

## PRICE FLOORS AND EXTERNALITY CORRECTION\*

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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.

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.<sup>1</sup> 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 (Sornpaisarn *et al.*, 2017), and are being implemented in several countries.<sup>2</sup> 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).<sup>3</sup> We

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The data and codes for this paper are available on the Journal repository. They were checked for their ability to reproduce the results presented in the paper. The author was granted an exemption to publish parts of their data because access to these data is restricted. However, the author provided the Journal with temporary access to some of the data, and a simulated or synthetic dataset for the others, which allowed the Journal to run their codes. The synthetic/simulated data and the codes for the parts subject to exemption are also available on the Journal repository. They were checked for their ability to generate the tables and figures presented in the paper, however the synthetic/simulated data are not designed to reproduce the same results. The replication package for this paper is available at the following address: <https://zenodo.org/record/5824456>.

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<sup>1</sup> The World Health Organization (2014) reports 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 United States \$249 billion in 2010.

<sup>2</sup> 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.

<sup>3</sup> It is thus illegal in Scotland to sell a 1 litre bottle of 40% ABV spirits for less than £20, or a 0.75 litre bottle of 13.5% ABV wine for less than £5.12.

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 outperforms 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, while 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 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.<sup>4</sup> 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 United Kingdom, 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 *et al.* (2019) to

<sup>4</sup> 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).

quantify the welfare 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 United Kingdom are dominated by supermarkets who face little restraint on alcohol pricing (with the exception of the floor), whereas in the United States 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, Auld, *et al.*, 2012; Stockwell, Zhao, *et al.*, 2012), 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 *et al.* (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, e.g., Grigolon *et al.*, 2018; 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 2 we use a difference-in-differences approach to estimate

its impact on prices and quantities. In Section 3 we compare the effects of the price floor with counterfactual tax reforms. A final section summarises and several online appendices provide additional detail.

## 1. Policy Context and Data

### 1.1. 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 motivated 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 (10 ml 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.

### 1.2. 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 (2020). A representative sample of UK households record all grocery purchases they make and bring into the home.<sup>5</sup> 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.<sup>6</sup>

#### 1.2.1. 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  $p_{jt}$  denote the price paid for product  $j$  on transaction  $t$ , and  $z_j$  the number of units of alcohol in product

<sup>5</sup> 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), see Office for National Statistics (2020).

<sup>6</sup> 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.

$j$ , 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  $p_{jt} < \pounds 0.50$ .

### 1.2.2. Quantities

The number of alcohol units purchased per adult per week by household  $i$  in year-week  $w$  is,  $Q_{iw} = \frac{1}{A_i} \sum_j z_j (\sum_{t \in T_{iw}} \eta_{jt})$ , where  $\eta_{jt}$  is the number of packs of product  $j$  bought on transaction  $t$ ,  $T_{iw}$  the set of transactions by household  $i$  in year-week  $w$ , 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,  $Q_{iw} = 0$ . On average, households buy 6 units of alcohol per adult per week (i.e., the average of  $Q_{iw}$  is 6).<sup>7</sup> 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 United Kingdom.

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  $\pounds 1.80$  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 towards 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 Giles and Robinson (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.

### 1.2.3. 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:  $\bar{Q}_i = \frac{1}{N_i} \sum_{w \in [2016m5, 2017m4]} Q_{iw}$ , where  $N_i$  denotes the number of weeks household  $i$  is 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.

<sup>7</sup> This average excludes abstainers, i.e., households that are never observed buying alcohol. Abstaining households account for approximately 15% of all households.

