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Estimation of integrated price elasticities for alcohol and tobacco in the United Kingdom using the living costs and food survey 2006–2017

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Abstract

Introduction: Evidence shows that price is an important policy lever in reducing consumption of alcohol and tobacco. However, there is little evidence of the cross-price effect between alcohol and tobacco.

Methods: This paper uses an econometric model which estimates participation and consumption elasticities, on data from the UK Living Costs and Food Survey 2006–2017 and extends the literature by, for the first time, estimating joint price elasticities for disaggregated alcohol and tobacco products. This paper presents new price elasticities and compares them to the existing literature.

Results: The own-price elasticity estimates are all negative for both participation and consumption. There is no pattern to the estimates of cross-price elasticities. The elasticity estimates, when used in the Sheffield Tobacco and Alcohol Policy Model, produce bigger changes in consumption for the same change in price compared to other elasticity estimates in the existing literature.

Discussion and Conclusions: Consumption of alcohol and tobacco are affected by the prices of one another. Policymakers should bear this in mind when devising alcohol or tobacco pricing policies.

KEYWORDS
alcohol, price elasticities, tobacco

1 | INTRODUCTION

Alcohol and tobacco are two of the leading behavioural risk factors for mortality and morbidity [1, 2]. They have been causally linked to various types of cancer [3–5], hypertension [6, 7] and stroke [8, 9] amongst other illnesses. While smoking and drinking alcohol are interesting health behaviours in their own right, the combination of the two is even more interesting. There is evidence of clustering between the two behaviours [10]—that is, smokers are more likely to be heavier drinkers. The demographics of people who consume alcohol and tobacco are different to those who just consume one, or neither, of the products. The two behaviours also have an impact on health which is more than additive [11–15] and so policies aimed at one behaviour should consider any changes in the other.

Evidence shows that price is an important policy lever in reducing consumption of alcohol and tobacco. A crucial variable of interest for policymakers is therefore the

price elasticity of demand—how much quantity demanded changes when prices change. For alcohol, two meta-analyses provide a good overview of the price elasticity of demand for alcohol [16, 17]. In the United Kingdom, the government uses alcohol price elasticity estimates from Sousa [18]. These price elasticities use data from Living Costs and Food Survey 2007 to 2012, with a Heckman model [19] to account for a high rate of non-consumption of alcohol. Previously, the government used alcohol price elasticities from Collis et al. [20], which estimated elasticities using the Tobit model using Living Costs and Food Survey data from 2001 to 2006. The Sheffield Alcohol Policy Model [21] uses price elasticity estimates from Meng et al., calculated using a pseudo-panel approach based on Living Costs and Food Survey 2001 to 2009 [22]. All three pieces of work estimate price elasticities for five alcohol products (beer, cider, wine, spirits, ready-to-drink) split by on-trade (bars, pubs and restaurants) and off-trade (supermarkets and shops) to form 10 different drink types.

For tobacco, Gallet and List provide a meta-analysis on the price elasticity of demand for tobacco [23]. The UK government uses time series analysis by Czubek and Johal [24] to inform its policy modelling using price elasticities. The UK government elasticities do not account for differing response for roll-your-own (RYO) and factory-made (FM) cigarettes. Cross-price elasticities for tobacco and alcohol as aggregate commodities have also been estimated in the existing literature. An early study in the United Kingdom uses aggregate level data on quarterly expenditures and finds evidence suggestive of negative cross price elasticities for beer, spirits, wine, cider and tobacco—when the price of one of these products goes up, the purchase of the other products goes down [25]. Other papers using individual consumption [26, 27] also find negative cross-price effects and consequently conclude that alcohol and tobacco are complements.

For both alcohol and tobacco, the existing elasticity estimates used by government are total price elasticities—that is, the overall decrease in consumption for a change in price. However, there are two underlying elasticities of interest: participation elasticities which reflect the change in the probability of consuming a good for a change in price; and conditional consumption elasticities which reflect the change in the amount consumed, given consumption, for a change in price.

