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Understanding the link between alcohol excises and the price of alcoholic drinks in UK supermarkets using scanner data

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Opinions and recommendations expressed in this report are those of the authors.

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Executive summary

- In the period between 2007 and 2016, the price of alcoholic beverages in the UK decreased by 19% on average. In the same period, consumption of alcoholic drinks is estimated to have decreased by around 12%. Despite the reduction in consumption, similar trends in the detrimental effects of overconsumption on health and society have not been observed.
- Specific taxes on alcohol (excises) have been central to alcohol policy in the UK, with their value increasing steadily in the past two decades. Yet questions remain about how effective taxes are in changing consumer prices in the UK, i.e. what is the extent of taxes being passed through to prices.
- Tax pass-through is the proportion of a unit price increase (e.g. of a £1 increase in tax) that actually reaches consumers.
- The extent of tax pass-through is specific to prevalent market conditions, therefore, evidence from other countries, although informative, is not necessarily valid for the UK. The purpose of this study was to investigate alcohol excise pass-through in the UK off-trade market.
- An important contribution is the use of data on prices paid by consumers to explore tax pass-through, since actual pass-through rates will be determined by producers' and consumers' responses to a regulated increase in prices.
- The study used unique data consisting of supermarket sales for over 17 million UK consumers recording prices and volumes for different alcoholic products over 26 weeks between 2008 and 2013. Pass-through was explored for the overall alcoholic drinks market, as well as for specific product categories (wine, beer and spirits) and by product volume and store size where sales were recorded.
- Pass-through was estimated using reduced form regressions of the logarithm of price on the logarithm of the excise value calculated from excise rates, alcoholic drink volume, and when applicable, alcohol content. Other factors thought to influence price included a time trend, VAT changes, and controls for seasonality of sales. Estimation was done using panel regression methods with adjustment for autocorrelated errors.
- The pass-through for the whole alcohol drinks market was estimated at 0.66, which implies that for a £1 increase in tax, only two thirds (£0.66) is passed onto the price, indicating an under-shifting of alcohol excises.
- By alcoholic drink category, there was no evidence of an effect of excises on prices of wine, lager, stout, cider and perry. The prices of ale/bitter and spirits like brandy, gin, rum and vodka responded to changes in tax with pass-through levels generally higher than the average for the market. However, evidence of over-shifting or under-shifting of tax was only observed for brandy and cider.
- Within product categories, differences in pass-through by volume and by store size did not show a coherent pattern across categories. Most alcoholic drink categories showed the greatest pass-through for the most commonly sold volume format (e.g. 750ml bottle for wines), but apart from this trend, some products showed greater pass-through for larger volumes (e.g. champagne, brandy) and other products showed greater pass-through for smaller sizes (e.g. liqueurs). Similar heterogeneity of pass-through across drink categories was observed by store type.

- Higher pass-through for spirits and other high-strength products may reflect the fact that consumers have less opportunity to shop around and buy similar products at lower prices, as is likely the case for wines. It may also reflect the different way in which these products are taxed (by alcohol content).
- These results suggest that an excise that targets alcohol content instead of number of units sold may deliver more effective tax pass-through, and ultimately, a change in consumer behaviour.

Introduction

In the UK, alcoholic drinks represent a valuable market. The Wine and Spirits Trade Association[1] quantifies the industry's worth at £39.9bn in sales, £21.1bn of which comes from wine and spirits alone (53%), almost equally split between on- and off-trade (£10.2bn and £10.9bn respectively). Overall, the price of alcoholic drinks has increased steadily since 1987[2], with an increase of almost 300% in 2017, with UK prices currently considered among the highest in the EU[3].

In more recent trends, however, figures from DEFRA indicate that in the period of 2007-2016, the price of alcoholic beverages decreased by 19%[4]. Relevantly, DEFRA additionally reports that this reduction in prices has been accompanied by a 12% decline in consumption. However, although alcohol consumption has decreased in the last decade, this has not translated into a reduction in the detrimental effects of excessive intake (HSCIC, 2016). For example, recent statistics indicate that the number of deaths associated with alcohol consumption was stable in the period 2001-2016, with a notable increase among those aged 60-70 (***Figure 1***).

[1] http://www.wsta.co.uk/images/Research/Market-Reports/2016MarketOverview.pdf , http://www.wsta.co.uk/resources/facts-figures
[2] https://www.ons.gov.uk/economy/inflationandpriceindices/timeseries/chbt/mm23
[3] https://www.ons.gov.uk/economy/inflationandpriceindices/articles/uktobaccoandalcoholpricesamonghighestineu/2018-02-01
[4] https://www.gov.uk/government/publications/food-statistics-pocketbook-2017/food-statistics-in-your-pocket-2017-prices-and-expenditure

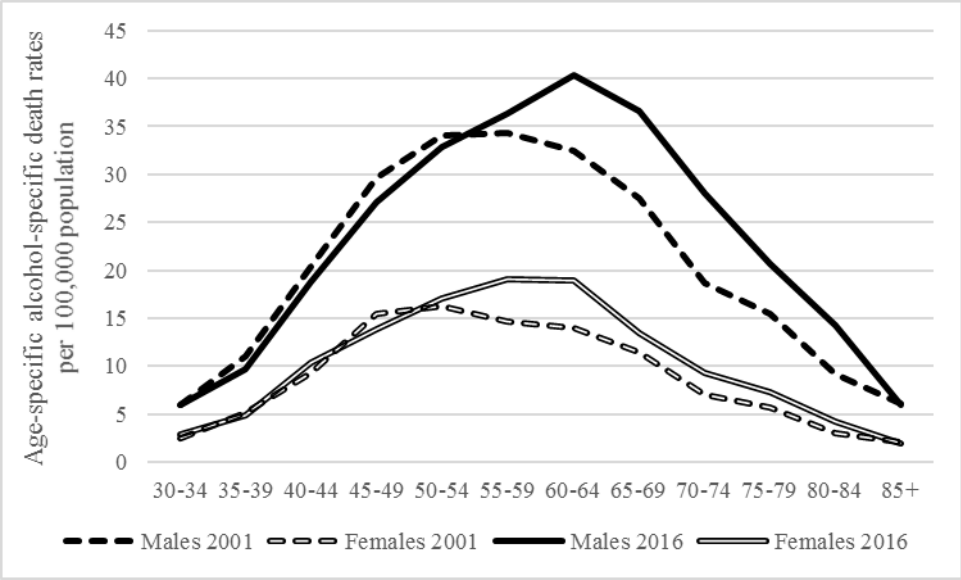


Figure 1. Deaths associated with alcohol consumption, by age (2001 vs 2016)
Source: Statistical Bulletin. Alcohol-specific deaths in the UK: registered in 2016. Office for National Statistics

The consequences of alcohol misuse represent an important health, social and economic burden in developed economies. Evidence indicates that excessive consumption of alcoholic drinks has a negative impact on crime, traffic accidents and traffic fatalities, and health (see, among others, Cook and Durrance, 2013, Markowitz, 2005, Wagenaar et al., 2010, Xu and Chaloupka, 2011, Stockwell et al., 2012, Saffer and Grossman, 1987). These negative effects represent a significant economic burden, which in the UK alone is estimated at around £51 billion/year[5] (Burton *et al.*, 2017). The main policy to tackle alcohol overconsumption in the UK has been through specific taxation (excises). Excise rates in the UK have been steadily increasing over the past two decades, with recent appeals to government to further increase the price of alcohol (Burton et al., 2017, Holmes et al., 2014, Griffith et al., 2017b).

The rationale for using alcohol excises to address alcohol intake levels is the existence of an inverse relationship between the price of alcohol and its consumption (see e.g., Wagenaar et al., 2009, Gallet, 2007), so that a regulated increase in prices would be expected to reduce sales and consumption of alcoholic drinks. An appealing aspect of alcohol taxation is that the total amount of tax consumers pay is proportional to the quantity they consume, so that heavy drinkers pay more tax overall than occasional ones. As a result, through a tax the policymaker can directly reach drinkers, and charge them proportionally to their consumption.

At the same time, the expected relationship between higher prices from taxation and consumption can drive behaviour only if the increase in costs imposed by the tax is effectively translated into noticeably higher prices at the point of purchase (e.g. Weyl and Fabinger, 2013, Bonnet et al., 2013). This concept, known as **tax pass-through**, reflects the extent by which the tax is passed onto the price the consumer pays or is (partially) absorbed by the retailer or manufacturer (Fullerton and Metcalf, 2002). As an example of the latter, when facing a tax increase, retailers can respond by switching to cheaper suppliers, helping to keep prices low.

[5] Similarly, crimes attributable to alcohol cost $84 billion in the US. (more than twice the costs of drugs, see Miller et al., 2006)

In the UK, alcohol excises have acted to increase supermarket prices by the exact amount of the tax for all alcoholic drinks, except low-priced drinks which showed a lower pass-through on retail prices (Ally *et al.*, 2014). Looking only at the prices that retailers charge for alcohol, however, does not provide an indication of the impact of taxation on the prices paid by consumers of alcoholic drinks. This is because, like retailers, consumers can adjust to price increases, for example by shifting to equivalent products that fit within their original price range, known as product substitution (DeCicca *et al.*, 2012). This will limit the ability of the tax to increase prices paid by the consumer and is particularly relevant in markets with a wide range of products available for consumers to choose from. Moreover, the response of consumers and suppliers to excises might cause product-specific pass-through rates, with some products or product sizes showing different adjustments (Moorthy, 2005, Durevall, 2018).

The potential limitations of excises as a mechanism to curb consumption are suggested from UK data on wine. Despite steadily increasing alcohol excises and prices (which increased by 36% in the past ten years, according to the Alcohol Price Index), wine consumption actually increased until 2008 (Panzone, 2012). This may be due to increases the affordability of alcohol more generally (HSCIC, 2016), as well as low pass-through of excise to the prices consumers pay. An understanding of the effectiveness of taxes in changing consumer prices (the pass-through rate) can therefore inform the debate on the ability of price-based interventions to tackle harmful consumption.