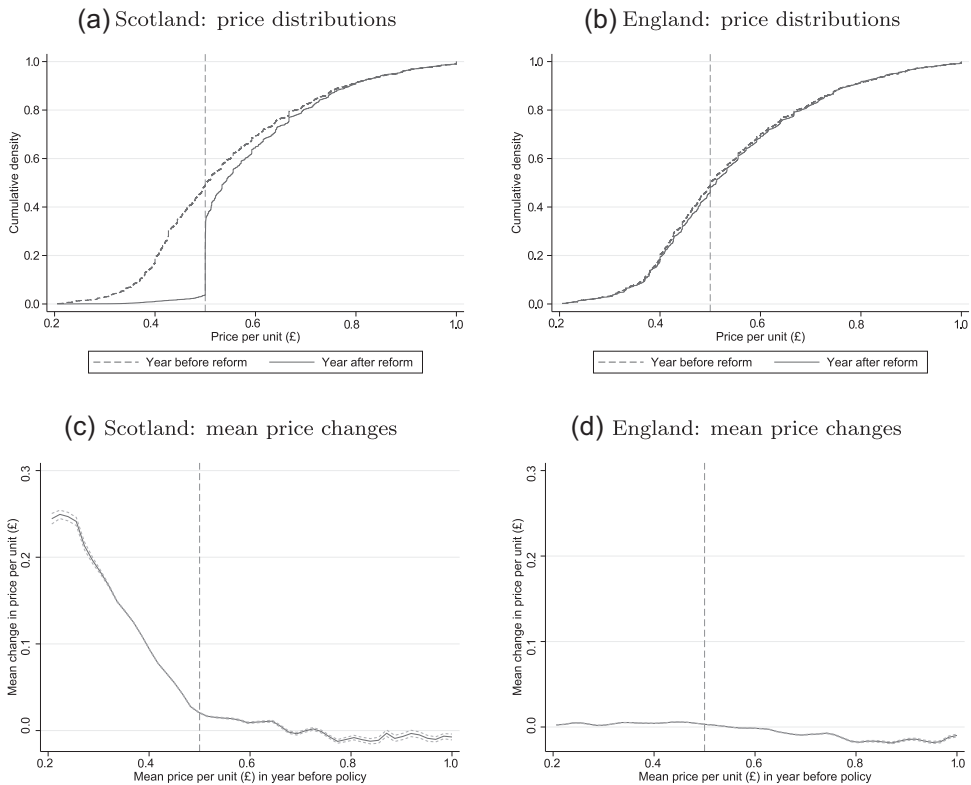


Fig. 1. *Impact of the Price Floor on Price Distributions.*

*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.

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 allows 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).

## 2. Effect of the Price Floor

### 2.1. *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.

Figure 1(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, Figure 1(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. Figure 1(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. Figure 1(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.

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 Subsection 2.3.

## 2.2. 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:

$$Q_{iw} = \beta \times \text{treat}_i \times \text{post}_w + \gamma_{m(w)} + \mu_i + \chi_{s(i)w} + \epsilon_{iw}, \quad (1)$$

where  $Q_{iw}$  denotes units per adult per week,  $\text{treat}_i$  is a dummy variable equal to one if household  $i$  lives in Scotland,  $\text{post}_w$  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,  $\mu_i$  denote a set of household fixed effects, and  $\chi_{s(i)w}$  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 test for parallel pre-policy trends by plotting estimates from a dynamic difference-in-differences specification, which replaces  $\beta \times \text{treat}_i \times \text{post}_w$  in (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 (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.,  $\mathbb{1}\{Q_{iw} > 0\}$ ); 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 correlation in unobservables across households living in the same area, for example, due to local store coverage or weather shocks.<sup>8</sup>

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%).

### 2.2.1. *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.

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 (1) where we allow the treatment effect to vary across groups:

$$Q_{iw} = \sum_{d=1}^D \beta_d \times \text{treat}_i \times \text{post}_w \times \mathbb{1}[i \in \mathcal{D}_d] + \gamma_{m(w)} + \mu_i + \chi_{iw} + \epsilon_{iw}. \quad (2)$$

Figure 2 plots the estimated  $\hat{\beta}_d$ s in each case, with the red line showing the average treatment effect. Figure 2(a) shows heterogeneity in treatment effects across the long-run drinking distribution.<sup>9</sup> It shows 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.