This paper updates and extends the literature by, for the first time, estimating joint price elasticities for disaggregated alcohol (10 products) and tobacco products (2 products) using the Living Costs and Food Survey 2006 to 2017. It also provides participation and consumption price elasticities, which are useful for policy modelling in the context of a relatively high proportion of the population not smoking or drinking. We compare these new elasticities with previous UK estimates.

2 | METHODS

2.1 | Data

We used data from the Living Costs and Food Survey (LCFS) from 2006 to 2017. The LCFS is a nationally representative annual survey of approximately 6000 households in the United Kingdom, with a repeat cross-section design. It requires each adult member of the household to complete a 2-week expenditure diary listing everything purchased. It also collects information about the individual (such as their age) and the household (such as the region), as well as information on especially large or irregular expenditure (such as domestic heating or the purchase of vehicles). For the purpose of this study, we used the secure licence version of the LCFS which records purchasing at the transaction level.

As part of the 2-week expenditure diary, respondents record all expenditure on alcohol and tobacco. For alcohol, this is split into 24 product types, which we aggregated up into five categories (beer, cider, wine, spirits, ready-to-drink and split) by two location types (on-premise [pubs, bars, restaurants] and off-premise [at-home consumption]) to give 10 products. The litres of product is provided by the respondents for off-trade purchases; for on-trade purchases they record the serving type, for example, 'bottle of beer'. We used estimates of typical serving size, and estimates of beverage strength to convert alcohol purchases into units of alcohol, where a unit is equal to 10 mL/8 g of pure alcohol. For example, a 750 mL bottle of 12% alcohol by volume wine is 9 units. Respondents also state the amount paid for the item, allowing price-per-unit to be calculated. For tobacco, respondents are only required to record whether the product is factory-made cigarettes or roll-your-own tobacco, and the amount paid. To estimate the number of cigarettes, or grams of tobacco, we used market research data from Nielsen on the most likely pack size for the price paid. This allows us to estimate the price-per-stick for cigarettes and RYO, assuming 0.5 g of RYO per cigarette [28].

Historical prices were adjusted using UK Retail Prices Index to generate real terms equivalent prices as at January 2017 that are comparable across the dataset. The dependent variables were transformed using the inverse hyperbolic sine transformation. We used the number of adults in the household, age of the oldest household member, the Government Office Region (12 regions in

the United Kingdom) of residence, and the survey year as control variables.

2.2 | Statistical model

A common approach with censored dependent variables is the Tobit model, as used by Collis et al. [20]. The Tobit model [29] is a combination of two steps—a Probit model to determine participation in the alcohol or tobacco market, and a linear regression to model the consumption level. The Tobit model assumes an underlying latent variable, which gives an observed variable greater than zero if the latent variable exceeds a threshold and zero otherwise. In doing so, it assumes that the underlying decision process for participation and consumption are the same and that any explanatory factors work in the same direction. For example, it assumes that higher income would have the same direction of effect on both, that is, make a person more likely to participate and to consume more given that they participate.

This key assumption of the Tobit model is relaxed by using the alternative developed by Cragg [30], which allows the underlying decision to be split into separate participation and consumption decisions. The model is sometimes referred to as the 'two-tier model', the 'two-stage model' or the 'double-hurdle model'. The participation decision is modelled as a binary Probit model, and the consumption decision as a truncated normal regression. We call this model the two-stage Tobit to distinguish it from the standard Tobit model.

The two-stage Tobit regression has been implemented for each of the 12 individual products, with the same full list of covariates: number of adults in the household, age, total expenditure (to proxy income), region and year.

2.3 | Comparison with previously published elasticities

Finally we compared the elasticities with the existing literature—using the latest elasticities used by the HM Revenue and Customs (HMRC) in the UK Government for impact assessment of alcohol price changes [18] and for tobacco price changes [23], as well as alcohol price elasticities developed by our own research team and used in our previous pricing policy analyses [21]. To do this, we incorporated the elasticities into the Sheffield Tobacco and Alcohol Policy Model [31]. We estimated the effect of three scenarios: (i) increasing the price of all 12 alcohol and tobacco products by 1% to capture the impact of both own-price and cross-price elasticities; (ii) 1% price increases for all 10 alcohol products only; and (iii) 1% price increases for the two tobacco products only. We calculated the resulting % change in mean weekly consumption of each individual product, using the baseline consumption based on the latest year (2019) of the Health Survey for England data and associated estimated baseline prices for each product based on Living Costs and Food Survey and market research data.