This study aims to further inform the evidence on tax pass-through for the UK off-trade alcohol market. Although previous work has looked extensively at the impact of different taxes on consumer prices, such as VAT (Poterba, 1996, Besley and Rosen, 1999, Nakamura and Zerom, 2010), other ad-valorem taxes (Bonnet and Réquillart, 2013, Cawley and Frisvold, 2017), as well as specific taxes (excises, e.g., Marion and Muehlegger, 2011, Ally et al., 2014, Kenkel, 2005), research for the UK alcohol market is very limited, with the exception of the work by Ally *et al.* (Ally et al., 2014). We build on previous work and expand current knowledge on alcohol excises by studying the impact of alcohol excises on actual consumer spending on alcoholic drinks, as opposed to the prices set by retailers. This is an important difference because suppliers' and consumers' behaviours may influence pass-through, as discussed above. The work explores differences by product type (wine, beer, spirits, and alcopops) that reflect the different excise paid by a product (as indicated below), as well as potential differences by product volume (which is category-specific). The unique dataset used consisted of supermarket (off-licence) sales for over 17 million UK consumers recording prices paid and volumes for different alcoholic products over 26 weeks between 2008 and 2013.

Theory on the impact of excises on consumer prices

Historically, academics and policy makers have had a keen interest in understanding who bears the impact of changes in price because this question has implications for the welfare of different agents in society and markets. For consumers, price changes influence disposable income, in turn affecting the demand for goods: for instance, a tax on alcohol will reduce the demand for alcoholic drinks, but consumers buying taxed products will also have less income to buy all other goods. For firms, changes in prices affect profitability, subsequently influencing the supply of goods: for example, an alcohol tax increases the costs of supplying wine, which, in combination with the consequent reduction in demand, reduces the profit associated to the supply of this wine.

Changes in prices can be both negative due to a drop in prices (e.g. discounts or subsidies), or positive, due to a price increase caused by higher input costs or taxes. This section explains the general economic theory of taxation, followed by a contextualisation of the theory of incidence and pass-through.

General theories of taxation

Policy-makers may have an interest in raising the cost of products or behaviours to account for external costs (externalities) that are not captured in the price paid by the consumer. In the specific case of alcohol, overconsumption causes external costs to society associated with the provision of healthcare to those individuals who consume above a safe limit (Wood *et al.*, 2018). Products or behaviours may also generate internal costs (internalities) to individuals that are also not fully incorporated into the price consumers pay. Internal costs are caused by mistaken or inaccurate beliefs about the long-term impact of consumption, which in turn cause unforeseen and high costs to consumers. One example is increased weight gain from underestimating calorie intake from drinks. Taxation is a key tool to ensure that market prices include internal and external costs; whereby the higher prices, in turn, reduce the occurrence of undesirable behaviours (Griffith et al., 2017c, Pigou, 1920, Baumol, 1972, Cook and Durrance, 2013).

There are two categories of indirect taxes: *ad valorem* taxes and specific taxes. *Ad valorem* taxes correspond to a fixed percentage of the initial price. The actual amount of tax paid then depends on the price of the good purchased. This is for instance the case with Value Added Tax (VAT). As a result, *ad valorem* taxes increase the price associated with each level of consumption (from the perspective of firms, by rotating the supply curve of prices and quantity upwards towards the left, ***Figure 2.a***). In contrast, a specific tax is a unit tax which adds a constant value to each unit of a product. This is the case with excise taxes, which add a fixed fee to each unit of a good, irrespective of the initial price. A specific tax then corresponds to an increase in production costs that causes firms to increase their prices by the amount of the tax (an upward parallel shift of the supply curve of a firm). In theory, the shift in costs equals the value of the tax (***Figure 2.b***). In practice, the value may differ depending on the tax pass-through.

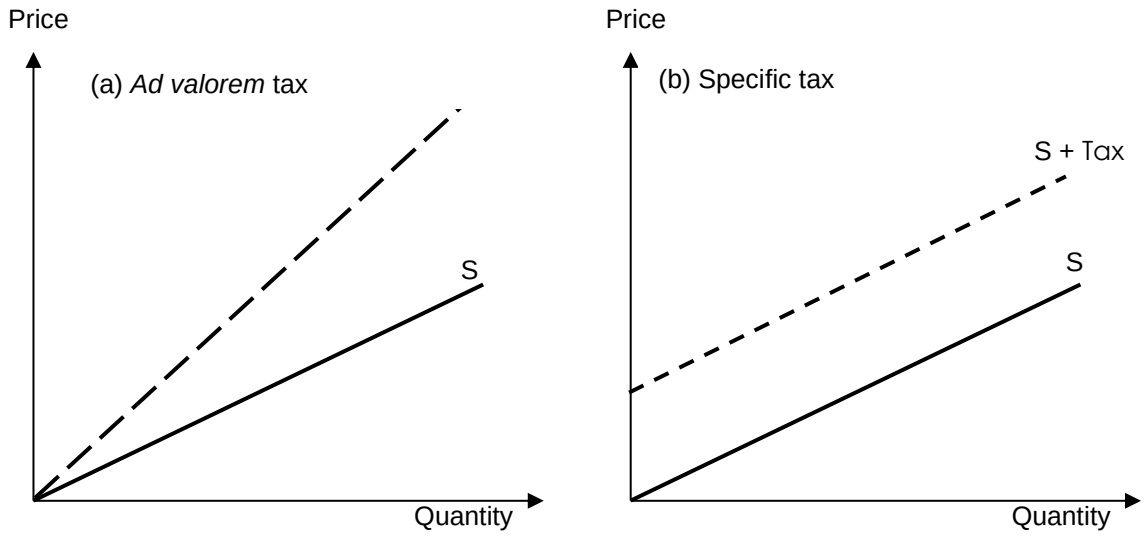


Figure 2. Graphical representation of *ad valorem* (a) and specific taxes (b)
S refers to supply.

General theory on tax incidence and pass-through

While taxation is expected to increase the costs to firms of supplying a good, a key question for policymakers is the ability of taxation to effectively alter the prices of products. There is also a question of understanding who bears the burden of (i.e. who pays for) the tax, referred to as "tax incidence" (Fullerton and Metcalf, 2002). Manufacturers and retailers are in charge of paying taxes, but may then i) fully pass the tax onto consumers, who will fully pay for them when buying the taxed good; ii) fully absorb the tax by reducing costs by the value of the tax; or iii) share the burden of the tax (equally or not) with consumers (Anderson et al., 2001, Bonnet and Réquillart, 2013, Fullerton and Metcalf, 2002, Marion and Muehlegger, 2011). Therefore, a key measure of incidence is the tax pass-through.

Tax pass-through is the proportion of a unit price increase (e.g. of a £1 tax increase) that actually reaches consumers (Ailawadi and Harlam, 2009, Fullerton and Metcalf, 2002). Mathematically, this is expressed as $\theta_i = \frac{\partial p}{\partial \tau}$, where ∂p represents the change in price, and $\partial \tau$ represents the change in tax. There are four possible outcomes:

- **Full pass-through**, $\theta_i = 1$, when the tax is fully passed onto prices, and consumers pay the full extent of the tax.
- **Zero pass-through**, $\theta_i = 0$, occurs when the tax is fully retained by the supplier. This case occurs only when the demand is perfectly elastic, and the producer internalises all the costs to avoid losing its consumers (Cawley and Frisvold, 2017).
- **Under-shifting,** $\theta_i < 1$ so that market prices increase by less than the value of the tax. Under-shifting may occur when the retailer or the manufacturer take on some of the burden of a tax, offsetting the increase in price by partially reducing management costs, e.g., by reducing labour costs, category costs, or adopting a new cost-saving technology (e.g., Marion and Muehlegger, 2011).
- **Over-shifting** occurs when producers increase prices by more than the value of the tax, so that $\theta_i > 1$. Over-shifting can happen when consumer demand does not respond to prices (is inelastic) and retailers have market power. In this case, firms realise that the tax will reduce sales volumes, but they can retain profits intact by raising prices above the value of the tax to compensate for the loss in sales.

The previous points suggest that pass-through rates, and by implication tax incidence, will depend on the characteristics of the supply and demand in a market. In markets that are characterised by perfect competition[6], there will be **full pass-through**. In this type of market, companies lose customers if they raise prices by more than the tax because consumers can find an equivalent good at a lower price; and they lose revenue to competitors if they charge prices that are increased by less than the full amount of the tax. An implication of perfectly competitive markets and full pass-through is that consumers and firms share an equal burden of the tax (i.e. **incidence** of the tax equals 0.5).

In contrast, over-shifting and uneven under-shifting (i.e. different from a 50-50 split) of taxes are more likely to occur in imperfectly competitive markets, such as the case of a monopoly or an oligopoly[7], and the extent of the **pass-through** (and the relative **incidence**) varies depending on how responsive the supply and the demand are to prices. As mentioned

[6] Perfect competition is characterised by, among other things, uniform products in a market, the fact that different firms in the market cannot influence market conditions, such as price, independently (firms are price takers), and that there are many firms in the market.

[7] A monopoly is characterised by the presence of only one supplier in the market that can exercise power over prices in the market. An oligopoly is characterised by a market supplied by only a small number of firms, and where the choice of price and quantity produced of one firm affect the profits of the other firms.

previously, **over-shifting** will be more likely if consumers cannot immediately adjust to changes in price. **Under-shifting** will be more likely in markets where consumers are very sensitive to price increases. Similar arguments apply for the supply side of the market, with higher pass-through generally occurring when supply is responsive to prices (price-elastic).

An important point implicit in the discussion on pass-through rates, is that these are determined at equilibrium prices, i.e. from the interaction of the behaviour of consumers (demand) and firms (supply). A graphical representation of this point is presented in ***Figure 3***, which shows that the actual price in the market and the resulting actual level of pass-through after a tax do not depend only on the prices firms set (the response of firms, S line in the graph), but also on the response of consumers to higher prices set by firms (the D line in the graph).

