Estimating Food and Drink Demand Elasticities

April 2022

Larissa da Silva Marioni, Ana Rincon-Aznar, Andrew Aitken,
Sandeep Kapur, Ron Smith, Walter Beckert

Table of Contents

1 Introduction

In June 2019 the UK government commissioned an independent review of England's food system, in order to develop an integrated National Food Strategy. The aim was to understand how the production, distribution and consumption of food affects our welfare and health, including their impact on the environment. The formulation of a food strategy requires a clear model of consumer demand, in order to understand how changes in market prices and consumers' incomes are likely to affect patterns of consumption of food and drink. Such a model would help us understand how market forces might affect health and to formulate appropriate policy responses. For instance, would growing income inequality combined with an increase in food prices result in worsening diet and increased obesity? If so, what policy interventions might be best designed to correct these? Further, it is possible that our food supply chains may be disrupted by current or future shocks: these might range from UK's exit from the EU, the effects of the COVID-19 pandemic and war in Ukraine. Once again, an accurate model of demand is necessary for the design of effective policy corrections.

This report provides a model of consumer demand for food and drink. Our focus is on estimating the elasticities of demand, which measure the sensitivity of the demand for a good to changes in prices or income. Estimating the price elasticity of demand for an individual item of food or drink allows us to assess how its demand varies when its price changes. Estimating a demand system for all food items allows us to assess how demand for various items changes, not just in response to their own prices, but also in response to changes in prices of other items. The expenditure elasticity tells us how demand for individual food items varies with changes in the consumers' overall expenditure on food: consumers on the lower end of the income distribution might have pattern quite different from those at the top percentiles. These estimates of consumer elasticity offer valuable insights. For instance, they enable policy-makers to anticipate the likely impact of food price inflation on patterns of consumption and nutrition. If the policy aim is to use selective taxation to alter the pattern of consumption towards a healthier nutritional balance, the estimated elasticities guide the choice of food items to be taxed. Expenditure elasticities of demand alter policy makers to the impact of changes in the income distribution.[1]

Following UK's exit from the EU and from the constraints of the Common Agricultural Policy, it would be helpful to understand how the UK's ability to set its own tariffs on food imports

[1] Measures of price elasticity provide other useful information too. Typically, a low price elasticity of demand in a sector indicates demand is not very sensitive to price, so that the sector is vulnerable to high markup of prices over cost, making a case for greater scrutiny of competition policy in that sector.

might affect prices and consequently food consumption. Brexit, and the lingering effects of the COVID-19 pandemic will also cause changes in migration flows which will affect many aspects of the food system from farming to restaurants. The relatively slow recovery from the recession following the 2007/8 financial crisis, and the austerity policies that followed, had divergent implications for households in different parts of the income distribution.

Several government policies have recently sought to alter peoples' eating behaviour in the last decade. For example, the '5-a-day' policy was introduced to encourage people to consume more fruit and vegetables, and information campaigns have highlighted the dangers of high salt and saturated fat consumption. In 2018 the government introduced a 'sugar tax' on sweetened drinks to reduce sugar consumption. Also, following consultation with industry, the government will restrict promotions on food and drinks high in fat, sugar and salt (HFSS) from October 2022 as part of the government's strategy to tackle obesity.

This study uses systems of demand equations known as the Almost Ideal Demand System (AIDS) to estimate empirically demand elasticities, applied to data drawn from Kantar's grocery market share database, a representative survey of 30,000 UK households. We investigate the extent to which consumption of food products changes in response to changes in their prices, as well as prices of other food products. This allows us to uncover 'substitution' or 'complementarity' relationships across food products, that is, to what extent goods are likely to substitute for one another in the event of a price change, or whether products are likely to be consumed together.

We compare patterns of purchase for consumption at home with those for 'out-of-home' consumption, drawing again on data from Kantar. We investigate whether the sensitivity of demand of food products to prices varies by socio-demographic group. Finally, we estimate 'nutrient elasticities' which measure the effect of changes in food prices on intake of a range of nutrients. This allows us to trace the impact of a change in price of any food category on, for instance sugar, fat or salt consumption and allows us to calibrate implications of hypothetical policy scenarios.

This report is organised as follows: Section 2 describes the data we use and provides some descriptive statistics; Section 3 describes the methodology for estimating demand elasticities; Section 4 presents our empirical estimates for price and expenditure elasticities of demand; Section 5 shows the results for the nutrient elasticities of demands; Section 6 examines some policy scenarios, and Section 7 concludes.

2 Data and descriptive statistics

The data used in this study are drawn from Kantar's Grocery Market Share database, which covers the recorded grocery purchasing habits of more than 30,000 demographically representative households in Great Britain. Households are recruited via stratified sampling, with quotas set by region, household size, age of main shopper, number of children, and occupation. The data considers items purchased throughout a given year. The main shopper in the household also provides socio-demographic information when joining the panel (and with subsequent annual updates), including marital status, social class, education, household size, number of children, income (brackets of) and life stage. We examine data on consumption 'at-home' and also provide results for 'out-of-home' purchases.

We analyse data on household purchases of food and drink for 2018 and 2019, the most recent years before purchasing patterns were distorted by the Covid-19 pandemic. Our dataset organises food and drink purchases in categories at three levels of product aggregation, namely categories 0, 1 and 2. **Error! Reference source not found.** lists the p roducts at each level of classification. Category 0 ('trading area') is the coarsest (or most aggregated) list, classifying purchases only as 'Alcohol', 'Ambient Groceries', 'Fresh & Chilled' foods and 'Frozen' foods. Category 1 ('sector') allows a finer classification: for instance, Frozen foods are disaggregated into 'frozen confectionery', 'frozen fish', 'frozen meat', etc. Category 2 ('market') is the finest categorisation we look at, allowing us to look at sub-categories within, say, frozen meat, to distinguish between beef, lamb, pork, etc. Table A1 in the Appendix presents a list of item codes for each category.

The database contains a total of 1,580,852 observations for the year 2018, and 1,575,236 for the year 2019, which comprise weekly purchases of single households Table2 provides descriptive statistics for various categories at the coarsest levels (level 0) of aggregation. We report the average household weekly spend for a range of food and drink products, its standard deviation, as well as the minimum and maximum expenditure values encountered in the dataset. In addition, we report the share of the total budget that is spent on each category of food or drink.

The average total weekly spend per household was just over £40 both in 2018 and in 2019. In 2018 the largest spend was in 'Total fresh and chilled' products with an average weekly spend of about £20, followed by 'Ambient groceries' with an average spend of just below £14, followed by Alcohol, with an average weekly spend of £4 and Frozen foods, with an average spend of £3. These consumption patterns are remarkably similar to those in 2019.

The standard deviation as well as maximum household spend suggest a high degree of variability in the data. For the total data the standard deviation is as large as the mean value with the maximum total weekly spend of £1,194 in 2018 and £921 in 2019. Purchases of alcohol display the highest level of dispersion relative to the mean. The maximum value of weekly household alcohol consumption in 2018 was of £574 and this went up to £853 in 2019.

A household may not buy items under every category in every week. For instance, if it buys no alcohol in a particular week, a zero would be recorded for Alcohol that week. The last column of Table 2 reports the fraction of weekly entries that are zero. Alcohol is purchased relatively infrequently: aggregating across all households and all weeks in the year, 77% of the recorded purchases under alcohol were zero. In contrast, Ambient groceries are a more frequent purchase, with the share of zero purchases being 26%. The proportion of households who did not spend anything in a particular week is around 25%.

Table 2 also reports the purchase patterns in terms of shares of total expenditure. The number of observations that allow us to compute these shares is lower than the original sample. This is because there are households which report zero total expenditure across all goods, which prevents us from computing the corresponding product shares.[2] In 2018, this sample of UK households spent about 50% of their weekly budget on fresh and chilled goods, 35% in ambient groceries and around 8% each on alcohol and on frozen goods.

Tables 3 and 4 show descriptive statistics for a more detailed category of products (Category 1). Dairy products is one of the categories with the largest average spend (£4.80 per week in 2018), along with chilled convenience products (£4 in 2018) and fresh meat (£2.70 in 2018). These are followed by bakery products (£2.15 in 2018), take-home soft drinks (£1.78) and frozen prepared foods (£1.90). In terms of shares, we see that dairy products account for 17% of the weekly spend, followed by chilled convenience products, which account for 12%, alcohol products (9%), bakery products (8%) and fresh meat (7%). Consumption patterns for 2019 are similar to those of 2018.

Table 3 also shows that the dairy products are the most frequently purchased category with only 31% of households not making purchases in a typical week, followed by ambient bakery

[2] As we would be dividing 0 over 0.

products, with 38% of households reporting zero purchases of these goods. Products that are less frequently purchased include (in brackets the percentage of households making zero purchases): fresh fish (89%), frozen fish (88%), frozen meat (97%), frozen poultry (97%), and slimming products (99%).

Tables 5 and 6 illustrate descriptive statistics for Category 2 products. Amongst the selection of products, the largest weekly spend was on average in chilled ready meals (£1.20 in 2018), followed by fruit (£2.34 in 2018) and vegetables (£2.43). Chilled ready meals account for 6% of total weekly expenditure on average, and fruits and vegetables 12% and 13% respectively. At this level of product aggregation, the most widely purchased good was bread, with about 50% of household making purchases of bread in a typical week).

Table 1. Classification of products into categories (Kantar data).

Category 0	Category 1	Category 2	Category 0	Category 1	Category 2
Total Alcohol	Alcohol		Total Fresh+Chilled		
Total Ambient Groceries	Ambient Bakery Products	Total Bread		Chilled Bakery Products	
	Ambient Slimming Products			Chilled Convenience products	Chilled Prepared Salad
	Biscuits				Chilled Ready Meals
	Canned Goods	Canned Vegetables			Chilled Vegetarian
		Ambient Vgtrn Products			Cooked Meats
	Hot Beverages			Chilled Drinks	
	Packet Breakfast			Dairy Products	Butter
	Pickle+Tbl Sce+Condiment				Eggs
	Savoury Carbohydrts+Sncks	Ambient Rice+Svry Noodles			Fresh Cream
		Dry Pasta			Margarine
	Savoury Home Cooking	Cooking Oils			Total Cheese
		Flour			Total Milk
	Sweet Home Cooking	Sugar			Yoghurt
	Take-home Confectionery			Fresh Fish	Chilled Prepared Fish
	Take-home Savouries				Shellfish
	Take-home Soft Drinks	Mineral Water			Wet/Smoked Fish
Total Frozen	Frozen Confectionery			Fresh Meat	Chilled Burgers+Grills
	Frozen Fish				Fresh Bacon Joint
	Frozen Meat	Frozen Bacon			Fresh Bacon Rashers
		Frozen Beef			Fresh Bacon Steaks
		Frozen Lamb			Fresh Beef
		Frozen Other Meat & Offal			Fresh Lamb
		Frozen Pork			Fresh Other Meat & Offal
		Frozen Sausages			Fresh Pork
	Frozen Poultry+Game				Fresh Sausages
	Frozen Prepared Foods	Frozen Ready Meals			Chilled Processed Poultry
		Frozen Vegetables			Cooked Poultry
		Frozen Vegetarian Prods			Fresh Poultry
				Fruit+Veg+Salads	Chilled Prepared Frt+Veg
					Fruit
					Nuts
					Vegetable

Table 1. Descriptive Statistics - Category 0

Variable	Observations	Mean	Std. dev.
Weekly Spend (£)			
Total Alcohol	1,580,852	4.06	11.75
Total Ambient Groceries	1,580,852	13.52	14.94
Total Fresh & Chilled	1,580,852	19.54	20.62
Total Frozen	1,580,852	3.30	6.09
Total weekly spend	1,580,852	40.41	40.16
Expenditure share			
Total Alcohol	1,193,357	0.08	0.15
Total Ambient Groceries	1,193,357	0.35	0.19
Total Fresh &Chilled	1,193,357	0.49	0.21
Total Frozen	1,193,357	0.08	0.11
Variable	**Observations**	**Mean**	**Std. dev.**
Weekly Spend (£)			
Total Alcohol	1,575,236	4.04	11.87
Total Ambient Groceries	1,575,236	13.60	15.07
Total Fresh &Chilled	1,575,236	19.37	20.45
Total Frozen	1,575,236	3.27	6.09
Total weekly spend	1,575,236	40.28	40.07
Expenditure share			
Total Alcohol	1,181,932	0.08	0.15
Total Ambient Groceries	1,181,932	0.35	0.19
Total Fresh& Chilled	1,181,932	0.49	0.21
Total Frozen	1,181,932	0.08	0.11

Table 3. Descriptive statistics, category 1, 2018.

Variable	Observations	Mean	Std. dev.	Max	Variable	Observations	Mean	Std. dev.
Weekly spend (£)					**Expenditure shares**			
Alcohol	1,580,852	4.06	11.75	574.26	Alcohol	1,190,835	0.09	0.17
Ambient Bakery Products	1,580,852	2.15	2.95	118.34	Ambient Bakery Products	1,190,835	0.08	0.09
Ambient Slimming Products	1,580,852	0.02	0.57	82.25	Ambient Slimming Products	1,190,835	0.00	0.01
Biscuits	1,580,852	1.27	2.32	118.08	Biscuits	1,190,835	0.04	0.07
Canned Goods	1,580,852	1.08	2.15	140.27	Canned Goods	1,190,835	0.03	0.06
Chilled Bakery Products	1,580,852	0.22	0.79	31.60	Chilled Bakery Products	1,190,835	0.01	0.03
Chilled Convenience Products	1,580,852	4.02	6.16	203.72	Chilled Convenience Products	1,190,835	0.12	0.13
Chilled Drinks	1,580,852	0.38	1.21	41.50	Chilled Drinks	1,190,835	0.01	0.04
Dairy Products	1,580,852	4.84	5.56	103.12	Dairy Products	1,190,835	0.17	0.14
Fresh Fish	1,580,852	0.56	2.14	156.85	Fresh Fish	1,190,835	0.02	0.06
Fresh Meat	1,580,852	2.70	5.30	242.23	Fresh Meat	1,190,835	0.07	0.11
Frozen Confectionery	1,580,852	0.69	1.85	86.37	Frozen Confectionery	1,190,835	0.02	0.05
Frozen Fish	1,580,852	0.44	1.59	86.94	Frozen Fish	1,190,835	0.01	0.04
Frozen Meat	1,580,852	0.11	0.81	66.03	Frozen Meat	1,190,835	0.00	0.02
Frozen Poultry+Game	1,580,852	0.15	1.16	127.29	Frozen Poultry+Game	1,190,835	0.00	0.03
Frozen Prepared Foods	1,580,852	1.90	4.08	137.67	Frozen Prepared Foods	1,190,835	0.05	0.09
Hot Beverages	1,580,852	0.96	2.51	258.10	Hot Beverages	1,190,835	0.03	0.07
Packet Breakfast	1,580,852	0.99	2.07	106.25	Packet Breakfast	1,190,835	0.03	0.06
Pickle+Tbl Sce+Condiment	1,580,852	0.43	1.09	59.65	Pickle+Tbl Sce+Condiment	1,190,835	0.01	0.03
Savoury Carbohydrts+Sncks	1,580,852	0.57	1.44	100.00	Savoury Carbohydrts+Sncks	1,190,835	0.02	0.04
Savoury Home Cooking	1,580,852	1.02	2.05	115.09	Savoury Home Cooking	1,190,835	0.03	0.06
Sweet Home Cooking	1,580,852	0.64	1.72	110.45	Sweet Home Cooking	1,190,835	0.02	0.05
Take-Home Confectionery	1,580,852	1.55	3.58	173.67	Take-Home Confectionery	1,190,835	0.05	0.09
Take-Home Savouries	1,580,852	1.06	2.00	84.20	Take-Home Savouries	1,190,835	0.03	0.06
Take-Home Soft Drinks	1,580,852	1.78	3.53	207.84	Take-Home Soft Drinks	1,190,835	0.05	0.09
Total spend								
Total weekly spend	1,580,852	33.60	34.52	960.15				

Note: we exclude the column of minima, as this was always zero.

Table 4. Descriptive statistics, category 1, 2019.

Variable	Observations	Mean	Std. dev.	Max	Variable	Observations	Mean	Std. dev.
Weekly Spend (£)					**Expenditure shares**			
Alcohol	1,575,236	4.04	11.87	853.06	Alcohol	1,179,331	0.09	0.17
Ambient Bakery Products	1,575,236	2.20	2.99	81.31	Ambient Bakery Products	1,179,331	0.08	0.09
Ambient Slimming Products	1,575,236	0.02	0.57	100.00	Ambient Slimming Products	1,179,331	0.00	0.01
Biscuits	1,575,236	1.29	2.34	138.13	Biscuits	1,179,331	0.04	0.07
Canned Goods	1,575,236	1.07	2.14	131.70	Canned Goods	1,179,331	0.03	0.06
Chilled Bakery Products	1,575,236	0.21	0.76	60.00	Chilled Bakery Products	1,179,331	0.01	0.03
Chilled Convenience Products	1,575,236	3.96	6.06	160.50	Chilled Convenience Products	1,179,331	0.12	0.13
Chilled Drinks	1,575,236	0.37	1.19	73.80	Chilled Drinks	1,179,331	0.01	0.04
Dairy Products	1,575,236	4.80	5.55	210.10	Dairy Products	1,179,331	0.17	0.14
Fresh Fish	1,575,236	0.57	2.12	173.46	Fresh Fish	1,179,331	0.02	0.06
Fresh Meat	1,575,236	2.63	5.22	313.12	Fresh Meat	1,179,331	0.07	0.11
Frozen Confectionery	1,575,236	0.66	1.82	93.70	Frozen Confectionery	1,179,331	0.02	0.05
Frozen Fish	1,575,236	0.44	1.62	76.50	Frozen Fish	1,179,331	0.01	0.04
Frozen Meat	1,575,236	0.10	0.79	93.55	Frozen Meat	1,179,331	0.00	0.02
Frozen Poultry+Game	1,575,236	0.14	1.14	64.00	Frozen Poultry+Game	1,179,331	0.00	0.02
Frozen Prepared Foods	1,575,236	1.92	4.13	137.12	Frozen Prepared Foods	1,179,331	0.06	0.09
Hot Beverages	1,575,236	0.96	2.51	342.64	Hot Beverages	1,179,331	0.03	0.07
Packet Breakfast	1,575,236	0.98	2.07	119.85	Packet Breakfast	1,179,331	0.03	0.06
Pickle+Tbl Sce+Condiment	1,575,236	0.43	1.08	51.15	Pickle+Tbl Sce+Condiment	1,179,331	0.01	0.03
Savoury Carbohydrts+Sncks	1,575,236	0.57	1.49	154.84	Savoury Carbohydrts+Sncks	1,179,331	0.02	0.04
Savoury Home Cooking	1,575,236	1.02	2.06	142.56	Savoury Home Cooking	1,179,331	0.03	0.06
Sweet Home Cooking	1,575,236	0.63	1.71	80.00	Sweet Home Cooking	1,179,331	0.02	0.05
Take-Home Confectionery	1,575,236	1.59	3.61	202.50	Take-Home Confectionery	1,179,331	0.05	0.09
Take-Home Savouries	1,575,236	1.09	2.05	193.21	Take-Home Savouries	1,179,331	0.03	0.06
Take-Home Soft Drinks	1,575,236	1.75	3.55	181.50	Take-Home Soft Drinks	1,179,331	0.05	0.08
Total spend								
Total weekly spend	1,575,236	33.46	34.44	919.28				

Note: we exclude the column of minima, as this was always zero.