3 | RESULTS

Tables 1 and 2 shows the results from the two-stage Tobit. The full regression results including the coefficients for covariates are shown in Table S1. The table presents the change in demand for the good in the column for a change in the price of the good in the row (see interpretation footnotes).

The estimated own-price elasticity of participation for tobacco is −0.169 for factory-made cigarettes (significant at the 5% level) and −0.089 for roll-your-own (not significant at the 5% level). This means that, after adjusting for other covariates, a 1% price increase in factory-made cigarettes has been associated with a 0.169% relative reduction in the number of people purchasing factory-made cigarettes. On overall smoking participation, reflected in the final column of Tables 1 and 2, both RYO and FM prices have a negative and significant effect. The estimated cross-price participation elasticity coefficients between FM and RYO are negative (i.e., they could be complements), but importantly neither product has statistically significant cross-price elasticities of participation; that is, a change in the price of roll-your-own does not appear to have affected the probability of smoking factory-made cigarettes, and vice-versa.

For conditional consumption of tobacco, the own-price elasticity of demand estimate is −0.513 for factory-made cigarettes and −0.226 for roll-your-own. This means that, after adjusting for other covariates, a 1% price increase in factory-made cigarettes has been associated with a 0.513% relative reduction in the number of factory-made cigarettes purchased by people who continue to be smokers after the price change. Again, both FM and RYO prices have an effect on overall tobacco consumption, though the effect is almost twice as large for the price of factory-made than it is for roll-your-own. Though cross price coefficients are negative, neither product has significant cross-price elasticities for conditional consumption; that is, a change in the price of roll-your-own does not appear to have affected the amount of factory-made cigarettes purchased, and vice-versa.

For alcohol, the estimated own-price elasticities of participation are negative and significant for all alcohol product types, ranging from −0.012 (on-premise

TABLE 1 Results for two-stage tobit elasticities (own- and cross-price elasticities for participation).

Price/ quantity	Beer off	Cider off	Wine off	Spirits off	RTD off	Beer on	Cider on	Wine on	Spirits on	RTDs on	FM	RYO	All tobacco
Beer off	−0.247***	−0.04	0.001	−0.047***	−0.011	−0.028***	−0.005	0.023	−0.002***	−0.004	−0.045***	−0.024*	−0.059***
Cider off	−0.033*	−0.116***	−0.02***	−0.043***	−0.002	0.003	−0.014***	0	0.022	−0.002	−0.02	−0.019	−0.028
Wine off	−0.064	−0.041	−0.314***	−0.033***	−0.009	−0.022	−0.014	0.004**	−0.009	−0.004**	−0.039	−0.008	−0.045
Spirits off	−0.057	−0.042	−0.047	−0.195***	−0.018	0.002	−0.004	−0.007	−0.017	−0.009	−0.028	−0.015	−0.038
RTD off	0.004	0.004	−0.027***	−0.03***	−0.031***	0.025	−0.004	−0.006	0.009	0.01	0	0.013*	0.009**
Beer on	−0.039	−0.003	0.054**	−0.013***	−0.004	−0.288***	−0.015*	0.094***	−0.014	−0.008	−0.089***	−0.03	−0.101***
Cider on	0.006	−0.021**	0.008	−0.014***	0.007	−0.002	−0.086***	0.011	−0.023	−0.012	−0.004	0.005**	0.009
Wine on	−0.023***	−0.01	−0.069*	−0.021***	−0.008**	−0.115	−0.022	−0.235***	−0.013**	−0.007	0.004	0.005	0.006
Spirits on	−0.026	−0.012	−0.009**	−0.03***	−0.001	−0.123***	−0.027***	−0.001	−0.176***	−0.025	−0.017	−0.016**	−0.024
RTDs on	0.003	0.003	0.005	−0.023***	0.007	0.013	0.01	0.025	−0.011	−0.012**	0.02	−0.007	0.014
FM cigs	0.042*	−0.025***	0.301**	0.015***	−0.026	0.213**	0.016	0.121*	0.062	−0.005	−0.169***	−0.135	−0.15***
RYO cigs	−0.039	0.024	−0.013	−0.05***	0.004	0.051	−0.007*	0.015	0.009	0	−0.08	−0.089*	−0.127***

