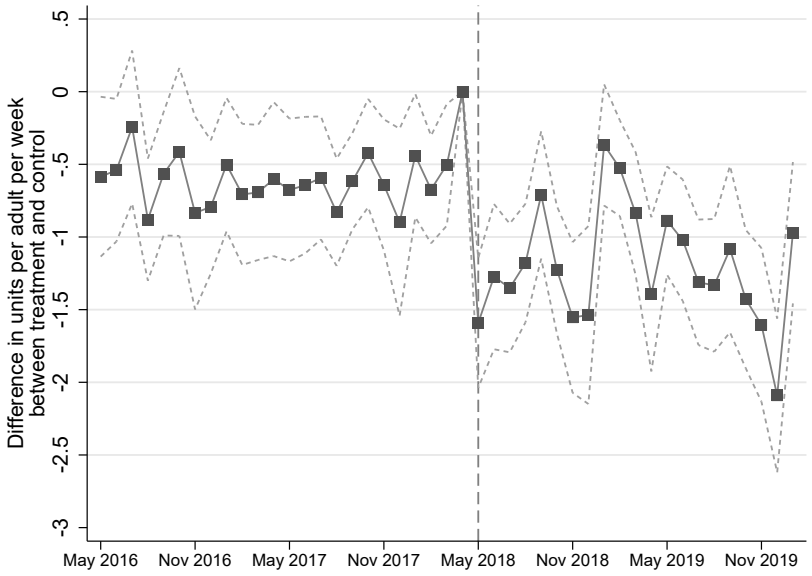
with stockpiling behaviour in anticipation of higher future prices. Following the introduction of the policy in May 2018, there was a drop in units purchased in Scotland relative to England. The month-to-month changes are somewhat noisy; however, overall there is a clear decline in Scotland relative to England from the period before to after the reform. The decline is 0.60 units per adult per week, which is highly statistically significant and represents an 11% reduction in average alcoholic units purchased (see Table 1).

Figure B.4: *Average units of alcohol purchases per adult per week in England and Scotland, 2016-20*



Notes: The figure shows the mean units purchased per adult per week across households in England and Scotland in each week from May 2016 to January 2020. We remove country-specific week effects from all series. The dashed vertical line shows the introduction of the Scottish price floor on 1 May 2018.

Figure B.5: *Dynamic event study: units purchased*



Notes: Figure plots the estimated $\hat{\beta}_m$s from equation (B.2), where we omit the year-month just prior to the introduction of the price floor in May 2018 (shown by the vertical dashed line). 95% confidence intervals are shown, with standard errors clustered at the county level.

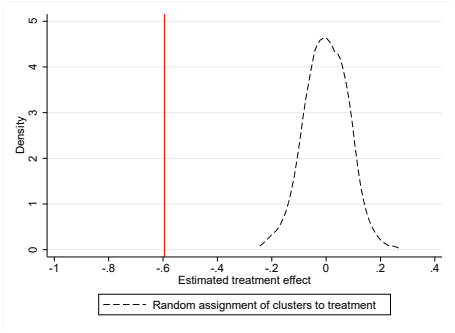
B.3 Randomisation inference

In our main analysis, we cluster the standard errors at the county level. A potential concern is that the number of treated clusters (counties in Scotland) are fewer than the number of control clusters (counties in England) and this can lead to unreliable inference. To address this concern we implement a randomisation inference procedure. For more details, see the discussion in MacKinnon and Webb (2020).

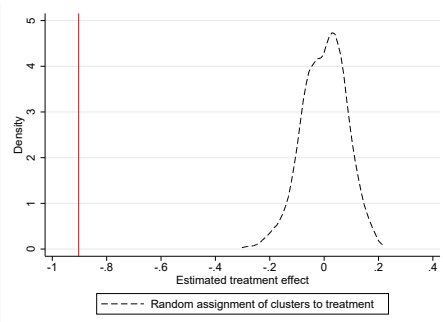
We have a total of 116 counties – 23 in Scotland and 93 in England. We randomly assign 23 from the full sample to the "treated" group and the remainder to the "control". We then re-estimate the difference-in-differences specification (equation 3.1), using these random groupings. We repeat this 500 times. Figure B.6 shows the distributions of the estimated treatment effects using the random assignment, alongside the actual estimated treatment effect (vertical red line). The figure shows that for all the dependent variables, the actual estimated effect is well outside the distribution of those estimated using random assignment. This gives us confidence about the statistical significance of our results.

