Evaluating the Impact of Minimum Unit Alcohol Pricing on Household Alcohol Expenditure in Scotland

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University of Kent, July 2024

Abstract

In May 2018 Scotland became the first country in the world to introduce a minimum unit price for alcoholic beverages of £0.50. The policy targets low-cost high-percentage alcoholic beverages sold by retailers, and primarily consumed by high-risk drinkers often residing in a low socio-economic position. This paper uses repeated cross-sectional survey data on monthly household expenditure, derived from the Living Costs and Food survey to compare alcohol expenditure pre and post-intervention in Scotland and England, with England acting as a control. This paper utilises a quasi-experimental two-stage propensity score matching approach combined with a difference-in-difference methodology, this report showcases that when controlling for low-income households, there is a statistically significant (99% CI) 27% reduction in expenditure on alcoholic beverages consumed off-premises by Scottish households relative to their English counterpart's, post-intervention. Whether this reduction can be solely attributed to the policy implementation is less clear. Nevertheless, as more countries in the UK have adopted or are consulting on a minimum unit price for alcohol, this paper can aid policy design and ministerial decision making.

Acknowledgements

I would like to express my deepest gratitude to my line managers, mentors, and lecturers for their invaluable guidance and encouragement throughout my degree. Their support has been instrumental in my journey. I also extend my heartfelt thanks to my family and my partner for their immense support, particularly my father, whose unwavering belief in me has been a constant source of strength.

1. Introduction

In 2021 the highest number of alcohol specific deaths were recorded for the UK – 9,641, with Scotland having a disproportionately high alcohol specific death rate relative to the rest of the UK (ONS 2022). The past few decades have seen these deaths in Scotland steadily increase from 427 in 1988 to 1,136 in 2018 – almost tripling in 30 years (NRS Scotland 2023). Some suggest that the contribution of alcohol to ill health is even greater, and that in 2015, alcohol was a factor in 3,705 deaths in Scotland – that is 1 in 15 deaths in Scotland in 2015 (57,327) were alcohol related (NHS Scotland 2018, p.5). Their distribution is not homogenous, with the alcohol mortality rate being eight times higher in the most deprived areas relative to the least deprived (Gov.Scot 2020). Research indicates that this relationship continues to be witnessed even after controlling for alcohol consumption variations between socio-economic groups (Katikireddi, et al 2017). In 2007 it was estimated that the societal cost of alcohol misuse in Scotland was £3.6 billion (NRS Scotland 2007, p.3), with an annual cost to NHS Scotland of over £405 million (NHS Health Scotland 2009, p.4).

In May 2018, after a 10-year consultation and campaign, Scotland became the first country in the world to introduce a Minimum Unit Price (MUP) for alcohol – 50p per UK unit (1 UK unit equals 8 grams of ethanol, therefore, MUP equals 6.25p per gram). Changing standard taxation, such as alcohol duty, would impact all alcoholic beverages and all consumers. Alcohol MUP works in tandem with conventional forms of taxation by aiming to tackle the lowest priced and most harmful forms of alcoholic drinks sold predominately by retailers (off-licenses) and are the beverages of choice by those residing in a lower socio-economic position (Shortt, et al 2015, pp3-5). Therefore, MUP acts as a targeted public health measure.

Through utilising a Propensity Score Matching Difference-in-Difference methodology and using alcohol expenditure as a proxy for alcohol consumption, this paper addresses the question if the introduction of alcohol MUP in Scotland has led to a reduction in consumption on alcohol across households in Scotland relative to those in England. As the majority of research on the impacts of alcohol MUP focuses on alcohol related harms, deaths, hospitalisations or sales, this study aims to fill an evidence gap by analysing the impact on household alcohol expenditure and by proxy, alcohol consumption.

The importance of this is demonstrated by countries such as Wales and Ireland recently adopting their own alcohol MUP (GOV.WALES, 2020, GOV.IE, 2021) and Northern Ireland consulting on the possibility of doing so (GOV.NI, 2022), alongside growing pressure for a similar policy in England (House of Commons Library 2020, p.3, The Telegraph 2023). In consequence, this paper has the potential to contribute to the literature and so influence and assist policy makers.

2. Literature Review

2.1 Policy Application & Theory

Minimum Unit Pricing (MUP) is a "sin" tax, which itself is a form of Pigouvian tax – a tax on a negative externality. A sin tax aims to lower or end the use of a good considered to be harmful or costly to society by making it more expensive to purchase. Historically in the UK, sin taxes have predominately targeted tobacco products, and more recently sugary drinks, through the Soft Drinks Industry Levy (Institute for Government, 2022).

The economic theory justification for government intervention is because of moral hazard. As the UK has a National Health Service (NHS), which is understood as free at the point of use, individuals do not bear the full cost of their actions. Therefore, economic agents are incentivised to increase their exposure to risk, as they do not bear the full costs of that risk. This "cost" is externalised to the public through the economic agents' actions, be that crime, health outcomes or otherwise. This cost is effectively "carried" by Governmental bodies funded by the public purse, such as the NHS.

Consumer behaviour theory indicates that when a normal good, such as alcohol (Čiderová & Ščasný 2022 p.334), is low priced, consumers will increase their consumption to maximise their utility. There is strong evidence linking low retail price of alcohol with high levels of consumption (Gallet 2007, p.133, Wagenaar et al, 2009, Nelson 2013, pp.4-8). Therefore, cheap alcohol makes alcohol more affordable, so increasing consumption which leads to greater alcohol-related harms (Anderson et al, 2009, Elder et al, 2010). There is a well-documented economic consensus of an inverse relationship between alcohol price and consumption/harm (Purshouse et al 2010, and Meier et al 2016).

Alcohol MUP is a structural intervention and an "upstream" policy, as it targets the whole population of harmful drinkers. The introduction of a price floor translates into the consumer bearing the full weight of the price increase, stopping retailers from being able to sell cheap alcohol as a "loss-leader" to attract consumers. However, this acts as a regressive tax because those on low incomes, who are most likely to purchase these products, must use a larger proportion of their budget to achieve the same level of utility or consumption relative to those on higher incomes.

This is perhaps why research indicates that low-income consumers have a greater propensity to reduce their alcohol consumption in response to a sin tax as any tax increase, costs those on a low-income proportionally more (Paraje, et al, 2023). Studies that fed into the Scottish MUP policy decision support this view. Angus et al (2016, p.7) estimated that the introduction of an alcohol MUP of £0.50 per unit would reduce aggregate alcohol consumption in Scotland by 3.5% per year. Furthermore, the policy would prevent 2,040 alcohol related deaths, and 38,900 hospital admissions over 20 years and to achieve the same outcomes would require a 28% increase in alcohol duty. Implying alcohol MUP is a more cost-effective targeted intervention.

The Institute of Alcohol Studies (Stockwell et al, 2013a, pp.2-3) found similar evidence when modelling for an alcohol MUP of £0.45.

2.2 Elasticities

Any reduction in consumption of a good, resulting from a tax increase, is dependent on the elasticity of said good, and the availability of substitutes. The widely accepted consensus is that alcohol is an inelastic good with an elasticity between -0.44 and -1, and has few substitutes (Gallet 2007, Wagenaar et al, 2009). More recent research conducted by HMRC (2014, p.19, & p.30 – Table 8A) supports this analysis and states that in the UK "all types of alcohol are price inelastic". However, price elasticities vary by consumption level, with high volume drinkers being less receptive to price increases (Pryce et al 2019). It follows that if a tax is not set to a high enough rate on an inelastic good, there will be little or no reduction in consumption, especially amongst the "largest" consumers of the good.

2.3 MUP Across the World

Scotland is the first country in the world to implement an alcohol MUP. Prior to this, research to examine the impacts of implementing an alcohol MUP only existed on a sub-national level, such as provinces in Canada and the Northern Territories of Australia (NTA), both seeking to minimising alcohol related harms, associated with high-percentage, low-cost forms of alcohol.

All 10 provinces in Canada have differing forms of alcohol MUP. Research indicates that a 10% increase in the minimum price of an alcoholic beverages reduced consumption by 8.43% in Saskatchewan (Stockwell et al, 2012a) and by 3.4% in British Columbia (Stockwell et al, 2012b), as well as reducing alcohol-attributed deaths by 31.7% in British Columbia (Stockwell et al 2013b). Alongside this, the introduction of MUP in Saskatchewan has also been attributed to a decrease in alcohol related emergency department visits for women, road traffic accidents, and assaults among young men (Sherki 2018). The aggregate evidence from all 10 provinces indicates that a 10% increase in the MUP of alcohol results in a "8% reduction in consumption, a 9% reduction in hospital admissions and a 32% reduction in wholly alcohol caused deaths – with further benefits accruing two years later" (Stockwell et al 2013a).