When faced with a higher price, consumers can cushion any price increase by using different strategies. Specifically, consumers can retain their frequency of consumption by: shifting to a cheaper category (e.g. purchasing beer instead of wine); shifting to a cheaper subcategory whilst remaining in the same overall excise category (e.g. purchasing a vodka-based alcopop instead of pure vodka); or shifting to a cheaper product within the same category (e.g. buying red wine as usual, but switching to a cheaper brand). These different adjustments made by consumers are eventually reflected in equilibrium prices and result in lower tax pass-through rates because the price increase imposed by the tax is mitigated by buying cheaper substitutes. Needless to say, the different strategies lead to different levels of alcohol intake.

Another important point from the above discussion is that, if the behaviour of consumers and firms differs by product category, the result will be product-specific pass-through rates within the market for alcoholic drinks (Moorthy, 2005, Durevall, 2018). This also implies that the average pass-through across product categories will depend on sales volumes across different categories, because it will be necessary to account for the fact that products with a lower pass-through might benefit from larger sales compared to those with higher pass-through.

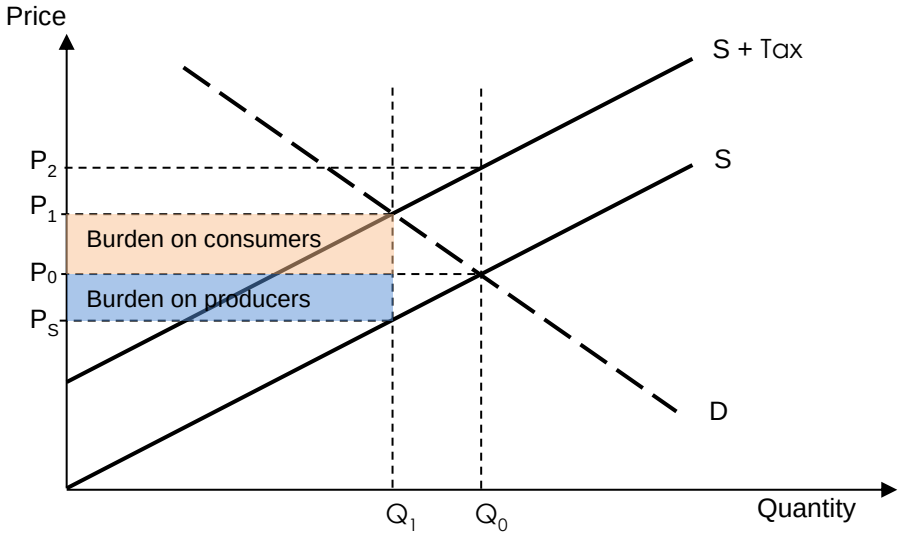


Figure 3. Graphical representation of excise pass-through
S refers to supply. D refers to demand. Initially, the market operates at an equilibrium characterised by a price P_0, and quantity sold Q_0. The excise shifts the supply curve upwards, increasing the price charged at any quantity level by the same amount. Because

demand remains the same, the new equilibrium will be characterised by a price P_1, where ($P_1 – P_0 <$ Tax), and quantity Q_1. A full pass-through would instead entail an increase from P_0 to P_2, which can only occur if demand is perfectly inelastic, i.e. the demand curve is a vertical line (see also Cawley and Frisvold, 2017). In this example, the increase in price from the tax is shared by consumers and manufacturers.

A mathematical model of tax pass-through applied to the alcohol market

The following section describes the logic of a mathematical model of tax pass-through for alcohol retail prices. Specifically, the section outlines a simple model of category-pricing decisions to characterise the behaviour of manufacturers and retailers in the market.

In retail environments, prices are defined at category level rather than at independent product level (Besanko *et al.*, 2005, Moorthy, 2005). In particular, retailers manage products collectively, so that category management costs are shared across products, and product-level mark-ups or discounts are selected to maximise total profit, which sums the profit associated to each product. This means that, if retailers compete on price in a particular category, in the presence of a regulated price increase (e.g. tax), they can mitigate the tax's effect on consumer prices by selectively deciding on the pass-through rate to apply on the basis of the product's market potential, accepting under-shifting in certain goods and recovering profit losses by over-shifting in other goods. Retailers can also adapt to regulations which impose higher prices by reducing overall category costs, for instance reducing staff, reducing the number of products in stock, or by changing to manufacturers who can supply products of the same quality at a lower price.

Mathematical model of tax pass-through

To understand the economic problem of the tax pass-through, imagine a retailer selling product *i* $(i = 1, \dots, N)$ in a category *r*. Following Bonnet *et al.* (2013), the retailer is assumed to be characterised by Bertrand competition, where the supplier maximises profit Π by setting retail prices *p*, and consumers respond by choosing quantity. This model represents the UK retailing sector, which is an oligopoly characterised by strong price competition. The profit function within category *r* corresponds to

$$\Pi_r = \sum_{i \in S_r} [(p_i^r - p_i^w - \tau_i) - c_r] q_i(p_i^r, p_{-i}^r) \qquad (1)$$

where p_i^r and p_i^w are, respectively, the retail and wholesale price of the good, τ_i is a specific alcohol tax, and S_r represents the set of products within a category. The term $q_i(p_i^r, p_{-i}^r)$ refers to the demand for product *i*, which depends on the price of the good, as well as the price of other options in the category. The cost $c_r(q_i, S_r)$ refers to average category costs per unit sold, which depend on the level of sales and the size of the category (see Dukes *et al.*, 2009). Notably, the nature of p_i^w depends on the nature of the manufacturing market: for instance, p_i^w will equal marginal production costs in competitive markets (e.g. with alcoholic drinks this might be the case for fragmented markets like wine); while in oligopolies (e.g. beer) p_i^w will depend on the type of pricing strategy (see, for instance, Anderson *et al.*, 2001).

The first-order condition entails that

$$\frac{\partial \Pi_i}{\partial p_i^r} = q_i + \sum_{i \in S_r} [(p_i^r - p_i^w - \tau_i) - c_r] \frac{\partial q_i}{\partial p_i^r} = 0 \qquad (2)$$

To see how this equilibrium changes as the tax changes, we differentiate equation (2) by the tax, to obtain

$$P = -H^{-1}C \qquad (3)$$

Where

$$P = \begin{bmatrix} \frac{\partial p_i^r}{\partial \tau_i} \\ \vdots \\ \frac{\partial p_k^r}{\partial \tau_i} \end{bmatrix}, C = \begin{bmatrix} \frac{\partial \Pi_i}{\partial \tau_i} \\ \vdots \\ \frac{\partial \Pi_k}{\partial \tau_i} \end{bmatrix}, \text{ and } H = \begin{bmatrix} \frac{\partial^2 \Pi_i}{\partial \tau_i^2} & \cdots & \frac{\partial \Pi_i}{\partial \tau_i \partial \tau_k} \\ \vdots & \ddots & \vdots \\ \frac{\partial \Pi_i}{\partial \tau_i \partial \tau_k} & \cdots & \frac{\partial^2 \Pi_i}{\partial \tau_i^2} \end{bmatrix}, i \neq k$$

As discussed in Moorthy (2005), equation (3) shows that the impact of the pass-through then depends on two key elements, as indicated above. One element is cost-related: a tax pass-through increases prices because the higher prices have to be passed on to consumers. A second element is instead strategic: the tax pass-through depends on the change in prices of other products sold by the retailer, as well as those of competing products in other retailers. Importantly, this result indicates that a tax pass-through will increase the price of all goods, but the size of the effect will depend on the magnitude of each individual term. In the case of a differentiated oligopoly, the resulting pass-through depends on the elasticity of demand of the producer's price (keeping all the other prices constant), on the elasticity of demand in response to all prices, and on the elasticity of the slope of demand with respect to equilibrium prices (Anderson et al., 2001).

The current work focuses on a single retailer, so the impact of prices in other retailers on current prices is not observed. This missing information limits the ability to generalise the results. However, in a price-competitive oligopoly such as the UK retailing sector, competitors are expected to ensure that the pass-through is competitive, and as close as possible to the ones of other retail chains (see Fullerton and Metcalf, 2002 for more details). An indication of the extent of switching to other retailers for alcohol-related purchases can be determined by estimating demand elasticities of substitution between the same product sold in a different store (after adjusting for product quality) if this data were available. Nevertheless, it is expected that results of this study mirror to a good extent the behaviour in the rest of the market, although differences in implementations might exist (e.g. which products have higher or lower pass-through).

Estimating the pass-through of alcohol excises in the UK

Findings from previous studies on tax pass-through

Previous studies specifically focusing on alcohol taxes have tended to find evidence of over-shifting of alcohol excises (see e.g., Dutkowsky and Sullivan, 2014). Using product-level data for the United States, Kenkel (2005) found evidence of over-shifting on retail prices collected in an in-store survey in all but one of the products studied, with pass-through rates varying across products. Similarly, using retail price collected from the Commerce Chambers (which are not consumer prices) Shrestha and Markowitz (2016) found evidence of over-shifting of US beer taxes. Young and Bielinska-Kwapisz (2002) found over-shifting of a joint alcohol excise and sales tax for most alcoholic drinks in the US. Using consumer-level Nielsen data, Conlon and Rao (2016) also found some over-shifting, which is explained in terms of the difficulty of retailers in making small price adjustments when taxes increase mildly. In the UK, Ally *et al.* (2014) found evidence of over-shifting for products sold above the median price. Finally, a study collecting store-level

retail prices provides evidence of a negative pass-through of US beer excises and under-shifting of sales taxes for two beer products with large market share (Hanson and Sullivan, 2015), which is justified as a likely behavioural response to the tax (although the article does not include supporting evidence for this claim).

The above provides evidence of a varying alcohol excise pass-through, which is often higher than one. However, these articles focus only on pass-through at the level of the prices set by producers and retailers. As such, previous studies do not indicate the final pass-through on equilibrium prices, which refer to the prices consumers actually pay. The next sections of this chapter report on the methods and data used in analyses. Section 0 presents the results of using off-licence prices paid by consumers in the UK for alcoholic drinks to estimate the pass-through rate of excises.

