

Impact on alcohol purchasing of a ban on multi-buy promotions: a quasi-experimental evaluation comparing Scotland with England and Wales

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ABSTRACT

Aims To evaluate the impact of the 2011 Scottish ban on multi-buy promotions of alcohol in retail stores. **Design and setting** Difference-in-differences analysis was used to estimate the impact of the ban on the volume of alcohol purchased by Scottish households, compared with those in England and Wales, between January 2010 and June 2012. **Participants** A total of 22 356 households in Scotland, England and Wales. **Measurements** Records of alcohol purchasing from each of four categories (beer and cider, wine, spirits and flavoured alcoholic beverages), as well as total volume of pure alcohol purchased. **Findings** Controlling for general time trends and household heterogeneity, there was no significant effect of the multi-buy ban in Scotland on volume of alcohol purchased either for the whole population or for individual socio-economic groups. There was also no significant effect on those who were large pre-ban purchasers of alcohol. Most multi-buys were for beer and cider or for wine. The frequency of shopping trips involving beer and cider purchases increased by 9.2% following the ban ($P < 0.01$), while the number of products purchased on each trip decreased by 8.1% ($P < 0.01$). For wine, however, these effects were not significant. **Conclusions** Banning multi-buy promotions for alcohol in Scotland did not reduce alcohol purchasing in the short term. Wider regulation of price promotion and price may be needed to achieve this.

Keywords Alcohol consumption, alcohol purchasing, difference-in-differences analyses, price promotions, regulation, Scottish ban on multi-buys.

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INTRODUCTION

Alcohol consumption is a major cause of ill health and is the third leading cause of morbidity and mortality in Europe, after tobacco and high blood pressure [1]. Excessive alcohol consumption also has major social and economic consequences: estimates put the number of alcohol-related violent crimes at close to 1 million in England and Wales in 2010–11 [2]; in England alone the total annual cost of alcohol-related harm to the National Health Service (NHS) was estimated at £3.5 billion in 2009–10 [3]. In light of the heavy burden resulting from excessive alcohol consumption, there is widespread recognition of the need to tackle the problem [4].

A substantial body of evidence points to price interventions, e.g. alcohol taxation, as the most effective and cost-effective means of reducing consumption and associated harm [5]. However, such measures have not thus far attracted strong public or political support, due possibly to scepticism about their effectiveness and ideological aversion to what could be seen as paternalistic interference [6–8]. Industry lobbying may also play a role [9].

Limiting certain price promotions of alcohol products appears to be less contentious and might still go some way towards reducing purchasing, given that price promotions temporarily reduce the unit price of alcohol which—other things being equal—should increase purchasing [10,11]. In addition, there is evidence from studies of processed foods suggesting that multi-buy

promotions—also called quantity discounts—promote stockpiling and, given their increased availability, increase consumption [12]. Such an effect might plausibly also occur for alcohol [13,14].

However, it might be that the industry would respond to potential revenue-reducing effects of limiting multi-buy promotions by simply replacing these with other forms of promotion, such as simple price reductions. This, in turn, could counteract the intended effects of the restriction, or even make alcohol more affordable.

The Scottish government became the first in the United Kingdom to attempt to influence alcohol purchasing by banning one particular type of alcohol promotion, multi-buy promotions, in 'off-trade' stores from October 2011 onwards as part of the Alcohol etc. (Scotland) Act 2010. Off-trade stores cover high street retail outlets including supermarkets, off-licences and convenience stores which sell alcohol for consumption off the premises (which accounts for 68% of pure alcohol sold in the United Kingdom in 2012 [15]), but not sales in pubs, bars and restaurants. More specifically, the Act specified that 'A package containing two or more alcoholic products (whether of the same or different kinds) may only be sold on the premises at a price equal to or greater than the sum of the prices at which each alcoholic product is for sale' [16]. Note that 'product' refers to Stock Keeping Unit, a unique code that embodies all attributes such as size, colour and packaging (including multi-packing). Examples of banned offers include 'buy-one-get-one-free' and 'two for £8' offers. The Act also involved other regulations, including a restriction of in-store alcohol display and a revised age verification policy, which needs to be borne in mind when considering the impact of the legislation. In this paper we provide the first in-depth evaluation of the short-term impact of this legislation on purchasing, using detailed consumer panel data from 22 356 UK households.