In October 2018 the Northern Territories of Australia (NTA) implemented an alcohol MUP of $1.30 per 10g of pure alcohol. Research commissioned by the Northern Territory Department for Health indicates the intervention has been successful in reducing the supply of low-cost, high-percentage alcoholic beverages, and has attributed to a 6.3% fall in total alcohol consumption (Frontier Economics 2022, p.12-13). The research also evidences a decline in alcohol related emergency department presentations, road traffic injuries and fatalities and most significantly, a reduction in alcohol related harms by 25.8%. However, the paper stresses the uncertainty and difficulty with solely attributing these reductions to the introduction of MUP.

Additional research commissioned by the Northern Territory Government, shows the policy has complemented existing legislation and implementation has been straightforward for businesses without impacting turnover or tourism (Coomber et al, 2020, p.26). This contrasts with claims made by the alcohol industry in the UK that the introduction of MUP will be negative for business, will reduce competition, and will lead to an increase in “bootlegging” (Beerguild 2013, Scotch Whiskey 2016).

The consensus in the NTA is that the policy has been a success, with the Drug and Alcohol review (Taylor 2023) stating that the policy was “considered a cost-effective approach that targeted and substantially reduced consumption, with minimal cost to government, and has likely resulted in returns, through reduced harms”. This is perhaps why the World Health Organisation (WHO) actively encourages the use of pricing policies to tackle alcohol related health problems (WHO 2010, 2019).

2.4 UK Alcohol MUP Research so far

Most research analysing the introduction of alcohol MUP in Scotland has focused on health and crime outcomes, with Wyper et al (2023) estimating a reduction of 13.4% in alcohol-related deaths. However, these estimates are not universal, with some research indicating that the introduction of MUP is responsible for 258 more alcohol-related emergency department visits (Katikireddi et al, 2021). Others question whether the policy had any impact on alcohol-related crimes (Bannister 2021). Nevertheless, evidence indicates there has been a significant reduction in grams of alcohol purchased weekly by households, and this is most prominent in low-income households (Anderson et al 2019, 2021). It is from this research and the possibly conflicting results, that this paper more closely analyses the impact on household expenditure and therefore consumption from the introduction of alcohol MUP.

3. Data & Methodology

3.1 Data Sources

The primary data source for this study is the Living Cost and Food survey (LCF), which is managed by the Office for National Statistics (ONS 2017) and available from the UK data service (UK Data Service 2022). The LCF collects information on household spending patterns on a monthly frequency and is considered the most significant survey on household expenditure in the UK due to its granular nature. The data is collected on a NUTS1 level – the 12 regions of the UK. However, for the purpose of this analysis, Wales and Northern Ireland have been excluded.

A limitation to this data is that the LCF does not track the same households across time. The households that complete the survey differ over time (namely each household appears only once) (UK Data Service, 2015, p.5). The LCF is a repeated cross sectional survey dataset that uses a multi-stage stratified random sampling to minimise the difference in composition of households across time (ONS 2023a, Point.5).

The ONS (2023b, Point.10) state that households "are selected at random from the Royal Mail's postcode Address File". Each year around 13,000 addresses are selected. However, if one of these addresses refuses to participate and complete the survey, they cannot be replaced with another household. Financial incentives, such as gift vouchers are used to encourage responses. From 2010 to 2020 this was £10 for each adult and £5 for each child in a household that completed an expenditure diary (ONS 2015, p.27). Nevertheless, of the 13,000 a year sample size, the average number of responders is between 5000 to 6000, a response rate of less than 50 percent (ONS 2021, Point.2).

This analysis runs from January 2010 to March 2020, meaning there are 23 "post-intervention periods/months" (MUP implemented May 2018). The rationale for this is twofold. The LCF has a two-year delay in publication so for instance, in April 2023 they published 2021 data, so the maximum time window was to December 2021. However, because of the COVID-19 pandemic, which led England and Scotland to go into lockdown on the 23rd and 26th of March respectively, it was decided to end the analysis in March 2020. This is because England and Scotland pursued very different lockdown rules, in terms of stringency and length. Thus, the underlying conditions during the pandemic period would have impacted consumer behaviour and expenditure patterns, leading to greater volatility.

Table 1 showcases summary statistics for some of the key variables for the treatment and control groups. As this is survey data, many variables are binary and as a result, these have not been included but will be employed as control variables later. Observing Table 1, it can be noted that a large proportion of households, in Scotland and England report no expenditure on alcohol. Additionally, alcohol expenditure (which is the dependent variable), showcases a wide range for both the treatment and control groups. As a result, this variable will be logged for the regression analysis phase. This will also enable the coefficients to be interpreted as elasticities.

Table 1: Summary Statistics: Scotland – 5,463 Observations, England – 43,283 Observations

Variable	Region	Mean	Median	Std.Dev	Min	50 Pctl	Max
Gross Income	Scotland	657.1	530.7	494.3	0.0	530.7	2496.2
	England	712.2	572.6	523.2	0.0	572.6	2496.2
Disposable Income	Scotland	582.9	496.2	385.8	0.0	496.2	1898.1
	England	613.3	536.4	404.2	0.0	536.4	1898.1
Expenditure on Spirits (off-premises)	Scotland	2.6	0.0	7.7	0.0	0.0	101.8
	England	1.7	0.0	5.8	0.0	0.0	135.9
Expenditure on Wine (off-premises)	Scotland	4.3	0.0	10.9	0.0	0.0	220.9
	England	4.4	0.0	11.1	0.0	0.0	346.5
Expenditure on Cider (off-premises)	Scotland	0.3	0.0	1.7	0.0	0.0	31.3
	England	0.4	0.0	1.9	0.0	0.0	86.8
Expenditure on Beer (off-premises)	Scotland	1.6	0.0	4.3	0.0	0.0	62.9
	England	1.8	0.0	4.9	0.0	0.0	161.9
Expenditure on Alcohol (off-premises)	Scotland	8.9	2.1	15.9	0.0	2.1	234.4
	England	8.3	2.0	15.3	0.0	2.0	366.3
Expenditure on Alcohol (on-premises)	Scotland	6.2	0.0	14.4	0.0	0.0	187.8
	England	7.5	0.0	16.5	0.0	0.0	452.5

Note: Gross and Disposable Incomes have been capped by the LCF to protect anonymity

3.2 Assumptions, Limitations & Uncertainty

For this paper, it is assumed that the ONS made no classification changes to the LCF – this was verified through data dictionaries. Secondly, any changes to alcohol policies or duty have been universal – impacting England and Scotland equally (GOV.UK 2024). Additionally, it has been assumed that the composition of the populations being analysed are not changing over time.

There is uncertainty surrounding consumer behaviour as it varies significantly across England and Scotland, be it, consumer preference – wine and cider in the Southern counties of England, or lager and whiskey in the Highlands and Islands of Scotland (LunzerWine.com 2023, All.com 2024, Idealo.co.uk, 2021). Additional differences pertain to laws around the sale of off-premises alcohol. In England alcohol can be purchased 24 hours a day, 7 days a week from retailers. However, in Scotland these purchases are only legal between 10am and 10pm (The National Scot 2023). Research from Germany (Marcus & Siedler 2015) indicates that banning the sale of late-night alcoholic beverages reduces alcohol-related hospitalisations amongst young people and decreases hospitalisations from assaults. Despite these findings, this paper does not control for these differences as the data is not sufficiently granular to only include alcohol purchased during the same time window.

In response to enquiries, the ONS explained that a low response rate can lead to biases and skews which can be different each year. The ONS also expressed a probable biased skew in favour of homeownership in the data. This is important because low-income households – those that MUP target, are more likely to be in rented or insecure accommodation (IFS 2023). Research indicates there is a link between insecure accommodation or homelessness, and drug and alcohol dependency (EMCDDA 2023, Hulse & Saugeres 2008, pp.1-3). Implying that those most impacted by alcohol MUP may not be present within the data set.

The LCF is only available on a regional level, therefore it was not possible to control for cross-border effects as this would require more granular data, such as Super Output level data on a postcode or Local Authority level. However, the rationale for not attempting to control for these cross-border effects is two-fold. Firstly, the geography of the Anglo-Scottish border is "hilly and largely rural" (Scotland.Org 2024). Secondly, alcohol MUP is targeted at low-income drinkers, who are less likely to have a car or finance to travel (The Health Foundation 2023). Considering this, it has been assumed that there would be minimal cross-border activity between England and Scotland.