<sup>8</sup> In Online Appendix B.3 we show that our inference remains valid under a random inference approach.

<sup>9</sup> Note, given that we use the period May 2016 to April 2017 to measure long-run units purchased per adult per week, in this case we estimate (2) over May 2017 to January 2020.



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 (0.126)	-2.249 (0.502)	-1.314 (0.279)	-0.00877 (0.003)	-0.903 (0.102)	0.259 (0.057)	-0.0796 (0.026)	-0.178 (0.106)	-0.213 (0.065)	-0.124 (0.040)
Mean of dep. variable	9.0	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 <sup>2</sup>	0.4610	0.7110	0.4965	0.3642	0.4677	0.2733	0.3851	0.4497	0.4050	0.3761
Number of observations	4,076,771	1,075,082	1,287,791	4,076,786	4,076,771	4,076,771	4,076,771	4,076,771	4,076,771	4,076,771
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 (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; column (5) for units p.a.p.w from products priced below the floor pre-reform, column (6) for units p.a.p.w from products priced above the floor pre-reform, column (7) for units p.a.p.w from beer, column (8) for units p.a.p.w from wine, column (9) for units p.a.p.w from spirits and column (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.

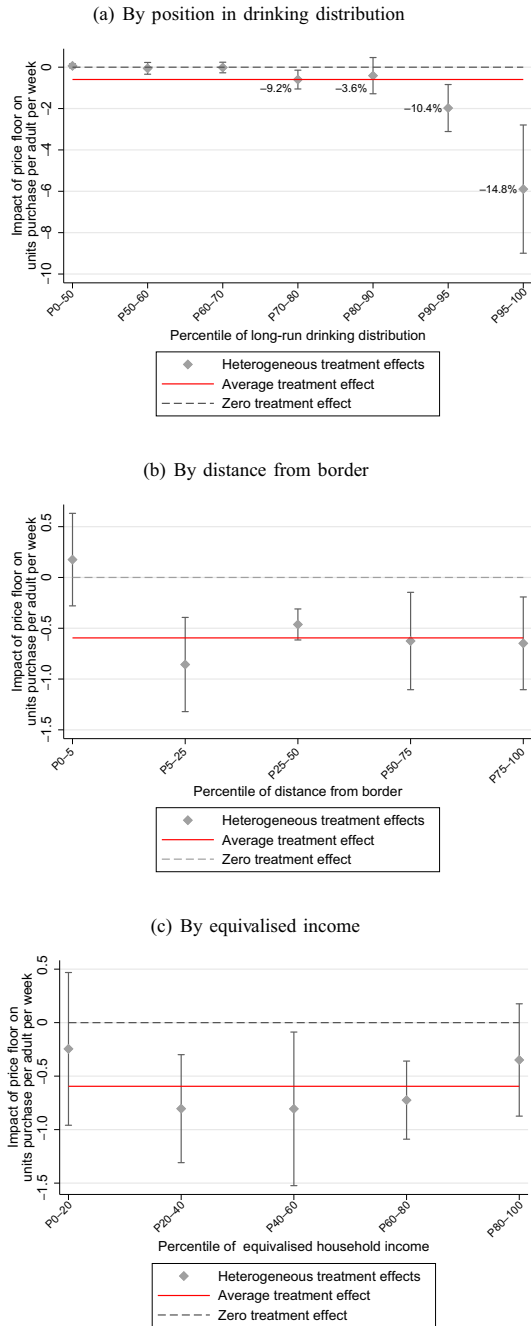


Fig. 2. Heterogeneity in Treatment Effects.

Notes: Each panel shows the estimated  $\hat{\beta}_{it}$ s from equation (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 cut-offs. Based on standard errors clustered at the county level, 95% confidence intervals are shown.

In Figure 2(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 52 km), 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,<sup>10</sup> likely due to the low population density around the Scotland-England border.

Figure 2(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.

### 2.3. *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 Figure 3(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 markers in Figure 3(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 Figure 3(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.