Figure B.6: *Randomisation inference for treatment effects*

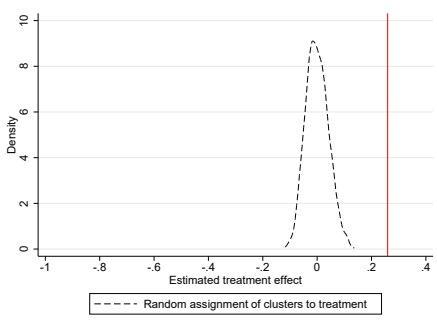
(a) Total units



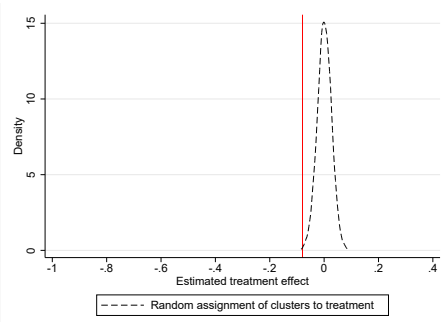
(b) Products previously below floor



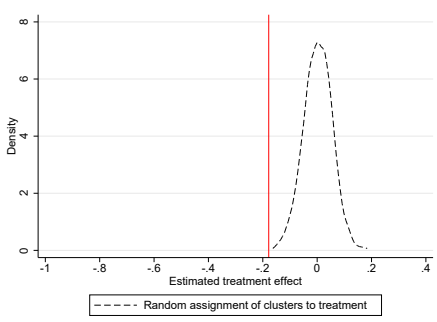
(c) Products previously above floor



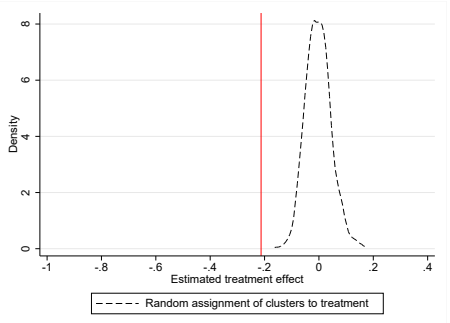
(d) Beer



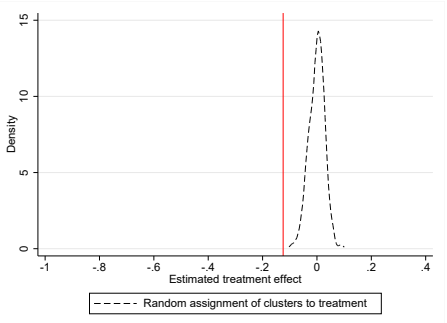
(e) Wine



(f) Spirits



(g) Cider

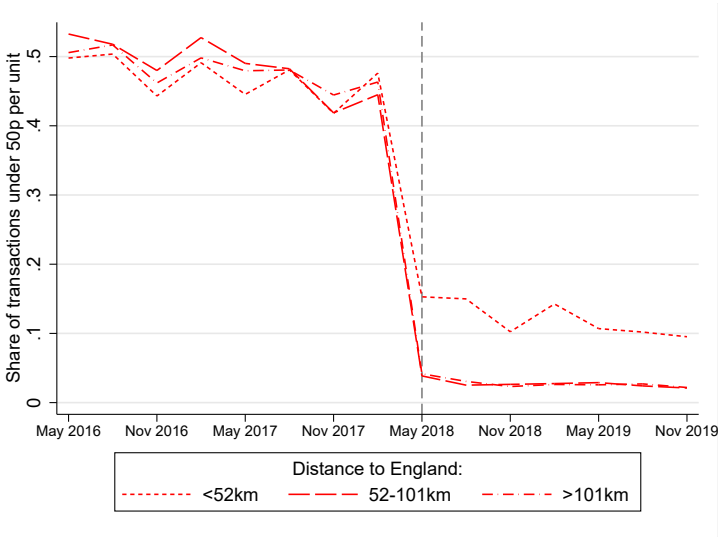


Notes: The red lines denote our average treatment effect estimates reported in Table 1. The distributions plot the estimated average treatment effects under random assignment of counties into treatment.

B.4 Heterogeneity in treatment effects

In Figure 2 we show that there was no significant reduction in units purchased following the introduction of the price floor for Scottish households living within 52km of the border with England. Figure B.7 provides additional evidence on this being driven by cross-border shopping, showing that 10-15% of transactions by households in this area are at prices below the floor (following its introduction) compared with close to zero for households further away from the border. It is important to note, however, that there are relatively few households in this region, and so they do not have a significant impact on our estimate of the average treatment effect.

Figure B.7: *Share of transactions by Scottish households below the price floor, by distance from the English border*