Data on retail sales and excises of alcohol

The empirical analysis estimates the excise pass-through in different categories of alcoholic drinks using data on the sales of alcoholic drinks in all stores across the UK of one of the largest UK retailers. This section presents a description of the data, while the next subsection will present the approach used to impute prices when the value was missing, i.e. when a product did not sell in a particular time period, but there was evidence that it was available in the market.

Specifically, the data refers to sales of alcoholic drinks recorded through the use of loyalty cards over 262 weeks (5 years, from February 2008 to February 2013). The data accounts for the transactions of around 17 million UK Clubcard holders, and contains (quantity weighted) average prices paid, quantity sold, and variety sold by product type (e.g. red wine, ready-to-drink spirits, etc.) across different store size formats (superstore, convenience store, etc.) and product volumes. Importantly, in the analyses that follow, we classify unique products as any combination of product category, size, and store format (e.g. a 750ml bottle of red wine sold in a convenience store is recorded as a different product to a 750ml red wine sold in a large store). We also add information on the Value Added Tax[8] (VAT). ***Table 1*** shows the sales (in litres sold) contained in the dataset per product category and year.

We dropped (the very rare) sales in shops with very limited presence in dataset (e.g., petrol-filling stations), keeping the most relevant store formats of the retailer, which were classified by square feet surface area as ‘Convenience’, ‘Medium’, ‘Large’ and ‘Extra-large’ stores, respectively. We also removed products with relatively small volumes (fruit wine, fruit beer, cocktails, syrup, wheat beer, and wine mixes – wines in cases of mixed colours) because their sales were very sparse and irregular, thus not providing enough observations for an estimate.

[8] Notably, the VAT changed several times in the time window of the analysis: the VAT rate was 17.5% until the 30/11/2008, it was then reduced to 15% from the 01/12/2008 to the 31/12/2009, and subsequently raised first to 17.5% from the 01/01/ 2010 to the 03/01/2011, and further raised to 20% on the 04/01/2011. See also https://www.gov.uk/vat-rates

Table 1. Total number of litres sold in store, by year and alcoholic drink type

Category	2008	2009	2010	2011	2013
Lager	4,037,032	4,297,388	4,613,291	4,937,363	2,794,058
White wine	1,601,464	1,631,432	1,583,397	1,565,287	1,194,441
Red wine	1,640,602	1,622,745	1,565,402	1,494,509	1,160,987
Cider	912,233	1,019,493	1,154,784	1,252,898	733,973
Ale/Bitter	1,030,106	1,031,157	1,097,497	1,167,944	666,579
Rosé wine	397,284	414,634	444,713	432,385	278,565
Vodka	187,666	189,067	200,999	202,894	143,770
Whisky	224,744	216,424	218,881	207,862	139,892
Sparkling wine	174,577	189,741	190,338	196,430	138,675
Stout	185,180	179,375	165,518	174,230	109,508
Fortified wine	178,433	153,240	155,672	140,483	93,054
Alcopops	163,628	154,100	154,120	152,898	83,240
Perry	52,512	99,258	113,361	141,097	82,241
Gin	92,855	93,696	91,129	94,114	60,812
Rum	62,396	68,617	77,689	74,404	50,933
Liqueur[a]	106,477	105,085	104,887	105,388	45,246
Brandy	64,579	62,115	60,802	58,804	43,074
Champagne	54,952	54,815	59,809	53,902	24,618
Spirits[b]	9,952	11,539	10,394	10,110	10,445
Fruit wine	25,079	24,513	26,797	23,159	16,095
Wheat beer	11,972	12,775	12,857	17,841	12,877
Wine mixed	25,606	30,404	28,338	29,745	12,870
Fruit beer	2,914	2,862	2,341	3,891	1,855
Cocktail	1,514	3,012	3,704	2,055	1,037
Syrup	592	447	744	1,074	817
Number of weeks	**45**	**52**	**52**	**52**	**8**

[a]Liqueur includes products such as Baileys, Grand Marnier, Cointreau, amaretto, cherry liqueur, crème de menthe liqueur, curacao liqueur, etc. [b]Spirits includes products such as schnapps, tequila, kirsch, grappa, and ouzo.

Table 2 presents the value of the excise charged on alcoholic drinks since April 2000. Data from the excise charged at any given point in time refers to HMRC alcohol excises data[9]. The table shows that excises have been growing steadily over time (the only exception is the drop in cider excise in June 2010). In particular, the UK government introduced an alcohol duty escalator in 2008 to annually increase the excise rate on all alcoholic drinks by 2% above the inflation rate. The escalator was then suspended at the end of 2013 for beer, and 2014 for other alcoholic drinks (Burton *et al.*, 2017). At the same time, the table reveals a significant variability in the magnitude of the excise across different products, as well as in

[9] See https://www.uktradeinfo.com/Statistics/StatisticalBulletins/Pages/BulletinArchive.aspx?viewname=Alcohol%20Duty%20Archive

the modality of charging the excise: the excise is charged by hectolitre for wines and ciders; per litre of alcohol for spirits; and for each percentage point of alcohol content for beer.

Table 2. Excise charged on alcoholic drinks since April 2000

Date of Change	Wine			Spirits		Beer	Cider		
	Still		Sparkling	Spirits-Based RTDs	Spirits		Still		Sparkling
Alcohol level	5.5%-15%	>15%-22%	8.5%-15%				1.2%-7.5%	>7.5%-8.5%	
01.04.00	154.37	205.82	220.54	-	19.56	11.89	26.13	39.21	166.70
07.03.01	154.37	205.82	220.54	-	19.56	11.89	26.13	39.21	166.70
01.06.02						11.89			
28.04.02	154.37	205.82	220.54	19.56	19.56	12.22	25.61	38.43	166.70
14.04.03	158.69	211.58	220.54	19.56	19.56	12.59			
22.03.04	163.47	217.95	220.54	19.56	19.56	12.59			
20.03.05	167.72	223.62	220.54	19.56	19.56	12.92	25.61	38.43	166.70
26.03.06	172.17	229.55	220.54	19.56	19.56	13.26	25.61	38.43	166.70
26.03.07	177.99	237.31	227.99	19.56	19.56	13.71	26.48	39.73	172.33
01.03.08							28.90	43.37	188.10
17.03.08	194.28	259.02	248.85	21.35	21.35	14.96			
01.12.08	209.82	279.74	268.75	22.20	22.20	16.15	31.21	46.83	203.14
23.04.09	214.02	285.33	274.13	22.64	22.64	16.47	31.83	47.77	207.20
29.03.10	225.00	299.97	288.20	23.80	23.80	17.32	36.01	54.04	217.83
30.06.10							33.46	50.22	217.83
28.03.11	241.23	321.61	308.99	25.52	25.52	18.57	35.87	53.84	233.55
01.10.11	241.23	321.61	308.99	25.52	25.52	18.57	35.87	53.84	233.55
26.03.12	253.39	337.82	324.56	26.81	26.81	19.51	37.68	56.55	245.32
25.03.13	266.72	355.59	341.63	28.22	28.22	19.12	39.66	59.52	258.23
24.03.14	273.31	364.37	350.07	28.22	28.22	18.74	39.66	59.52	264.61
23.03.15	273.31	364.37	350.07	27.66	27.66	18.37	38.87	58.75	264.61
21.03.16	277.84	370.41	355.87	27.66	27.66	18.37	38.87	58.75	268.99
13.03.17	288.65	384.82	369.72	28.74	28.74	19.08	40.38	61.04	279.46
Type of tax	£ per hectolitre of product			£ per litre of pure alcohol		£ per 1% ABV per hectolitre	£ per hectolitres of product		

Source: HMRC (2017). The area shaded in grey indicates the period considered in this document.

Missing data: multiple imputations

A limitation in the use of sales data from retailers is that observations on prices and quantities are missing if the product did not sell in a particular time period. In this case, the product has no price, and a pass-through rate cannot be calculated. Missing observations on sales might be due to a product being discontinued or not yet being introduced in the market; or reflect the seasonality of a product that is only sold on certain occasions during the year. In many instances, however, missing information on sales in the dataset indicates that a product was on offer but did not sell, or was temporarily out of stock. This type of missing information occurs particularly in infrequently purchased categories with a large variety of products, which have a slow turnaround and are stocked, but from which consumers purchase irregularly. In this case, the product has a market price (and, consequently, a pass-through rate), but the value is not observed.

To address the naturally occurring levels of missing information on sales and prices, a two-step strategy was followed. As a first step, those products that sold in less than 77% of the total number of weeks of sales data available (262) were removed from analyses. Values below this proportion were assumed to represent a measure of infrequent purchases. Most products falling into this lower range represented rare volume sizes in the market, or the fact that a particular volume format of an alcoholic drink did not sell frequently in certain store types.

As a second step multiple imputation chained equation (MICE) methods were used to impute missing average price and average discount values using a predictive mean matching (PMM) specification with the number of closest observations (nearest neighbours) set at 4. Prices were imputed as logarithms and then re-transformed in the imputed data sets. The covariates used to estimate the imputed values of prices and discounts were based on all other complete (i.e. non-missing) available information in the data (store type, volume of product, quantity sold per week, number of different products within a category sold per week, and number of customers purchasing the category per week). In addition, variables for weekly weather conditions (sunshine and rain) and Fourier time trends (to capture potential breaks) of level 4 were included. In total, five imputations for each missing value were generated. ***Table 3*** shows the initial level and proportion of missing values once infrequently purchased products were excluded, and the number and proportion of imputed observations after MICE.

Table 3. Number and percentage of incomplete observations on price

Variable	Complete	% of total	Incomplete	% of total	Imputed	% of incomplete*	Total	% of total
lnprice	91103	98	1645	2	1645	100	92748	100
discount	91072	98	1676	2	1676	100	92748	100

*Percentage of incomplete after MICE imputation. lnprice: logarithm of price.

Estimation strategy for pass-through rates

The section presents the econometric methods implemented to estimate the pass-through rate of the tax on alcoholic drinks. It describes the chosen methods to deal with general features of data on alcohol sales of different products over time, and in particular prices, and excise.