3.3 Difference-in-Difference Methodology & Propensity Score Matching

A common approach to analyse the impact of a policy intervention is to employ a Difference-in-Difference methodology (DD). Card and Kreuger (1993) pioneered this methodology through their work analysing the impact of a minimum wage increase on employment levels between neighbouring states in the US – one state that received the treatment (New Jersey) and one that did not and acted as the control (Pennsylvania). This paper utilises this methodology to analyse the impact of the introduction of alcohol MUP on alcohol expenditure with Scotland being the group that received the treatment and England acting as the control group.

A key requirement for conducting a DD methodology is the assumption of parallel trends where no time-varying differences exist pre-intervention between the treatment and control groups and that in the absence of treatment, both groups follow parallel or common paths over time. This assumption enables any treatment effect to be attributable to the policy intervention. If the assumption does not hold, and the trends are different, any estimated treatment effect obtained would be biased, or invalid. As the LCF survey is pooled cross-sectional data, meaning the population of survey respondents are changing across time, it cannot be assumed that they are identically distributed, especially given the moderate response rate.

Figure 1 displays monthly household alcohol expenditure by English and Scottish households, indexed from January 2010 (=100). Strong seasonality is observed, and Scottish households exhibit high volatility. This may reflect data size, or other differences. However, these results are indicative, but not absolute that Scottish and English households may not share parallel trends. A placebo DD was conducted to provide a more robust answer.

Figure 1: Household Alcohol Expenditure by English and Scottish households from January 2010 = 100. Dashed line represents policy implementation May 2018.

A placebo DD omits the treatment group and uses a "fake" treatment group in its place – a group that did not receive the intervention. For robustness purposes, six Placebo difference-in-differences were conducted. A region was designated as the "fake" treatment group on two different time-periods (May 2015 and May 2018) three times. These regions were the North-West, London and the South-West, with the rest of England acting as the control group, with Scottish households omitted. For the parallel trends assumption to hold, there should be zero impact. However, each of these six regressions evidenced a statistically significant reduction in alcohol expenditure in the "fake" treatment region, relative to the rest of England, (See Annex 10.1 for the output). The impact witnessed indicates an underlying difference in trends in the data that is external to the policy, which may be driving the divergence between the two groups. Whilst not definitive, these findings reinforce the suspicion of a lack of equal or parallel trends. This is likely borne from the survey not tracking the same people overtime and the poor response rate (around 50%), introducing skews and creating an unbalanced dataset. To attempt to control for non-parallel trends, and much of the uncertainty and limitations already discussed in the data, Propensity Score Matching (PSM) was employed.

PSM is a quasi-experimental method whereby recipients and non-recipients of the treatment are matched by a propensity score which is the probability of treatment given a vector of shared observable characteristics, thereby creating a comparable counterfactual. These two approaches combined, the PSM-DD estimator, are commonly used together as their joint strengths offset their individual weaknesses (Heckman et al, 1997, Blundell & Dias 2000 and Hong 2013). For instance, PSM cannot account for unobserved characteristics, but DD can account for time-invariant unobserved heterogeneity.

Most of the literature relating to PSM utilises time-series or panel data that track the same units overtime. The data being used in this paper is repeated cross-sectional survey data on a monthly frequency which does not track the same units overtime. Therefore, the matching was conducted on a monthly basis, and these "monthly matchings" were aggregated together to form an "artificial" dataset. Whilst limited, there is precedent in the literature for such a novel approach (Blundell & Dias 2000 and Binci et al 2018).

The data "wrangling" for this phase took place in R studio and followed the step-by-step guide of Randolph et al (2014), utilising the "Matchit" package (Greifer 2023). PSM is a two-stage analytical approach. A binary variable was created that took the value of 0 for control (England) and 1 for treatment (Scotland). Next, a logistic (logit) regression was used to generate propensity scores for each unit of observation based on key characteristics. These were: disposable income, household size, category of dwelling, tenure type (mortgage, rented ect), age and the number of male or female adults in the household act as covariates (See Annex 10.2 for further information on these variables).

The second stage matches households in the different groups (treatment and control) with similar propensity scores so differences in the outcome measure can be considered the treatment effect (Stuart 2010). This study presents two alternative methods as a "robustness check" when matching treated households with those in the control group: Nearest Neighbour with one-to-one matching and no replacement (Nearest Neighbour 1 – NN1); Nearest Neighbour with two-to-one matching and no replacement (Nearest Neighbour 2 – NN2).

In essence, this methodology selects a control group from England which matches Scottish households that have the closest propensity score. The one-to-one ratio means that each control observation was only matched once to a treatment observation. Therefore, with two-to-one matching, two control units can be matched to each treated unit. Matching with replacement means matching one control observation to numerous treatment observations. This is usually conducted when there are more treatment observations than control. As this is not the case, it is not necessary to match with replacement.

For PSM to be valid, two key assumptions need to hold. These are the common support assumption – all estimated propensity scores must reside within 0 and 1, and the conditional independence assumption which states that once the relevant characteristics have been accounted for, any outcome measure is independent and can only be attributed to the policy intervention. This means that any treatment effect is dependent on how balanced the treatment and control groups are post-matching.

After the data cleaning phase and PSM, NN1 had 5,701 observations and NN2 had 7,523 – from a raw dataset of 53,844 observations. As the accuracy of PSM is dependent on reducing imbalance between the groups, these "artificial" datasets were assessed to make sure the propensity scores and covariate balance were sensible and equally distributed. This can be observed in Figures 2,3,4 and 5 which display similar results for both methods. Figures 2 and 3 showcase that propensity scores are distributed in a similar fashion, all residing between 0 and 0.25 (falling within the assumed 0 and 1). Figures 4 and 5 exhibit slightly different raw control histograms, but significantly, for the individual methods, their matched treated and controls are identical. The most noteworthy difference resides in figures 6 and 7 which present the covariate balance for NN1 and NN2 'before' (red dots) and 'after' the adjustment (blue dots). Analysing the left-hand side, the standardised mean differences, it can be observed that all the adjusted dots now fall within the dotted lines, signifying they are balanced using both nearest neighbour matching. This pattern is observed for the variance ratios on the right-hand side too. It is important to note that only disposable income, household size and category of dwelling were considered unbalanced pre-matching. Overall, this means that PSM has been successful, and inferences can be made on a treatment effect on the treated.