Note: Red numbers are significant negative effects, that is, a price rise is associated with a consumption reduction. Green numbers are significant positive effects, that is, a price rise is associated with a participation increase. Black numbers are non-significant coefficients. Interpretation: If the price of off-premise cider increases by 1%, we estimate that participation in purchase of off-premise cider decreases by −0.116% (own price participation elasticity), and that participation in purchase of other products is also affected e.g. participation in off-premise beer falls by −0.033% (cross-price participation elasticity).

Abbreviations: FM, factory-made; RTD, ready-to-drink; RYO, roll-your-own.

***$p < 0.01$.

**$p < 0.05$.

*$p < 0.1$.

TABLE 2 Results for two-stage tobit elasticities (conditional consumption elasticities estimated using Living Costs and Food Survey data 2006 to 2017).

Price/ quantity	Beer off	Cider off	Wine off	Spirits off	RTD off	Beer on	Cider on	Wine on	Spirits on	RTDs on	FM	RYO	All tobacco
Beer off	−1.197***	−0.049	−0.041	−0.105***	−0.075	−0.123***	−0.112	−0.044	−0.209***	−0.035	−0.164***	−0.112*	−0.184***
Cider off	−0.072*	−1.136***	−0.125***	−0.100***	0.022	−0.071	−0.333***	0.049	0.074	0.008	0.031	−0.003	−0.025
Wine off	−0.003	0.053	−0.342***	−0.063**	0.063	0.005	0.045	0.062**	0.031	0.221**	−0.05	0.061	−0.007
Spirits off	0.017	0.022	0.011	−0.221***	−0.071	−0.036	−0.082	0.056	−0.063	0.004	0.023	0.018	0.024
RTD off	0.002	−0.021	−0.108***	0.004	−0.486***	−0.017	0.047	−0.044	−0.062	−0.071	0.055	0.161*	0.122**
Beer on	−0.045	0.036	0.08**	0.045	0.009	−0.803***	−0.131*	0.149***	0.018	−0.153	−0.179***	−0.106	−0.242***
Cider on	0.089	−0.169**	−0.049	0.084	0.092	−0.066	−0.342***	0.006	0.041	0.032	0.001	0.31**	0.104
Wine on	0.074***	0.043	−0.04*	−0.002	0.188**	−0.037	0.027	−0.387***	0.059**	−0.073	0.025	0.014	0.037
Spirits on	−0.008	−0.03	0.062**	0.013	−0.015	−0.181***	−0.174***	−0.014	−0.777***	−0.055	−0.009	0.143**	−0.013
RTDs on	−0.017	−0.079	−0.034	−0.004	−0.103	−0.016	0.111	0.048	0.026	−0.144**	−0.029	0.001	−0.035
FM cigs	−0.285*	−1.021***	0.4**	0.358**	0.364	0.451**	−0.225	0.397*	0.378	−0.504	−0.513***	−0.222	−0.64***
RYO cigs	−0.095	0.041	−0.005	0.007	−0.335	0	−0.425*	0.121	−0.018	0.283	−0.08	−0.226*	−0.352***

Note: Red numbers are significant negative effects, that is, a price rise is associated with a consumption reduction. Green numbers are significant positive effects i.e. a price rise is associated with a consumption increase. Black numbers are non-significant coefficients. Interpretation: If the price of off-premise cider increases by 1%, we estimate an own price conditional consumption elasticity i.e. for the people still purchasing off-premise cider their estimated percentage reduction in volume of units purchased is −1.136%. We also estimate cross-price conditional consumption elasticities e.g. If the price of off-premise cider increases by 1%, for the people still purchasing off-premise beer, their estimated reduction in volume of units purchased is −0.072%.

Abbreviations: FM, factory-made; RTD, ready-to-drink; RYO, roll-your-own.