At time *t*, alcoholic product *i* is purchased in the market at a (VAT-inclusive) price p_{it}, of which an amount τ_{it} is the product-level excise. The pass-through of the tax can then be

estimated using the reduced-form regression[10] (DeCicca et al., 2012, Besley and Rosen, 1999, Nakamura and Zerom, 2010, Marion and Muehlegger, 2011, Bonnet et al., 2013)

$$ln(p_{it}) = a_i + \delta_i ln(\tau_{it}) + \gamma x_{it} + \varepsilon_{it} \qquad (4)$$

where x_{it} refers to a set of factors that influence price, and a_i are product-specific characteristics (fixed effects). The residuals ε_{it} are assumed to be serially autocorrelated, so that $\varepsilon_{it} = \theta\varepsilon_{it-1} + \nu_{it}$.

A panel regression with autocorrelated errors[11] was used to estimate this equation, removing fixed effects by demeaning. This model refers to a reduced form pricing function, which assumes that the value of the tax is unrelated to the price consumers pay. This is a realistic assumption if we consider that in a duty escalator the tax is set externally by a policy-maker in advance and without prior knowledge of consumption.

Equation (4) presents both the price and the tax as logarithms to better handle the potential heteroskedasticity and non-normality of the data. As a result, δ_i refers to a tax-elasticity and measures the percentage change in price resulting from a percentage change in the tax. From the value of δ_i, the pass-through rate for product *i* can be estimated as

$$\rho_i = \frac{\partial p}{\partial \tau} = \delta_i \frac{p_{it}}{\tau_{it}} \qquad (5)$$

Following this equation, full pass-through is represented by $\boldsymbol{\rho_i = 1}$; over-shifting of tax by $\boldsymbol{\rho_i > 1}$, and under-shifting by $\boldsymbol{\rho_i < 1}$. Three different analyses to estimate the value of the pass-through ρ_i were conducted:

a) Overall pass-through across all product categories, volume types and store types. This was the estimated pass-through for the alcohol drinks market as a whole.

b) Pass-through by product category, resulting in the estimated pass-through for 19 different product categories in the data: alcopops, ale/bitter, brandy, champagne, cider, fortified wine, gin, lager, liqueur, perry, red wine, rosé wine, rum, sparkling wine, spirits, stout, vodka, whisky, and white wine.

c) Pass-through by product category, volume size and store type. In this analysis we interacted the effect of the tax on price with a qualitative variable capturing the most common volume format in the market for a specific category, any volumes below this and any volumes above this; and separately, the effect of the tax for the four different store size formats in the data.

Results on the pass-through of alcohol excises

This section presents the estimated pass-through rates of alcohol excise for alcoholic drinks using UK data from supermarket sales. Before reporting the individual estimates of pass-through described at the end of section 0, the section looks at trends over time of alcohol tax and prices.

[10] Note that Besley and Rosen actually test the regression $(p_{it} - \tau_{it}) = \beta_{0i} + \beta_{1i}x_{it} + \delta_i\tau_{it} + \varepsilon_{it}$, where the tax-free price of the product is regressed against the tax. This approach directly tests null hypothesis of unit pass-through in the form $\delta_i = 0$.

[11] Command xtregar in statistical software Stata (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC).

Trends in tax and prices over time

Trends over time in alcohol tax and average prices paid for different alcoholic drinks provide a simple overview of the behaviour of prices of alcoholic drinks when taxes increased in the period between March 2008 and March 2013. Seasonality aside (with prices peaking in the Christmas period), as expected, generally prices paid increased as the tax increased. ***Figure 4a-4h*** plot these values over time. This relationship was particularly evident for still wine, fortified wines, alcopops and spirits. The relationship was instead less clear for sparkling wines, beer, and cider. Perry showed an overall decline in price despite an increasing excise (***Figure 4g***). Importantly, these graphs show that excise pass-through rates, which capture the relationship between excise and prices, varied across product categories.

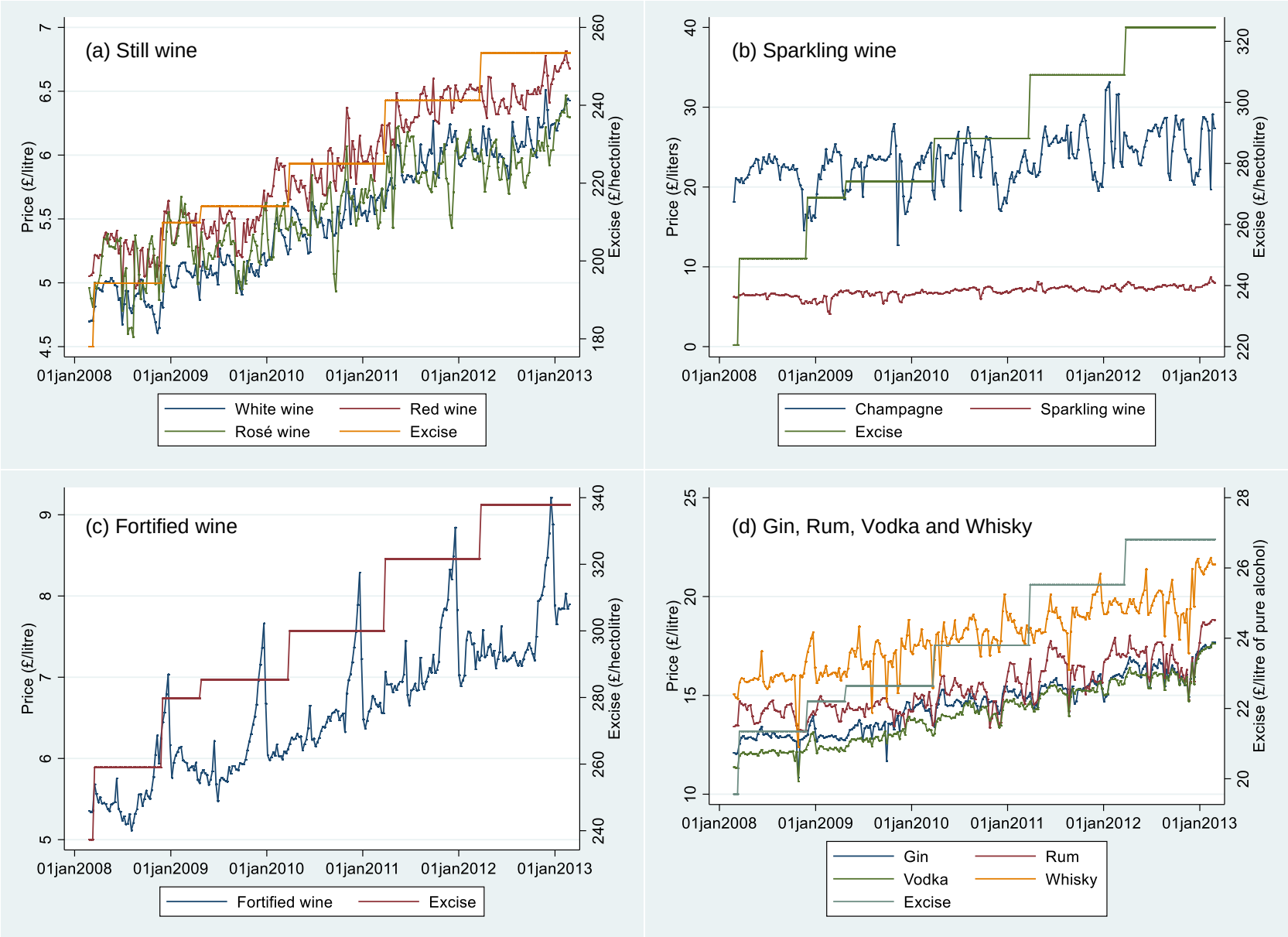


Figure 4. Graphical representation of trends in price paid and excise charged, by product