Table 5. Descriptive statistics, category 2, 2018 (continue)

Variable	Observations	Mean	Std. dev.	Max		Observations	Mean	Std. dev.	Max
Weekly Spend (£)									
Ambient Rice+Svry Noodles	1,580,800	0.27	0.97	100.00	Fresh Pork	1,580,800	0.31	1.35	93.45
Ambient Vgtrn Products	1,580,800	0.00	0.07	22.68	Fresh Poultry	1,580,800	1.06	2.94	239.15
Butter	1,580,800	0.43	1.29	59.88	Fresh Sausages	1,580,800	0.31	1.04	37.50
Canned Vegetables	1,580,800	0.06	0.32	22.95	Frozen Bacon	1,580,800	0.01	0.29	30.00
Chilled Burgers+Grills	1,580,800	0.14	0.81	91.18	Frozen Beef	1,580,800	0.02	0.37	31.04
Chilled Prepared Fish	1,580,800	0.06	0.49	50.01	Frozen Lamb	1,580,800	0.01	0.34	42.03
Chilled Prepared Frt+Veg	1,580,800	0.45	1.18	53.94	Frozen Other Meat & Offal	1,580,800	0.00	0.11	21.00
Chilled Prepared Salad	1,580,800	0.16	0.62	30.30	Frozen Pork	1,580,800	0.00	0.12	18.00
Chilled Processed Poultry	1,580,800	0.19	0.95	52.00	Frozen Ready Meals	1,580,800	0.34	1.54	85.00
Chilled Ready Meals	1,580,800	1.20	3.29	177.72	Frozen Sausages	1,580,800	0.05	0.38	62.50
Chilled Vegetarian	1,580,800	0.05	0.46	44.50	Frozen Vegetables	1,580,800	0.26	0.84	29.00
Cooked Meats	1,580,800	1.01	1.93	57.46	Frozen Vegetarian Prods	1,580,800	0.11	0.79	62.57
Cooked Poultry	1,580,800	0.23	1.04	56.00	Fruit	1,580,800	2.34	3.70	113.75
Cooking Oils	1,580,800	0.16	0.79	113.30	Margarine	1,580,800	0.23	0.72	28.40
Dry Pasta	1,580,800	0.10	0.41	48.00	Mineral Water	1,580,800	0.24	0.92	52.60
Eggs	1,580,800	0.39	0.83	36.00	Nuts	1,580,800	0.27	1.15	115.18
Flour	1,580,800	0.05	0.36	60.00	Shellfish	1,580,800	0.09	0.64	74.00
Fresh Bacon Joint	1,580,800	0.11	0.81	50.28	Sugar	1,580,800	0.11	0.49	32.60
Fresh Bacon Rashers	1,580,800	0.40	1.11	58.41	Total Bread	1,580,800	0.72	1.09	39.48
Fresh Bacon Steaks	1,580,800	0.05	0.45	27.24	Total Cheese	1,580,800	1.36	2.40	90.94
Fresh Beef	1,580,800	0.97	2.92	140.02	Total Milk	1,580,800	1.31	1.87	76.32
Fresh Cream	1,580,800	0.16	0.58	31.08	Vegetable	1,580,800	2.43	3.37	88.77
Fresh Lamb	1,580,800	0.21	1.51	110.99	Wet/Smoked Fish	1,580,800	0.41	1.86	133.94
Fresh Other Meat & Offal	1,580,800	0.03	0.32	56.76	Yoghurt	1,580,800	0.73	1.56	56.00
					Total spend				
					Total weekly spend	1,580,800	19.60	20.25	631.7

Note: we exclude the column of minima, as this was always zero.

Table 5. Descriptive statistics, category 2, 2018. (end of table)

Variable	Observations	Mean	Std. dev.		Observations	Mean	Std. dev.
Expenditure share							
Ambient Rice+Svry Noodles	1,176,460	0.01	0.05	Fresh Pork	1,176,460	0.01	0.05
Ambient Vgtrn Products	1,176,460	0.00	0.87	Fresh Poultry	1,176,460	0.04	0.09
Butter	1,176,460	0.02	0.06	Fresh Sausages	1,176,460	0.01	0.05
Canned Vegetables	1,176,460	0.00	0.02	Frozen Bacon	1,176,460	0.00	0.01
Chilled Burgers+Grills	1,176,460	0.01	0.03	Frozen Beef	1,176,460	0.00	0.02
Chilled Prepared Fish	1,176,460	0.00	0.02	Frozen Lamb	1,176,460	0.00	0.01
Chilled Prepared Frt+Veg	1,176,460	0.02	0.06	Frozen Other Meat & Offal	1,176,460	0.00	0.01
Chilled Prepared Salad	1,176,460	0.01	0.04	Frozen Pork	1,176,460	0.00	0.01
Chilled Processed Poultry	1,176,460	0.01	0.04	Frozen Ready Meals	1,176,460	0.02	0.07
Chilled Ready Meals	1,176,460	0.06	0.13	Frozen Sausages	1,176,460	0.00	0.02
Chilled Vegetarian	1,176,460	0.00	0.02	Frozen Vegetables	1,176,460	0.01	0.05
Cooked Meats	1,176,460	0.05	0.09	Frozen Vegetarian Prods	1,176,460	0.01	0.04
Cooked Poultry	1,176,460	0.01	0.05	Fruit	1,176,460	0.12	0.14
Cooking Oils	1,176,460	0.01	0.04	Margarine	1,176,460	0.01	0.05
Dry Pasta	1,176,460	0.01	0.03	Mineral Water	1,176,460	0.01	0.05
Eggs	1,176,460	0.02	0.05	Nuts	1,176,460	0.01	0.06
Flour	1,176,460	0.00	0.02	Shellfish	1,176,460	0.00	0.02
Fresh Bacon Joint	1,176,460	0.00	0.03	Sugar	1,176,460	0.01	0.03
Fresh Bacon Rashers	1,176,460	0.02	0.05	Total Bread	1,176,460	0.05	0.09
Fresh Bacon Steaks	1,176,460	0.00	0.02	Total Cheese	1,176,460	0.07	0.11
Fresh Beef	1,176,460	0.04	0.09	Total Milk	1,176,460	0.09	0.13
Fresh Cream	1,176,460	0.01	0.03	Vegetable	1,176,460	0.12	0.13
Fresh Lamb	1,176,460	0.01	0.04	Wet/Smoked Fish	1,176,460	0.02	0.06
Fresh Other Meat & Offal	1,176,460	0.00	0.01	Yoghurt	1,176,460	0.04	0.08

Note: we exclude the column of minima, as this was always zero.

Table 6. Descriptive statistics, category 2, 2019. (continue)

Variable	Observations	Mean	Std. dev.	Max		Observations	Mean	Std. dev.	Max
Weekly Spend (£)									
Ambient Rice+Svry Noodles	1,360,747	0.30	1.04	154.00	Fresh Pork	1,360,747	0.32	1.40	101.86
Ambient Vgtrn Products	1,360,747	0.00	0.09	17.40	Fresh Poultry	1,360,747	1.15	2.99	329.30
Butter	1,360,747	0.49	1.36	57.22	Fresh Sausages	1,360,747	0.34	1.07	52.25
Canned Vegetables	1,360,747	0.07	0.33	25.20	Frozen Bacon	1,360,747	0.01	0.28	22.64
Chilled Burgers+Grills	1,360,747	0.15	0.82	83.10	Frozen Beef	1,360,747	0.02	0.38	45.00
Chilled Prepared Fish	1,360,747	0.07	0.52	39.47	Frozen Lamb	1,360,747	0.02	0.36	44.00
Chilled Prepared Frt+Veg	1,360,747	0.47	1.19	42.50	Frozen Other Meat & Offal	1,360,747	0.00	0.10	16.00
Chilled Prepared Salad	1,360,747	0.16	0.63	34.00	Frozen Pork	1,360,747	0.00	0.14	26.66
Chilled Processed Poultry	1,360,747	0.21	1.00	45.00	Frozen Ready Meals	1,360,747	0.37	1.60	117.96
Chilled Ready Meals	1,360,747	1.29	3.33	152.50	Frozen Sausages	1,360,747	0.05	0.39	93.55
Chilled Vegetarian	1,360,747	0.06	0.55	38.00	Frozen Vegetables	1,360,747	0.28	0.87	29.00
Cooked Meats	1,360,747	1.08	1.96	50.00	Frozen Vegetarian Prods	1,360,747	0.13	0.84	82.04
Cooked Poultry	1,360,747	0.26	1.09	42.00	Fruit	1,360,747	2.55	3.78	117.32
Cooking Oils	1,360,747	0.17	0.79	59.97	Margarine	1,360,747	0.25	0.75	27.00
Dry Pasta	1,360,747	0.11	0.44	64.00	Mineral Water	1,360,747	0.23	0.89	87.48
Eggs	1,360,747	0.40	0.84	28.32	Nuts	1,360,747	0.32	1.24	191.16
Flour	1,360,747	0.05	0.38	39.00	Shellfish	1,360,747	0.09	0.64	72.42
Fresh Bacon Joint	1,360,747	0.12	0.87	54.74	Sugar	1,360,747	0.12	0.50	34.40
Fresh Bacon Rashers	1,360,747	0.42	1.13	63.00	Total Bread	1,360,747	0.77	1.12	34.97
Fresh Bacon Steaks	1,360,747	0.06	0.48	27.17	Total Cheese	1,360,747	1.50	2.49	78.63
Fresh Beef	1,360,747	1.03	2.95	129.85	Total Milk	1,360,747	1.43	1.93	122.84
Fresh Cream	1,360,747	0.18	0.61	28.00	Vegetable	1,360,747	2.70	3.51	109.75
Fresh Lamb	1,360,747	0.23	1.60	112.00	Wet/Smoked Fish	1,360,747	0.47	1.94	165.33
Fresh Other Meat & Offal	1,360,747	0.03	0.34	30.00	Yoghurt	1,360,746	0.80	1.60	46.15
					Total spend				
					Total weekly spend	1,360,747	21.31	20.13	556.02

Note: we exclude the column of minima, as this was always zero.

Table 6. Descriptive statistics, category 2, 2019. (end of table)

Variable	Observations	Mean	Std. dev.		Observations	Mean	Std. dev.
Expenditure share							
Ambient Rice+Svry Noodles	1,100,854	0.01	0.05	Fresh Pork	1,100,854	0.01	0.05
Ambient Vgtrn Products	1,100,854	0.00	0.01	Fresh Poultry	1,100,854	0.04	0.09
Butter	1,100,854	0.02	0.06	Fresh Sausages	1,100,854	0.01	0.05
Canned Vegetables	1,100,854	0.00	0.02	Frozen Bacon	1,100,854	0.00	0.01
Chilled Burgers+Grills	1,100,854	0.01	0.03	Frozen Beef	1,100,854	0.00	0.02
Chilled Prepared Fish	1,100,854	0.00	0.02	Frozen Lamb	1,100,854	0.00	0.01
Chilled Prepared Frt+Veg	1,100,854	0.02	0.06	Frozen Other Meat & Offal	1,100,854	0.00	0.00
Chilled Prepared Salad	1,100,854	0.01	0.04	Frozen Pork	1,100,854	0.00	0.01
Chilled Processed Poultry	1,100,854	0.01	0.04	Frozen Ready Meals	1,100,854	0.02	0.07
Chilled Ready Meals	1,100,854	0.06	0.13	Frozen Sausages	1,100,854	0.00	0.02
Chilled Vegetarian	1,100,854	0.00	0.02	Frozen Vegetables	1,100,854	0.01	0.05
Cooked Meats	1,100,854	0.05	0.09	Frozen Vegetarian Prods	1,100,854	0.01	0.04
Cooked Poultry	1,100,854	0.01	0.05	Fruit	1,100,854	0.12	0.14
Cooking Oils	1,100,854	0.01	0.04	Margarine	1,100,854	0.01	0.05
Dry Pasta	1,100,854	0.01	0.03	Mineral Water	1,100,854	0.01	0.05
Eggs	1,100,854	0.02	0.05	Nuts	1,100,854	0.02	0.06
Flour	1,100,854	0.00	0.02	Shellfish	1,100,854	0.00	0.02
Fresh Bacon Joint	1,100,854	0.00	0.03	Sugar	1,100,854	0.01	0.03
Fresh Bacon Rashers	1,100,854	0.02	0.05	Total Bread	1,100,854	0.05	0.09
Fresh Bacon Steaks	1,100,854	0.00	0.02	Total Cheese	1,100,854	0.07	0.11
Fresh Beef	1,100,854	0.04	0.09	Total Milk	1,100,854	0.09	0.13
Fresh Cream	1,100,854	0.01	0.04	Vegetable	1,100,854	0.13	0.13
Fresh Lamb	1,100,854	0.01	0.05	Wet/Smoked Fish	1,100,854	0.02	0.06
Fresh Other Meat & Offal	1,100,854	0.00	0.01	Yoghurt	1,100,854	0.04	0.08

Note: we exclude the column of minima, as this was always zero.

3 Methodology for estimating demand elasticities

This study uses a standard model of demand, the Almost Ideal Demand System (AIDS), to estimate elasticities of demand of food and drink. These elasticities measure the sensitivity of demand to the prices consumers face and to their income or overall budget.

We report a range of different elasticities. The own-price elasticity of demand for a product indicates the percentage change in quantity demanded of a product in response to a one percent increase in its own price. For most products, an increase in the price results in a reduction in demand, so that the computed value of own-price elasticity tends to be negative number.

Demand is classified as being relatively elastic or inelastic based on the magnitude of the elasticity estimate. For instance, if the estimated value of own price elasticity is -2, it suggests that a one percent increase in price will lead to a two percent reduction in the quantity demanded. Here the absolute value of elasticity is greater than one (or, equivalently, its value is less that minus 1, in simple algebraic terms). Here the demand is relatively sensitive to changes in price, so is said to be elastic.

In contrast, if the elasticity estimate lies between 0 and -1 (equivalently, less than one in terms of its absolute value), demand is classified as being inelastic. Zero elasticity describes the case where demand is completely insensitive to price.

Cross-price elasticities of demand measure the proportional changes in demand for a product in response to changes in the price of other goods. More precisely, the cross-price elasticity measures the percentage change in the quantity demanded on good A when the price of some other good B increases by one percent. The cross price effect depends on how goods A and B relate to each other in the consumption basket. If goods A and B are substitutes in consumption (consider Coke and Pepsi, which many people regard as alternatives), one might expect that an increase in the price of Pepsi might cause demand for Pepsi to fall and for Coke to rise, so that the computed value of the cross-price elasticity for Coke with respect to the price of price of Pepsi would be positive. In contrast, if goods C and D are complements (consider milk and tea, which are usually consumed together), an increase in price of tea might lower demand for milk too, so that the computed price elasticity would be negative. Indeed, the estimated value of cross-price elasticity allows us to distinguish empirically between pairs of goods that are substitutes (positive cross-price elasticity) or complements (negative cross-price elasticity).

Income or expenditure elasticity of demand measures how demand changes in response to an increase in income or overall expenditure. More precisely, it measures the percentage increase in consumption when income or expenditure increases by one percent. A value of expenditure elasticity greater that 1 suggest a more than proportionate increase in demand for that good as income rises. At low levels of income, the bulk of household's expenditure might be on necessities. As incomes rises, households might be able to spend more of goods that are not absolutely essential, so that expenditure on these might rise faster than income, Economists use the estimated expenditure elasticities to distinguish between necessities (those whose expenditure elasticity is between 0 and 1) and 'luxuries' (where estimated expenditure elasticity is greater than 1). Some goods might have negative expenditure elasticities (their demand falls as expenditure rises): these are classified as inferior goods.

The details of the AIDS model are provided in the Appendix (see section 9.1). Here we highlight some relevant technical aspects of the model.

3.1 Parameters of interest

Strictly speaking, there is not a single "correct" estimate of a price or expenditure elasticity; instead, there is a wide range of possible estimates. These will differ, for instance, depending on the specification chosen for the demand function, on the total expenditure measure used, on the sample employed, and on a range of many other factors. One notable distinction relates to compensated vs uncompensated elasticities of demand. on

When the price of any individual good rises, the increase reduces the consumer's real income. The implied reduction in real income can be large when the price increase relates to goods that have large shares in the consumers' expenditure. Compensated demand functions and associated *compensated demand elasticities* assume that consumers are compensated for this fall in income, leaving them at the same utility level that they enjoyed prior to the price increase. With this adjustment, the elasticity measure captures the pure substitution effect as relative prices change in which the consumer buys less of the good whose price has increased (and more of other goods that have become relatively cheaper).