Notes: The lines show the share of transactions by Scottish households under the £0.50 unit price before and after the introduction of the price floor in May 2018 for households that live within 52km of the English border, between 52-101km and above 101km.

Table B.2 shows how the fraction of households' alcohol baskets from beer, wine, spirits and cider in year prior to the introduction of the price floor vary across percentiles of the distribution of long-run alcohol purchases. The top panel shows numbers for all units and the bottom panel shows numbers for units priced below the floor.

Table B.2: *Fraction of alcohol basket affected by price floor, across the drinking distribution*

	Beer	Wine	Spirits	Cider
% of total units from type				
P0-50	26.6	40.5	18.7	14.2
P50-60	26.9	45.4	16.6	11.1
P60-70	26.4	48.4	15.3	9.9
P70-80	26.3	48.9	16.2	8.6
P80-90	22.8	51.1	18.6	7.5
P90-95	20.7	49.2	23.2	6.8
P95-100	15.5	46.6	30.1	7.7
% of type's units from below floor products				
P0-50	30.6	31.8	25.9	25.0
P50-60	35.8	37.4	34.0	32.0
P60-70	40.1	38.3	42.0	37.3
P70-80	45.1	42.1	47.8	45.8
P80-90	51.9	46.0	60.1	51.4
P90-95	58.6	49.3	68.1	64.8
P95-100	62.1	55.2	79.2	74.6

Notes: The top panel shows the mean percentage of units from each alcohol type across the drinking distribution, in the year prior to the introduction of the price floor. The bottom panel shows the mean percentage of units from each type that were bought below the price floor, in the year prior to its introduction, across the drinking distribution.