Figure 2: NN1 – Distribution of Propensity Scores

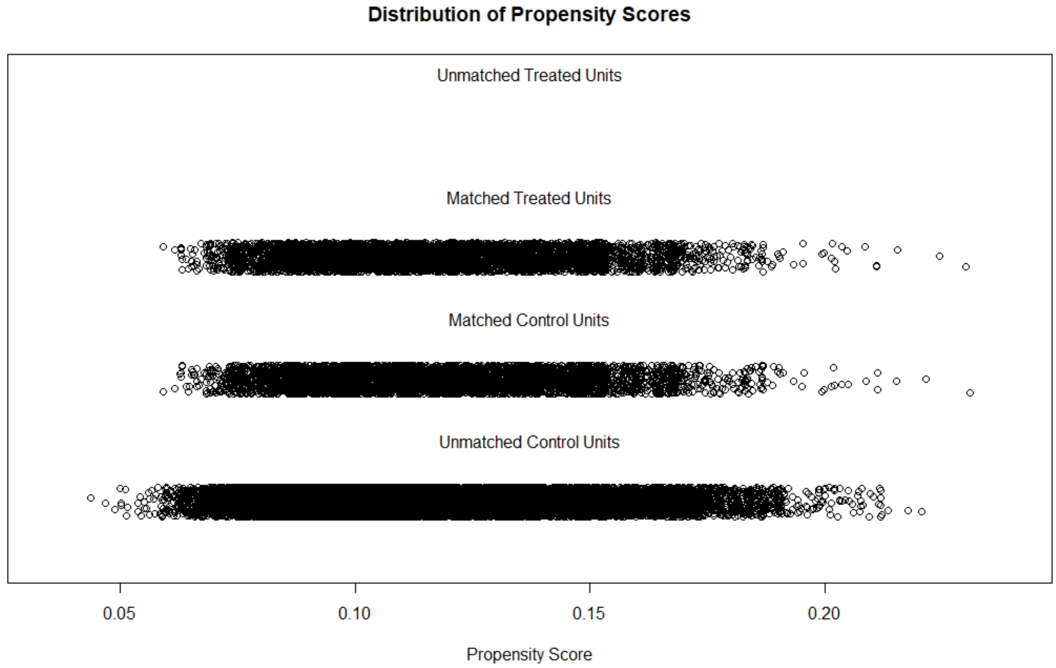


Figure 3: NN2 – Distribution of Propensity Scores

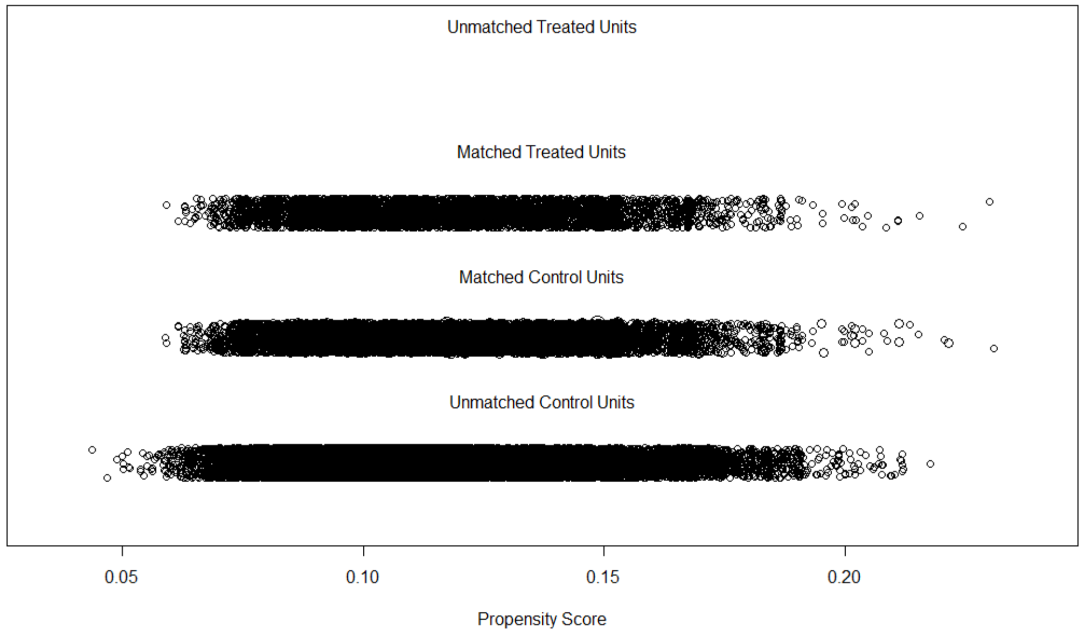


Figure 4: NN1 – Histograms

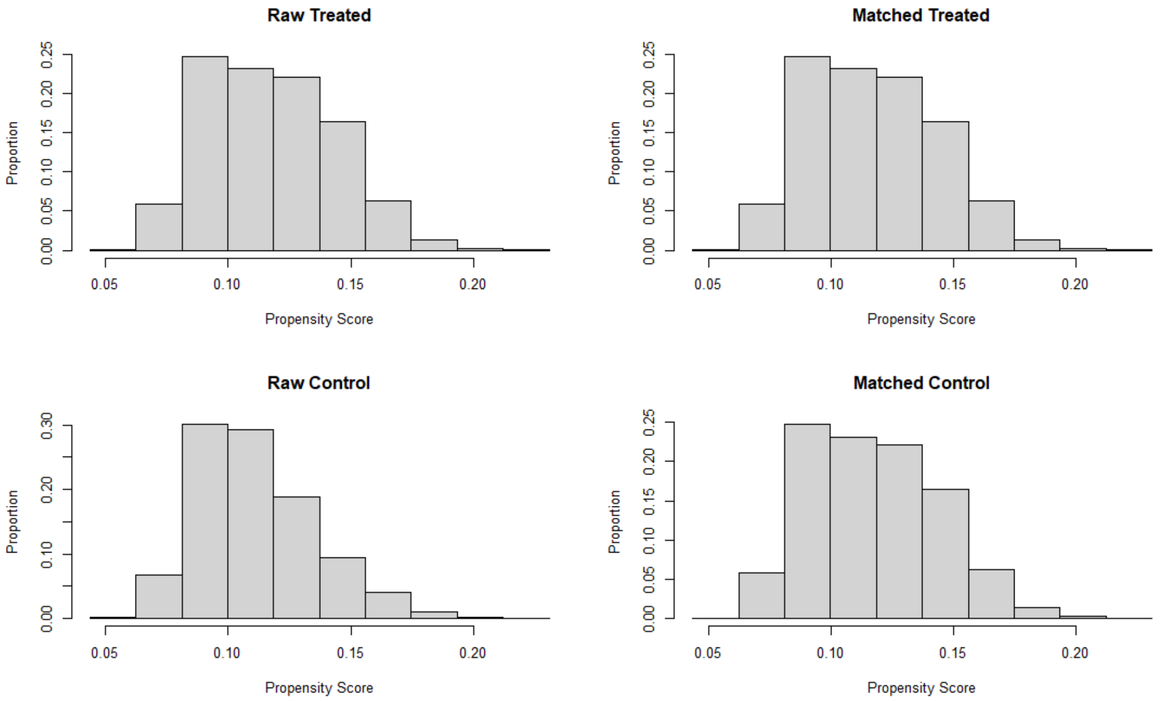


Figure 5: NN2 – Histograms

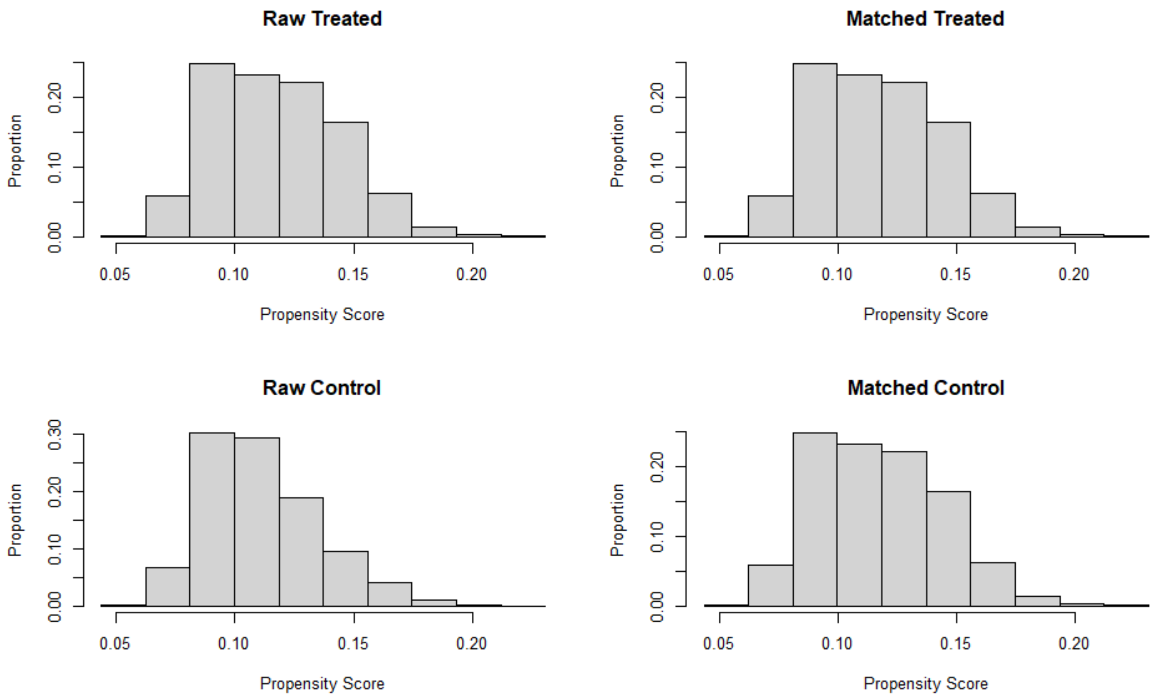


Figure 6: NN1 – Covariate Balance

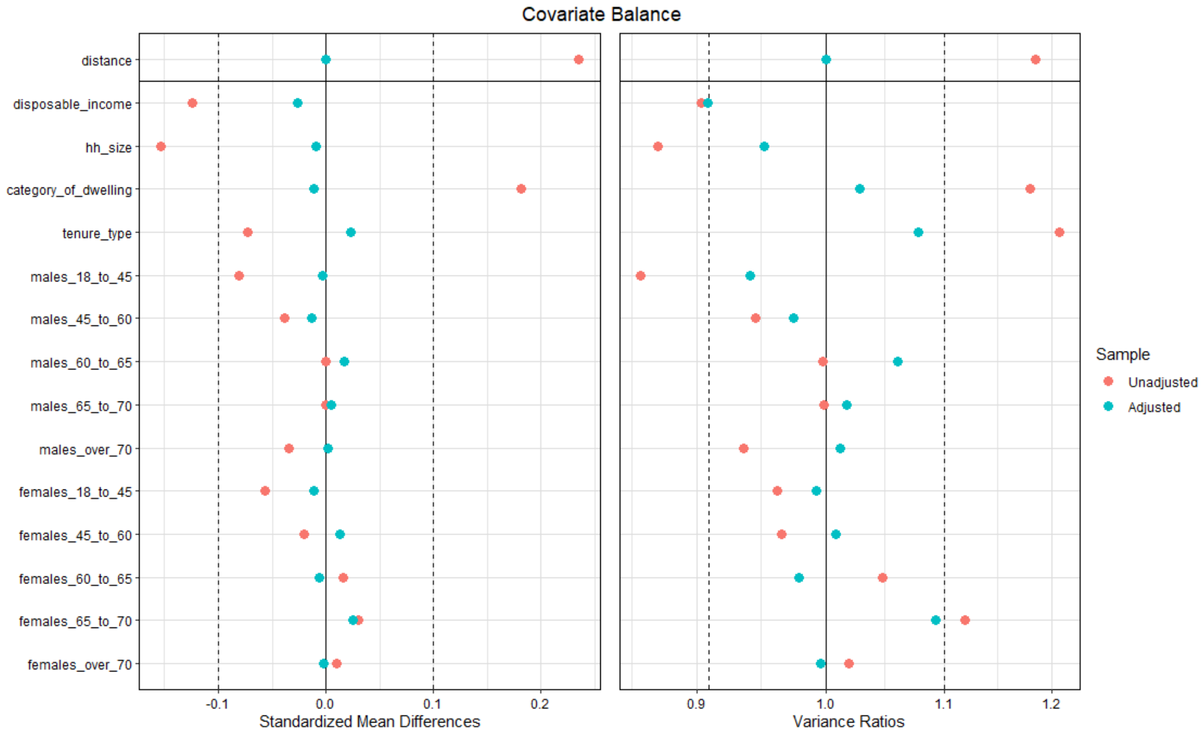
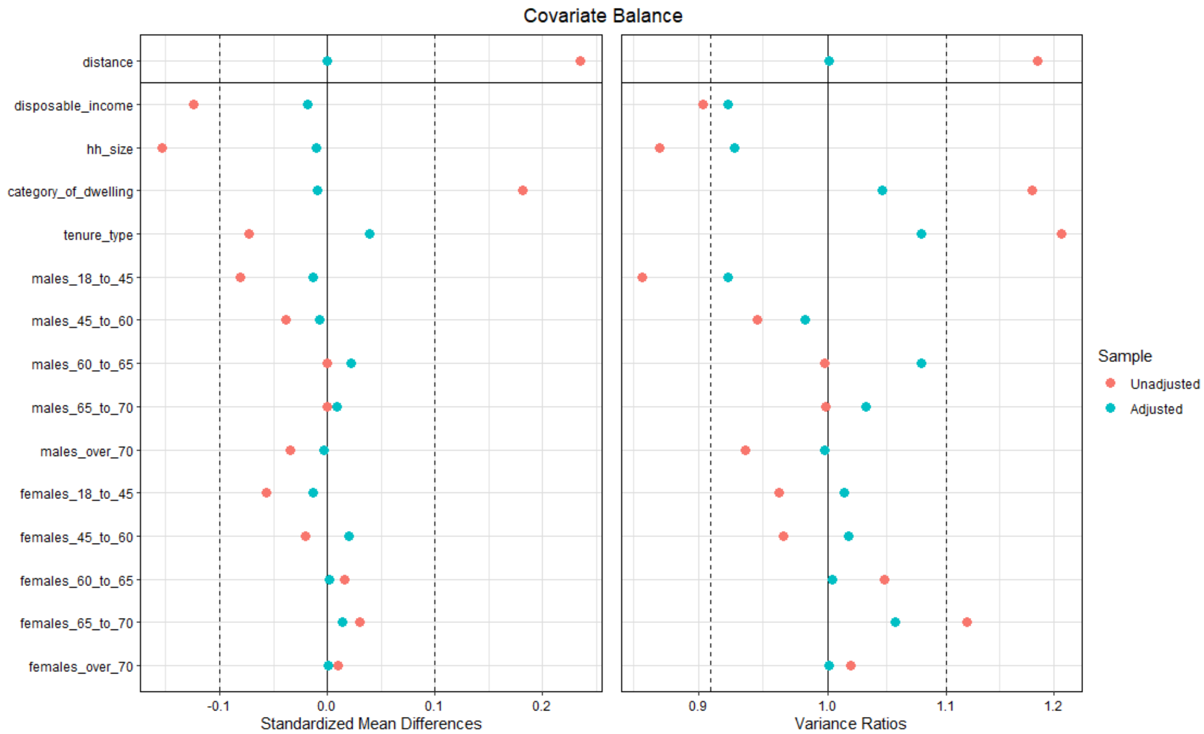


Figure 7: NN2 – Covariate Balance



3.4 Empirical Strategy

$$ln(alcohol\_expenditure)_t = \beta_0 + \delta_t + \beta_1 treated_t + \beta_2 pre\_post_t + \beta_3 X_t + \varepsilon_t$$

The above equation outlines the baseline model to be examined. Where *ln(alcohol_expenditure)* is the natural log of the amount of household expenditure on alcohol and *t* is time. β_0 is the constant and the coefficient of the interaction variable delta, (δ_t) indicates the impact of the policy intervention. $\beta_1 treated_t$ and $\beta_2 pre\_post_t$ are binary variables that represent regions that where (1) or where not (0) exposed to the treatment and months that were pre (0) or post (1) intervention. $\beta_3 X_t$ represents control variables such as inflation rate and household size and ε_t is the error term. A list of the control variables can be seen in Table 2.

Table 2. List of Variables

Variable Name	**Variable Description**
ln(alcohol_expenditure) – Dependent Variable	The natural logarithm of weekly expenditure on alcohol "brought home" – purchased from retailers.
Treated	Dummy for treatment group: =0 control group, =1 treatment group
Time	Dummy for time-period: =0 pre-treatment,=1 post-treatment
DD	Difference-in-difference estimator
Household composition	The breakdown of the number of people residing in the household on a normal basis
Alcohol consumed on premises (away from home)	Alcohol consumed at pubs, restaurants etc. On premises purchases.
Category of Dwelling	Type of house; whole house, bungalow detached, bungalow semi-detached, terraced house, flat, other
Tenure Type	Type of tenure; local authority rented, housing association, rented unfurnished, rented furnished, owned with mortgage, owned outright, rent free, other.

The rationale for employing these control variables is as follows; household composition acts as a proxy for age and sex, as there is a well-documented relationship between alcohol consumption and gender, with males more likely to have higher consumption than females (Alcohol Change UK 2022). Tenure Type and Category of Dwelling provide an indication of socio-economic standing. From the literature there is a correlation between insecure accommodation and low-income, i.e. those who are most likely to consume "cheap" forms of alcohol reside in rented or insecure accommodation, they are not homeowners, as referenced earlier. Disposable income has been omitted from the following models due to perfect collinearity with alcohol expenditure. Inflation was included to account for price rises across the period.