***$p < 0.01$.

**$p < 0.05$.

*$p < 0.1$.

ready-to-drink) to −0.314 (off-premise wine). Again, this means, for example, that, after adjusting for other covariates, a 1% price increase in off-premise wine has been associated with a 0.314% relative reduction in the number of people purchasing off-premise wine. There are various significant cross-price elasticities, with most of them being negative, for example, a 1% price increase in off-premise beer is associated with small reductions in the proportions of people purchasing off-premise spirits, on-premise spirits and on-premise beer. These negative cross-price results suggest a degree of complementarity, that is, that an increase in the price of off-premise beer suppresses purchasing of other products too. There are a small number of positive cross price effects, for example, a 1% price increase in on-premise beer is associated with small increases in the proportions of people purchasing off-premise wine and on-premise wine. The cross-price elasticities corresponding to the same beverage but in the other sector is not always significant—for example, the price of on-premise beer does not significantly affect the probability of purchasing off-premise beer.

For conditional consumption of alcohol, again all own-price elasticities are negative and significant, ranging from −0.144 (on-premise ready-to-drink) to −1.197 (off-premise beer). The same observation applies to cross-price elasticities as with participation: no definitive rule or pattern in terms of significant cross-price elasticities, with most of the cross-price effects being negative, some being small and positive and no consistent link between the same beverage type across trade sectors.

A key novel aspect from this work is to provide estimated effects of changes in alcohol prices on changes in tobacco use, and of changes in tobacco prices on changes in alcohol use.

The effects of alcohol prices on tobacco use are small but statistically significant, and are especially focussed on beer prices. For off-premise beer, increases in price are significantly associated with reduced participation on both FM and RYO cigarettes, and also significantly associated with a reduction in the number of both FM cigarettes and RYO purchased for those people who do continue to purchase these products. Increases in the price of on-premise beer are significantly associated with reduced FM cigarette participation and consumption, though RYO effects are non-significant. For RYO tobacco participation and consumption, there are four alcohol products which show a significant association to a change in their price—off-premise beer, off premise ready-to-drink, on premise cider and on premise spirits.

The effects of FM cigarette prices on alcohol use are large and statistically significant, but again vary in direction depending on the alcohol product and the patterns also differ for participation effects and consumption effects. An increase in FM cigarette prices is associated with a reduction in off-premise cider participation, but an increase in participation in five other products: three off premise products—beer, wine and spirits, and two on-premise products—beer and wine. For consumption effects, an increase in FM cigarette prices is associated with a reduction in off-premise beer and a particularly large reduction in off-premise cider consumption, but is also associated with an increase in off-premise wine, off-premise spirits, on-premise beer and on-premise wine. RYO tobacco prices show fewer significant effects than FM cigarette prices. An increase in RYO tobacco price is only associated with small reductions in participation of off-premise spirits and on-premise cider, and for consumption effects—only a reduction in on-premise cider.

3.1 | Model comparisons

Table 3 shows the results of the comparison of the effects of our new two-stage Tobit elasticity estimates and previously published estimates from HMRC and our own prior research.

For alcohol, price changes in all 10 of the individual alcohol products have larger estimated effects when using the new two-stage Tobit elasticity estimates than when using the current HMRC elasticities from Sousa [18], for example, a 1% price rise in all 10 alcohol products produces an estimated change in off-premise beer consumption that is around three times larger: −1.69%, rather than the HMRC estimate of −0.56. For some products the difference is much smaller, for example, on-premise wine (−0.2% c.f. −0.15%) and on-premise spirits (−1.10% c.f. −0.95%). The effect on all five off-premise products collectively shows a 2.9 times larger effect (−1.23% c.f. −0.43%), and for all five on-premise produces a 2.4 times larger effect (−1.23% c.f. −0.52%), and for all 10 alcohol products together a 2.7 times larger effect (−1.23% c.f. −0.45%).

For tobacco, price changes in the two products have slightly larger estimated effects when using the new two-stage Tobit elasticity estimates than when using the current HMRC elasticities from Czubek and Johal [24]. A 1% price rise in both products at the same time would produce a change in factory made cigarette consumption of −0.89% (c.f. −0.58%), and a change in RYO of −0.69% (c.f. −0.58%).