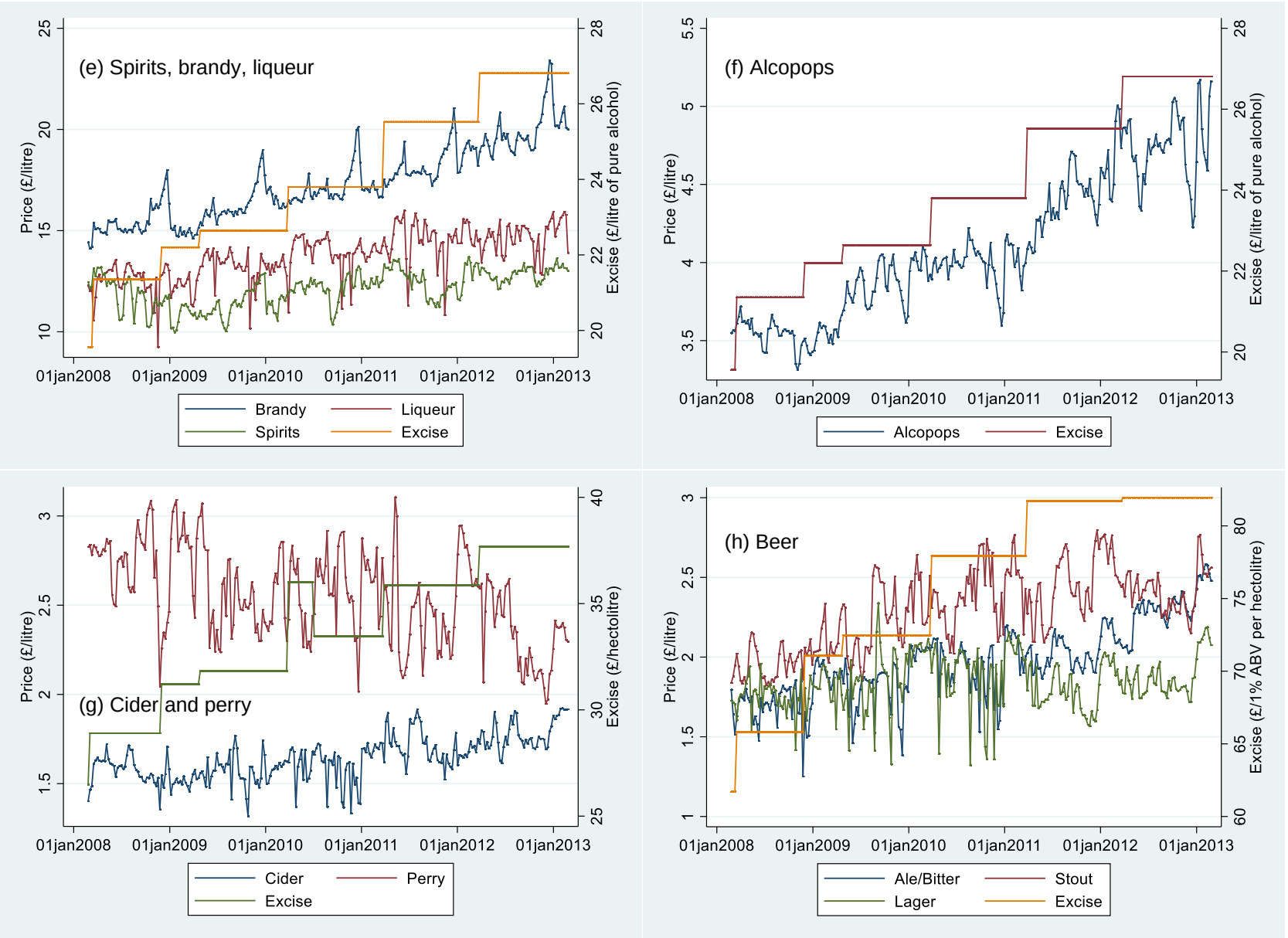


Figure 5. Graphical representation of trends in price paid and excise charged, by product (continued)

Alcohol pass-through for the alcoholic drinks market

The estimated pass-through for the whole alcoholic drinks market is presented in ***Table 4***. This figure reflects the estimate from equations (4) and (5) using the panel regression analysis (a) from section 0, which included all products. Results provide evidence of an incomplete pass-through or under-shifting of the alcohol excise, so that for every £1 increase in tax only two thirds, £0.66, were passed onto the price.

The estimated pass-through for the whole alcoholic drinks market is, however, an average that does not capture the diversity of products in the market and the possibility that the pass-through differs significantly across drink categories. ***Table 5*** reports estimates of the panel regression conducted separately for each drink category (analysis b, section 0), presented graphically below ***Table 5***. These results indicate that the pass-through rate varies considerably across excise level and drink category. The analyses provide results on two questions: whether the prices of the products in the category responded to a tax increase; and if so whether this increase was greater or lower than one.

With the exception of ales and bitter, prices of high-strength drinks like brandy, gin, rum, and vodka, etc. were affected by alcohol tax changes (*p-value* < 0.05). In contrast, there was no evidence of an effect of changes in alcohol excise on the prices of wines (still and sparkling) and beers, cider and perry. Products with a pass-through rate significantly different than one, however, were only brandy and cider. The lack of significance was driven by a large variance, caused by significant variability of the estimates over time. Key differences underlying this variability may have been driven by the volume of the bottle and the store where the product was sold. The impact of these variables was tested in the next section.

Table 4. Estimated alcohol pass-through rate for the whole alcohol drinks market

Drink category	Pass-through	S.E.
All products	0.66*†	0.10

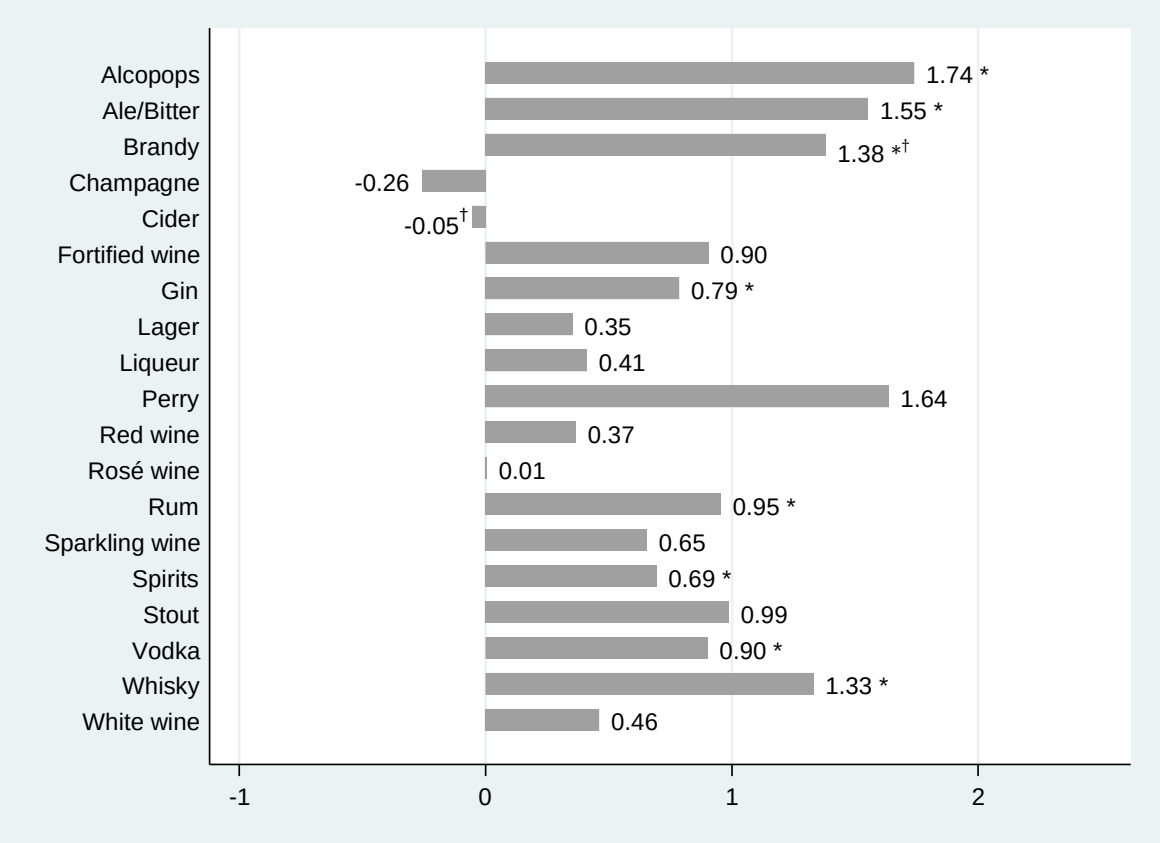
S.E.: standard error. Pass through estimated using a panel regression correcting for autocorrelation using unique product type (category, volume size and store type) as unit of analysis over time.
*5% significance or lower for the null hypothesis H_0: $\rho = 0$; †5% significance or lower for the null hypothesis H_0: $\rho = 1$.

Table 5. Pass-through rates of different alcoholic drink categories

Excise class	Drink category	Pass-through	S.E.
Beer	Ale/Bitter	1.55*	0.63
	Lager	0.35	0.39
	Stout	0.99	0.94
Still cider	Cider	-0.05†	0.50
	Perry	1.64	1.78
Sparkling wine	Champagne	-0.26	2.04
	Sparkling wine	0.65	0.51
Still wine (>15%-22%)	Fortified wine	0.90	0.47
Still wine (5.5%-15%)	Red wine	0.37	0.72
	Rose wine	0.01	0.93
	White wine	0.46	0.45
Spirits	Alcopops	1.74*	0.43
	Brandy	1.38*†	0.18
	Gin	0.79*	0.20
	Liqueur[a]	0.41	0.42
	Rum	0.95*	0.14
	Spirits[b]	0.69*	0.31
	Vodka	0.90*	0.08
	Whisky	1.33*	0.43

S.E.: standard error. Pass through estimated using a panel regression correcting for autocorrelation using unique product type (category, volume size and store type) as unit of analysis over time.
*5% significance or lower for the null hypothesis H_0: $\rho = 0$; †5% significance or lower for the null hypothesis H_0: $\rho = 1$.
[a]Liqueur includes products such as Baileys, Grand Marnier, Cointreau, amaretto, cherry liqueur, crème de menthe liqueur, curacao liqueur, etc. [b]Spirits includes products such as schnapps, tequila, kirsch, grappa, and ouzo.

*5% significance or lower for the null hypothesis H_0: $\rho = 0$; †5% significance or lower for the null hypothesis H_0:



$\rho = 1$. Liqueur includes products such as Baileys, Grand Marnier, Cointreau, amaretto, cherry liqueur, crème de menthe liqueur, curacao liqueur, etc. Spirits includes products such as schnapps, tequila, kirsch, grappa, and ouzo.

Alcohol pass-through for the alcoholic drinks market: impact of volume size and store size

Results in the previous section presented the average pass-through for a category of alcoholic drinks. However, a retailer who manages a category rather than individual products can allow the pass-through to vary depending on the characteristics of the product and the characteristics of the store where the product is sold. In this section, we test whether the pass-through rates vary across store format and product volume. Estimates are relative to a baseline volume, selected as the most commonly observed product volume in the category (e.g., 0.75l bottle for wine), and a baseline store type, selected as extra-large stores.

Results indicate that pass-through rates vary considerably depending on whether the product is smaller or larger than the baseline reference volume, as well as on the format of the store where this product is sold (***Table 6***). The pass-through rates of ***Table 6*** can be compared visually in ***Figure 6*****a-6c** (additional pass-through by volume) and ***Figure 7*****a-7c** (additional pass-through by store format). Note that the pass-through in these figures refers to the additional £ of tax passing through (positive sign) or being absorbed (negative sign) relative to the baseline category.