In contrast, *the uncompensated price elasticities* of demand take into account both substitution and income effects, The latter effect arises because a price increase for one good lowers overall disposable income, which also alters demand. For most 'normal' goods (that is, whose expenditure elasticity is positive), the income effect will lower demand further, reinforcing the substitution effect of an increase in its price. If the good in question is inferior, the income effect would offset the substitution effect to some extent. In this report we mostly focus on uncompensated demand elasticities, which consider both the substitution and the income effects of a price change.

The appropriate estimate of the parameter of interest depends on how the elasticity estimate will then be used: the loss function in the jargon of statistical decision theory. Different estimates are useful for different purposes. Consider the impact of a policy that intends to curb the consumption of alcohol by increasing its price. The impact of this policy would differ across individuals. Teetotallers, who did not consume alcohol to begin with, would remain unaffected. At the other extreme, there might be those addicted to alcohol, whose consumption may not be curbed much in terms of quantity – an instance of inelastic demand --though they may switch to cheaper forms of alcohol. Within these two extremes, there would be many whose demand for alcohol is elastic, so that quantity consumed would fall as price rises. Our estimated elasticities are averages across these types (weighted by their consumption levels).

We assume that for the current project's purposes the policy relevant group are those in between these two disparate groups, with non-zero elasticities. The aggregate estimate is a weighted average of these groups in between. Alcohol is a special case, but similar issues apply to other products: our elasticity estimates will be an average across heterogeneous groups. The specifications and approach adopted in this project are informed by discussions with Defra in relation to the main parameters of policy interest.

3.1.1 Endogeneity issues

A concern in estimating demand functions is always the potential endogeneity of prices and expenditure which arises from the interplay between supply and demand forces.[3] As well as price influencing quantity demanded, quantity demanded influences price, as retailers may respond to a demand increase with a price increase. This two-way causation problem is referred to as the endogeneity of prices and can bias the estimated coefficients. But since we are looking at household data, we expect the impact of their purchase decision on prices to be small.

At the individual level, the construction of the data can pose challenges, especially in the presence of 'non-linear pricing' where unit prices vary with the quantity purchased The most common form of non-linearity comes from promotions like *"Buy one, get one free":* where even

[3] There is a large literature on the econometric treatment of the endogeneity of prices in market demand analysis. See, for example, Berry (RAND 1994) and Berry, Levinsohn and Pakes (*Econometrica*, 1995).

an individual buyer can influence the unit price: when the buyer adds a second unit to their basket, the implied unit price falls by 50%, generating negative correlation between unit prices and demand adjustments.

We attempt to minimise this problem by constructing an alternative measure of prices less likely to be influenced by the pattern of purchases. One version of these prices is calculated by dividing household expenditure on a particular good by the household associated quantity. In addition, we also estimate the prices as national expenditure on a particular good or category divided by the associated *national* quantity. With the latter prices are interpretable as national average prices, per unit volume, that are common to all consumers. This effectively eliminates individual consumer level selection effects and hence mitigates endogeneity concerns. In addition, we also reduce identifying variation, e.g. by removing local discounts and promotions.

A similar issue arises with expenditure. If there is a positive demand shock there will be more expenditure on a particular good which will increase total expenditure, which is the sum of the expenditures on particular goods. This will generate a positive covariance, biasing the total expenditure upwards. However, a constraint on this within the AIDS system is that the adding up constraint requires that the sum of the income coefficients are equal to zero, so there cannot be a general upward bias.[4]

3.1.2 Zero purchases

As is clear from the descriptive statistics in section 2 a proportion of the observations are zeros, which indicates that some households did not buy a positive quantity of some goods in at least some weeks. These zero purchases may reflect a range of scenarios. A household's purchase pattern may have recurring zeros for some categories if they never purchase products in that category: think of households which do not drink alcohol or do not eat meat, for instance. Transitory zeros involve households that sometime buy and sometimes do not buy a particular product category. These fall into two main groups: Inventory non-buyers and price sensitive non-buyers. Nearly all these products are durable to some extent, as for instance many perishables can be frozen. Some households are regular buyers but may not buy in a particular week because they already have a sufficient inventory. There may be other households that are not regular buyers but will buy if the price is sufficiently low. Of course, inventory management may itself react to price variations as buyers tend to stock up when the

[4] Deaton and Muellbauer (*American Economic Review*, 1980).

price is low. Strictly speaking, this price effect causing the household to go from zero to some amount is not an elasticity: one cannot have a percentage change from zero. But the estimated elasticities will be average effects.

The zero issue comes up in a variety of contexts and there is a large literature on it. The earliest estimator was the Tobit, whose likelihood had a Probit element for the zero observations and a standard regression likelihood for the non-zero observations. It assumes that the same process drives both elements. One can think of there being different processes driving the extensive margin, the number of households who make a purchase, and the intensive margin, how much they purchase, given that they have made a purchase. There are a range of two-part models of this process.[5] However, in the context of food demand the purchase/not-purchase part is generally dynamic, conditional on past purchases which capture both inventory and habit effects.[6] Such models are likely to be more difficult to interpret in a policy context.

In the international trade literature, it is common to use a Poisson quasi-maximum likelihood or negative binomial models for over-dispersed count data and there are generalisations.[7] The shares data used in the AIDS model are not count data and strictly the model assumes no corner solutions at zero. AIDS also does not constrain the predicted shares to lie in the zero one interval, though this is not a particular problem if the parameter of interest is the elasticity.

3.1.3 Nutrient elasticities

We also estimate the effects of prices of food and drink on the intake of some key nutrients, specifically, energy, protein, carbohydrates, sugar, fat, saturated fat, fibre and sodium. Different items of food and drink contain these nutrients in varying amounts. As changes in prices or income lead consumers to adjust their pattern of consumption, those adjustments affect the nutritional balance.

The impact of price changes on overall nutrient consumption can be complex. An increase in the price of sugary soft-drinks will typically reduce the consumption of those drinks (the own-

[5] For example, Hausman (Journal of Econometrics, 1979) develops a two-stage budgeting model. Dubin and McFadden (Econometrica, 1984) propose a discrete-continuous demand model that essentially captures a two-part choice process in which a multinomial choice is followed by a continuous demand choice.
[6] See, for example, Ailawadi and Neslin (Journal of Marketing Research, 1989) and Watt, Beckert, Cornelsen and Smith (unpublished manuscript, 2021)
[7] A recent survey is Bellego, C., D. Benatia and L.-D. Pape. (2021), Dealing with logs and zeros in regression models, SSRN.

price elasticity measures the extent of reduction), reducing sugar consumption from soft drinks. But that reduction may trigger substitution towards other sugar-rich foods, such as confectionary. So even when sugar consumed directly from sugary drinks falls, total sugar consumption might increase if a switch towards sugar-intensive substitutes causes sugar from other sources to rise. The extent of these indirect adjustments is measured by various cross-price elasticities. The overall impact of the increase in prices of sugary soft drinks must capture the direct effect on sugar intake via the reduced consumption of soft drinks and the indirect effects via altered consumption of other sugar-intensive items of food.

Our estimation allows us to trace the impact of a change in price of one item or category of food and drink on the intake of a specific nutrient from all items in the consumption basket. The nutrient elasticity of the demand for sugar with respect to the price of soft drinks computes the percentage change in sugar consumption from all sources as the price of soft drink increases by one percent.

Our estimates of price and expenditure elasticities for an entire system and demand allows us to compute such nutrient elasticities for any particular nutrient with respect to any specific item of food or drink. The computation of nutrient elasticities, described in Appendix 9.2, depends on various factors. Apart from the magnitude of the price and expenditure elasticities, computed nutrient elasticities depend on the nutritional density of various items of food, and the shares of those items in overall consumption of the nutrient. We use nutrient data provided by Kantar to compute nutrient elasticities for the eight nutrients of concern.

4 Empirical results of estimating demand elasticities

In this section we report the results of implementing the AIDS approach, where we estimate the model separately for categories of products 0, 1, and 2. We then organise the discussion around particular products of interest and illustrate existing variation in estimated elasticities. We estimate the models separately for 2018 and 2019 and find that the results are generally remarkably stable across these two years. To avoid repetition, in this report we focus mostly on the (uncompensated) elasticities estimated for the more recent year 2019.

As discussed above, our baseline elasticity estimates are averages over different types of people. However we recognise that the demand responses to price changes could change for different segments of the population. We then estimate elasticities by demographic subgroup, considering two dimensions: life stages and social class.

We compare variations in demand elasticities across seven life stages in our sample of households: pre-family, young family with children aged 0-4 years, middle family with children aged 5-9 years, family with children aged 10+ years, older dependents, empty nesters, and retired. For variations across social class, we consider the following categories: higher & intermediate managerial, administrative, professional occupations (AB), supervisory, clerical & junior managerial, administrative and professional occupations (C1), skilled manual occupations (C2), semi-skilled and unskilled manual workers (D) and state pensioners, casual and lowest grade workers, unemployed with state benefits (E).

4.1 Overview of results for categories 0, 1 and 2

In this section we summarise the key results of estimating the AIDS model for different levels of product aggregation. We begin by reporting results for own-price and expenditure elasticities for categories 0,1, and 2. We then discuss more detailed results including cross-price elasticities for selected products (mainly within category 1 which comprises 25 different products).

Category 0 products

Figure 1 presents the own-price elasticities for category 0 of products.[8] Category 0 is the most aggregated and comprises the following four product groups: 'alcohol', 'ambient groceries', 'fresh and chilled products', and 'frozen products'. We report here the results on the estimated uncompensated elasticities, which take into account income effects. We see in the graph that they are remarkably similar to the estimates of the compensated elasticities.

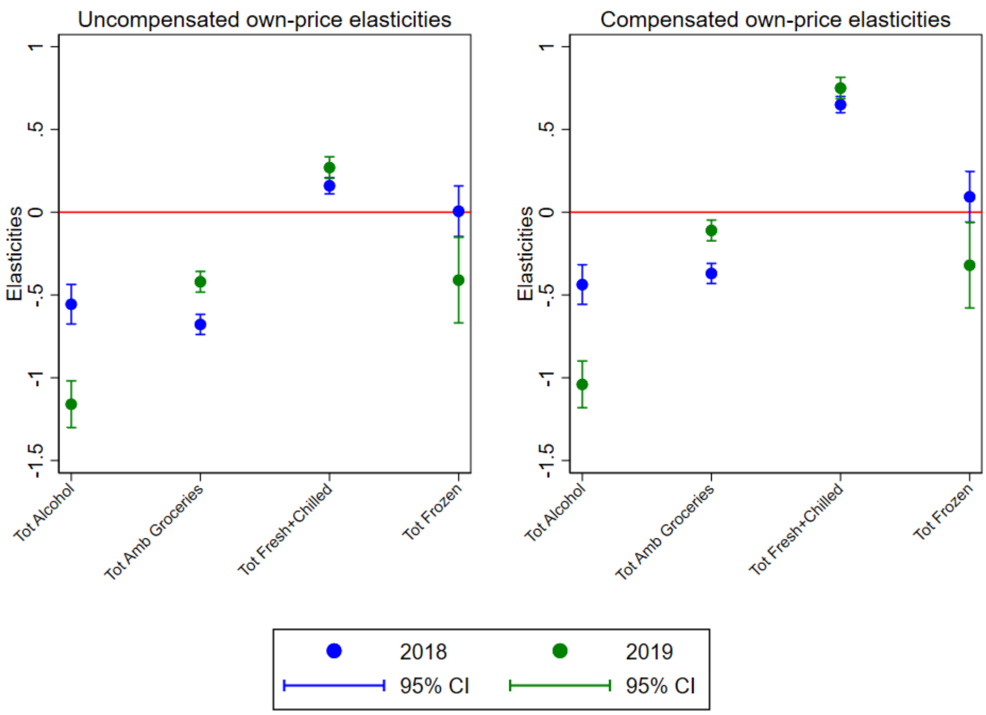
Own-price elasticities of demand are found to be negative for alcohol, ambient groceries and frozen products (though for the last case the estimated elasticity for 2018 was close to zero). Thus, in line with economic theory, demand for these products tends to fall in response to a price increase. The demand for alcohol is more elastic than other categories at this level of aggregation. The price elasticity of demand for fresh and chilled products is found to be positive, with uncompensated price elasticity estimated to be 0.16 and 0.27 in 2018 and in 2019, respectively. This latter value suggests that a 1% increase in price of these products is

[8] Note that the horizontal red line at 0 is to help identify estimates of elasticity that are statistically significant. The bold circles capture the estimated point elasticities for 2018 and 2019, and the vertical segments capture a 95% confidence interval around those point estimates. When the confidence interval straddles the red horizontal line, we cannot reject the hypothesis that the true elasticity is zero. The same applies to all other graphs presented in this report.

associated with a 0.27% *increase* in their consumption (if everything else stays constant, as is the usual interpretation of these elasticities). This result is puzzling, and we need to treat it with caution, as it may arise due to the way the data is aggregated.

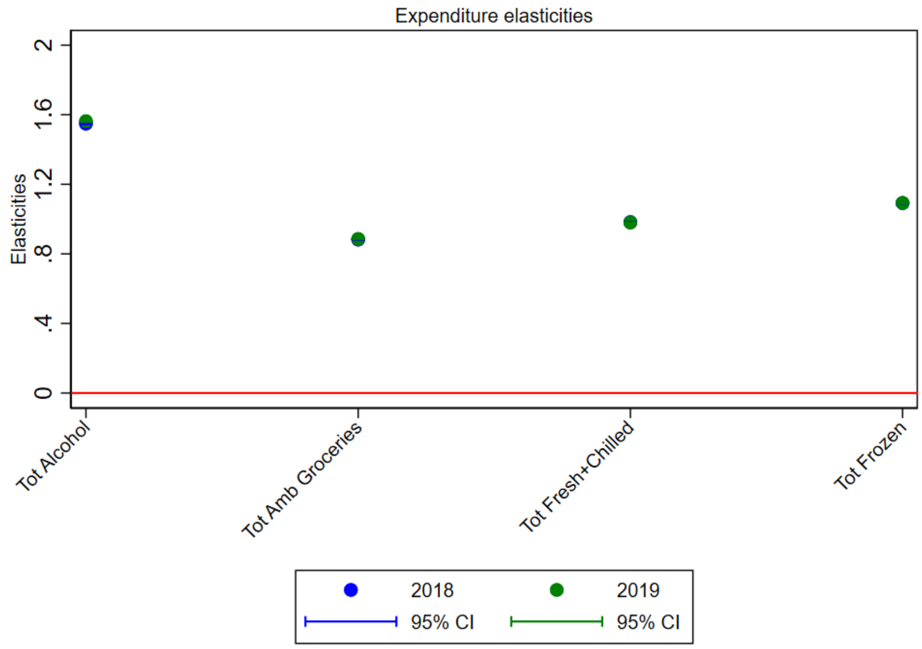
Figure 2 illustrates the expenditure elasticities for category 0. The estimated expenditure elasticities are all positive: demand increases as income rises, so that all these categories can be classified as 'normal' goods. The expenditure elasticity is the greatest for alcohol, and exceeds 1, with demand rising more than proportionately when income rises: this allows us to classify alcohol as a luxury good. The expenditure elasticities for other categories is less than 1, denoting necessary goods.

Figure.1: Own-price elasticities – category 0



Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure 2: Expenditure elasticities – category 0

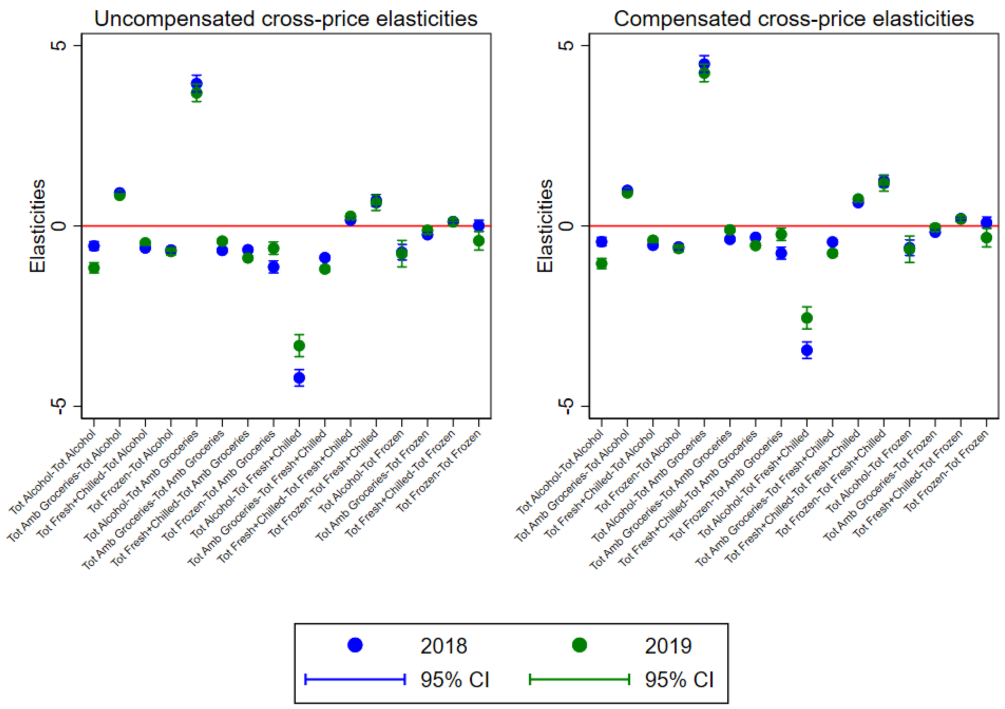


Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure 3 presents the cross-price elasticities for category 0. We find that there is substitution (positive cross-price elasticity) between total ambient groceries and alcohol. A 1% increase in the price of alcohol increases the demand for total ambient grocery by 0.85% (in 2019). Conversely, a 1% increase in the price of ambient groceries increases the demand for alcohol by 3.69%. There is also a substitution relationship between fresh & chilled product and frozen products. A 1% rise in the price of fresh and chilled products increases the demand of frozen products by 0.64%. On the other hand, a 1% rise in the price of total frozen leads to an increase in the demand for total chilled and fresh by 0.11%.