There are two key differences between the analysis done by Sousa [18] and our comparison of effects in Table 3. Firstly, we do not estimate the effect of a 1% duty change—we estimate the effect of a 1% price change. Since duty is only a proportion of the price, a 1% increase in duty is a much smaller change in mean price than 1%.

TABLE 3 Comparison of the effects of a 1% price change in all 12 products.

Estimated percentage changes in mean population consumption[a] for 1% increases in prices										
		New two-stage tobit estimates			Previous Sheffield estimates for alcohol (Meng)			HMRC estimates (Sousa [18] for alcohol; Czubek & Johal [24] for tobacco)		
Individual products		1% price rise (all) (%)	1% price rise (alcohol) (%)	1% price rise (tobacco) (%)	1% price rise (all) (%)	1% price rise (alcohol) (%)	1% price rise (tobacco)	1% price rise (all) (%)	1% price rise (alcohol) (%)	1% price rise (tobacco) (%)
Off-premise	Beer	−1.82	−1.69	−0.13	−0.94	−0.94		−0.56	−0.56	
	Cider	−1.95	−1.62	−0.33	−1.13	−1.13		−0.56	−0.56	
	Wine	−0.86	−0.96	0.11	−0.12	−0.12		−0.33	−0.33	
	Spirits	−0.75	−0.80	0.10	−0.50	−0.50		−0.36	−0.36	
	RTDs	−0.53	−0.54	0.00	−0.62	−0.62		−0.06	−0.06	
On-premise	Beer	−1.68	−1.89	0.18	−1.11	−1.11		−0.61	−0.61	
	Cider	−1.31	−1.14	−0.17	−0.07	−0.07		−0.54	−0.54	
	Wine	−0.12	−0.20	0.09	0.76	0.76		−0.15	−0.15	
	Spirits	−1.02	−1.10	0.12	1.42	1.42		−0.95	−0.95	
	RTDs	−0.53	−0.45	−0.08	1.13	1.13		−0.02	−0.02	
Factory-made cigarettes		−1.33	−0.48	−0.89				−0.58		−0.58
Hand-rolled tobacco		−0.38	0.30	−0.69				−0.58		−0.58
Subtotalled products										
All off-premise alcohol		−1.25	−1.23	−0.01	−0.52	−0.52		−0.43	−0.43	
All on-premise alcohol		−1.11	−1.23	0.12	−0.12	−0.12		−0.52	−0.52	
Total alcohol		−1.21	−1.23	0.03	−0.41	−0.41		−0.45	−0.45	
Total tobacco		−0.89	−0.12	−0.80				−0.58		−0.58

Abbreviations: HMRC, HM Revenue & Customs; RTD, ready-to-drink.

[a]Weekly units of alcohol/weekly cigarettes (0.5 g hand-rolled tobacco = 1 cigarette stick).

Thus, for example, the results shown in the second to last column of Table 3 would be and are larger than the results from Sousa [18]. Secondly, the estimates will vary depending on the relative weights of different alcohol products; if, for example, on-premise beer accounts for a larger share of consumption in Sousa's data [18] then the price elasticity for on-premise beer will have a larger effect.

The combined interacting effects of changing alcohol and tobacco prices together are also interesting. A 1% price increase in all 12 products is estimated to produce an overall change in alcohol consumption of −1.21% (c.f. −0.45% assuming HMRC Sousa [18] for alcohol, Czubek and Johal [24] for tobacco, and no cross price effects between alcohol and tobacco). The same price increase is estimated to produce an overall change in tobacco consumption (i.e., both FM and RYO combined) of −0.89% (c.f. −0.58% for HMRC).