<sup>10</sup> In particular, re-estimating (1) omitting Scottish households within 52 km of the border leads to a very similar estimate.

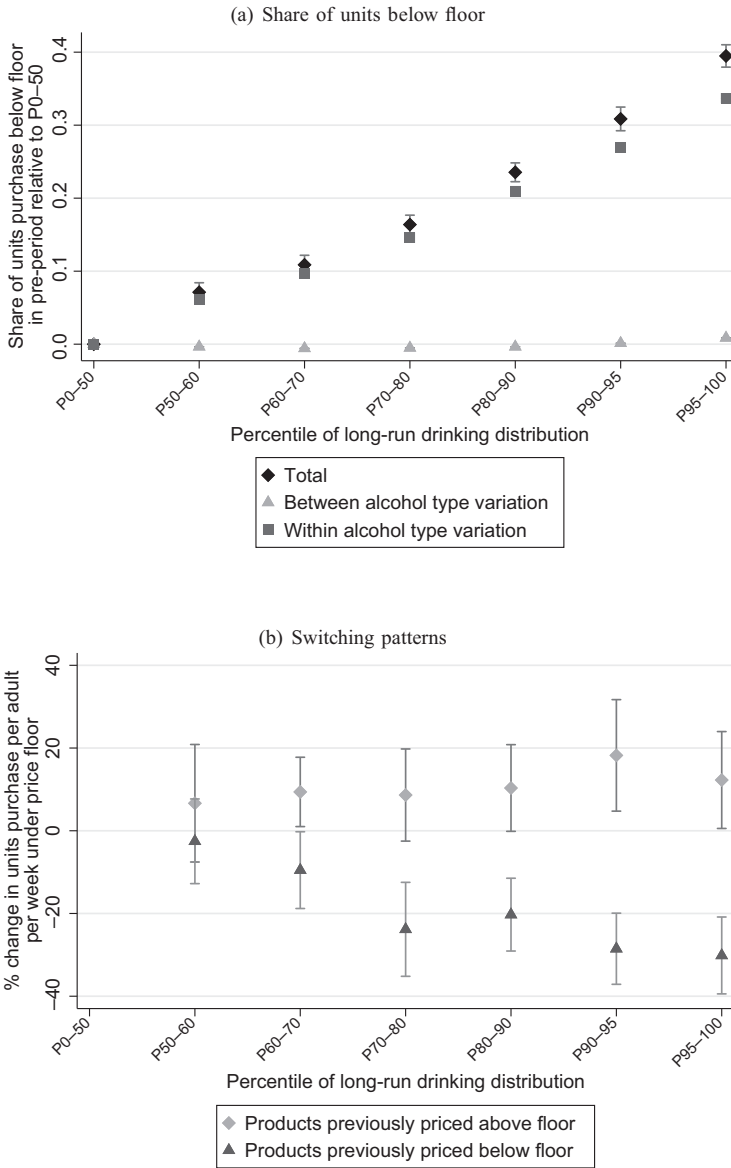


Fig. 3. Targeting of the Price Floor at Heavy Drinkers.

Notes: Panel (a) 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. Panel (b) 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. Based on standard errors clustered at the county level, 95% confidence intervals are shown.

### 3. 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 *et al.*, 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., 500 ml, 1–2 litres or 2×700 ml) (see Griffith *et al.* 2019, table 4.3). 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.<sup>11</sup> 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.<sup>12</sup>

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, 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.<sup>13</sup>

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.<sup>14</sup> When externalities are linear in consumption (so heavy drinkers account for 60% of externalities), each unit of alcohol consumed is equally costly and

<sup>11</sup> 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.

<sup>12</sup> 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.

<sup>13</sup> See Table C.1 in Online Appendix C.

<sup>14</sup> See Online Appendix C.4 for further details.