In many instances there was no significant difference for volume sizes or store sizes in the effect of tax changes on product prices. Observing significant differences by volume size, there was no obvious linear trend (e.g. most pass-through rates being higher with higher

volume sizes), but instead rates varied by product. Looking at volume size, for **wine, fortified wine, sparkling wine, beers, cider, whisky** and **gin**, the standard product size was most frequently the one with the highest pass-through rate compared to smaller as well as larger formats. For **brandy**, **champagne**, and other **spirits**, the higher pass-through appeared for the larger sizes; while for **perry** and **liqueurs** the higher pass-through was charged on the smaller sizes.

In terms of store formats, pass-through was highest for medium stores for **fortified wines** and **brandy**, pass-through was highest in small stores for **cider**, **perry**, and other **spirits**; and for **red**, **white**, and **sparkling wines**, as well as **liqueur**, pass-through increased with size of the store, up to the large stores. Finally, for **lager** and **gin**, pass-through was lower in small stores, but it was the same for all other formats.

Table 6. Estimated pass-through by category, store size and product volume

Excise class	Drink category	Reference volume	Reference volume/ Extra-large store		Change from reference to:									
					Lower volume		Higher volume		Convenience store		Medium store		Large store	
			Pass-through	S.E.	Pass-through	S.E.	Pass-through	S.E.	Pass-through	S.E.	Pass-through	S.E.	Pass-through	S.E.
Beer	Ale/Bitter	0.50 l	1.5*	0.74	-0.27	0.4	0.67	0.41	-0.47	0.43	-0.3	0.37	0.09	0.33
	Lager	0.50 l	1.26*	0.47	-0.69*	0.27	-0.93*	0.28	-0.57*	0.21	-0.16	0.2	-0.1	0.19
	Stout	0.44 l	1.67	0.99	0.45	0.4	-2.38*	0.4	0.33	0.62	-0.3	0.4	-0.1	0.4
Still cider	Cider	0.50 l	4.97*†	0.91	-6.91*	0.86	-7.25*	0.77	3.54*	0.75	1.25	0.7	0.49	0.67
	Perry	0.50 l	-2.14	1.87	6.4*	1.14	1.49	1.1	3.07*	1.47	0.23	1.24	-0.08	1.17
Sparkling wine	Champagne	0.75 l	-1.13	2.17	NA	NA	2.36*	0.88	-0.73	1.39	0.06	1.08	-0.28	1.08
	Sparkling wine	0.70 l	1.40*	0.55	-0.88*	0.24	NA	NA	-1.13*	0.38	-0.63*	0.29	-0.06	0.29
Still wine (>15%-22%)	Fortified wine	0.75 l	1.84*	0.63	-3*	0.46	-0.3	0.45	0.6	0.63	1.01*	0.43	0.29	0.41
Still wine (5.5%-15%)	Red wine	0.75 l	0.79	0.80	-0.1	0.52	0.21	0.54	-1.48*	0.6	-1.08*	0.49	-0.01	0.47
	White wine	0.75 l	1.46*	0.52	-1.38*	0.26	-0.6*	0.24	-0.68*	0.3	-0.28	0.28	0.05	0.23
	Rosé wine	0.75 l	0.52	0.93	-1.37*	0.33	-0.14	0.33	0.2	0.37	-0.34	0.32	0.53	0.35
Spirits	Alcopops	0.25 l	1.55*	0.55	NA	NA	0.16	0.31	0.51	0.4	0.2	0.33	-0.25	0.31
	Brandy	0.70 l	1.26*	0.27	-0.32	0.21	0.54*	0.26	0.12	0.29	0.61*	0.25	-0.04	0.23
	Gin	0.70 l	1.10*	0.26	-0.74*	0.19	-0.29	0.17	-0.58*	0.21	0.33	0.19	0.16	0.19
	Liqueur[a]	0.70 l	-0.12†	0.56	1.75*	0.42	0.17	0.48	-1.04	0.59	-0.88*	0.44	-0.19	0.43
	Rum	1.00 l	1.21*	0.17	-0.24*	0.1	NA	NA	-0.24	0.14	-0.1	0.12	-0.04	0.12
	Spirits[b]	0.50 l	0.16†	0.34	0.72*	0.23	0.9*	0.18	1.32*	0.32	-0.14	0.22	-0.25	0.17
	Vodka	0.70 l	0.90*	0.11	0.32*	0.08	0.1	0.07	-0.78*	0.09	0.04	0.08	-0.01	0.08
	Whisky	0.70 l	1.57*	0.58	-0.89*	0.43	-0.08	0.4	-0.04	0.46	0.49	0.43	-0.02	0.41

Reference volume in litres. Pass through estimated using a panel regression correcting for autocorrelation using unique product type (category, volume size and store type) as unit of analysis over time. Differences by volume size and store size from interaction of the effect of the tax with three dummy variables for volume size (reference category, below reference and above reference) and four store size dummy variables (convenience store, medium store, large store and extra-large store).

*5% significance or lower for the null hypothesis H_0: $\rho = 0$; †5% significance or lower for the null hypothesis H_0: $\rho = 1$.

[a]Liqueur includes products such as Baileys, Grand Marnier, Cointreau, amaretto, cherry liqueur, crème de menthe liqueur, curacao liqueur, etc. [b]Spirits includes products such as schnapps, tequila, kirsch, grappa, and ouzo.

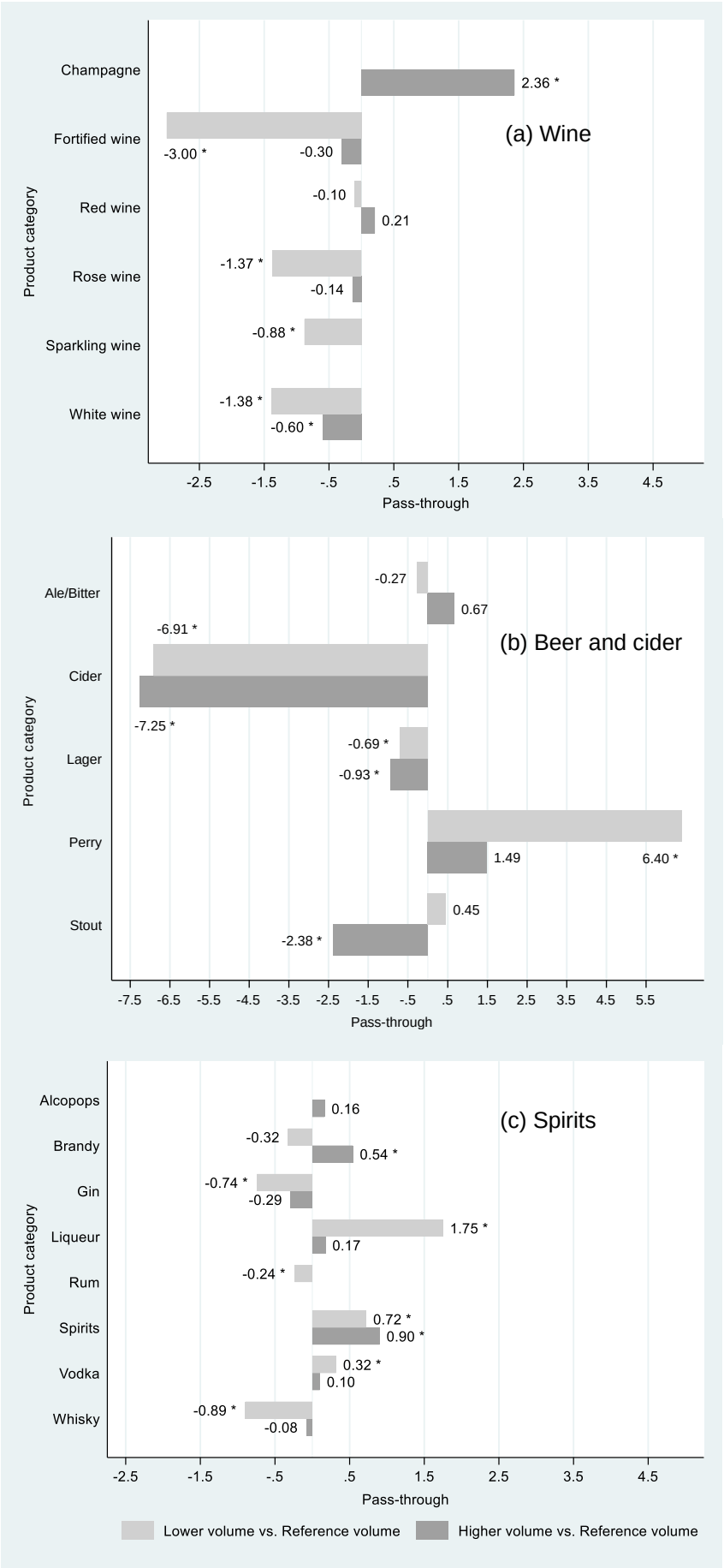


Figure 6. Pass-through rates of different categories by volume size for (a) wine, (b) beer, cider and perry and (c) spirits.
Pass-through from estimates in ***Table 6***.