C Additional details on policy comparison

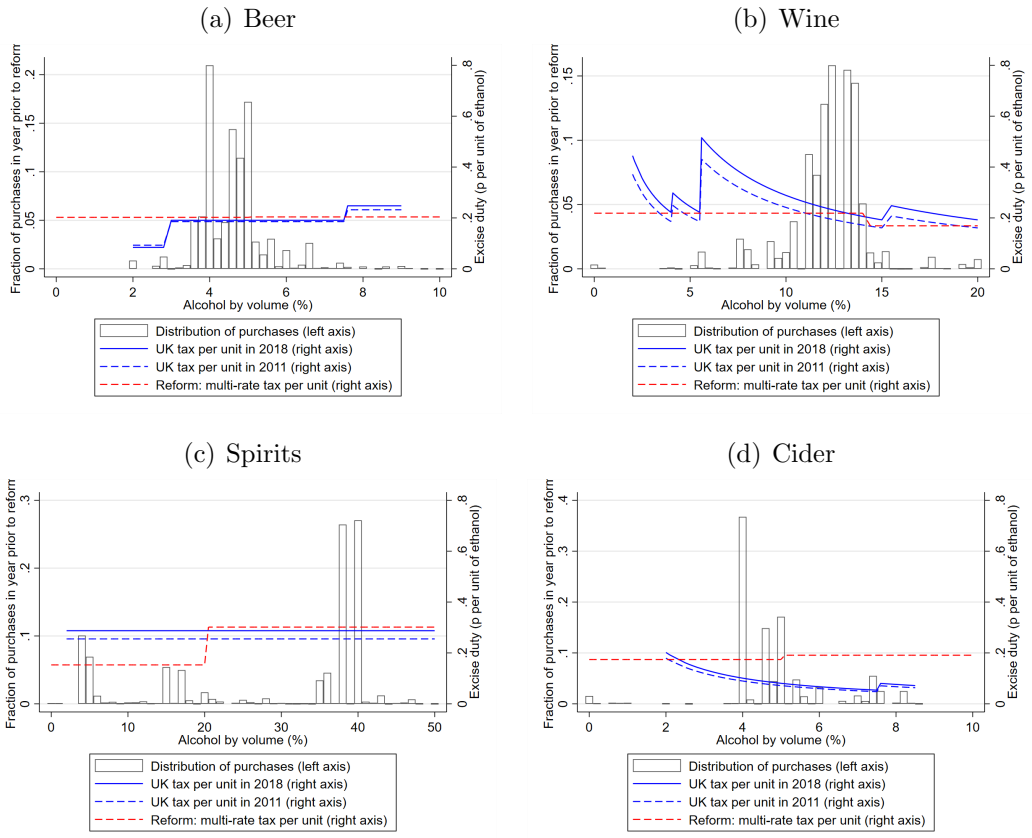
C.1 Alcohol duties and tax reforms

In the UK alcohol products are taxed both under a system of alcohol duties and a general consumption (value added) tax (VAT). Alcohol duties vary across alcohol segments and by alcoholic strength; these are shown in Figure C.1. Wine and cider are taxed volumetrically, i.e., per litre sold, with rates varying across different strength bands, which leads to the downward sloping kinked lines when the rates are expressed per unit of alcohol. Spirits and cider are taxed per unit. The system of alcohol duties is broadly similar to those in European countries. It also shares key features with US alcohol duties (such as higher rates on spirits), although US tax rates are levied at a lower rate. VAT is levied at a rate of 20% on the duty inclusive price.

In Section 4 we compare the effect of the price floor with two counterfactual tax reforms. First, a single rate levied in proportion to ethanol content, set so that the average reduction in units purchased is the same as under the price floor. This rate

is equal to £0.248 per unit. Second, we consider a multi (eight) rate system taken from Griffith, O'Connell, and Smith (2019), under which the eight rates are optimal if heavy drinkers create 95% of the externalities from drinking.[3] We adjust the rates by a common factor so that the average reduction in units purchased is the same as under the price floor, allowing us to directly compare across the different reforms. The red lines in Figure C.1 show the rates under this multi-rate system. The tax per unit for beer and wine is similar to under the UK system. A big difference under the multi-rate system is the variation in tax rate by strength for spirits, and also a significant increase in the tax on cider, to bring it in line with beer taxation.