METHODS

Data

Alcohol purchasing data from Kantar WorldPanel's Household panel (<http://www.kantarworldpanel.com>) from January 2010 to June 2012 were used in the analysis. Compared to other data sources (including the Scottish Household Survey and the Living Costs and Food Survey), the Kantar WorldPanel Household data provide richer information about purchasing behaviour (e.g. larger sample size, longer study duration and more frequent observations) and have recently been used increasingly by academic research [17–19]. In addition, they were the only data available at the time of conducting the analysis.

The data comprise records of the take-home purchases of a sample of 22 356 households living in the United Kingdom. The variables include the volume of alcohol purchased in four categories: (i) beer and cider; (ii) wine; (iii) spirits; and (iv) flavoured alcoholic beverages (FABs), as well as detailed information on household-specific characteristics, including socio-economic status and region of residence.

The panel was set up by the data company by inviting households to join the panel via letter or e-mail, with addresses obtained from mailing lists. Vouchers from high street retailers or vouchers for leisure and days-out are offered as compensation for participation in the panel (the average reward was about £100 per household per year). The UK Office of National Statistics (ONS) census information and the UK Broadcasters' Audience Research Board (BARB) Establishment survey were used to define the target population. A stratified sampling method was used, with stratum variables being region (six regions in the United Kingdom), household size and age of main shopper.

The panel households are required by the data company to record all purchases brought back to their homes using barcode scanners, and also to send digital images of till receipts to the company. Households are included in the data set only if they provide data to a satisfactory degree in the first 2 months. The quality of data sent by the households (e.g. scanning compliance) is monitored continuously and maintained throughout the survey periods by the data company. For further details on the data used see Supporting information, section 1.

Starting from the raw Kantar WorldPanel Household panel data we constructed a household-level panel data set measuring the volume of alcohol purchased before and after the Scottish ban (which started on 1 October 2011). Households that joined or dropped out from the panel during the survey period were included in the analysis if they were present for at least one quarter before and after the ban (July 2011–December 2011).

Research design

We evaluated the impact of the ban of multi-buy promotions on the volume of alcohol purchased in Scotland by using a difference-in-differences analysis [20–23], with English and Welsh households, which were not exposed to the legislation, as the control group. The difference-in-differences method compares the difference in the volume of alcohol purchased by Scottish households in pre- and post-ban periods with the same difference observed in the control group (English and Welsh households). The design is recommended, for example, by the Magenta Book [23] in evaluating policies in an observational setting.

The difference-in-differences method relies crucially on the assumption that, in the absence of legislation, time trends in the volume of alcohol purchased are the same in both groups, as any significant baseline difference in trends may lead to spurious findings. A 'placebo' difference-in-differences analysis was therefore conducted to check for baseline differences using data from the previous year (January 2010–June 2011), with a hypothetical ban in October 2010, for which no 'effect' was expected. The methods underlying this 'difference-in-difference-in-differences' analysis [24] are described in more detail in the Supporting information, section 2.

Analyses were conducted separately for the four alcohol categories, as well as for total pure alcohol, to examine the overall effects across categories. It is important to note that beer or cider and wine account for by far the biggest volume of sales via multi-buys (see Supporting information Table S1-1 and S1-2). Therefore we expect that most, if any, of the effects of the policy will be concentrated in these categories. The volume of pure alcohol is defined by the aggregated volume of alcohol purchased from the four categories, weighted using average alcohol by volume (ABV) of each category [25]. It should be noted that, as average ABV is applied, the analysis of pure alcohol does not account for potential substitution between higher and lower ABV products within a given alcohol category.

Because we were interested primarily in the purchasing behaviour of regular purchasers, we restricted our sample to households which had purchased alcohol at least once in the pre- and post-ban periods. This excluded never or very occasional purchasers, as has been conducted in comparable analyses [26] (details in Supporting information Table S2-1 to S2-5). We applied a logarithm transformation to normalize the highly skewed and long-tailed distribution of the raw volume of alcohol purchased [26–28] (see Supporting information Figs S1 and S2).

The analyses were conducted within a regression-based framework. The treatment effect was estimated by least-squares with household-level fixed effects (i.e. within-household estimation). Therefore, our estimates are robust to any household level heterogeneity which does not vary in the short term, such as household size, education and region of residence (Supporting information section 2). The estimation of standard errors takes into account the sampling stratification using cluster-robust standard errors, which allows for within-stratum correlation and for heteroskedasticity [29]. The analyses were conducted using Stata SE version 11.2.