Figure 3 also shows that there is now a complementary relationship (negative cross-price elasticity) between alcohol and fresh & chilled products. A 1% increase in the price of alcohol reduces the demand for fresh and chilled products by 0.47%; conversely, a 1% rise in the price of fresh & chilled products decreases the demand for alcohol by 3.32%. Other pairs that display complementarity include alcohol with frozen products, ambient groceries with fresh & chilled products, and ambient groceries with frozen products.

Figure 3. Cross-price elasticities – category 0



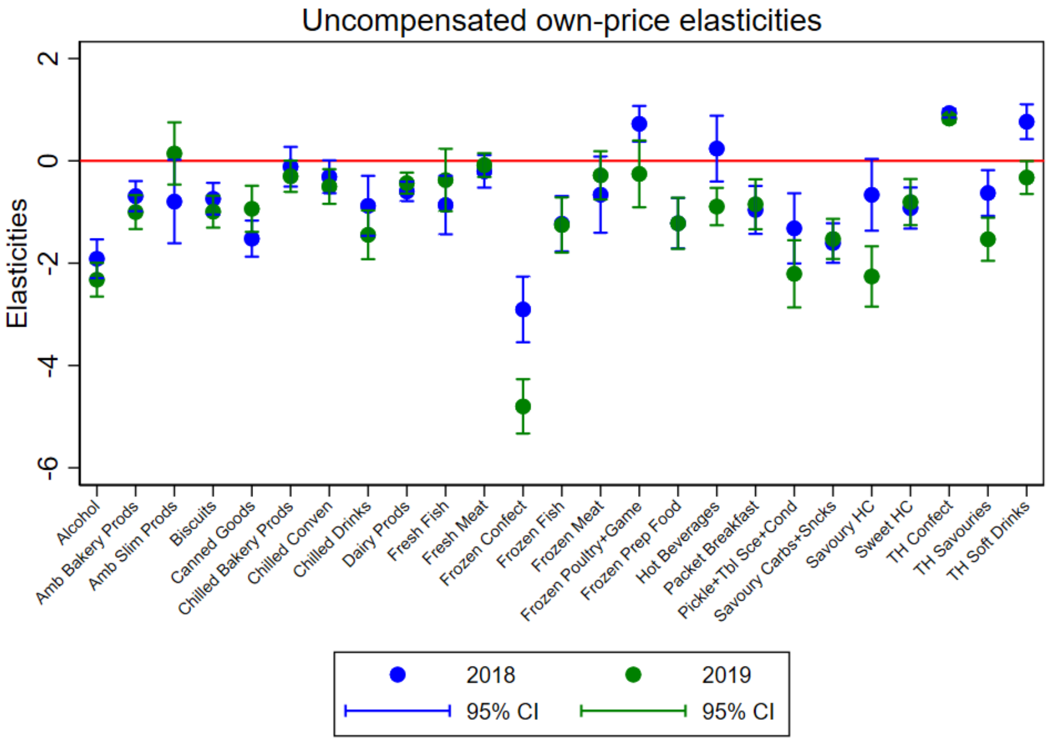
Source: Authors' calculations from Kantar's Grocery Market Share data.

Category 1 products

Figure 4 shows the uncompensated own-price elasticities for all 25 products of category 1. Unsurprisingly, and in line with economic theory, most own-price elasticities are found to negative, indicating that demand falls as prices rise. The effect is particularly strong for frozen confectionery: the estimated values of elasticity of around -3 in 2018 and -4.8 in 2019 suggest that a 1% increase in the price of these products is associated with 3% to 4.8% reduction in their demand.

Once again, some elasticity estimates do not sit well with standard theoretical expectation. For instance, take-home confectionery displays positive own-price elasticity in both years, which suggests that increases in the price of these goods result in an increase in their demand. Notably, some other products, such as take-home soft drinks display positive own-price elasticity but only in year 2018.

Figure 4: Uncompensated own-price elasticities – category 1

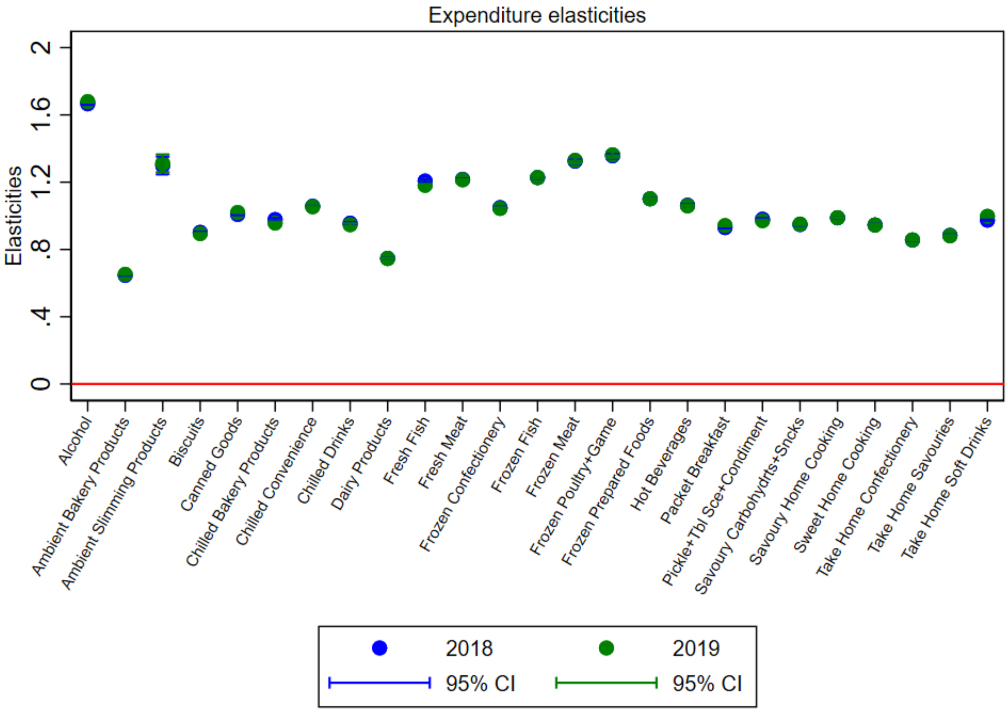


Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure 5 shows expenditure elasticities for category 1 products. They are always positive and range between 0.6 and 1.6 values, which means that these are all normal goods that see their demand increase when total expenditure increases. The products that are more sensitive (elastic) to expenditure, aside from alcohol (1.7) are ambient slimming products, frozen meat and frozen poultry and game (all around 1.3). At the other end, the demand for dairy products and ambient bakery products[9] does not vary as much with income, with expenditure elasticity around 0.7. In sub-section 4.2 we discuss in detail results for key products.

[9] Ambient bakery products include bread, morning goods and ambient cakes and pastries.

Figure 5: Expenditure elasticities – category 1



Source: Authors' calculations from Kantar's Grocery Market Share data.

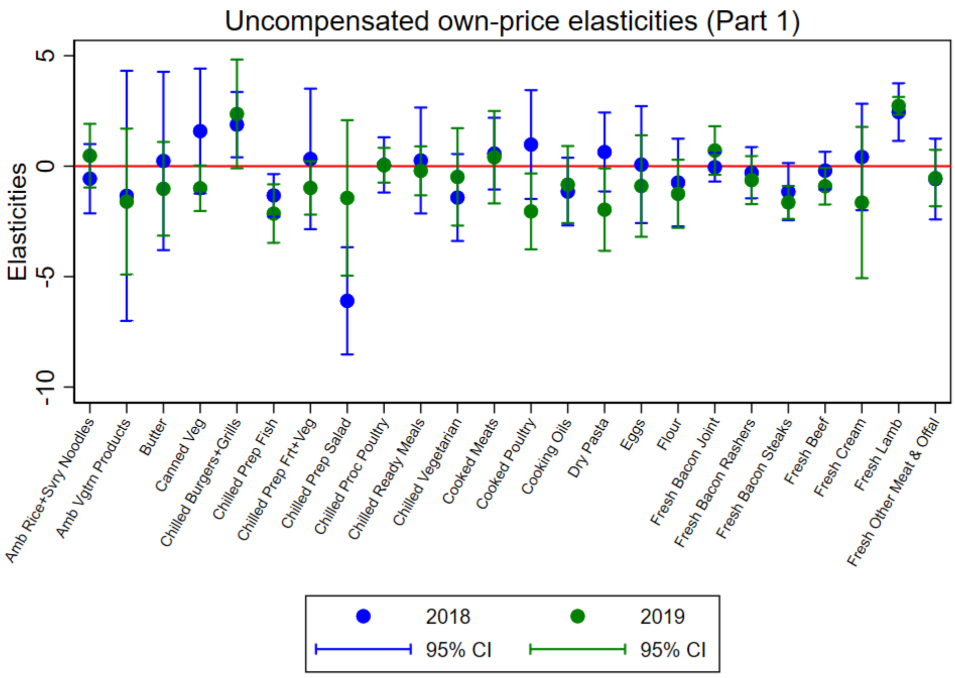
Category 2 products

Figures 6.1 and 6.2 illustrate the results for (uncompensated) own-price elasticities for the 48 products of category 2. We show also confidence bands around estimates as many of the estimates are statistically insignificant.[10]

The products for which we estimate statistically significant elasticities (at 95% level of significance) are (values are for 2019): chilled prepared fish (-2.15), dry pasta (-1.97), fresh bacon steaks (-1.64), fresh beef (-0.91), fresh lamb (2.73), fruit (-0.78), margarine (-1.38), mineral water (1.74), vegetable (-1.02), wet/smoked fish (-1.58) and yoghurt (-0.96). In all cases these are negatives except in the case of lamb and mineral water.

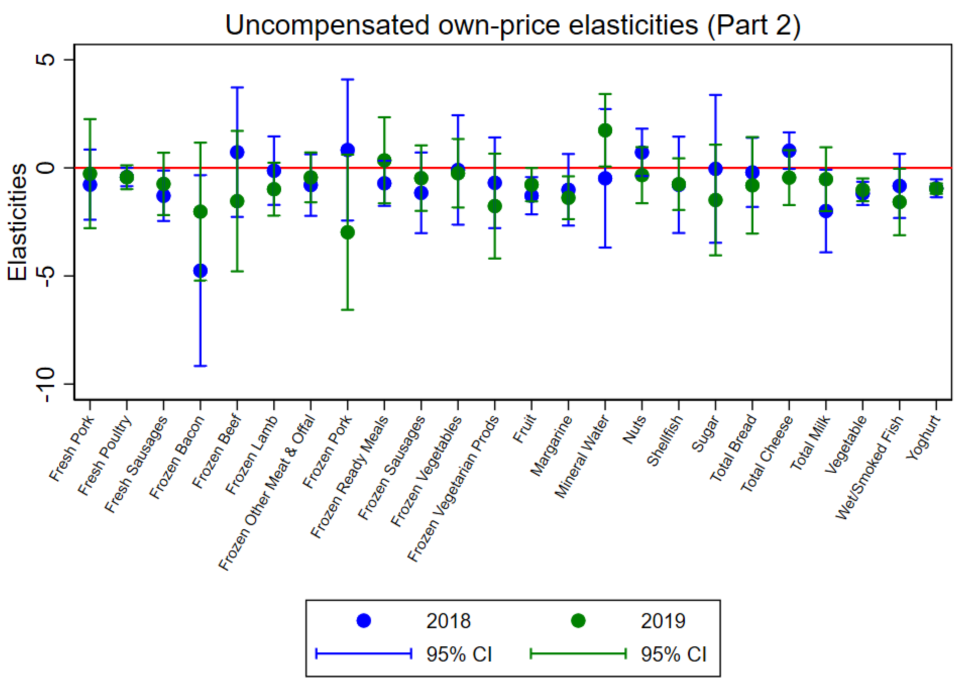
[10] If the confidence interval straddles the horizontal red line, then the estimate is not statistically different from 0 at the 95% level of confidence

Figure 6.1. Uncompensated own-price elasticities – category 2, Part 1.



Source: Authors' calculations from Kantar's Grocery Market Share data.

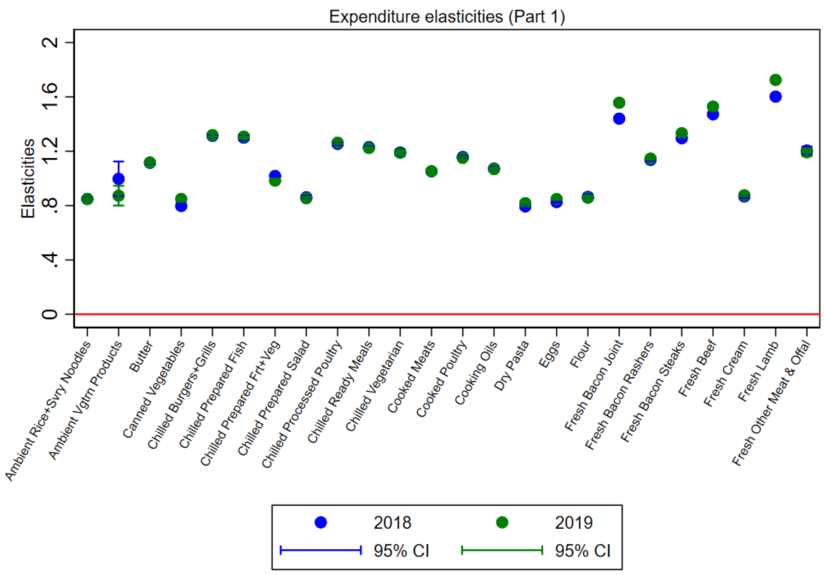
Figure 6.2: Uncompensated own-price elasticities – category 2, part 2



Source: Authors' calculations from Kantar's Grocery Market Share data.

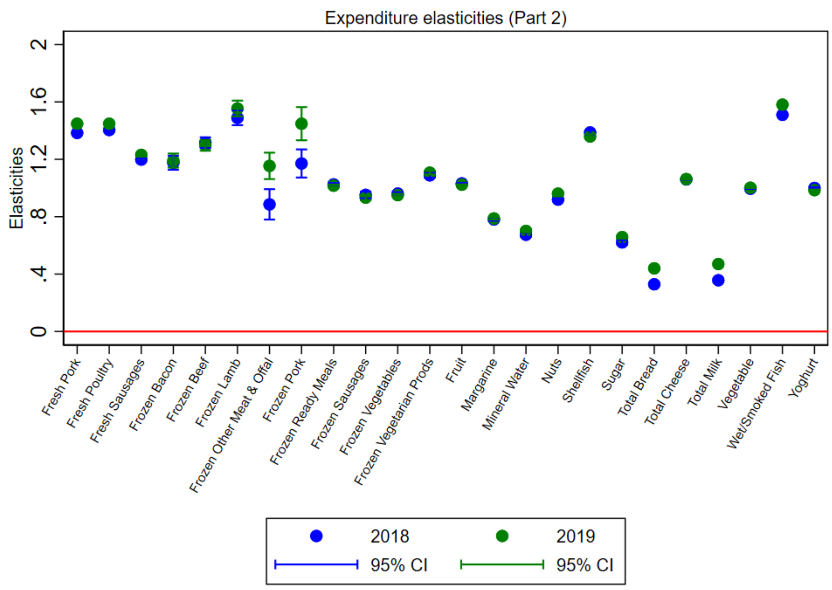
The case of lamb is particularly striking. The large and positive value of the elasticity is found in both years, 2018 and 2019. This is in contrast with earlier results by Tiffin et al (2011) who found that lamb was one of the types of meat products that was most price sensitive, as the estimated elasticities during period 2002 to 2009 were around to -0.5 for most years.

Figure 7.1. Expenditure elasticities – category 2, part 1



Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure 7.2: Expenditure elasticities – category 2, part 2



Source: Authors' calculations from Kantar's Grocery Market Share data.

Figures 7.1 and 7.2 now shows the expenditure elasticities for category 2 products. We show that those products most elastic to expenditure in 2019 include: fresh lamb (1.73), wet/smoked fish (1.58), fresh bacon joint (1.56), frozen lamb (1.55), fresh beef (1.53), frozen pork (1.45), shellfish (1.36), frozen beef (1.3), chilled prepared burgers and grills (1.32), and chilled prepared fish (1.31).

4.2 Analysis for selected product groups

In this section we focus on selected products in category 1 to explore findings on cross-price elasticities across products. Cross-price elasticities show the percentage change in the quantity demanded for a product if the price of another product increases by one percent. A negative value of the estimated cross-price elasticity shows that demand falls in response to the increase in price of the related good, indicating that the pair of goods are complements in consumption. In contrast, a positive cross-price elasticity indicates that the pair of goods are substitutes. The absolute value of the cross-price elasticity, positive or negative, shows the magnitude of the relationship. If the estimated cross-price elasticity is not significantly different from zero, it suggests that the pair of goods are unrelated in consumption.

Table 7.1 and Table 7.2 are heatmaps that contain only those own-price and cross-price that are statistically significant for 2018 and 2019, respectively. We show the elasticities in a red-yellow-green colour scale in which red is the most negative elasticity and green is the most positive one. Each column shows the percentage changes in demand for various food groups as a result of a one percent increase in the price of various goods, starting with the price of alcohol in the first column. Reading Table 7.2 for 2019 data, we see that the cross-price elasticity of demand for frozen confectionery with respect to the price of alcohol was -2.79: this means that a 1% increase in the price of alcohol would decrease the demand for frozen confectionery by 2.79%.