4. Results

4.1 Model 1 – Baseline Specification

The final phase of the research is to determine the treatment effect from the policy intervention. Model 1, a Fixed Effects (FE) Ordinary Least Squares (OLS) baseline specification, analyses the entire population of households in Scotland versus England. The Fixed Effects employed were year and quarter to control for any impacts on the treatment outcome that may be influenced by economic shocks or seasonality. A Random Effects Model was also tested, however, the results of a Hausman test rejected the null hypothesis indicating that a FE model is the preferred specification. The equation for Model 1 is depicted below, with Table 3 reporting the regression output for the two PSM methodologies – NN1 and NN2 (see Annex 10.3.1 for full regression output).

$$\begin{aligned} ln(alcohol\_expenditure)_t \\ &= \beta_0 + \delta_t + \beta_1 treated_t + \beta_2 pre\_post_t + \beta_3 Inflation\ Rate_t \\ &+ \beta_4 Household\ Composition_t + \beta_5 Alcohol\ not\ at\ home_t \\ &+ \beta_6 Category\ of\ Dwelling_t + \beta_7 Tenure\ Type_t + \varepsilon_t \end{aligned}$$

Table 3. Model 1 Regression Output – Dependent Variable is *ln(alcohol_expenditure)*

	NN1 (1:1)	**NN2 (2:1)**
DD Coefficient	0.039	0.016
	(0.022)	(0.025)
Inflation Rate	-0.097	-0.096
	(0.083)	(0.091)
Household Composition	0.013***	0.012***
	(0.001)	(0.001)

Alcohol on premises	0.007***	0.008***
	(0.000)	(0.001)
Category of Dwelling	-0.053***	-0.057***
	(0.012)	(0.008)
Tenure Type	0.043***	0.040***
	(0.007)	(0.004)
Observations	5701	7523
Within R^2	0.041	0.043
Adjusted R^2	0.041	0.044
F Statistic	33.89***	44.73***

*Standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01*

Observing Table 3, Model 1 showcases no significance in the treatment variable. Curiously, the treatment variable returns a positive coefficient, implying that alcohol consumption increased post-intervention, though neither is statistically significant. This is contrary to the prevailing literature (Anderson et al 2019, 2021).

Analysing the control variables for Models NN1 and NN2 it can be noted that all show statistical significance at the 1% level except from the rate of inflation. Additionally, all variables, report very small standard errors, implying precise estimates.

Investigating the model outputs further, it can be observed that the Adjusted R-squared value is very low (0.04) implying that the control variables are not contributing much to the model. This is to be expected as there are few variables included. Whilst there are several factors that impact an individual's expenditure on alcohol, such as age, gender, family background, socio-economic status (Collins 2016), many were not possible to capture as these questions were not asked in the survey. Nor was it possible to acquire these due to data limitations, inadequacies, or compatibility issues.

4.2 Model 2 – Regional Restrictions

Model 2, a FE-OLS model, was refined to analyse Scotland versus the North-East and North-West of England. The rationale behind this is two-fold. Firstly, these regions report the highest and closest alcohol specific mortality rates in England relative to Scotland – indicating a behavioural pattern amongst consumers (ONS 2022). Secondly, is the need to control for underlying characteristics such as alcohol preference as outlined in the Assumptions, Limitations and Uncertainty section. Table 4 reports summary statistics of alcohol preference and expenditure between the North-East and North-West of England. Observing these figures versus Scotland these regions report closer summary statistics than those for England. Therefore, Model 2 aims to control for behavioural differences between Scotland and England by controlling for the regions in England that are most similar to Scotland according to the data.

Table 4: Summary Statistics for Scotland – Observations = 5,463, England – Observations = 43,283, North-East and North-West England – Observations = 8,374

Variable	Region	Mean	Median	Std.Dev	Min	50 Pctl	Max
Gross Income	Scotland	657.1	530.7	494.3	0.0	530.7	2496.2
	England	712.2	572.6	523.2	0.0	572.6	2496.2
	NE-NW	635.6	507.9	470.1	0.0	507.9	2496.2
Disposable Income	Scotland	582.9	496.2	385.8	0.0	496.2	1898.1
	England	613.3	536.4	404.2	0.0	536.4	1898.1
	NE-NW	569.9	496.2	368.1	0.0	482.8	1898.1
Expenditure on Spirits (off-premises)	Scotland	2.6	0.0	7.7	0.0	0.0	101.8
	England	1.7	0.0	5.8	0.0	0.0	135.9
	NE-NW	2.4	0.0	5.8	0.0	0.0	100.0
Expenditure on Wine (off-premises)	Scotland	4.3	0.0	10.9	0.0	0.0	220.9
	England	4.4	0.0	11.1	0.0	0.0	346.5
	NE-NW	4.1	0.0	9.8	0.0	0.0	170.4
Expenditure on Cider (off-premises)	Scotland	0.3	0.0	1.7	0.0	0.0	31.3
	England	0.4	0.0	1.9	0.0	0.0	86.8
	NE-NW	0.3	0.0	1.9	0.0	0.0	42.2
Expenditure on Beer (off-premises)	Scotland	1.6	0.0	4.3	0.0	0.0	62.9
	England	1.8	0.0	4.9	0.0	0.0	161.9
	NE-NW	2.0	0.0	4.4	0.0	0.0	108.0
Expenditure on Alcohol (off-premises)	Scotland	8.9	2.1	15.9	0.0	2.1	234.4
	England	8.3	2.0	15.3	0.0	2.0	366.3
	NE-NW	8.8	2.1	14.6	0.0	2.1	192.9
Expenditure on Alcohol (on-premises)	Scotland	6.2	0.0	14.4	0.0	0.0	187.8
	England	7.5	0.0	16.5	0.0	0.0	452.5
	NE-NW	7.9	0.0	17.4	0.0	0.0	452.5

Note: Gross and Disposable Incomes have been capped by the LCF to protect anonymity

Table 5. Model 2 Regression Output – Dependent Variable is *ln(alcohol_expenditure)*

	NN1 (1:1)	**NN2 (2:1)**
DD Coefficient	-0.088	-0.111**
	(0.080)	(0.034)
Inflation Rate	-0.062	-0.057
	(0.109)	(0.100)
Household Composition	0.011***	0.011***
	(0.002)	(0.002)
Alcohol on premises	0.006***	0.006***
	(0.000)	(0.001)
Category of Dwelling	-0.051***	-0.047***
	(0.012)	(0.009)
Tenure Type	0.045***	0.044***
	(0.009)	(0.007)
Observations	3,446	3,815
Within R^2	0.034	0.035
Adjusted R^2	0.035	0.037
F Statistic	20.46***	22.66***

*Standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01*

The regression output from Model 2 can be observed in Table 5 (see Annex 10.3.2 for full regression output). NN1 and NN2 showcase a 9% and an 11% reduction in alcohol expenditure post-intervention in Scotland. However, only for Model NN2 is this decline statistically significant. Conversely, the control variables report similar coefficients and statistical significance to Model 1. This is likely because the four statistically significant control variables are tied to disposable income, which was omitted due to perfect collinearity. In consequence these control variables are likely "picking up" the statistical significance of disposable income as they are all associated with disposable income and socio-economic status. This highlights the need for more model refinements.

4.3 Model 3 – Low-Income Households

As noted in the Literature Review, Alcohol MUP is targeted at high-percentage, low-cost forms of alcohol predominately purchased and consumed by low-income households. Model 3 applies the baseline model specification to a restricted sample including only observations for low-income households. A low-income is defined as less than 60% of the median income (DWP 2023). Data on weekly median income was sourced on a regional level from the Annual Survey of Hours and Earnings (ASHE) (Nomis 2024). These median figures were then reduced to calculate the amount defined as constituting a low-income for each year, as showcased in Table 6. They were then applied to each region in the dataset on an annual frequency, as a filter, to make sure the dataset only included those defined as low-income. The ASHE data married well to the LCF as both were on a regional level and recorded income on a weekly frequency. Table 7 showcases the regression output for Model 3 (see Annex 10.3.3 for full regression output).

Table 6. Low-Income Weekly Earnings – Calculated from ASHE Median Income Figures

	Low-Income Band (Weekly Earnings)		
Year	**North-East**	**North-West**	**Scotland**
2010	£164.00	£173.70	£177.60
2011	£165.00	£170.00	£179.40
2012	£167.20	£174.60	£183.70
2013	£172.80	£179.60	£187.80
2014	£173.90	£181.70	£191.60
2015	£181.10	£183.70	£196.00
2016	£183.10	£188.40	£199.30
2017	£188.20	£191.60	£203.40
2018	£190.40	£197.80	£210.00
2019	£198.50	£207.00	£218.00
2020	£201.60	£213.00	£226.70

Table 7. Model 3 Regression Output – Dependent Variable is *ln(alcohol_expenditure)*