Subsample analyses

We conducted two subsample analyses:

- 1 testing for differential effects by socio-economic status, splitting the sample into three groups according to the UK Registrar General's social classes, based on occupation (advantaged: professional or higher managerial; middle: skilled non-manual or skilled manual; less advantaged: semi-skilled or unskilled manual) [30]; and
- 2 exploring the effects on households purchasing 'higher' volumes of alcohol pre-ban (top 50% and top 25% of households)—i.e. the subgroups of particular policy relevance.

Effects on frequency of purchasing and quantity of alcohol purchased per trip

We further investigated the purchasing patterns for the four alcohol categories for (i) the frequency of shopping trips involving purchases; (ii) the number of products purchased per trip; (iii) the volume (in ml or pure alcohol units) purchased per trip; and (iv) the mean size of the products purchased. In what follows, we use 'product' to refer to the Stock Keeping Unit, i.e. a pack containing multiple beer bottles would be defined as one product.

RESULTS

Table 1 provides descriptive statistics and results of the difference-in-differences estimation for alcohol purchased per quarter for the four alcohol categories and for total volume of pure alcohol.

The log-scaled volume of alcohol purchased is presented separately for Scottish and English and Welsh households in the pre- and post-ban periods. In panel A of Table 1 we present the main difference-in-differences results. The volume of alcohol purchased in the post-ban period is generally larger than in the pre-ban period both in Scotland and in England and Wales. This reflects high volumes of alcohol purchased during the Christmas period. Panel B of Table 1 shows the robustness check using the data from the preceding year, when the ban was not implemented and for which no 'effect' is expected. Comparing volume of alcohol purchased between January 2010 and June 2011 (panel B) to purchases from January 2011 to June 2012 (panel A), there was a general decline in purchasing both in Scotland and in England and Wales.

In panel A of Table 1, which shows the main analysis, there was no significant effect of the ban on volume of alcohol purchased apart from spirits, which showed a statistically significant decline of 6.57% [point estimate: -0.068 , 95% confidence interval (CI) = -0.132 to -0.004 , equivalent to -80.6 ml per quarter]. However, in panel B (using equivalent data from the previous year), spirits again showed a statistically significant decline in

Table 1 Impact of the multi-buy ban on the volume of alcohol purchased per quarter in Scotland (difference-in-differences estimation).

| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) |
|--|--|------------------------|------------------------|-------------------------|-------------------------|-------------------------|---|------------------------|---|-------------------------|
| | Beer and cider | | Wine | | Spirits | | Flavoured alcoholic beverages | | Total pure alcohol | |
| | England and Wales | | England and Wales | | Scotland | | England and Wales | | Scotland | |
| | Scotland | | Scotland | | Scotland | | Scotland | | Scotland | |
| Panel A: January 2011–June 2012 (pre-ban period: January 2011–September 2011; post-ban period: October 2011–June 2012) | | | | | | | | | | |
| Log volume (raw volume) ^a | 8.341 (4192.3 ml) | 8.511 (4967.7 ml) | 7.907 (2716.7 ml) | 7.837 (2533.4 ml) | 7.111 (1225.9 ml) | 6.917 (1009.3 ml) | Pre-ban 6.701 (813.2 ml) | 6.566 (710.2 ml) | Pre-ban 4.029 (56.2 units) | 3.970 (53.0 units) |
| | Post-ban 8.463 (4735.1 ml) | 8.588 (5364.7 ml) | 8.009 (3008.0 ml) | 7.963 (2872.8 ml) | 7.350 (1556.7 ml) | 7.224 (1371.8 ml) | Post-ban 6.657 (778.1 ml) | 6.546 (696.2 ml) | Post-ban 4.258 (70.7 units) | 4.206 (67.1 units) |
| Difference of log volume: post-ban–pre-ban | 0.122 | 0.077 | 0.102 | 0.126 | 0.239 | 0.307 | –0.044 | –0.020 | 0.230 | 0.236 |
| Difference-in-differences (95% CI) | 0.045 (–0.030, 0.119) | –0.024 (–0.077, 0.029) | –0.024 (–0.077, 0.029) | –0.068 (–0.132, –0.004) | –0.068 (–0.132, –0.004) | –0.024 (–0.197, 0.149) | –0.024 (–0.197, 0.149) | –0.006 (–0.059, 0.046) | | |
| Scotland–England and Wales | | | | | | | | | | |
| Percentage change (%) | 4.59% | –2.36% | –2.36% | –6.57% | –6.57% | –6.57% | –2.39% | –2.39% | –0.62% | –0.62% |
| Absolute change (ml) ^b | 192.4 ml | –64.2 ml | –64.2 ml | –80.6 ml | –80.6 ml | –80.6 ml | –19.4 ml | –19.4 ml | –0.3 units | –0.3 units |
| Observations (number of households) | 24 372 (12 186) | 25 490 (12 745) | 25 490 (12 745) | 16 072 (8 036) | 16 072 (8 036) | 16 072 (8 036) | 2898 (1449) | 2898 (1449) | 36 610 (18 305) | 36 610 (18 305) |
| Panel B: control sample: January 2010–June 2011 (pre-ban equivalent period: January 2010–September 2010; post-ban equivalent period: October 2010–June 2011) | | | | | | | | | | |
| Log volume (raw volume) | 8.462 (4727.8 ml) | 8.602 (5440.2 ml) | 7.939 (2804.2 ml) | 7.864 (2601.8 ml) | 7.140 (1261.0 ml) | 6.912 (1004.1 ml) | Pre-ban equivalent 6.578 (719.3 ml) | 6.644 (768.0 ml) | Pre-ban equivalent 4.147 (63.2 units) | 4.029 (56.2 units) |
| | Post-ban equivalent 8.474 (4787.0 ml) | 8.601 (5439.5 ml) | 8.026 (3058.6 ml) | 7.954 (2846.0 ml) | 7.386 (1613.2 ml) | 7.246 (1401.8 ml) | Post-ban equivalent 6.813 (910.1 ml) | 6.687 (802.3 ml) | Post-ban equivalent 4.296 (73.4 units) | 4.231 (68.8 units) |
| Difference of log volume: post-ban equivalent–pre-ban equivalent | 0.012 | –0.001 | 0.087 | 0.090 | 0.246 | 0.334 | 0.235 | 0.043 | 0.149 | 0.203 |
| Difference-in-differences (95% CI) | 0.013 (–0.043, 0.068) | –0.003 (–0.042, 0.036) | –0.003 (–0.042, 0.036) | –0.087 (–0.143, –0.032) | –0.087 (–0.143, –0.032) | –0.087 (–0.143, –0.032) | 0.192 (–0.004, 0.387) | 0.192 (–0.004, 0.387) | –0.054 (–0.097, –0.011) | –0.054 (–0.097, –0.011) |
| England and Wales | | | | | | | | | | |
| Observations (number of households) | 21 892 (10 946) | 23 722 (11 861) | 23 722 (11 861) | 14 810 (7 405) | 14 810 (7 405) | 14 810 (7 405) | 2480 (1240) | 2480 (1240) | 33 424 (16 712) | 33 424 (16 712) |
| Difference-in-differences (95% CI) | 0.032 (–0.060, 0.125) | –0.021 (–0.083, 0.041) | –0.021 (–0.083, 0.041) | 0.019 (–0.070, 0.109) | 0.019 (–0.070, 0.109) | 0.019 (–0.070, 0.109) | –0.216 (–0.479, 0.047) | –0.216 (–0.479, 0.047) | 0.048 (–0.018, 0.114) | 0.048 (–0.018, 0.114) |
| Percentage change (%) | 3.28% | –2.08% | –2.08% | 1.95% | 1.95% | 1.95% | –19.41% | –19.41% | 4.87% | 4.87% |
| Absolute change (ml) ^b | 137.6 ml | –56.5 ml | –56.5 ml | 24.0 ml | 24.0 ml | 24.0 ml | –157.8 ml | –157.8 ml | 2.7 units | 2.7 units |
| Total observations | 46 264 | 49 212 | 49 212 | 30 882 | 30 882 | 30 882 | 5378 | 5378 | 70 034 | 70 034 |

^aRaw volume refers to the back-transformed mean of log-scaled volume, i.e. the geometric mean of volume. As the distribution of raw volume of alcohol purchased is highly right-skewed (see Supporting information Fig. S1), geometric mean is smaller than the usual arithmetic mean. Table S2 provides the arithmetic mean of raw volume purchased. ^bAbsolute change is evaluated using the estimated percentage change for the back-transformed mean volume for Scottish households in the pre-ban period in 2011 (January 2011–September 2011). All analyses were conducted based on the log-scaled volume, therefore the predicted absolute change in the table does not necessarily equate to the simple differences of the back-transformed mean log-scaled volume. Percentage change was calculated using the estimated treatment effect with the log-scaled outcome variable, i.e. percentage change = $\exp(\tau) - 1$, where τ is the point estimate of the treatment effect. The absolute change is evaluated at the baseline (Scotland pre-ban). In column (9) and (10), units of alcohol are calculated by the following: unit = volume (ml) \times alcohol by volume (ABV). In the aggregation of alcohol from the four categories, average ABV for each category was used in the analysis, following a UK Office of National Statistics document [25]. CI = confidence interval.

the absence of any ban, indicating differences in baseline time trends between Scotland and England and Wales. When this difference is taken into account, as shown in the final row of Table 1, there is no longer any significant effect of the ban on spirit purchases. Trends in patterns of purchasing are illustrated in Fig. 1.