Table 7.1 Heatmap of statistically significant own-price and cross-price elasticities - 2018

	Alcohol	Amb Bakery Prods	Amb Slim Prods	Biscuits	Canned Goods	Chilled Bakery Prods	Chilled Conven	Chilled Drinks	Dairy Prods	Fresh Fish	Fresh Meat	Frozen Confect	Frozen Fish	Frozen Meat	Frozen Poultry+Game	Frozen Prep Foods	Hot Beverages	Packet Breakfast	Pickle+Tbl Sce+Condiment	Savoury Carbs+ Sncks	Savoury HC	Sweet HC	TH Confect	TH Savouries	TH Soft Drinks
Alcohol	-1.914			0.659							-0.578	-0.567			0.168								0.559		-0.572
Ambient Bakery Products		-0.690		0.347	-0.576					0.196		0.487			-0.085	-0.371			0.336	-0.202			-0.060	0.312	
Ambient Slimming Products	3.982		-0.796		-5.138	-2.479	6.329					5.166										-4.581	-2.897		9.919
Biscuits	1.382	0.655		-0.741		-0.343	-0.636								-0.096	0.785		-1.049		0.391			-0.209		
Canned Goods		-1.389	-0.101		-1.521	-0.448		0.449		0.500	-0.725	3.330			-0.146	-0.551	-0.599		0.451	-0.414	-0.723		-0.273		1.313
Chilled Bakery Products			-0.242	-2.061	-2.214							1.100				1.032		-1.058		-1.211			-0.275		1.914
Chilled Convenience			0.035	-0.220			-0.312					-0.345			0.058								-0.342		0.224
Chilled Drinks		-0.951			1.237		0.905	-0.879		-0.740		-1.743			0.182				-0.953		1.719				
Dairy Products	0.144								-0.598						-0.061								-0.176		-0.200
Fresh Fish		0.933	0.124		1.047			-0.570		-0.864	0.797	-0.930											-0.340		-0.741
Fresh Meat	-0.615				-0.343											0.539									-0.532
Frozen Confectionery	-2.155	1.810	0.163	-0.449	5.327	0.355	-1.993	-1.015	-0.838	-0.704		-2.905			0.540	-1.701	1.954	2.069			1.053		-0.128	-1.422	-0.887
Frozen Fish			0.123							0.523			-1.229										-0.269	-1.024	-0.724
Frozen Meat		-2.844	-0.223			-0.771			1.831					-0.662			-1.727					1.410		-1.863	-2.632
Frozen Poultry+Game	3.718	-1.871			-1.334		1.870		-2.962			3.039			0.724					-1.800		-1.168	-1.714		
Frozen Prepared Foods	0.704	-0.572		0.575	-0.340						0.720	-0.652				-1.219		0.505					-0.239		-0.481
Hot Beverages	0.621			-0.469	-0.691							1.405										-0.631	-0.120		
Packet Breakfast		0.431		-1.337		-0.224						1.358				0.874		-0.959			-0.620		-0.237		
Pickle+Tbl Sce+Condiment	-0.914	1.993	0.161	-0.744	1.151	0.405	-1.203	-0.884		-0.569	0.529	-0.708	0.425	-0.240	0.289		0.949	0.609	-1.320						-1.236
Savoury Carbohydrts+Sncks		-0.909		0.881	-0.768	-0.455	0.971				0.451				-0.369	0.605				-1.607			-0.294	0.771	-0.585
Savoury Home Cooking	0.839	-0.923	-0.102	-0.358	-0.777		0.863	0.672	-0.477	0.480		0.709					-0.658	-0.638			-0.664		-0.172		
Sweet Home Cooking	0.963		-0.150								-0.660				-0.213		-0.907					-0.923	0.375		
Take Home Confectionery	0.981						-0.809		-0.635						-0.126								0.932		
Take Home Savouries	-0.392	0.706							0.753		-0.584	-0.872	-0.358		0.087					0.410			0.150	-0.629	
Take Home Soft Drinks	-0.822		0.124		0.829	0.244	0.520		-0.693		-0.707	-0.348				-0.488							-0.105		0.764

Source: Authors' calculations from Kantar's Grocery Market Share data.

Table 7.2 Heatmap of statistically significant own-price and cross-price elasticities – 2019

	Alcohol	Amb Bakery Prods	Amb Slim Prods	Biscuits	Canned Goods	Chilled Bakery Prods	Chilled Conven	Chilled Drinks	Dairy Prods	Fresh Fish	Fresh Meat	Frozen Confect	Frozen Fish	Frozen Meat	Frozen Poultry+Game	Frozen Prep Foods	Hot Beverages	Packet Breakfast	Pickle+Tbl Sce+Condiment	Savoury Carbs+ Sncks	Savoury HC	Sweet HC	TH Confect	TH Savouries	TH Soft Drinks
Alcohol	-2.324			0.814								-0.705											0.475		-0.862
Ambient Bakery Products	0.520	-1.002		0.383	-0.296	0.173	-0.522	-0.245									-0.375							0.749	
Ambient Slimming Products									-7.643		3.377												-1.730		
Biscuits	1.646	0.727		-0.994	-0.591	-0.394						-0.577				-0.446	0.239			0.431		0.301	-0.187	-0.647	
Canned Goods	0.527	-0.753		-0.745	-0.938	-0.330	0.636	0.410	-0.581		-0.242	1.869		-0.112		-1.076				-0.431	-0.477		-0.278		0.966
Chilled Bakery Products	1.658	2.094		-2.478	-1.655	-0.302	1.311							-0.250	-0.396					-1.313	-1.216	-0.837	-0.340		2.258
Chilled Convenience		-0.385	0.027				-0.502		-0.526														-0.238		
Chilled Drinks		-1.686	0.097		1.142			-1.446				-0.932			0.370	1.410				0.892	1.368	-0.568	-0.185	-0.841	-0.625
Dairy Products	0.126		-0.028				-0.329		-0.435														-0.138		
Fresh Fish	-0.744																						-0.177		
Fresh Meat																							-0.183		
Frozen Confectionery	-2.788		0.084	-1.199	3.089			-0.556		0.408		-4.800		0.172	1.111	2.896	0.786	1.147	-1.181	0.600	2.510	-0.467	-0.385	-0.758	-1.838
Frozen Fish	0.534			0.613									-1.255										-0.151		-1.289
Frozen Meat	-2.294					-0.677						1.404			0.559		1.209								
Frozen Poultry+Game	2.135					-0.760		1.275	-2.586		0.923	6.455		0.397		-2.014		-1.802	1.802	-3.159	-3.018		-1.100		3.086
Frozen Prepared Foods				-0.344	-0.649			0.303				1.052				-1.221				-0.293	-0.789		-0.134		0.560
Hot Beverages	0.453	-1.075										0.541					-0.894						-0.222		0.431
Packet Breakfast	0.363					-0.166	-0.515					0.728			-0.195			-0.849		-0.341		-0.388	-0.205		0.879
Pickle+Tbl Sce+Condiment	-0.851				0.649	0.411			1.079			-1.803			0.475	1.471			-2.209		1.062	-0.804	-0.173	0.746	
Savoury Carbohydrts+Sncks	0.413			0.985	-0.787	-0.479	0.796	0.589			0.399	0.667			-0.601	-0.887		-0.597		-1.526		0.385	-0.268	0.531	
Savoury Home Cooking					-0.508	-0.259		0.526		0.314		1.624			-0.334	-1.398			0.449		-2.260	0.396	-0.091		0.386
Sweet Home Cooking	1.152			0.624		-0.277						-0.467						-0.617		0.349		-0.806	0.109		-0.659
Take Home Confectionery	0.815						-0.533		-0.483		-0.227												0.826		
Take Home Savouries	-0.316	1.719		-0.768				-0.287		-0.279	-0.427	-0.432					0.311			0.276			0.186	-1.533	
Take Home Soft Drinks	-1.290				0.619	0.288					-0.245	-0.711	-0.298		0.207	0.603	0.245	0.536				-0.255	-0.118		-0.327

Source: Authors' calculations from Kantar's Grocery Market Share data.

Demand for Alcohol

Figure 8 shows the (uncompensated) elasticities[11] for products in category 1. The own-price elasticity for alcohol (category 1) is approximately -2.32, which shows again that is quite elastic. The expenditure elasticity for alcohol (see Figure 5) is 1.68, which is also elastic, implying that as income rises, demand for alcohol rises more than in proportion.

The cross-price elasticities of demand for alcohol throws up some interesting results. Some seemingly unrelated products are revealed to be substitutes. The cross-price elasticity of demand for alcohol with respect to the price of biscuits is 0.81, and with respect to take-home confectionery is 0.48. This implies that the demand for alcohol increases by 0.81% for every 1% increase in the price of biscuits and by 0.48% for a 1% increase in the price of confectionary. This is illustrated in Figure 8.

As Figure 8 shows, other products show complementarity in consumption. The cross-price elasticity of demand for alcohol is negative with respect to the price of frozen confectionery (-0.71), and take-home soft drinks (-0.86). In terms of magnitudes these estimates suggest that a 1% increase in the price of these goods would decrease the demand for alcohol by 0.71% and 0.86%, respectively.

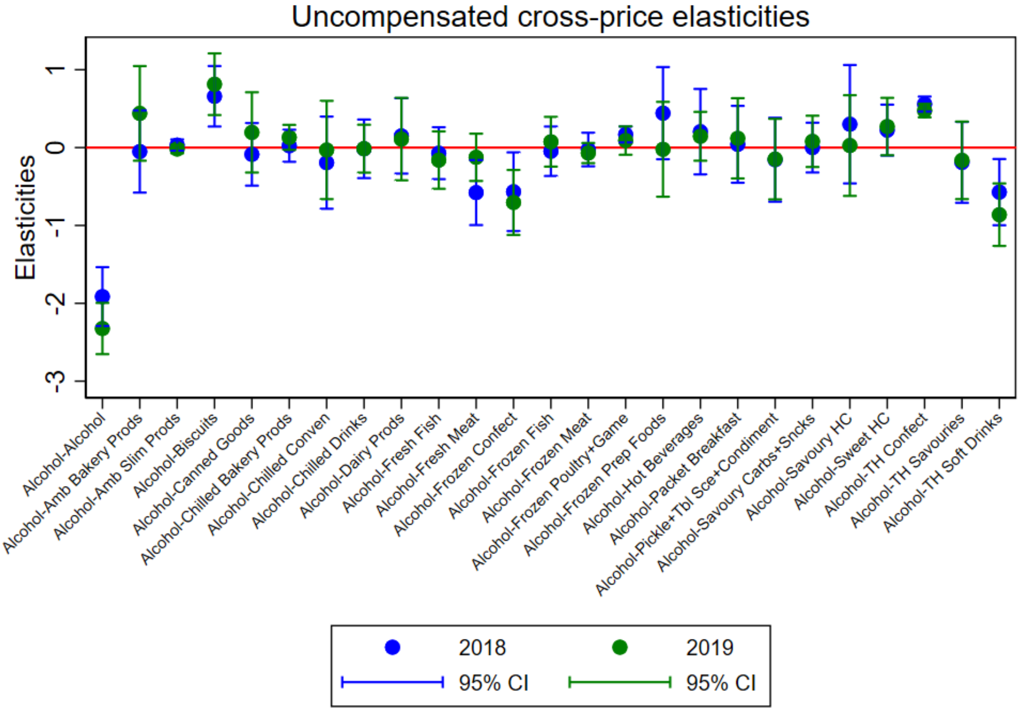
Impact of alcohol prices on demand for other goods

We also look at the effect of a change in the price of alcohol on demand for other products. For example, the cross elasticity of demand for biscuits with respect to the price of alcohol is estimated to be around 1.65. This means that a 1% increase in the price of alcohol will increase the demand for these products by 1.65% (this result suggests they are substitutes). We find that there is also an elastic substitution relationship between alcohol and sweet home cooking (1.15) and take-home confectionery (0.82).

Once again, other product display complementarity in consumption. For example, the cross price elasticity of the demand for frozen confection with respect to the price of alcohol is -2.79, so that a 1% increase in the price of alcohol will reduce demand for frozen confectionery by 2.79%. Likewise, that increase in the price of alcohol will reduce the demand for take-home soft drinks by 1.29%, frozen meat by 2.29% and take-home savouries by 0.32%.

[11] The compensated elasticities are generally almost identical to the compensated elasticities and the full results can be found in the accompanying tables and documentation.

Figure 8: Uncompensated cross-price elasticities – category 1, Alcohol



Source: Authors' calculations from Kantar's Grocery Market Share data. This figure shows the effect on alcohol demand of price changes in the other goods shown.

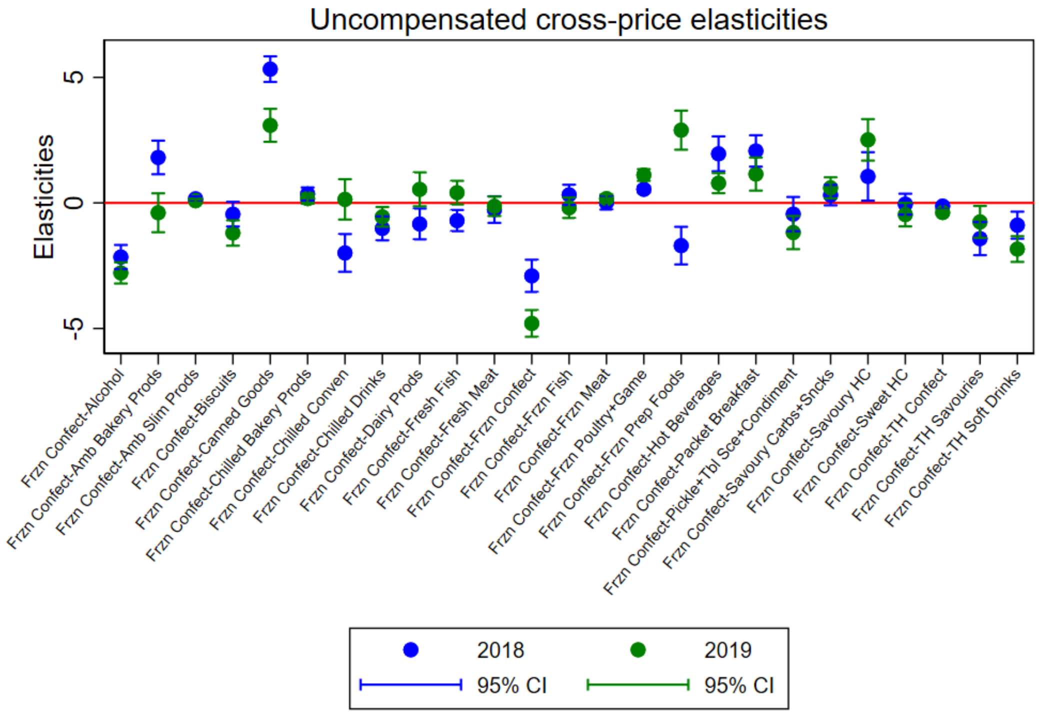
Frozen confectionery

The demand for frozen confectionary is quite sensitive, with an own-price elasticity of around -3 in 2018 and almost -4 in 2019 (see Figure 4). The expenditure elasticity for frozen confectionery is just over 1 (see Figure 5), implying that as income rises demand for frozen confectionery rises more than proportionately.

The cross-price elasticity of demand of frozen confectionery with respect to the price of other goods identifies some substitutes, as shown in Figure 9. These include frozen prepared foods, savoury home cooking, packet breakfast, and frozen poultry and game, with an increase in the price of these goods increasing the demand of frozen confectionery by 2.90%, 2.51%, 1.15% and 1.11% respectively. The cross-price elasticity of canned goods is estimated to be 3.09, so a 1% increase in the price of canned goods will increase the demand for frozen confectionery by just over 3%. This is shown in Figure 9, which illustrates the effect on frozen confectionery demand of changes in the price of other goods.

Other products are found to have a complementary relationship. The cross-price elasticity of demand for frozen confectionary is negative with respect to the price of alcohol (-2.79) and take-home soft drinks (-1.84).

Figure 9: Uncompensated cross-price elasticities – category 1, frozen confectionery



Source: Authors' calculations from Kantar's Grocery Market Share data. This figure shows the effect on frozen confectionery demand of price changes in the other goods shown.

<u>Take-home confectionery</u>

The own-price elasticity for take-home confectionery (category 1) is approximately 0.8 in both 2018 and 2019 (see Figure 4), meaning that demand is inelastic, that is, not particularly responsive to changes in price. This may be because other food items are not perceived as substitutes for take-home confectionery, and even if prices rise, households continue buying confectionery. The expenditure elasticity for take-home confectionery is around 0.9, implying that demand rises slightly less than in proportion to increase in income (see Figure 5).

Take-home confectionery and alcohol appear to be substitutes; when the price of alcohol goes up, demand for take-home confectionery goes up (and vice versa). There is a complementary relationship between take-home confectionery and chilled convenience products foods, dairy products and fresh meat. Consumers respond to a price decrease of these products by increasing their consumption of take-home confectionery.

It is also interesting to look at the effect of a change in price of take-home confectionery on other products. The cross-price elasticity of demand for biscuits with respect to the price of take-home confectionery is -0.19. Thus, take-home confectionery and biscuits appear to be complements. Other products whose demand falls in response to an increase in the price of take-home confectionary include fresh fish, frozen fish, savoury carbohydrates and snacks, and savoury home cooking. Conversely, the cross elasticity of demand of take-home savouries with respect to take-home confectionery is 0.19, so a 1% increase in the price of take-home confectionery will increase the demand for take-home savouries by 0.19%. Similarly, a 1% increase in the price of take-home confectionery will increase demand for sweet home cooking by 0.11%.

There is clear evidence of a complementary relationship between a range of goods that are relatively high in sugar. The demand for take-home confectionary falls when its price rises, but there is simultaneous reduction in the quantity demanded of several other products that are high in sugar (biscuits, chilled bakery products, chilled convenience products, chilled drinks, frozen confectionery, dairy products, frozen prepared foods, hot beverages, packet breakfast, take-home soft drinks). Although the relationship is complementary, the cross elasticity of demand is not that large, meaning that a change in the price of take-home confectionery results in a less than proportionate change in the quantity demanded of the other goods.