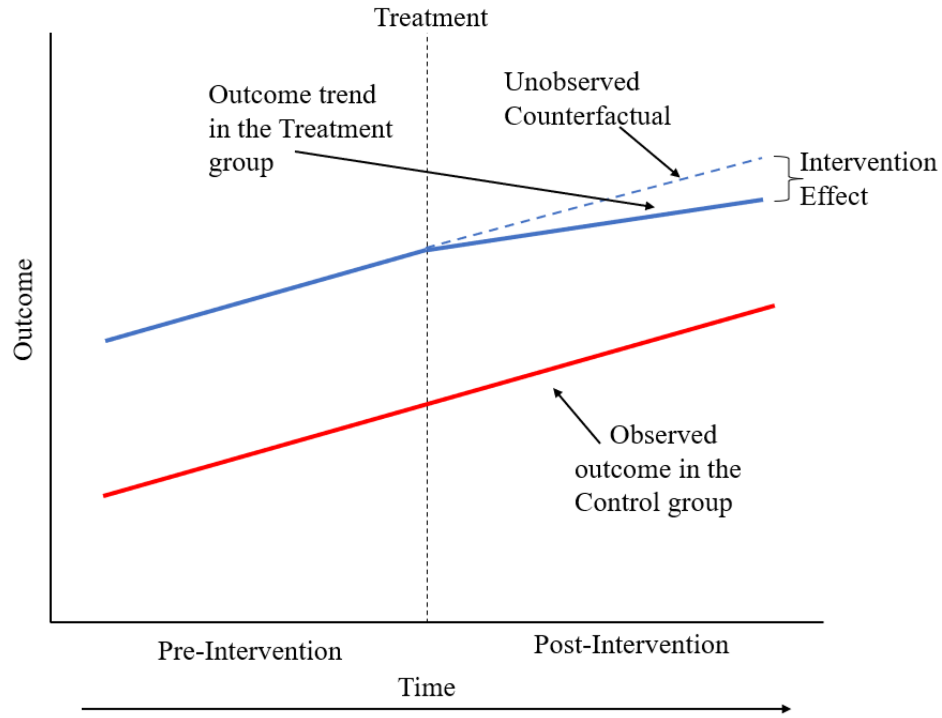
	NN1 (1:1)	**NN2 (2:1)**
DD Coefficient	-0.314*	-0.271***
	(0.154)	(0.067)
Inflation Rate	-0.021	0.048
	(0.145)	(0.154)
Household Composition	0.005	0.000
	(0.010)	(0.011)
Alcohol on premises	0.013	0.016*
	(0.008)	(0.008)
Category of Dwelling	-0.082**	-0.064*
	(0.035)	(0.031)
Tenure Type	0.045*	0.038*
	(0.023)	(0.021)
Observations	520	571
Within R^2	0.053	0.054
Adjusted R^2	0.041	0.043
F Statistic	3.05***	3.35***

*Standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01*

Observing Table 7, the DD estimator returns a coefficient value of -0.31 (NN1) and -0.27 (NN2), which are statistically significant at the 10% and 1% level respectively. This indicates that both models estimate that the introduction of alcohol MUP has led to a reduction on alcohol expenditure in Scotland relative to the North-East and North-West of England of 31% and 27% respectively when controlling for low-income households. This is visually represented in Figure 8. Additionally, for both models the category of the dwelling and tenure type is also statistically significant, as is the amount of alcohol consumed on premises for Model 3 – NN2.

Model 3, NN1 and NN2 report the highest Adjusted R-squared values, be it with minimal difference from the previous models. However, these results are still small, implying that the additional control variables are not adding much explanatory power to the model. Similarly, the reduced F-statistic compared to the earlier models raises questions, though it is still statistically significant.

Figure 8. Visual Representation of the Difference-in-Difference estimator/treatment effect



4.4 Robustness Checks

A Breusch-Pagan (BP) test was undertaken on all models to test for heteroskedasticity as it is most likely to occur in cross-sectional data consisting of large samples. The null hypothesis was rejected revealing the presence of heteroskedasticity. To rectify this, the coefficients reported above were calculated using White's Robust Standard Errors to mitigate the negative effects of heteroskedasticity. A Durbin-Watson (DW) test was also conducted for Model 3 NN1 and NN2 which returned test results of 1.95 and 1.98 respectively. As these results are close to 2, the null hypothesis is not rejected and there is no presence of autocorrelation in either model.

5. Discussion & Outlook

Model 3 NN2 was selected as the preferred specification. The rationale for this is that due to the 2:1 matching it has a slightly larger sample size than NN1 which appears to have captured more individuals impacted by the policy intervention. From this Model 3 NN2 showcases greater explanatory power relative to NN1 through the R-squared and F-statistic, though these differences are marginal. The interpretation of these results is that when controlling for consumer preference and income bands, households in Scotland showcased a statistically significant reduction in alcohol consumption by 27% at the 1% level. Whilst these findings are of a higher magnitude, they are in line with the prevailing literature that the introduction of alcohol MUP has led to a reduction in alcohol consumption (Anderson et al 2019, 2021).

However, the shortcomings of this analysis cannot be overlooked nor can the level of overall low explanatory power in these findings which is partly due to the need for more variables that influence alcohol consumption and the biases within the data collection, such as a skew towards home ownership and towards those who do not reside in a lower-socio economic position. This is highlighted in the fact that the final model contains just 571 observations from a dataset of more than 50,000. This shows how few households who are possibly impacted by the policy are captured in the survey as discussed in the limitations section.

The descriptive statistics analysed in Table 4 predominately contain households who consume zero alcohol from retailers. Further research could utilise a dataset that solely captures low-income alcohol consumers who are most likely to be impacted by the intervention. It could also source more granular data on a postcode or local authority level and control for possible cross border effects, which this study does not do, as discussed in the limitations section. This would be beneficial for countries who share a "population dense" border. Again, research might investigate if there has been any substitution effect from alcohol to other substance abuse that may now be cheaper than alcohol.

Scotland has a disproportionately high alcohol related deaths rate relative to the rest of the UK and this public health emergency has an economic impact on Scottish public services such as the NHS, with an estimated annual financial cost of £405 million. Therefore, as has been showcased, alcohol MUP has the ability to alter consumer behaviour and shift consumption downwards, possibly reducing the negative consequences and costs of excessive consumption.

Those who are most likely to consume and be negatively affected by high-percentage low-cost forms of alcohol, largely reside in a lower socio-economic position. Alcohol MUP has the potential to help lower inequality and improve life outcomes by reducing the impacts through reducing consumption. However, there must be a level of caution. Alcohol MUP is a regressive tax, which may worsen situations for the most "problematic" drinkers – such as alcoholics and those who do not have the propensity to alter their consumption patterns. Therefore, alcohol MUP may result in a larger proportion of their budget being spent on alcohol.

Furthermore, policy makers will need to adjust the rate of MUP to allow for inflation, otherwise MUP will become less effective, and consumption and harm may rise in consequence. It is noteworthy that the Scottish Government in April 2024 announced that alcohol MUP would increase from £0.50 to £0.65 the primary rationale being to counteract the effects of inflation (Gov.Scot 2024).

6. Conclusion

This paper sought to assess whether the introduction of minimum unit alcohol pricing in Scotland had impacted household expenditure and by proxy, consumption, on alcohol purchased from retailers. Through conducting a PSM-DD methodology, this study has found a statistically significant 27% reduction in alcohol expenditure amongst low-income households post-intervention in Scotland compared to the North-East and North-West of England. However, due to the limitations with the data and modelling, it is difficult to dissect if these findings can solely be attributed to the policy implementation and further analysis is encouraged.

This paper, nevertheless, has found encouraging indicators that alcohol MUP is an effective measure targeted at those on low-incomes with a propensity to consume low-cost high percentage forms of alcohol. Additionally, this paper highlights the need for consistent uplift of alcohol MUP in line with inflation to avoid MUP's effectiveness being eroded over time. As Ireland and Wales have now adopted alcohol MUP, with Northern Ireland consulting on this, alongside growing pressure in England for a similar policy, these results may hopefully feed into the growing debate and body of literature and thus aid ministerial decision making and policy design.