The main results are unaffected by either socio-economic status or the volume of alcohol purchased pre-ban, except for the two cases in which purchases of spirits for the middle socio-economic group decreased by 7.36%, and total pure alcohol for households purchasing the most alcohol pre-ban (top quartile) increased by 6.6% in Scotland (Supporting information Table S3-1). However, again the robustness check (difference-in-difference-in-differences analysis) (Supporting information Table S3-2 and S3-3) suggests that these effects found in the main analysis may be spurious.

Effects on frequency of purchasing and quantity of alcohol purchased per trip

We analysed purchasing patterns for the four alcohol categories using additional outcome variables: (i) frequency of shopping trips involving any purchases from the category per quarter; (ii) number of products purchased from the category per trip; (iii) volume of purchasing from the category per trip (in ml); and (iv) average size of products purchased (in ml). These results are shown in Supporting information Table S4-1.

The average frequency of shopping trips involving beer and cider increased by 9.2% ($P < 0.01$) in Scotland post-ban compared to shopping patterns in England and Wales (equivalent to 0.13 more trips per quarter), with no significant change for the other alcohol categories. Fewer products per trip were purchased following the ban for beer and cider, for wine and for spirits. For beer and cider, the significant reduction is 8.1% (equivalent to 0.15 fewer products per trip). However, the effects for wine and spirits were not robust to different model specifications (Supporting information Table S4-2). The size of the effects for beer and cider were more pronounced for less advantaged socio-economic groups (see Supporting information Table S4-3).

Robustness checks and a supplementary analysis

We conducted several additional robustness checks and a supplementary analysis, as follows:

1 Panel difference-in-differences regressions: the same data were used as in Table 1, but disaggregated into quarterly time-periods. This allows more flexible modelling with additional time-varying control variables, including seasonal variables such as temperature and regional unemployment (see Supporting information—section 6 and Table S5).

2 Analysis using a different sample window: in the main analysis, the pre-ban period (January 2011–September 2011) and the post-ban period (October 2011–June 2012) cover different months of the year. We implemented another difference-in-differences analysis using a different sample window, with the pre-ban period ranging from October 2010 to June 2011, and post-ban from October 2011 to June 2012 (see Supporting information Table S6).

3 Excluding shopping over the Christmas period (defined here as the whole of December): this period could potentially show different trends in Scotland compared to England and Wales, thereby distorting our main results (see Fig. 1, Supporting information Fig. S3 and Table S7).

None of these analyses affected the main results or conclusions of the principal analysis.

4 Analysis of potential differential effects of the multi-buy ban in terms of quality of products, by looking at the effects separately by branded products and super-market own-label products. The results showed that the ban of multi-buys did not significantly increase or decrease the volume of alcohol from branded products, nor own-label products (see Supporting information Table S8).

DISCUSSION

Our results from both main and subgroup analyses show that in the short term—i.e. 9 months post-intervention—the ban on multi-buys in Scotland has failed to impact upon the volume of alcohol purchased. These findings are broadly in line with those from a recent descriptive analysis published in a Scottish NHS report [31]. The report presented a before-and-after comparison of total sales volume of alcohol, finding no decline in weekly sales volume of pure alcohol and separate analyses of beer, wine and spirits in Scotland. We confirm these results based on a more extensive statistical analysis and using a different data set to examine whether purchases of alcohol at the household level (rather than aggregated sales figures) have been affected by the ban.

We examined three hypotheses that may explain the lack of effect of the multi-buy ban:

1 Scottish stores did not comply with the legislation.

This is unlikely, and it was rejected following direct observations of selected stores (see Supporting information section 11).