Dairy products

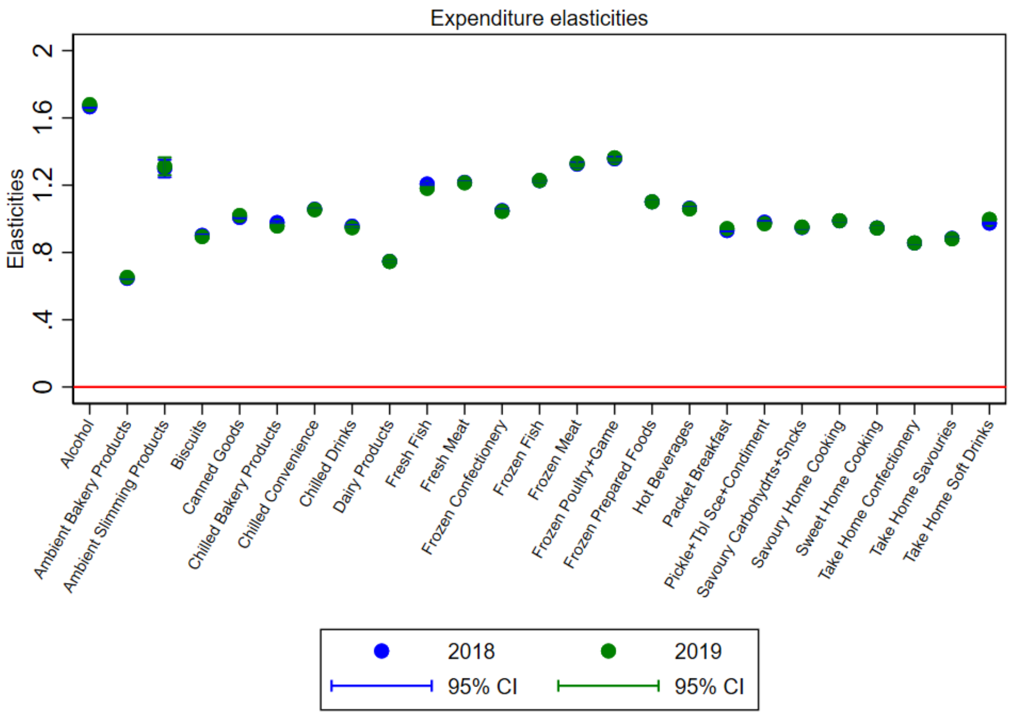
The own price elasticity for dairy products (category 1) is -0.6 in 2018 and -0.44 in 2019, meaning that demand is inelastic (see Figure 4). The expenditure elasticity is about 0.75 in both years, implying that dairy products are a necessity and the quantity demanded will rise as income rises (see Figure 5).

There is generally little relationship between demand for dairy products with respect to the price of other products; in other words, changes in the price of other products generally have little effect on the demand for dairy products. There are some inelastic relationships between demand for dairy products and the price of other products. For example, the cross-price elasticity of demand for dairy products with respect to chilled convenience products is -0.33 and take-home confectionery is -0.14, so a 1% increase in the price of chilled convenience products or take-home confectionery will decrease demand for dairy products by 0.33% and 0.14%, respectively. Dairy products and these products are thus seen as complements.

There also appears to be a complementary relationship between the price of dairy products and the demand for several products. The cross elasticity of demand for frozen poultry and game with respect to dairy products is -2.59, so a 1% increase in the price of dairy products will reduce demand for frozen poultry and game by 2.59%. A 1% increase in the price of dairy products will also reduce demand for canned goods by 0.58%, chilled convenience products by 0.53%, and for take-home confectionery by 0.48%. However, a 1% increase in the price of dairy products will increase demand for pickles, table sauces and condiments by 1.08%.

Sweet home cooking

The own-price elasticity for sweet home cooking (category 1) is -0.81 (uncompensated) in 2019, meaning that demand is inelastic (see Figure). The expenditure elasticity is about 0.95 so that the quantity demanded will rise more or less in proportion with increase in income (see



).

There is an inelastic substitution relationship between the demand for sweet home cooking and biscuits (0.62), savoury carbohydrates and snacks (0.35) and take-home confectionery (0.11). A 1% increase in the price of biscuits, savoury carbohydrates and snacks or take-home confectionery will increase demand for sweet home cooking by 0.62%, 0.35% or 0.11%, respectively. In addition, there is an elastic substitution relationship between sweet home cooking and alcohol (1.15). Also, there is a complementary relationship between the demand for sweet home cooking and chilled bakery products (-0.28), chilled drinks (-0.34), frozen confectionery (-0.47), packet breakfast (-0.62), and take-home soft drinks (-0.66).

The cross elasticity of demand of chilled bakery products with respect to sweet home cooking is -0.84 (complements), so a 1% increase in the price of sweet home cooking will reduce the demand for chilled bakery products by 0.84%. There is also an inelastic complementary relationship between the price of sweet home cooking and demand for pickle, table sauces and condiment (-0.81), chilled drinks (-0.57), frozen confectionery (-0.47), packet breakfast (-0.39) and take-home soft drinks (-0.26). The cross elasticity of demand for biscuits with respect to sweet home cooking is 0.3, for savoury carbohydrates and snacks is 0.39 and for savoury home cooking is 0.4, so a 1% increase in the price of sweet home cooking will increase the demand for biscuits by 0.3%, savoury carbohydrates and snacks by 0.39% and for savoury home cooking by 0.4%.

Ambient bakery products

The own price elasticity for ambient bakery products (category 1) is -0.69 (inelastic) in 2018, and -1 (elastic) in 2019 (see Figure 4). The expenditure elasticity is about 0.65 in both years (see Figure 5), meaning that a 1% rise in expenditure increases the demand for ambient bakery products by 0.65%.

Our results show that here is a substitution relationship between ambient bakery products and take-home savouries (0.75) and alcohol (0.52). That is, a 1% increase in the price of take-home savouries will increase the demand for ambient bakery products by 0.75% and a 1% increase in the price of alcohol will increase the demand for ambient bakery products by 0.52%. Similarly, there is also a substitution relationship between ambient bakery products and biscuits (0.38) and chilled bakery products (0.17).

A complementary relationship can be seen between ambient bakery products and canned goods (-0.30), chilled convenience products (-0.52), chilled drinks (-0.25), and hot beverages (-0.38). Thus, a 1% increase in the price of these products will decrease the demand for ambient bakery products by the correspondent elasticity.

Changes in the price of ambient bakery products also impact the demand for other products. For instance, a 1% rise in the price of ambient bakery products will increase the demand of biscuits by 0.73%, demand of chilled bakery products by 2.09%, and take-home savouries by 1.72%.

On the contrary, a 1% increase in the price of ambient bakery products will decrease the demand of canned goods by 0.75%, chilled convenience products by 0.39%, chilled drinks by 1.69%, and hot beverages by 1.08%.

Take-home soft drinks

The uncompensated own price elasticity for take-home soft drinks (category 1) is inelastic and around 0.76 in 2018 and -0.33 in 2019 (see Figure 4). The expenditure elasticity is about 0.97 (0.99) in 2018 (2019), indicating that as income rises the demand also rises but slightly less than in proportion (see Figure 5).

From the heat-map in Table 4, one can see that there is a substitution relationship between take-home soft drinks and canned goods (0.62), chilled bakery products (0.29), frozen poultry and game (0.21), frozen prepared foods (0.60), hot beverages (0.25), and packet breakfast goods (0.54) Thus, a 1% increase in the price of canned goods, for example, will increase demand for take-home soft drinks by 0.62%.

Conversely, there is a complementary relationship between take-home soft drinks and alcohol (-1.3), fresh meat (-0.25), frozen confectionery (-0.71), frozen fish (-0.30), sweet home cooking (-0.26), and take-home confectionery (-0.12). In this case, a 1% increase in the price of alcohol or fresh meat, for instance, will decrease the demand for take-home soft drinks by 1.3% or 0.25%, respectively.

Considering changes in the price of take-home soft drinks, one can see a large substitution relationship with chilled bakery products (2.26), and more moderate relationship with canned goods (0.97), packet breakfast (0.88), frozen prepared foods (0.56) and hot beverages (0.43). In other words, a 1% increase in the price of take-home soft drinks, for instance, will increase the demand for chilled bakery products by 2.26%.

The cross-price elasticities also highlight the complementary relationship of take-home soft drinks and a range of other products. A 1% rise in the price of take-home soft drinks will decrease the demand for alcohol by 0.86%, the demand for chilled drinks by 0.20%, frozen confectionery by 1.84%, frozen fish by 1.29%, and sweet home-cooking by 0.66%.

Savoury home-cooking

The uncompensated own price elasticity of savoury home-cooking is fairly elastic, around -2.26, in 2019 (see Figure 4). That is, a 1% increase in the price of savoury home-cooking will decrease its demand by 2.26%. The expenditure elasticity is around 0.99 (see Figure 5), which suggests that as income rises by 1%, the demand of savoury home cooking will increase by 0.99%.

The cross-price elasticities in 2019 indicate a substitution relationship between savoury home cooking and frozen confectionery (1.62), chilled drinks (0.53), fresh fish (0.31), pickle, table sauces, and condiment (0.45), sweet home cooking (0.40) and take-home soft drinks (0.40). Thus, increases in the price of these goods will increase the demand of savoury home cooking. For example, a 1% rise in the price of frozen confectionery will increase the demand of savoury home cooking by 1.62%.

On the contrary, a complementary relationship is observed between savoury home cooking and canned goods (-0.51), chilled bakery products (-0.26), frozen poultry and game (-0.33), frozen prepared foods (-1.40), and take-home confectionery (-0.09).

A 1% increase in the price of savoury home-cooking, in turn, will increase the demand for chilled drinks by 1.37%, the demand for frozen confectionery by 2.51% and pickle, table sauces and condiment by 1.06%. These are substitute goods. Conversely, a 1% rise in the price of savoury home cooking will decrease the demand of canned goods by 0.48%, the demand for chilled bakery products by 1.22%, and frozen poultry and game by 3.02% (complementary relationship).

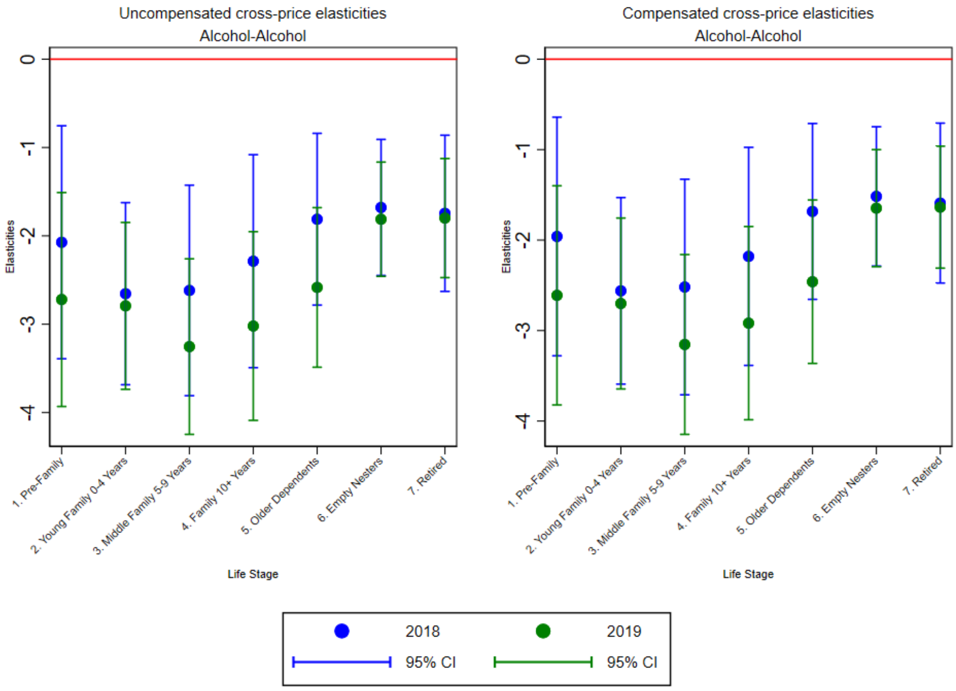
4.3 Analysis by demographic groups

So far, we have focused on the elasticities estimated on the full household database. We now explore the elasticities for the three most consumed products, alcohol, dairy products and chilled convenience products, by socio-demographic subgroup (disaggregating by life stage and social class). Note that we report on cross-price elasticities that are statistically significant.

4.3.1 Life stage

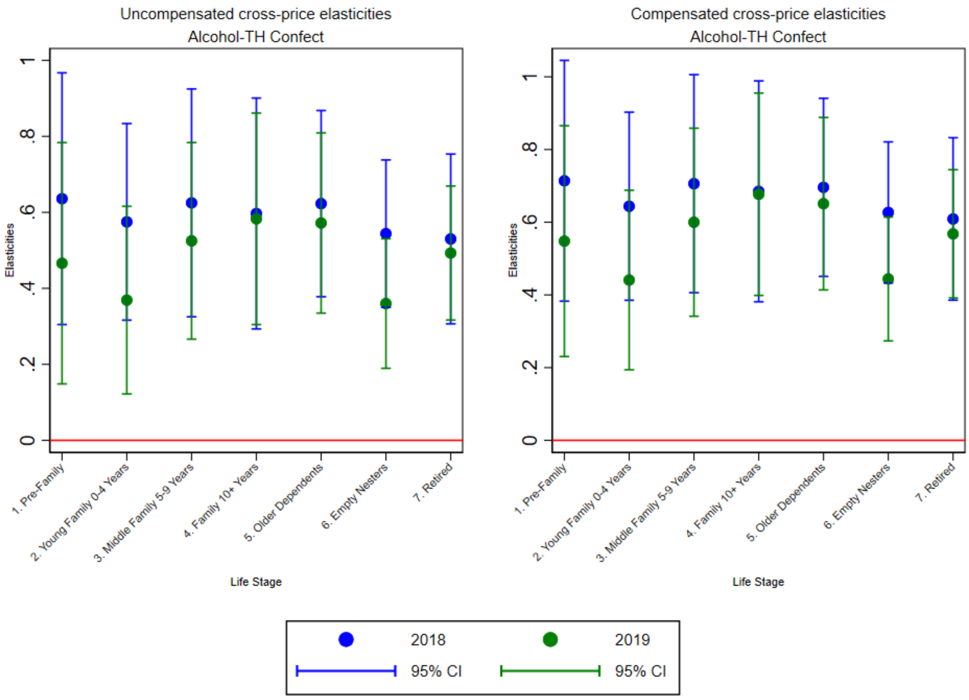
Figure 10 shows the own-price elasticity for alcohol by a household's life stage. For all socio-demographic groups, the elasticities are negative, which implies that demand for alcohol decreases as its price increases. Further, demand is relatively elastic. Alcohol appears more elastic in 2019 than in 2018 for all groups, which means that overall, it has become more sensitive to price changes. Middle families are characterised by the highest elasticity of demand (-3.25), indicating that a 1% increase in the price of alcohol is associated with a 3.25% decrease in demand. The groups whose demand of alcohol is least affected by prices are the retired people (-1.80) and empty nesters (-1.81).

Figure 10 – Own-price elasticity by life stage – category 1, alcohol



Source: Authors' calculations from Kantar's Grocery Market Share data.

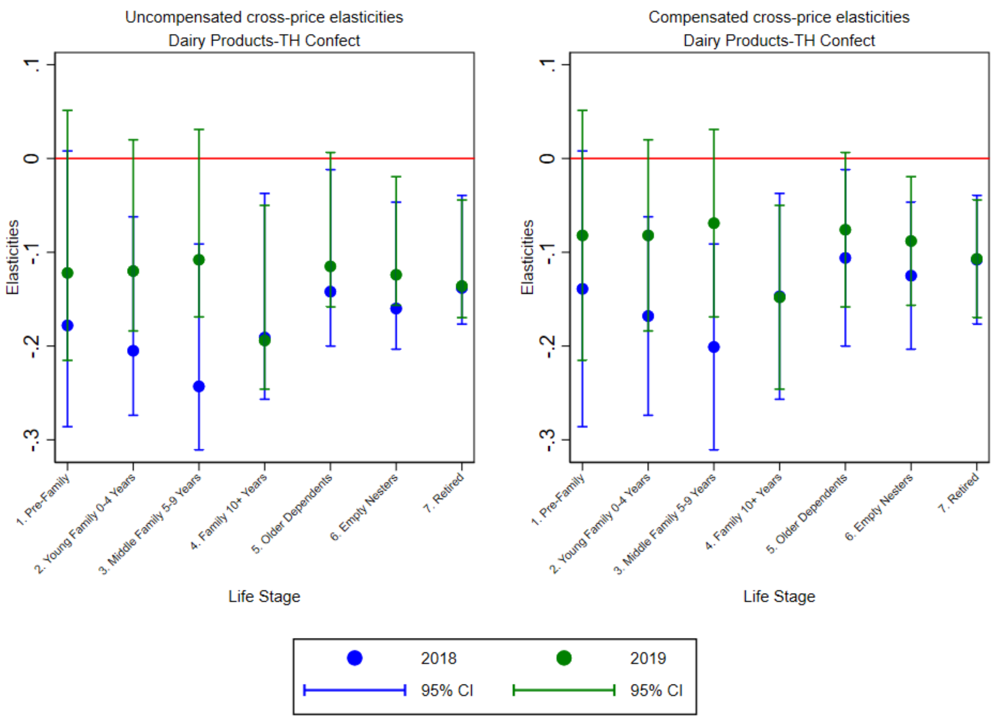
Figure 11 – Cross-price elasticity by life stage – category 1, alcohol



Source: Authors' calculations from Kantar's Grocery Market Share data.