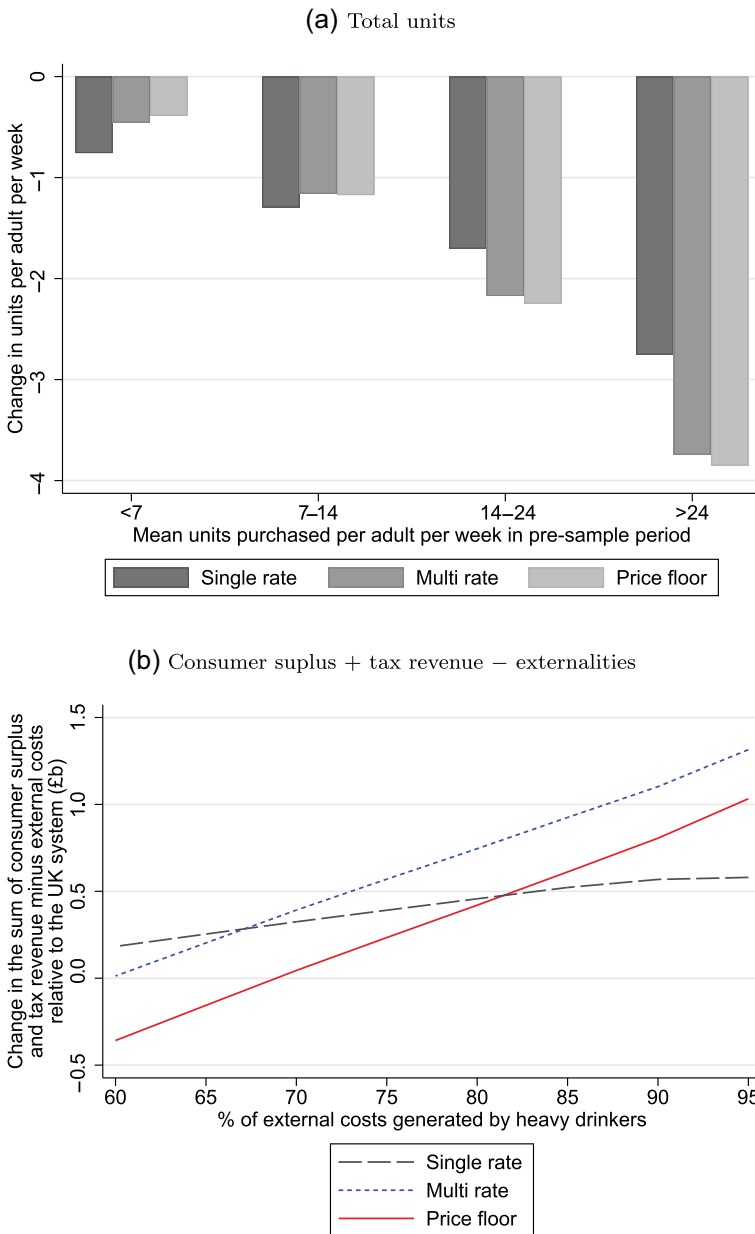


Fig. 4. Impact of Price Floor and Tax Reforms.

Notes: Panel (a) shows the impact of the reforms on units across the long-run drinking distribution. Panel (b) 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 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.

A government may choose to place weight on the profits that accrue to the alcohol industry. We do not directly measure profits,<sup>15</sup> but we can compute the windfall gains that a price floor confers on sellers of products previously sold below the floor,<sup>16</sup> 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).

#### 4. 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 United Kingdom was highly constrained by European law in the tax reforms that were legally permissible. However, this is no longer the case and means the United Kingdom 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.

<sup>15</sup> 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.

<sup>16</sup> Let  $\bar{\mathbf{p}}^1$  and  $\bar{\mathbf{p}}^0$  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  $(\bar{\mathbf{p}}^1 - \bar{\mathbf{p}}^0)\mathbf{q}(\mathbf{p}^1)$ . This corresponds to the change in firm profits under perfect competition and marginal cost pricing.

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Additional Supporting Information may be found in the online version of this article:

### Online Appendix Replication Package

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