2 Scottish households circumvented the ban by online and/or cross-border shopping.

This hypothesis was also rejected. First, the proportion of online purchasing in the data is small, and excluding online purchases does not affect the results substantially (see Supporting information Table S7). As for

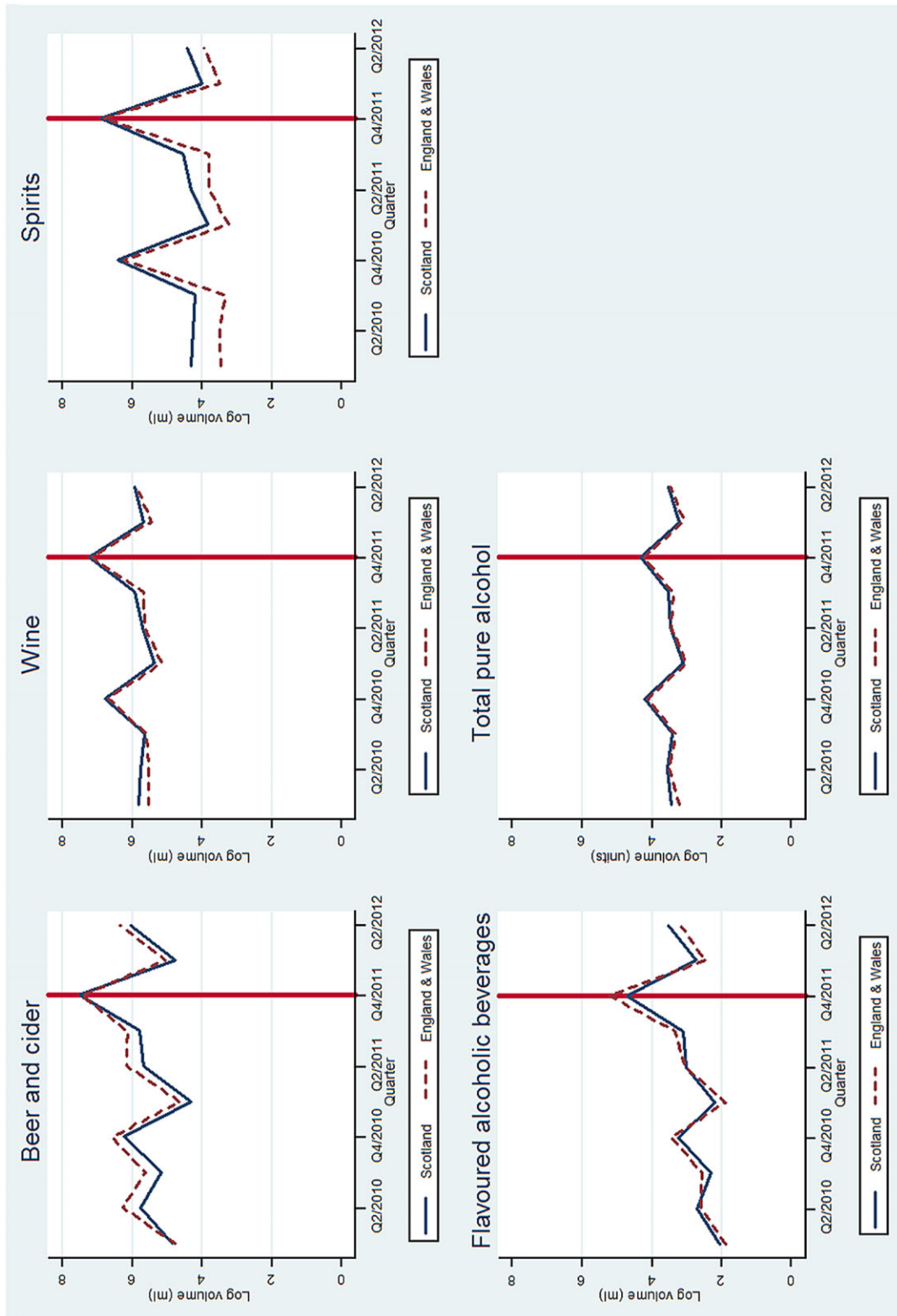


Figure 1 Trends in alcohol purchasing in Scotland, England and Wales 2010–12. Vertical lines in the figures represent the introduction of the multi-buy ban. Annual rises in sales in quarter 4 relate to Christmas sales (trends excluding the Christmas period are shown in the Supporting information in Fig.S3). The volume of pure alcohol is the aggregated volume of alcohol purchased from the four categories, weighted using average alcohol by volume (ABV) of each category. Total pure alcohol is measured by log volume of alcohol units

cross-border purchasing, excluding households located on the border between England and Scotland did not alter the main results (see Supporting information Table S7).

3 Deals that were multi-buys in England and Wales were run as temporary price reductions in Scottish stores (Kantar WorldPanel, personal communication; also see Supporting information section 11 for photographs of shelves of beer products in selected supermarkets), so it became possible to buy alcohol at the same discount as in the multi-buy deals but for smaller financial outlays, i.e. making the deal affordable to a wider range of the population.