Another product that impacts on the demand for alcohol is take-home confectionery. Figure 11 presents the cross-price elasticity between these two products, again by life stage group. As one can see, elasticities are positive for all life stages (substitutes relationship) but inelastic, indicating that an increase in the price of take-home confectionery will increase the demand for alcohol less than proportionally. In other words, a 1% increase in the price of take-home confectionery will increase the demand for alcohol by 0.58% for family 10+ years and by 0.57% for older dependents. Overall, these cross-price elasticities are smaller in 2019 compared to the previous year.

Figure 12 – Cross-price elasticity by life stage – category 1, dairy products

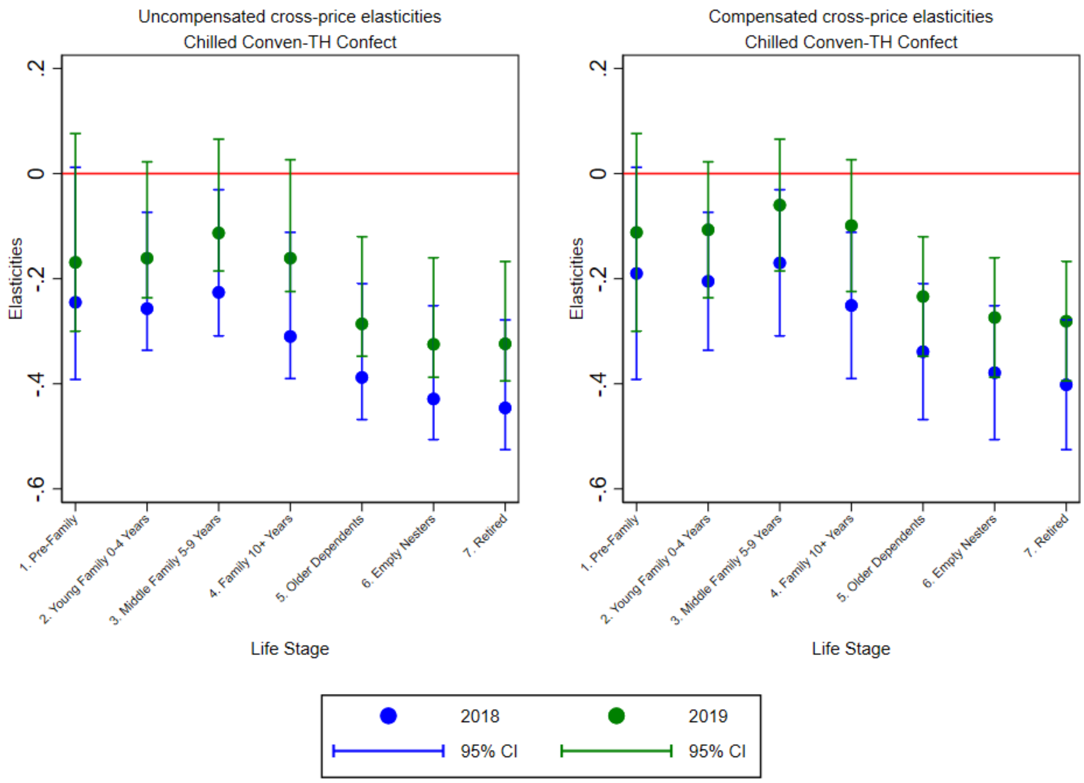


Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure 12 shows the cross-price elasticities between dairy products and take-home confectionery. Focusing in 2019, all elasticities are negative (complementary relationship) and inelastic. But these are only significant for family 10+ years, empty nesters and retired. That is, a 1% increase in the price of take-home confectionery will decrease the demand for dairy products by 0.19%, 0.12% and 0.14%, respectively, across these groups.

The cross-price elasticities between chilled convenience products and take-home confectionery (Figure 13) are negative (complementary relationship) and inelastic. In all life stages, elasticities are smaller in magnitude in 2019 compared to 2018, but these are statistically significant only for older dependents (-0.29), empty nesters (-0.33) and retired (-0.32). Therefore, a 1% increase in the price of take-home confectionery will decrease the demand for chilled convenience products by 0.29% for older dependents, by 0.33% for empty nesters and 0.32% for retired individuals.

Figure 13 – Cross-price elasticity by life stage – category 1, chilled convenience products

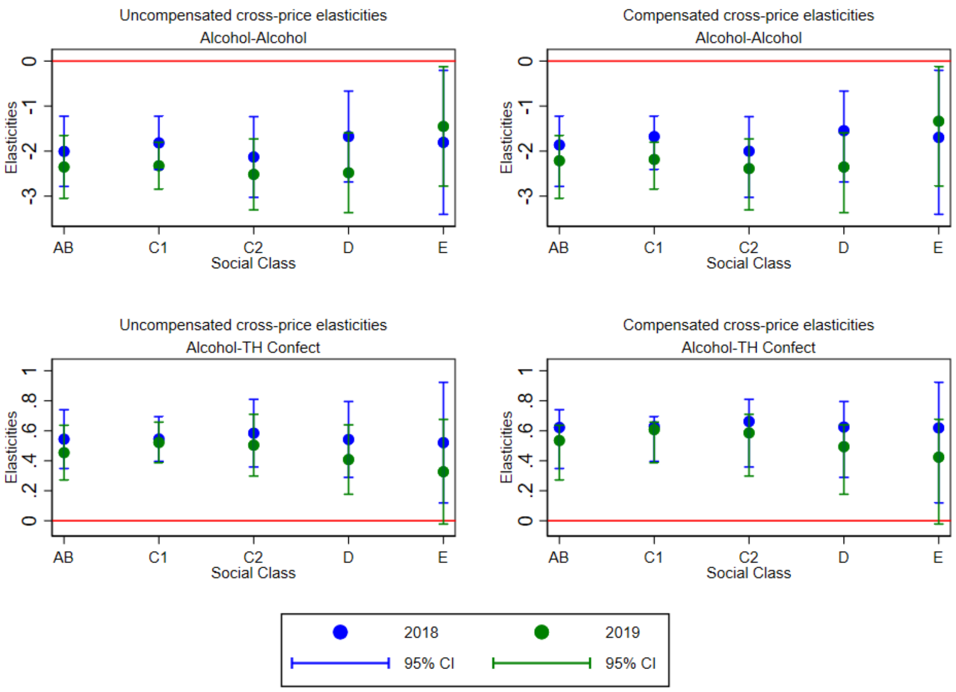


Source: Authors' calculations from Kantar's Grocery Market Share data.

4.3.2 Social class

Figure 14 shows the cross-price elasticities for alcohol by social class. At the top, we show that the own-price elasticity is the most elastic for social class C2 (-2.52), which comprises those with skilled manual occupations. This is followed by social class D (with an estimated elasticity of -2.48) which comprises semi-skilled and unskilled manual workers. A 1% increase in the price of alcohol will decrease demand by 2.52% and 2.48% for social classes C2 and D, respectively. On the contrary, alcohol is less elastic for social class E (which comprises state pensioners for instance), as a 1% increase in the price of alcohol decreases the demand for alcohol by 1.45%.

Figure 14 – Cross-price elasticity by social class – category 1, alcohol



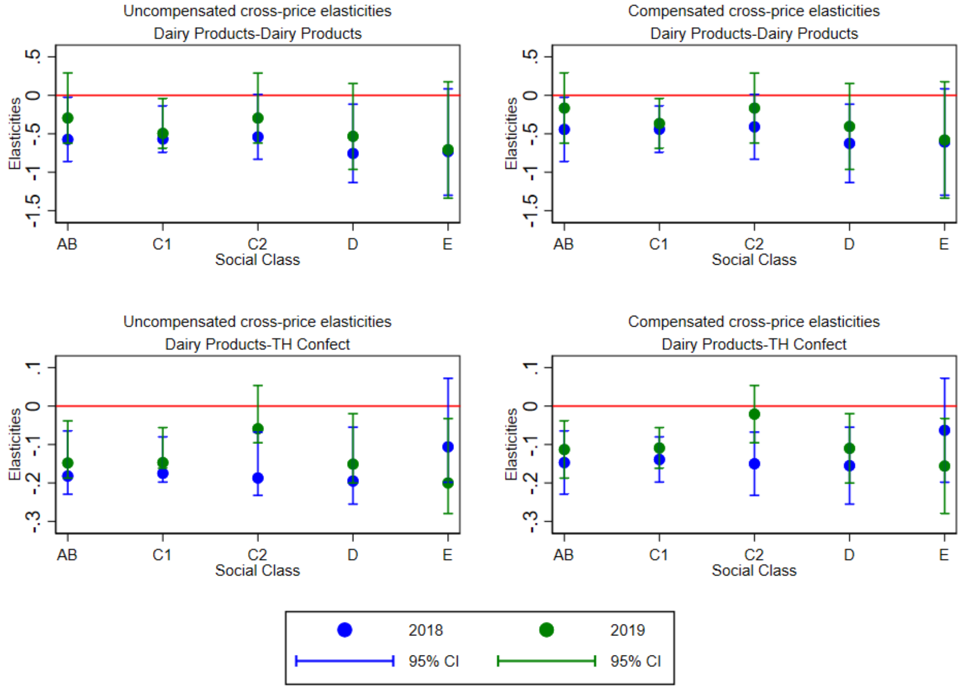
Source: Authors' calculations from Kantar's Grocery Market Share data.

At the bottom of Figure 14 are the cross-price elasticities between alcohol and take-home confectionery. There is a substitution and an inelastic relationship between these two products for all social classes. The largest elasticity is for social class C1 (0.52), which comprises administrative clerks and professionals. A 1% increase in the price of take-home confectionery increases the demand for alcohol for this group by 0.52%.

Figure 15 illustrates the results for dairy products by social class. Regarding dairy products' own-price elasticity (graphs at the top) one can see that it is significant only for social class C1, that is supervisory, clerical & junior managerial, administrative and professional occupations. This was estimated to be -0.5 in 2019, which suggests that a 1% increase in the price of dairy products reduces their demand by 0.5% for this sociodemographic group. For the other social classes, we do not find any statistically significant result in 2019.

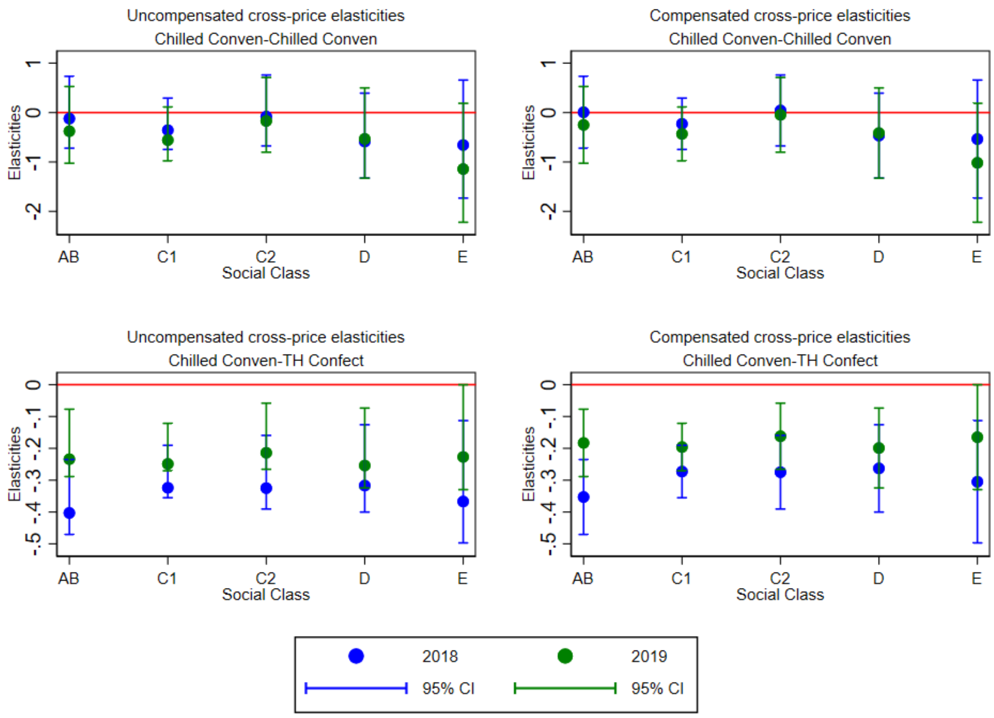
There is a complementary and inelastic relationship between dairy products and take-home confectionery for all social classes (as demonstrated at the bottom of Figure 15). Social class E, which includes the state pensioners, has the most sensitive cross-price elasticity (-0.2). This suggests that a 1% increase in the price of take-home confectionery decreases demand for alcohol by 0.2% for this sociodemographic group.

Figure 15 – Cross-price elasticity by social class – category 1, dairy products



Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure 16 – Cross-price elasticity by social class – category 1, chilled convenience products



Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure 16 shows the results for chilled convenience products by social class. We find that own-price elasticities are not significant in any of the social classes (graphs at the top). On the contrary, cross-price elasticities between chilled convenience products and take-home confectionery (graphs at the bottom) are significant, inelastic and negative (complementary relationship), but there is very little variation across social classes. Social class C2, which includes skilled manual workers, has the smallest elasticity (-0.21) among all social classes, while social class C1 (administrative and professional) and D (semi-skilled and unskilled manual workers) have the highest elasticities (around -0.25). That is, a 1% increase in the price of take-home confectionery will decrease the demand for chilled convenience products by social class C2 by 0.21%, and for social classes C1 and D by 0.25%.

4.4 Out-of-home data

The Out-of-home dataset covers a sample of households drawn from the main dataset, amounting to around 4,600 in each year. Like the at home consumption analysis, we focus on 2018 and 2019 as the most recent years prior to covid-19. The products are also classified by sector and market, but the categorisation is not fully equivalent to that of the take-home dataset.

Figure 17 shows the uncompensated own-price elasticities for 30 products in the out-of-home market.[12] As expected, most own-price elasticities are negative, which indicates that there is a decrease in demand in response to an increase in the price of the product. The most elastic products are sandwich fillers, for which elasticity is around -10 in 2019. This means that a 1% increase in the price of these products is associated with 10% demand decrease.

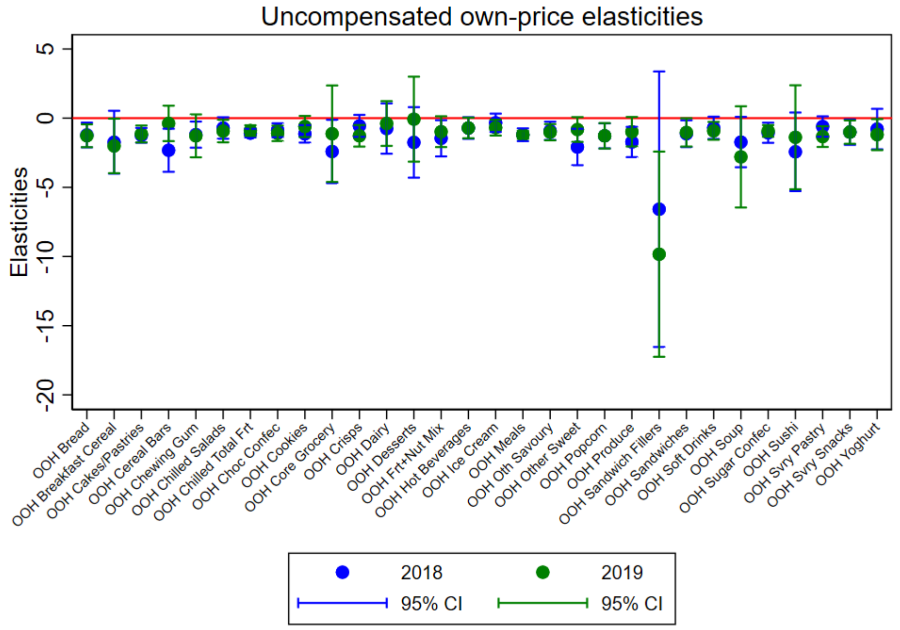
For sugary products such as cakes/pastries, chocolate confectionery and sugar confectionery the own-price elasticities are relatively stable between 2018 and 2019. There are some exceptions. The demand for products such as chewing gum, cookies and 'other sweet' products was slightly elastic in 2018 (-1.2, -1.1 and -2, respectively), but inelastic in 2019. On the other hand, savoury products such as crisps are inelastic in 2018, as demand does not change in response to price change, but are more elastic in 2019 (-1.3). Other savoury snacks are similarly elastic (-1) in both years.

For products such as dairy, desserts, hot beverages, soup and sushi the elasticities are not significantly different from zero (in both years analysed).

[12] Baby food, bread substitutes, condiments and toaster pastries were excluded due to the small sample size.

Although the product mapping of the take-home and out-of-home datasets cannot exactly be matched, we attempt to compare results across similar product types. We see that demand for out-of-home bread (Figure 17) is slightly elastic (-1.2) while that for take-home bread (Figure 6.2) is inelastic. Conversely, demand for out-of-home salads (Figure 17) is inelastic (-0.7 and -0.9 in 2018 and 2019, respectively) while that for chilled prepared salads (Figure 6.1) is very elastic (around -6 in 2018). Demand for out-of-home produce (Figure 17) is elastic in 2018 (-1.7) and as for take-home fruits (Figure 6.2) and vegetables (-1.3 and -1.2, respectively).