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Annex

10.1 Placebo Difference-in-Difference Regression Output

10.1.1 London – May 2018 – Dependent Variable is *ln(alcohol_expenditure)*

Variable	Coefficient
DD Coefficient	-0.058**
	(0.023)
Treated	0.004
	(0.018)
Time	0.117***
	(0.023)
Inflation Rate	-0.019
	(0.093)
Household Composition	0.015***
	(0.000)
Alcohol on premises	0.008***
	(0.000)
Category of Dwelling	-0.053***
	(0.007)
Tenure Type	0.041***
	(0.005)
Observations	23,581
Within R^2	0.046
Adjusted R^2	0.048

*Standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01*

10.1.2 London – May 2015 – Dependent Variable is *ln(alcohol_expenditure)*

Variable	Coefficient
DD Coefficient	-0.059**
	(0.025)
Treated	0.013
	(0.022)
Time	0.062***
	(0.002)
Inflation Rate	-0.027
	(0.093)
Household Composition	0.015***
	(0.001)
Alcohol on premises	0.008***
	(0.000)
Category of Dwelling	-0.053***
	(0.007)
Tenure Type	0.041***
	(0.005)
Observations	23,581
Within R^2	0.046
Adjusted R^2	0.048

*Standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01*

10.1.3 North-West – May 2018 – Dependent Variable is *ln(alcohol_expenditure)*

Variable	Coefficient
DD Coefficient	0.054** (0.018)
Treated	0.024 (0.013)
Time	0.104*** (0.026)
Inflation Rate	-0.019 (0.093)
Household Composition	0.015*** (0.000)
Alcohol on premises	0.008*** (0.000)
Category of Dwelling	-0.053*** (0.007)
Tenure Type	0.041*** (0.005)
Observations	23,581
Within R^2	0.047
Adjusted R^2	0.048

*Standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01*

10.1.4 North-West – May 2015 – Dependent Variable is *ln(alcohol_expenditure)*

Variable	Coefficient
DD Coefficient	0.051* (0.023)
Treated	0.011 (0.008)
Time	0.051*** (0.005)
Inflation Rate	-0.027 (0.093)
Household Composition	0.015*** (0.000)
Alcohol on premises	0.008*** (0.000)
Category of Dwelling	-0.053*** (0.007)
Tenure Type	0.041*** (0.005)
Observations	23,581
Within R^2	0.046
Adjusted R^2	0.048

*Standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01*

10.1.5 South-West – May 2018 – Dependent Variable is *ln(alcohol_expenditure)*

Variable	Coefficient
DD Coefficient	-0.054*
	(0.027)
Treated	-0.016
	(0.022)
Time	0.119***
	(0.025)
Inflation Rate	-0.019
	(0.093)
Household Composition	0.015***
	(0.000)
Alcohol on premises	0.008***
	(0.000)
Category of Dwelling	-0.053***
	(0.007)
Tenure Type	0.041***
	(0.005)
Observations	23,581
Within R^2	0.046
Adjusted R^2	0.048

*Standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01*

10.1.6 South-West – May 2015 – Dependent Variable is *ln(alcohol_expenditure)*

Variable	Coefficient
DD Coefficient	0.029*
	(0.041)
Treated	-0.041
	(0.032)
Time	0.053***
	(0.007)
Inflation Rate	-0.026
	(0.093)
Household Composition	0.015***
	(0.000)
Alcohol on premises	0.008***
	(0.000)
Category of Dwelling	-0.053***
	(0.007)
Tenure Type	0.041***
	(0.005)
Observations	23,581
Within R^2	0.046
Adjusted R^2	0.048

*Standard errors in parentheses. * p<0.1; ** p<0.05; *** p<0.01*

10.2 List of PSM Variables

Variable Name	Variable Description
Disposable Income	The natural logarithm of weekly expenditure on alcohol "brought home" – purchased from retailers.
Household Size	The total number of people residing within the household, includes adults and children.
Category of Dwelling	Type of house; whole house, bungalow detached, bungalow semi-detached, terraced house, flat, other
Tenure Type	Type of tenure; local authority rented, housing association, rented unfurnished, rented furnished, owned with mortgage, owned outright, rent free, other.
Males 18-to-45	Number of males 18-to-45 in household
Males 45-to-65	Number of males 45-to-65 in household
Males 65-to-70	Number of males 65-to70 in household
Males 70+	Number of males over 70 in household
Females 18-to-45	Number of females 18-to-45 in household
Females 45-to-65	Number of females 45-to-65 in household
Females 65-to-70	Number of females 65-to70 in household
Females 70+	Number of females over 70 in household

10.3 Results Section Models – Regression Output

10.3.1 Model 1 – NS1 – Regression Output

	Coefficient	Std.Error	t-value	p-value
DD Coefficient	0.039	0.025	1.592	0.145
Treated (0=control, 1=treated)	0.108	0.022		
Time (0=pre, 1=post)	0.180	0.019	4.822	0.000***
Inflation Rate	-0.097	0.083		
Household Composition	0.013	0.001	9.032	0.000***
Alcohol on premises	0.007	0.000		
Category of Dwelling	-0.053	0.012	-1.181	0.267
Tenure Type	0.043	0.007		
			9.110	0.00***
			7.907	0.00***
			-4.473	0.00***
			6.274	0.00***
Observations	5701			
Within R^2	0.041			
Adjusted R^2	0.041			
F Statistic	33.89***			

* p<0.1; ** p<0.05; *** p<0.01

10.3.2 Model 1 – NS2 – Regression Output

	Coefficient	Std.Error	t-value	p-value
DD Coefficient	0.016	0.025	0.644	0.535
Treated (0=control, 1=treated)	0.093	0.021	4.318	0.000***
Time (0=pre, 1=post)	0.224	0.021	10.632	0.000***
Inflation Rate	-0.096	0.081	-1.057	0.318
Household Composition	0.012	0.001	10.871	0.000***
Alcohol on premises	0.008	0.001	9.554	0.000***
Category of Dwelling	-0.057	0.008	-6.856	0.000***
Tenure Type	0.040	0.004	11.299	0.000***
Observations	7523			
Within R^2	0.043			
Adjusted R^2	0.044			
F Statistic	44.73***			

* p<0.1; ** p<0.05; *** p<0.01

10.3.3 Model 2 – NS1 – Regression Output

	Coefficient	Std.Error	t-value	p-value
DD Coefficient	-0.088	0.080	-1.105	0.297
Treated (0=control, 1=treated)	0.079	0.075	1.053	0.319
Time (0=pre, 1=post)	0.295	0.065	4.507	0.001***
Inflation Rate	-0.062	0.109	-0.567	0.584
Household Composition	0.011	0.002	4.439	0.002***
Alcohol on premises	0.006	0.000	7.135	0.000***
Category of Dwelling	-0.051	0.012	-4.230	0.012***
Tenure Type	0.045	0.009	4.800	0.009***
Observations	3,446			
Within R^2	0.033			
Adjusted R^2	0.035			
F Statistic	20.46***			

* p<0.1; ** p<0.05; *** p<0.01

10.3.4 Model 2 – NS2 – Regression Output

	Coefficient	Std.Error	t-value	p-value
DD Coefficient	-0.111	0.034	-2.481	0.035**
Treated (0=control, 1=treated)	0.094	0.043	2.176	0.057*
Time (0=pre, 1=post)	0.033	0.034	9.874	0.000***
Inflation Rate	-0.057	0.100	-0.572	0.581
Household Composition	0.011	0.002	5.258	0.001***
Alcohol on premises	0.006	0.001	8.417	0.000***
Category of Dwelling	-0.047	0.009	-4.976	0.001***
Tenure Type	0.044	0.007	6.385	0.000***
Observations	3815			
Within R^2	0.035			
Adjusted R^2	0.037			
F Statistic	22.66***			

* p<0.1; ** p<0.05; *** p<0.01

10.3.5 Model 3 – NS1 – Regression Output

	Coefficient	Std.Error	t-value	p-value
DD Coefficient	-0.314	0.154	-2.045	0.071*
Treated (0=control, 1=treated)	-0.036	0.126	-0.285	0.782
Time (0=pre, 1=post)	0.357	0.154	2.591	0.029**
Inflation Rate	-0.021	0.146	0.149	0.885
Household Composition	0.005	0.010	0.467	0.651
Alcohol on premises	0.013	0.008	1.603	0.143
Category of Dwelling	-0.082	0.035	-2.329	0.45**
Tenure Type	0.045	0.023	1.937	0.085*
Observations	520			
Within R^2	0.053			
Adjusted R^2	0.041			
F Statistic	3.05***			

* p<0.1; ** p<0.05; *** p<0.01

10.3.6 Model 3 – NS2 – Regression Output

	Coefficient	Std.Error	t-value	p-value
DD Coefficient	-0.271	0.067	-4.011	0.003***
Treated (0=control, 1=treated)	-0.11	0.069	-0.153	0.882
Time (0=pre, 1=post)	0.345	0.077	4.443	0.002***
Inflation Rate	0.048	0.154	0.314	0.761
Household Composition	0.000	0.011	0.078	0.939
Alcohol on premises	0.016	0.008	2.081	0.067*
Category of Dwelling	-0.064	0.031	-2.064	0.069*
Tenure Type	0.038	0.021	1.854	0.097*
Observations	571			
Within R^2	0.054			
Adjusted R^2	0.043			
F Statistic	3.35***			

* p<0.1; ** p<0.05; *** p<0.01