Most large-scale stores in the United Kingdom operate a national pricing policy, which seeks to equate the prices paid in Scotland and England and Wales [32]. Therefore, the response to the multi-buy ban of some in the industry is likely to have been the replacement of multi-buy promotions with temporary price reductions; for example, replacing a buy-one-get-one-free offer with a simple 50% off, in order to maintain the same price per product (Kantar WorldPanel, personal communication). In further support of this hypothesis, a recent submission to the UK House of Commons Health Committee by the Association of Convenience Stores [33] states that: 'experience from Scotland shows that restricting promotions can actually make alcohol more affordable for problem drinkers. For example, rather than a person needing £12 to buy three bottles of wine, they can buy one for £4, when the actual single unit cost would have been £5'. Our results provide additional support for this hypothesis, as households appear to have responded to the ban by purchasing beer or cider products on more occasions but buying fewer products per trip.

While we tested extensively the robustness of our findings, there are three main limitations to the analysis: first, as the Alcohol etc. (Scotland) Act (2010) also included restrictions on in-store marketing of alcohol products and a revised age verification policy, it is impossible to isolate the independent effects of the multi-buy ban. However, excluding data from younger households (i.e. main shopper aged 30 years or less), the main results were largely maintained (Supporting information Table S7), suggesting that the new age-verification policy was unlikely to account for the lack of effect of the multi-buy ban. Moreover, these accompanying regulations were also intended to decrease alcohol purchases and we found no such decrease.

Secondly, this evaluation focuses on the short-term (i.e. 9 months) impact of the multi-buy ban on purchases. As more data become available, a longer-term evaluation on alcohol consumption and its health effects would be desirable. Furthermore, the current policy is meant to be combined with more direct minimum unit pricing regu-

lation, following recent Scottish legislation [34]. We cannot exclude the possibility that the effect of the ban will materialize once it is part of a broader policy mix.

Thirdly, although the underlying data set is a high-quality, actively maintained commercial data set, there are limitations in the data itself that need to be borne in mind when interpreting the results. Most notably, the data consist of take-home purchases from off-trade stores only, and therefore purchases of alcohol at bars and restaurants, which account for about one-third of the total alcohol market [15], are not included in the data. Moreover, the purchasing data are self-reported and may therefore be subject to bias and under-reporting. It is also conceivable that due to recruitment problems the high end of very harmful alcohol consumers is not part of the sample.

Mindful of these limitations, our findings represent an important contribution to public health research as well as to policy. In terms of the former, the study adds to the few existing 'natural experiment' evaluations of actual policy interventions—an area that was singled out in the recent Medical Research Council (MRC) Guidance as a key priority for public health research [35], given the difficulty of evaluating population-level interventions in randomized controlled trials. The existing literature of relevant alcohol policy appraisal has been based upon *ex-ante* demand–response simulations via mathematical or statistical modelling [36,37]. Although those models are an essential input to the examination of policy scenarios, they tend to ignore any potential compensatory supply responses by the industry to the legislation in question, and thus may be prone to overly optimistic predictions [18]. Our *ex-post* analysis complements the existing modelling approaches by providing a direct evaluation of the actual policy, capturing the net effect of all demand and supply responses that result upon the introduction of the policy.

In terms of policy, the results should inform policymakers who are considering enacting similar alcohol policies nationally and internationally. Thus far, at least in Europe, the most frequent price intervention in the alcohol market has been that of imposing excise duties on alcoholic beverages [38]. However, there appear to be limits in the form of political and public acceptability regarding further extension of these measures [39]. There is reason to believe that countries may be seeking other, less contentious pricing policies—a characteristic that would arguably be met by the restriction of quantity discounts. However, our findings suggest that while this policy may be politically more feasible, it appears ineffective, at least in the short term. In practice, future policy design should seek to factor in potential supply-side responses that could mitigate the intended effect of the policy. In the case of the multi-buy ban examined here,

retailers appear to have responded by simply replacing multi-buys with simple price reduction. Banning all forms of price promotion of alcohol may be considered a more effective option [36], yet such a policy may still be compromised by reductions in the standard price of alcohol products, thereby making alcohol more affordable. More encompassing regulation of price promotion and price is probably required in order to reduce alcohol purchasing and, in turn, consumption and related harms.

Declaration of interests

None.