Figure C.1: *UK system of alcohol duties in 2018*



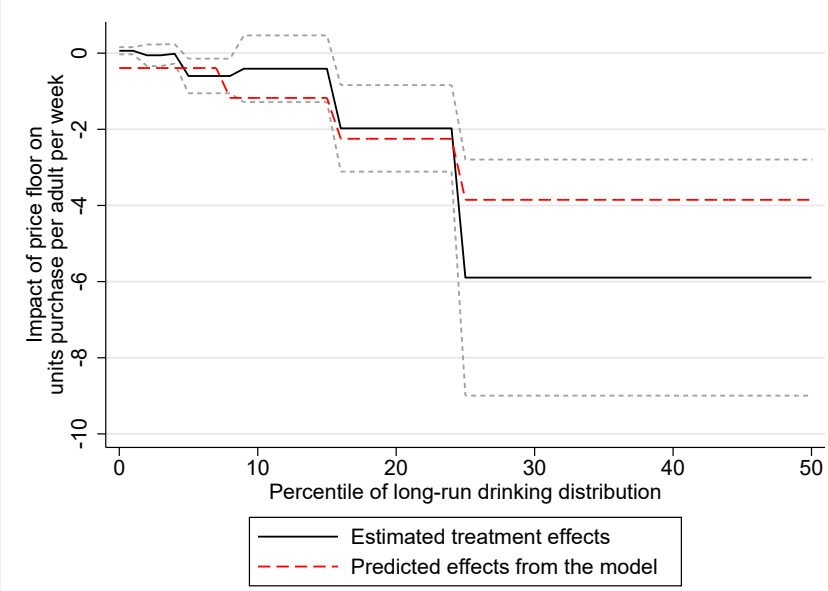
Notes: Figure shows the distribution of ABV content in the year prior to the introduction of the price floor, by alcohol types. The blue solid (dashed) line shows the excise duty, expressed per unit, levied in 2018 (2011) on different alcohol types, and the red dashed line shows the excise duty (per unit) under our counterfactual multi-rate system studied in Section 4.

[3]Optimality also depends on the removal of VAT and its replacement with higher alcohol duties.

C.2 Model validation

In order to compare the impact of the price floor with counterfactual tax reforms, we use the demand model estimated in Griffith, O'Connell, and Smith (2019). Figure C.2 compares the heterogeneous effect of the price floor on alcohol purchases from our demand model with the difference-in-differences estimates.[4] The groups over which we estimate the heterogeneity differ across the two approaches; nonetheless, the model does a good job of capturing the fact that the price floor leads to larger reductions in units purchased for heavier drinkers.

Figure C.2: *Model validation*



Notes: The solid line shows the estimated heterogeneous treatment effects across the drinking distribution, as shown in Figure 2(a). The red line shows the predicted effects from the demand model; in this figure we combine the top two drinking groups from the Griffith, O'Connell, and Smith (2019), which are approximately equivalent to the top 5% of drinkers used in this paper.

C.3 Targeting of policy reforms

Table C.1 shows the change in units from cheap and strong products under the three policy reforms, across the long-run drinking distribution.

[4]To account for price inflation between 2011 (the time period we use to estimate demand) and 2018 (when the Scottish price floor was introduced), we deflate the price floor in line with the change in the median price per unit from 2011 to 2018.

Table C.1: *Impact of policies on strong and cheap units, across drinking distribution*

	Single rate	Multi-rate	Price floor
Change in units from cheap products			
$<$ 8 units p.a.p.w	-0.64	-0.71	-0.77
8-14 units p.a.p.w	-1.02	-1.38	-1.77
14-24 units p.a.p.w	-1.13	-2.34	-3.39
$>$ 24 units p.a.p.w	-0.94	-2.98	-4.26
Change in units from strong products			
$<$ 8 units p.a.p.w	0.24	-0.43	-0.22
8-14 units p.a.p.w	0.54	-0.84	-0.51
14-24 units p.a.p.w	1.45	-1.42	-1.06
$>$ 24 units p.a.p.w	1.78	-2.11	-1.73

Notes: The top panel shows the change in units per adult per week from cheap products (those priced below the floor, pre-reform) across the long-run drinking distribution, under each reform. The bottom panel shows the change in units per adult per week from strong products (those with ABV above 30%) across the long-run drinking distribution, under each reform.