4 | DISCUSSION

This paper has estimated, for the first time, joint price elasticities for disaggregated tobacco and alcohol products. These elasticities are of interest to health policymakers because alcohol consumption and smoking are not isolated behaviours—people who smoke often drink alcohol and vice versa. The elasticity estimates, when used in the Sheffield Tobacco and Alcohol Policy Model, produce bigger changes in consumption for the same change in price compared to other elasticity estimates in the existing literature. Generally, the price elasticity estimates are also larger by themselves than those used in existing policy modelling, though it is worth noting that the UK government tobacco elasticities suggest that the price of roll-your-own tobacco has about a quarter of the effect on overall tobacco consumption than that of factor-made cigarettes whereas our estimates are in the region of a half. Every method will result in different elasticity estimates, and there are some existing methods which impose restrictions [32]. We chose not to impose restrictions on our model to allow full flexibility; this may result in some elasticity estimates that appear larger than others in the literature. Of course, further research could explore the impact of imposing conditions (perhaps using a Bayesian approach) using the same data.

We acknowledge that our results are, in places, somewhat different to those in the literature (including the meta-analyses). This is because our work extends the existing literature; the two most important aspects of this are as follows. First, we have extended the literature by adding tobacco prices into alcohol demand estimates which removes an important potential omitted variable bias that is present in the HMRC alcohol analyses. Secondly, we also extend the method by allowing for, and building into the estimation process, the separate participation and consumption effects.

The work is not without limitations with respect to the data. Firstly, the data is repeated cross-sectional data meaning that households are not observed over time. The 2-week diary period also introduces problems around stockpiling; this paper has assumed that households not purchasing a product type during the 2-week diary window do not purchase through the rest of the year. Finally, assumptions were necessary regarding the strength and size of products purchased as these characteristics are not captured in the dataset.

Further research would be useful to analyse repeat cross-sectional datasets in other countries to examine whether these findings on the direction and scale of own-price and cross-price effects for the alcohol and tobacco products are similar. The ideal dataset would be an individual longitudinal record of the prices paid and amount purchased, alongside a clear understanding of the distribution of process faced by consumers at each time point. Unfortunately this does not exist in the United Kingdom. Further work to develop such an integrated longitudinal dataset would be valuable. There is the potential opportunity to do further research to analyse price elasticity effects using the 'Kantar Worldpanel' dataset, which has longitudinal data but only for off-premise supermarket purchases.

The work has clear implications for policy; it estimates cross-price elasticities for alcohol and tobacco at a disaggregated level. These estimates could be used in policy impact assessment by Government as a sensitivity analysis to compare against the elasticities that are currently used. The work could also be used in tax policy appraisal using mathematical modelling such as the Sheffield Tobacco and Alcohol Policy Model [33]. Given the strong associations between alcohol consumption and a range of alcohol-related harms, a decrease in demand due to price increases is likely to translate into reduced mortality, morbidity and wider social harms such as crimes, absence from work and harms to family members. Another key message from the paper is that price has an effect on both the participation and consumption decisions. For tobacco, it is arguably the participation decision that matters most for policy—reducing the number of smokers—whereas alcohol policy tends to address consumption amongst drinkers.

While this work has extended the literature for alcohol and tobacco products, the approach is generalisable and future work could consider the growth of alcohol and tobacco substitutes such as e-cigarettes and no/low alcohol products. Future work could also extend the

knowledge around infrequent purchase and consumption by using panel data such as Kantar Worldpanel, though this data only captures off-trade purchasing. The methods used in this paper are also generalizable to other products such as food, where both the participation and consumption decisions are of interest.

In conclusion, this study has developed novel estimates of the price elasticity of alcohol and tobacco products and their interaction in the UK association, which will be of use in further research and policy analysis.

AUTHOR CONTRIBUTIONS

RP, AB, DG, CA contributed to funding acquisition. RP, LW, AB, DG, CA contributed to methodology. RP, LW contributed to formal analysis. LW and DM contributed to validation. RP, LW, AB contributed to Writing – Original Draft Preparation. All authors contributed to Writing – Review & Editing.

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CONFLICT OF INTEREST STATEMENT

The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health and Social Care.

DATA AVAILABILITY STATEMENT

Department for Environment, Food and Rural Affairs, Office for National Statistics. (2019). Living Costs and Food Survey, 2006–2017: Secure Access. [data collection]. 11th Edition. UK Data Service. SN: 7047, http://doi.org/10.5255/UKDA-SN-7047-11.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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