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Supporting information

Additional Supporting Information may be found in the online version of this article at the publisher's web-site:

Figure S1 Kernel density plot of the raw volume of alcohol purchased per quarter

Figure S2 Kernel density plot of the log-scaled volume of alcohol purchased per quarter

Figure S3 Time trends in alcohol purchasing excluding Christmas (January 2010–June 2012) (comparable figure including Christmas is Fig. 1 in the main paper)

Table S1-1 Total volume of alcohol purchased in Scotland from January 2011 to September 2011 (pre-ban period only) by promotional category (Kantar WorldPanel data).

Table S1-2 Total volume of alcohol purchased in England and Wales from January 2011 to June 2012 (pre-ban and post-ban periods) by promotional category (Kantar WorldPanel data).

Table S2-1 Mean volume of beer and cider purchased by households pre- and post-ban (volume per quarter), by household purchasing patterns.

Table S2-2 Mean volume of wine purchased by households pre- and post-ban (volume per quarter), by household purchasing patterns.

Table S2-3 Mean volume of spirits purchased by households pre- and post-ban (volume per quarter), by household purchasing patterns.

Table S2-4 Mean volume of flavoured alcoholic beverages (FABs) purchased by households pre- and post-ban (volume per quarter), by household purchasing patterns.

Table S2-5 Mean total pure alcohol (measured by units) purchased by households pre- and post-ban (units per quarter), by household purchasing patterns.

Table S3-1 Difference-in-differences estimation of the impact of the multi-buy ban on the volume of alcohol purchased per quarter in Scotland by (a) socio-economic group and (b) volume of alcohol purchased pre-ban.

Table S3-2 Difference-in-difference-in-differences estimates of the impact of the multi-buy ban on volume of alcohol purchased per quarter in Scotland by (a) socio-economic group and (b) volume of alcohol purchased pre-ban (difference-in-difference-in-differences version of Table S3-1).

Table S3-3 Sensitivity analyses of the results of Table S3-1 and S3-2 (using different cut-off values for volume of alcohol purchased pre-ban: top 50, 33, 25, 20 and 5%).

Table S4-1 Difference-in-differences estimates of the impact of the multi-buy ban on (i) the frequency of trips involving alcohol purchasing per quarter, (ii) the number of alcohol products purchased per trip, (iii) the volume of alcohol purchased (in natural volume, ml) per trip and (iv) the average size of alcohol products (in natural volume, ml).

Table S4-2 Difference-in-difference-in-differences estimates of the impact of the multi-buy ban on (i) the frequency of trips involving alcohol purchasing per quarter, (ii) the number of alcohol products purchased per trip, (iii) the volume of alcohol purchased per trip (in natural volume, ml) and (iv) the average size of alcohol products

(in natural volume, ml) [difference-in-difference-in-differences version of Table S4-1).

Table S4-3-1 Subsample analysis for the impact of the multi-buy ban on (i) the frequency of trips involving alcohol purchasing per quarter in Scotland (in Table S4-1 and S4-2), by (a) socio-economic group and (b) volume of alcohol purchased pre-ban.

Table S4-3-2 Subsample analysis for the impact of the multi-buy ban on (ii) the number of alcohol products purchased per trip in Scotland (in Table S4-1 and S4-2), by (a) socio-economic group and (b) volume of alcohol purchased pre-ban.

Table S4-3-3 Subsample analysis for the impact of the multi-buy ban on (iii) the volume of alcohol purchased per trip (in natural volume, ml) in Scotland (in Table S4-1 and S4-2), by (a) socio-economic group and (b) volume of alcohol purchased pre-ban.

Table S4-3-4 Subsample analysis for the impact of the multi-buy ban on (iv) the average size of alcohol products

(in natural volume, ml) in Scotland (in Table S4-1 and S4-2), by (a) socio-economic group and (b) volume of alcohol purchased pre-ban.

Table S5 Panel difference-in-differences estimates.

Table S6 Difference-in-differences using different sample window (pre-ban: October 2010–June 2011; post-ban: October 2011–June 2012).

Table S7 Subsample analyses of difference-in-difference-in-differences estimates of the impact of the ban on alcohol volume purchased (point estimate only)—(i) excluding purchases made during Christmas; (ii) excluding purchases made online; (iii) excluding households located near the border; and (iv) excluding households with a main shopper aged 30 years or younger.)

Table S8 Difference-in-difference-in-differences estimates of the impact of the multi-buy ban on volume of alcohol purchased per quarter in Scotland, separately by branded products and supermarket own-label products.