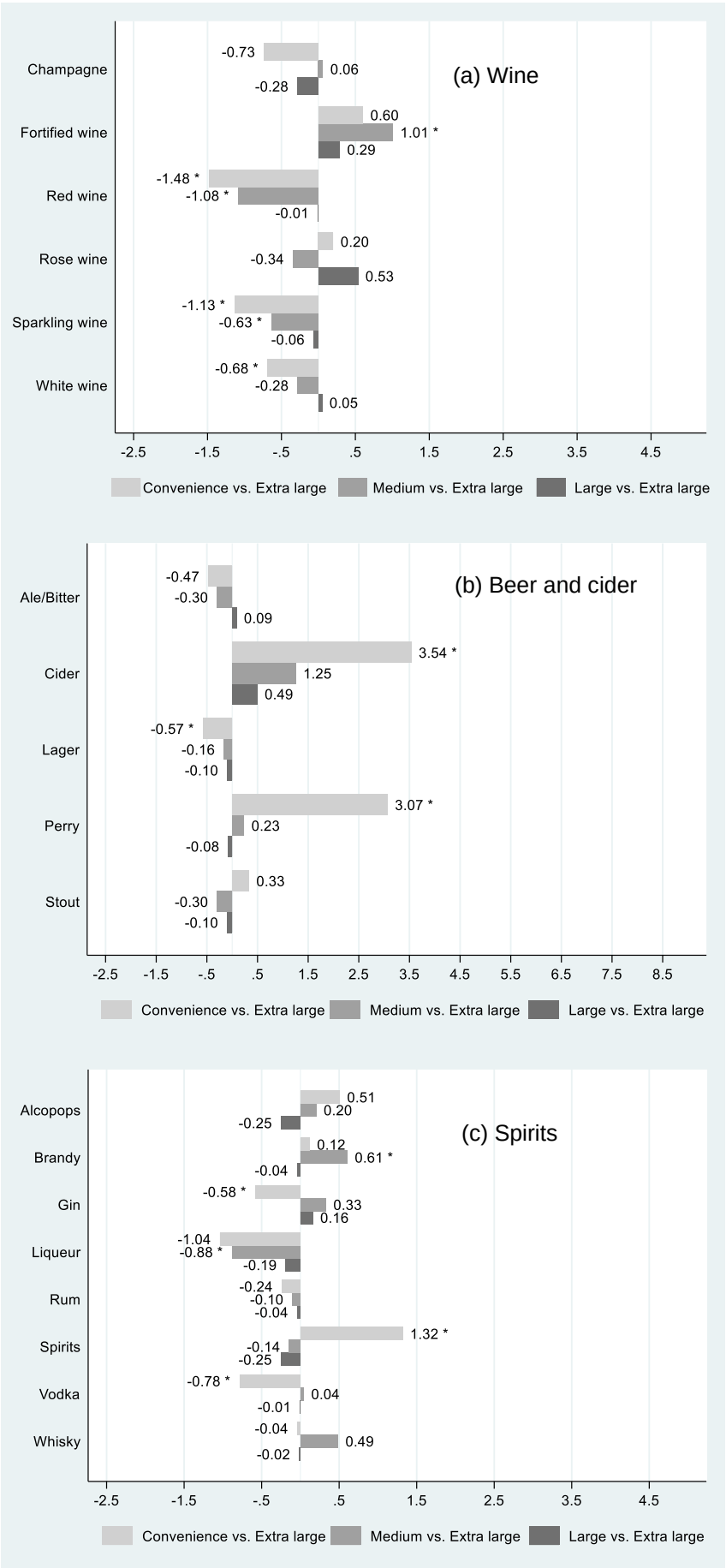


Figure 7. Pass-through rates of different categories by size of store format for (a) wine, (b) beer, cider and perry and (c) spirits

Pass-through from estimates in ***Table 6***.

Discussion

This study explored and tested the impact of alcohol excises on the price of alcoholic drinks paid by consumers. A key question for policy-makers in setting an alcohol excise is whether it is effective in changing the behaviour of consumers. This research provides a first step in this assessment using a unique source of information on alcohol sales to show the relationship between alcohol excises and market prices. Compared to previous research, the use of market prices allows an insight into the actual impact of the tax on the price consumers pay, rather than on the price producers offer consumers. This section summarises the results presented in this report with a view to observing the extent to which prices are influenced by changes in taxation, and how these results can guide the design of improved alcohol pricing policies.

The impact of alcohol excise on the price of alcoholic drinks

As expected, alcohol excises are an effective tool to increase the prices consumers pay for alcoholic drinks. This result is in line with previous research estimating the impact of taxes on the price of alcoholic drinks (e.g., Ally et al., 2014, Kenkel, 2005), as well as other commodities like cigarettes (e.g., DeCicca et al., 2012), and fuel (e.g., Marion and Muehlegger, 2011). In the UK, previous research showed that alcohol excises increased the price that consumers are charged for alcoholic drinks, providing evidence of a full pass-through and over-shifting (Ally *et al.*, 2014). This means that retailers do increase the price of their products following a regulated price increase by at least the value of the tax. However, our results using the price that consumers pay for alcohol showed that the average pass-through for all alcoholic drinks was instead less than one (prices increased by slightly less than the value of the tax), sitting at around a £0.66 price increase for each £1 of tax increase. This value may be reflecting the fact that the price increase from the tax stimulates a substitution effect by consumers, who move away from products with a higher post-tax price to products with lower post-tax price. More generally, the estimate for the overall pass-through is in line with estimated cost pass-through in marketing research (e.g., Besanko et al., 2005) suggesting that retailers and manufacturers treat regulated price increases similarly to any other change in production and retailing costs.

Results also show a substantial variability in the way the excise is transmitted to prices. In particular, in a market where the retailer manages a category instead of a single product, pricing is done collectively, and the pass-through varies depending on the strategic relevance of different retail channels, and the profitability of different products. In other words, manufacturers in different sectors will be able to respond and adapt differently to the increase in taxation; and retailers can ensure that certain products (e.g. the most common size) with large market shares are less affected by the tax compared to products that sell less before the tax. Results indicate that the pass-through indeed changed by different store formats and different product volumes. Notably, the differences at category level reflect to a good extent the ability of consumers to shop around, a factor that is associated with higher price elasticities of demand, which in turn influence pass-through rates (Anderson *et al.*, 2001). For instance, there is a large variety of still wines (5.5%-15% ABV) available in the market, allowing consumers to find a suitably cheaper replacement when faced with a price increase due to tax; this behaviour is then reflected in a pass-through rate for this category which is lower than the average for the alcoholic drinks market. Other segments, particularly brandy, whisky, and alcopops, cannot count on similar levels of variety and choice, and this might explain their higher pass-through rates.

The pass-through of alcohol taxes and current alcohol policies

While the results support the notion that alcohol taxes have in many categories the potential to change behaviour by increasing the prices consumers pay, there is a less clear understanding of whether taxes are effective in reducing alcohol intake. In fact, a key limitation of current alcohol pricing policies is the disconnect between alcohol content and alcohol taxation (Griffith *et al.*, 2017a). Apart from spirits, where the tax is linked to the litres of pure alcohol, the value of the excise is unrelated to the alcohol content of the category. For example, still wines in the 8.5-15% ABV excise range pay less than champagne in the same ABV range; while the excises for beer (taking into account an average ABV of 4.4%) are considerably higher than still cider excise, despite having comparable alcohol content. Similarly, tax does not change according to alcohol content within the same category. For instance, an 11% ABV wine and a 14.5% ABV wine pay the same excise, despite having a different impact on health. The above suggests that a linear alcohol tax that more clearly targets the alcohol content of products, and therefore the amount of alcohol actually consumed, may be more effective in addressing excessive levels of alcohol intake in society.

The results of this study suggest that a linear alcohol excise (i.e. one where the value of the tax is based on alcohol content rather than by unit of drink) would result in higher tax pass-through. The excise for spirits is charged by their alcohol content, and their pass-through was always higher than the average for the whole sector. Similarly, the tax of beer is designed as an excise per %ABV, and the pass-through was again higher than for other categories with taxes based on unit of product sold (with the exception of lagers. However, in this case, there is a very concentrated oligopoly). Conversely, wines and ciders are priced by unit of volume, and the pass-through in most instances was lower than the average, and in some instances very close to zero. Findings from other similar alcohol tax policies that target alcohol content, such as minimum pricing policy, show that such an approach increases the price of alcoholic drinks significantly (Griffith *et al.*, 2017b). Future research should assess and compare these two alternative pricing policies in their ability to pass the tax onto actual consumer prices.

Future research directions

The increasing availability of large consumption datasets allows the gathering of better evidence to determine the impact of regulations on actual consumption behaviour, because it records consumers making binding transactions in a dynamic environment. These datasets provide a rich source of information which allow substitution patterns to be studied, which can explain how behaviour and choices change as a policy (e.g. the value of the excise) changes. A key limitation of existing datasets for the study of alcohol policies, however, is often the lack of exact information on the alcohol content of different products. The potential addition of precise information on alcohol content would allow more precise evidence on the effectiveness of policy to reduce alcohol intake, for example by product reformulation, in addition to studying changes in what consumers purchase.

This analysis did not incorporate information on consumer demand to estimate the pass-through rate of the tax, i.e. on how consumers change the amount and the type of alcoholic drinks purchased when faced with a price increase. However, because the pass-through rate depends on the price elasticity of demand, consumer preferences may be a relevant factor in the estimation of a pass-through rate. This could be done using a structural supply model to advance the reduced-form estimation presented in this report (following, e.g.,

Bonnet et al., 2013, Besanko et al., 2005). Future research could test to what extent consumer preferences influence the pass-through rate in the present dataset.

Finally, while this report focused on the role of excise taxes, there is also a need for a better understanding of the role of discounts in the process of price formation for alcoholic drinks. Discounts are a crucial tool for retailers and manufacturers to ensure that stocks are managed dynamically, resulting in products that are progressively sold and never kept in the warehouse for too long. As indicated in the mathematical model of this report (section 0), prices are managed at a category level, and the same may apply to promotions and discounts. However, discounts and price-based promotions erode the price increase of the tax, and the potential illusion of a bargain may give an incentive to consume (Panzone, 2012). Currently, however, there is no indication in the literature of whether alcoholic drinks are promoted differently across excise categories, nor to what extent discounts favour alcohol over-consumption. More research is needed to understand the impact of a combination of price increases (taxes) and decreases (discounts) on consumer behaviour, and particularly on the consumption of alcoholic drinks.

Conclusion

The present work tested for the impact of alcohol excises on the price of alcoholic drinks that consumers pay. Results indicate that overall taxes are only partially passed onto consumer prices, an indication that the effect of taxation on prices does not achieve its full potential for increasing prices and, consequently, consumer choices.

Results can differ significantly across product categories, so that, in some categories, tax is more effectively passed to consumers than others. As a result, there is a need to more clearly understand the barriers that limit the full pass-through of alcohol excises, and particularly determine strategies (behavioural as well as structural) to ensure the tax is fully reflected on the prices consumers pay. The ability to continue working with large sales datasets to accurately model consumers and manufacturers will be key to improve the efficacy of policy interventions aiming at healthier patterns of consumption of alcoholic drinks.

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