C.4 Welfare

We compare the impact of three reforms: the price floor, the single ethanol tax rate, and the multi-rate ethanol tax system. Let $\mathcal{P}^\iota$, for $\iota = \{\text{base}, \text{single}, \text{multi}, \text{floor}\}$, denote the policy environment. The function we use to evaluate the impact of different policies is given by:

$$W(\mathcal{P}^\iota) = \sum_i v_i(\mathbf{p}(\mathcal{P}^\iota)) + R(\mathcal{P}^\iota) - \sum_i \phi_i(\mathcal{Q}_i(\mathcal{P}^\iota)), \tag{C.1}$$

where $v_i(.)$ is the money metric utility of consumer i, $\mathbf{p}$ is the vector of alcohol prices (expressed per unit), $R(\cdot)$ is the total tax (both duty and VAT) revenue from alcohol sales, and $\phi_i(\cdot)$ is the total externality from alcohol consumption of consumer i. Here we write prices and quantities as a function of $\mathcal{P}^\iota$, which denotes the policy environment.

The externality function, $\phi_i(\mathcal{Q}_i(\mathcal{P}^\iota))$, is unknown. We assume that $\phi(\cdot)$ is an increasing (weakly) convex function, and parametrise it as a quadratic function with two parameters, (ϕ_0, ϕ_1):

$$\phi_i(\mathcal{Q}_i) = \phi_0 \mathcal{Q}_i + \phi_1 \mathcal{Q}_i^2. \tag{C.2}$$

(ϕ_0, ϕ_1) jointly determine both the aggregate external cost and the degree of convexity of the function. As in, Griffith et al. (2019), we calibrate the function to match the aggregate external cost estimated based on a study by the UK Cabinet Office (2003). We then show how the results vary for different degrees of convexity

of the function. Specifically, we vary the share of external costs generated by "heavy drinkers", who we define as those that consume more than 15 units per adult per week. This is around 10% of households, but this group buys 60% of all ethanol purchased. If the externality function was linear (i.e. the marginal externality is constant), then the heavy drinkers would generate 60% of the external costs. We calibrate (ϕ_0, ϕ_1) for eight specifications, in which heavy drinkers generate: 60%, 65%, 70%, 75%, 80%, 85%, 90% and 95% of the external costs.

Figure 4(b) shows the change $W(\mathcal{P}^\iota) - W(\mathcal{P}^{\text{base}})$ under each calibration of the externality function for the three different reforms. Table C.2 shows the change in tax revenue and consumer surplus, the values of which do not depend on the calibration of the externality function, under each reform.

Table C.2: *Policy comparison: tax revenue and consumer surplus*

	Tax revenue	Consumer surplus
Multi rate	178	-916
Price floor	-585	-659
Single rate	466	-1167

Notes: Numbers shown are in £m per year.

A government may choose to place weight on the profits that accrue to the alcohol industry. We do not directly measure profits,[5] but we can compute the windfall gains that a price floor confers on sellers of products previously sold below the floor,[6] which equals £383 million per year. These gains are enough to offset the differences between the multi-rate tax system and the price floor in consumer surplus plus tax revenue net of externalities, that we report in Figure 4(b). Therefore, if the government places equal value on firm profits as it does on consumer surplus and public funds, or if it can claw back alcohol industry windfall gains due to the price floor through taxation, the overall performance of the price floor is similar to the multi-rate tax system (though with markedly different effects for consumers, firms and public revenues).

[5]We do not observe product level marginal costs, and it is beyond the scope of this study to estimate them for the thousands of alcohol products that comprise the UK alcohol market.

[6]Let $\tilde{\mathbf{p}}^1$ and $\tilde{\mathbf{p}}^0$ denote the vector of tax-exclusive post- and pre-reform prices, $\mathbf{p}^1$ and $\mathbf{p}^0$ denote the corresponding tax-inclusive prices and $\mathbf{q}(\mathbf{p})$ denote the vector of demands. We define windfall industry gains as $(\tilde{\mathbf{p}}^1 - \tilde{\mathbf{p}}^0)\mathbf{q}(\mathbf{p}^1)$. This corresponds to the change in firm profits under perfect competition and marginal cost pricing.

C.5 Firm pricing behaviour

In our policy simulations we assume that the legal incidence of policy is fully reflected in prices. In practice, this means that the impact of a price floor is to increase the price of varieties that are priced below the floor to the floor and other prices remain unaffected, and that taxes are fully shifted to consumer prices. Whether this assumption is reasonable is an empirical question. Figure 1 offers clear and direct evidence that it is reasonable for a price floor. It shows that following the introduction of the price floor in Scotland, there was clear bunching of prices at the new floor, with the prices of products formerly below the floor moved to the floor, and little change in the prices of products priced above the floor.

In the existing literature, there is evidence of both over and undershifting of alcohol taxes to consumer prices. For example, Butters et al. (2020) finds that local excise duty changes are passed one-for-one through to consumer prices of beer, liquor, cigarette, and soda. In contrast, Kenkel (2005), Ally et al. (2014) and Young and Bielińska-Kwapisz (2002) find evidence of both under- and overshifting. Here we provide evidence of complete pass-through in our setting. We use variation in the alcohol duty rates over the period 2010-12 and an approach similar to that of Besley and Rosen (1999). Over the period 2010-12 there were several changes in the duty levied on different types of alcohol. We look at the effect of this on prices to assess whether pass-through is complete. As in Section 2, we let j denote alcohol product, and t denote transaction; ρ_{jt} denotes the transaction price of j on t. We let τ^d_{jt} denote the total amount of duty liable on product j on transaction t, and let τ^v_t denote the VAT rate applied to transaction t. Let $\tilde{\rho}_{jt}$ denote the tax-exclusive price:

$$\rho_{jt} = (1 + \tau^v_t)(\tilde{\rho}_{jt} + \tau^d_{jt})$$

First, we estimate whether changes in duty lead to changes in the tax-exclusive price, $\tilde{\rho}_{jt}$, following an approach similar to that of Besley and Rosen (1999):

$$\ln \tilde{\rho}_{jt} = \beta \tau^d_{jt} + \mu_j + \gamma_{r(t)} + \xi_{m(t)} + \zeta_{y(t)} + \epsilon_{jt} \tag{C.3}$$

where μ_j are product fixed effects, $\gamma_{r(t)}$ are retailer fixed effects, $\xi_{m(t)}$ and $\zeta_{y(t)}$ are month and year fixed effects. The coefficient of interest is β. If $\beta > 0$ then there is over-shifting of the tax (the tax-exclusive price increases when the tax rises), and $\beta < 0$ corresponds to undershifting. If we cannot reject $\beta = 0$ then we cannot reject complete pass-through of the tax to prices. Column (1) in Table C.3 shows that we cannot reject $\beta = 0$.

Second, we estimate an alternative specification that uses the fact that:

$$\frac{d\rho_{jt}}{d\tau^d_{jt}} = (1 + \tau^v_t) + \frac{d\tilde{\rho}_{jt}}{d\tau^d_{jt}}. \tag{C.4}$$

If pass-through is complete, then $\frac{d\rho_{jt}}{d\tau^d_{jt}} = (1 + \tau^v_t)$. We therefore estimate:

$$\rho_{jt} = \alpha\tau^d_{jt} + \mu_j + \gamma_{r(t)} + \xi_{m(t)} + \zeta_{y(t)} + \epsilon_{jt}$$

and test whether α is significantly different from $1 + \bar{\tau^v_t} = 1.2$. Column (2) in Table C.3 shows that we cannot reject $\alpha = 1 + \bar{\tau^v_t}$.

Table C.3: *Tax pass-through*

	(1) Log tax-exclusive price	(2) Price
Alcohol duty liable	-0.03 [-0.08,0.03]	1.21 [1.08,1.33]
Product effects	Yes	Yes
Month effects	Yes	Yes
Year effects	Yes	Yes
Retailer effects	Yes	Yes

Notes: Column (1) shows the estimated $\hat{\beta}$ from equation (C.3) and column (2) shows the estimated $\hat{\alpha}$ from equation (C.4). The square brackets show 95% confidence intervals; standard errors are heteroskedasticity robust and clustered at the product level.

To summarise, we find that there was no statistically significant change in the *tax-exclusive* price as a result of duty changes, and that the consumer prices changed by one plus the VAT rate. These results are consistent with complete pass-through of alcohol taxes to prices.

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