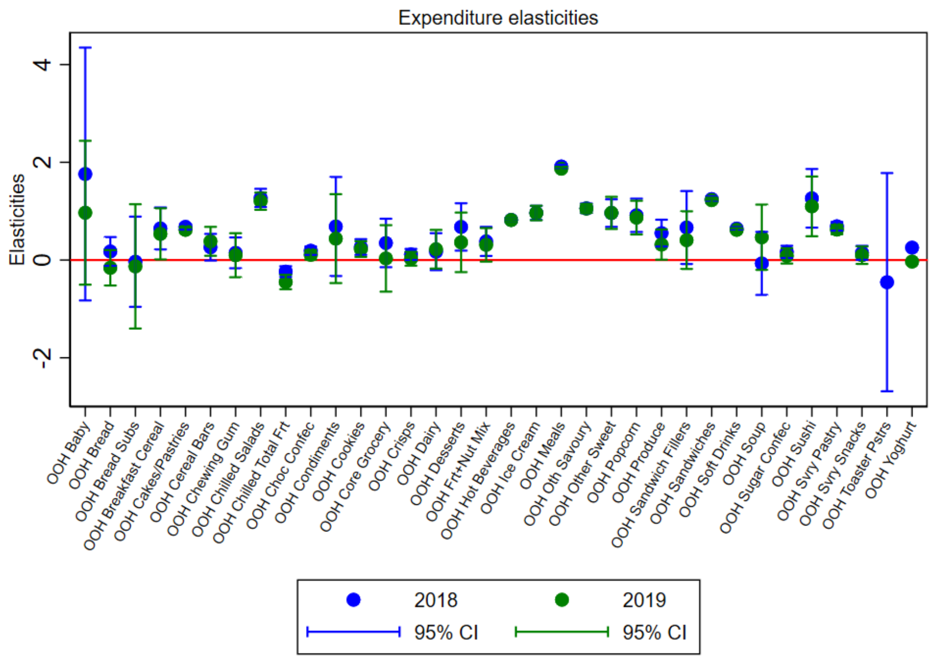
Figure 17. Uncompensated own-price elasticities – Out-of-home



Source: Authors' calculations from Kantar's Grocery Market Share data.
Note: Baby food, bread substitutes, condiments and toaster pastries were excluded due to the small sample size.

Figure 18 shows the expenditure elasticities for all 34 products in the out-of-home market. Most products are normal goods, which means that their demand increase when expenditure increases. The expenditure elasticity is highest for meals (1.9) followed by chilled salads (1.3). Chilled total fruit is the only product with a negative expenditure elasticity in both years, which indicates that demand decreases when total expenditure increases.

Figure 18. Expenditure elasticities – Out-of-home



Source: Authors' calculations from Kantar's Grocery Market Share data.

5 Nutrient Elasticities

From a public health perspective, there is growing interest in the nutritional content of our consumption basket of food and drink. It is well recognised that what we eat and drink can have significant impact on the state of our health. Diets that are rich in sugar or fats, especially saturated fats, or sugar increase the incidence of obesity and associated morbidity. High levels of salt consumption lead to hypertension and cardiac stress.

The public policy response to growing concerns about nutrition has various strands. One approach has been to guide consumers towards healthier food choices by providing them easy-to-understand information about the nutritional content of what they consume. For processed food, simple 'traffic light' labels can alert buyers to food that has high levels of potentially deleterious nutrients (calories, fat, saturated fat, sugar and salt) using simple colour coding: red indicates a high level of some deleterious nutrient, amber a medium level and green a low level. A second strand aims to influence demand for by placing restrictions on advertising of foods that are classified as high in fats, salt or sugar (HFSS).

A third strand aims to guide consumers towards healthier food habits by using the price mechanism. For instance, the Soft Drinks Industry Levy, introduced in April 2018, imposed a tax (ranging from 18 to 24p per litre) on soft drinks that have high levels of added sugar. Scotland has imposed a minimum unit price for alcohol to limit excessive consumption of alcohol.

The design of such price-based mechanism requires careful analysis and assessment. While it may be tempting to impose a tax on categories of food or drink that are regarded as deleterious – for instance, a tax on sugary drinks – the effectiveness of these taxes on limiting sugar consumption would depend on the consumers' response to that price increase. If a tax on sugary drinks induces consumers to substitute towards other high-sugar items, such as confectionary, the tax would be less effective in limiting overall sugar consumption.

Estimating the demand system, which examines how prices affect the entire consumption basket, allows a comprehensive assessment of the likely impact of price or expenditure variations. We estimate elasticities of demand for various nutrients by translating the price and expenditure elasticities of specific items of food and drink into their nutritional values. Our database provides information for eight different nutrients: namely, energy (measured in kilocalories), sugar, sodium, fat, saturated fat, protein, carbohydrates and fibre.

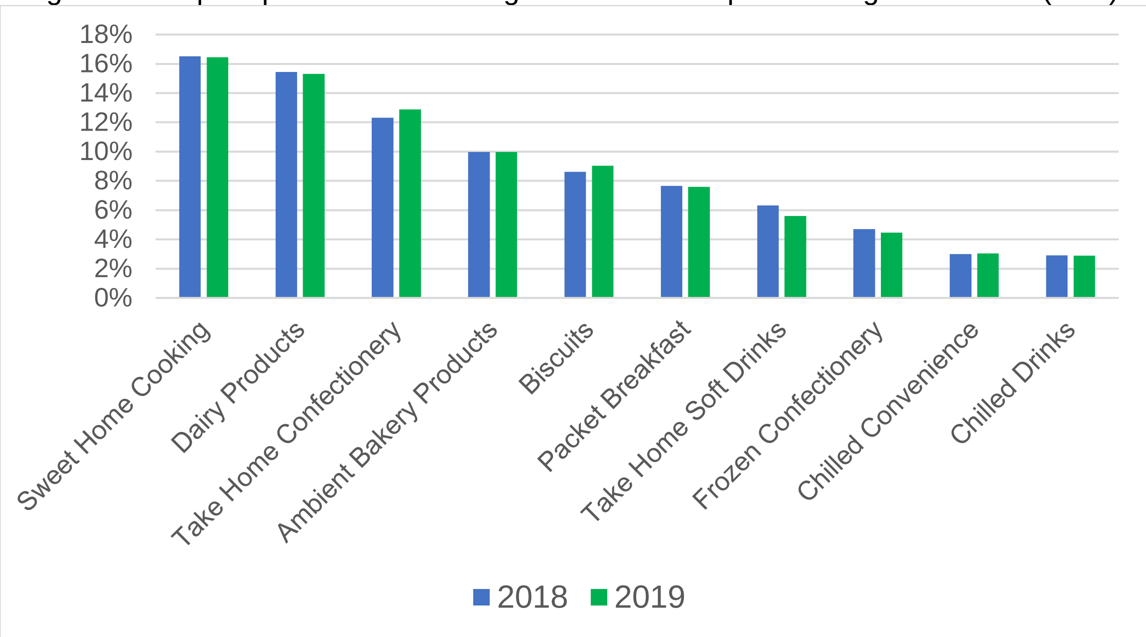
The nutrient elasticity for sugar, for instance, allows us to estimate the percentage change in total demand for sugar from all types of food and drink when the price of some specific item of food or drink increases by one percent. For instance, a tax on sugary soft drinks will have both a direct effect (as consumers cut back on purchases of soft drinks) and an indirect effect (as they may switch to other items that are high in sugar). Importantly, the nutrient elasticities capture both the direct and indirect effects.

We also compute the expenditure elasticity of nutrient demand, which estimates the percentage change in demand for a specific nutrient when a consumer's overall expenditure increases by one percent. Once again, nutrient expenditure elasticities computed from a complete demand system can capture the myriad ways in which changes in expenditure affect the entire consumption basket, and through that the content of any particular nutrient.

For each of the eight nutrients we first compute the share of that nutrient obtained from various items of food and drink. We pick the list of items from Category 1, so that there is a total of 25 items of food and drink. Any particular nutrient might be obtained from multiple items in the consumption basket: sugar, for instance, may be obtained from soft drinks, biscuits, confectionary, and so on. Using information on the sugar-density of each item of food and the quantity consumed of each item, we compute the share of total sugar consumption that comes from various items.

Figure 19 shows the relative shares of dietary sugar by their sources. The patterns are very similar in our datasets for 2018 and 2019. The largest contributor to overall sugar consumption is sweet home cooking products, accounting for 16% of the total, followed by dairy products (15%) and take-home confectionery (just over 12%).

Figure 19. Top 10 product contributing to total consumption of sugar in the UK (in %).



Source: Authors' calculations from Kantar's Grocery Market Share data.

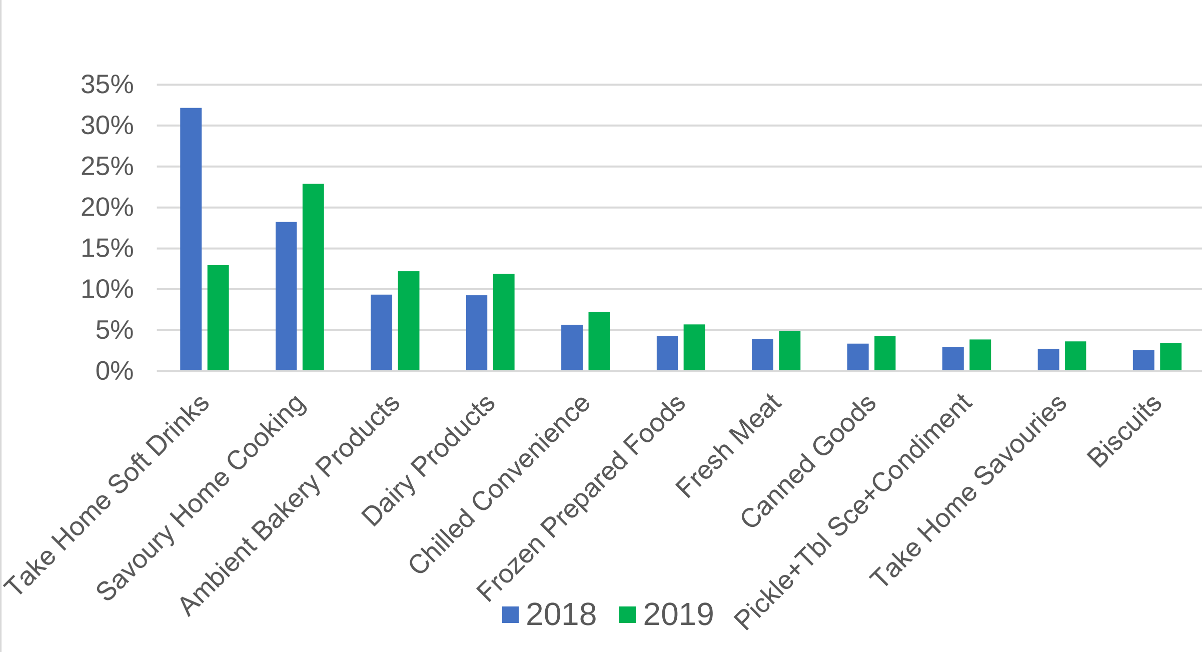
Figure 20 provides a similar breakdown of contributors to dietary sodium (that is, salt). Here the data suggests some marked changes. Take-home soft drinks accounted for 32% of all sodium consumed in 2018 but this decreased to about 13% in 2019.[13] Other products increased their contribution to total sodium consumed: savoury home cooking products (from 18% to 23%), ambient bakery products (from 9% to 12%) and dairy products (from 9% to 12%).

Figure 21 reports the source for intakes of fat. Dairy products are the largest single item here (31%), savoury home cooking (9%), chilled convenience products (9%), and ambient bakery products (8%). In this case the changes from 2018 to 2019 have also been minor.

---

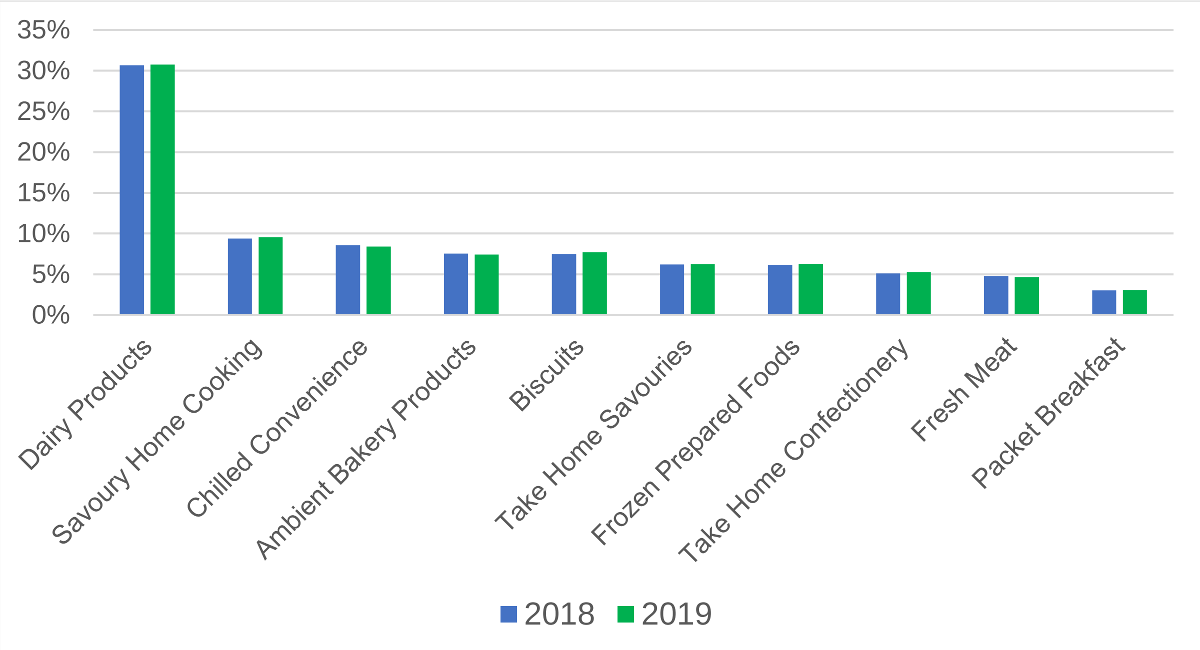
[13] That take-home soft drinks were such a significant source of dietary sodium in 2018 seems surprising and may be due to anomalies in how salt content was reported on each pack of soft drinks consumed.

Figure 20. Top 10 products contributing to total consumption of sodium in the UK (in %).



Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure 21. Top 10 products contributing to consumption of fat in the UK (in %).



Source: Authors' calculations from Kantar's Grocery Market Share data.

Tables A.2 and A.3 in the Appendix show the distributional shares for consumption for all eight nutrients from the 25 products in Category 1 considered here. We then obtained nutrient elasticities combining our data on shares of each nutrient from various items of food and drink, with our estimates of price and expenditure elasticities obtained previously. The technical details are described in the Appendix, and only summarized here.

To compute nutrient elasticities, we multiply the matrix of estimated price and expenditure elasticities (as in expression A.10 in the Appendix) by the matrix of nutrient shares accounted by each product (expression A.11 in the Appendix). In this computation we only consider those estimated elasticities that are statistically significant (90% confidence intervals). The computation of the nutrients elasticities thus relies on two components. First, on how a change in price of a product affects its demand as well as that of other products. This is what we computed in the first part of the analysis. Second, we consider what is the share of those products in the total consumption of nutrients, that is, salt, sugar, fat, etc. We add up all those cross-terms when multiplying the matrices, and we obtain a weighted average of effects. For instance, in order to understand how change in price of alcohol may change the intake of sugar, we consider the own-price elasticity of alcohol weighted by the share of sugar intake accounted by alcohol products, and also the cross-price elasticities of other products to changes in prices of alcohol multiplied by the shares of these products in total sugar intake. We add all these effects up to obtain nutrient elasticity for sugar with respect to the price of alcohol. Thus, we can see that the overall nutrient elasticities depend crucially on how consumers substitute between products of different nutrients composition.

The estimated nutrient elasticities are reported as a matrix. Each row of the matrix reports the estimated nutrient elasticities for a particular nutrient, with the typical element in this row capturing how overall demand for that nutrient changes in response to a change in the price of a specific item of food or drink, or to a change in the overall expenditure.

Tables 8 and 9 report the estimated nutrients elasticities for a small selection of products. Figures A.1-A.8 in the Appendix provide a complete report of nutrient elasticities for all eight nutrients and all 25 products.

Intake of dietary sugar

For dietary sugar, price elasticities are in the range of -0.2 to 0.3. For 2018, the products with the largest negative elasticities include chilled convenience products foods (-0.21), biscuits (-0.18), packet breakfast goods (-0.13), and dairy products (-0.12). To appreciate these magnitudes, they imply, for instance, that a 10% increase in the price of biscuits would lead to a 1.8% decrease in sugar intake. It is important to emphasise that these are partial calculations, in that the assume that the price of biscuits alone increase, with other prices and total expenditure held constant.

Some price elasticities for sugar are found to be positive, notably for alcohol products (0.25), canned goods (0.23) and frozen confectionery (0.16). This suggests, for instance, that a 10% increase in price of alcohol would lead to a 2.5% *increase* in the overall consumption of sugar, as consumers substitute away from alcohol towards other products that have a high concentration of sugar.

The expenditure elasticity for sugar is around 0.9, a value consistent with prior evidence (Tiffin, et al., 2011). This value suggests that a 10% increase in overall expenditure will lead to an increase of about 9% in sugar consumption.

Nutrient elasticities for sugar for 2019 are not dramatically different to those in 2018, with some notable differences. For 2019, the sugar elasticity of biscuit prices was close to 0 (-0.03) and the elasticity for dairy products was less negative (-0.12). In contrast, the sugar elasticity for frozen confectionery has become stronger (from -0.01 in 2018 to -0.31 in 2019).

Intake of dietary sodium

For 2018, the intake of dietary sodium shows the largest negative elasticities (most elastic) for dairy products (-0.35), fresh meat (-0.22) and savoury home cooking (-0.13). These estimates suggest for instance, in the case of dairy products, that a 10% increase in their price would reduce the overall intake of sodium by 3.5%. The nutrient elasticity of demand for sodium is positive for chilled convenience products (0.25) and frozen confectionery (0.10).

In 2019, in contrast, the intake of sodium was less elastic relative to the price dairy products (-0.08) and fresh meat (-0.06) and more elastic in the case of savoury home cooking (-0.53). Elasticity in the case of chilled convenience products was negative (-0.08), and in the case of frozen confectionery still positive and with a larger value (0.31).

Intake of dietary fat

Next, we turn to describing impact of changes in selected product prices and total food expenditure on the intake of dietary fat. The tables and Appendix also contain analogous information for saturated fats.

In 2018 the intake of dietary fat displays large negative values for elasticities with respect to the price of dairy products (-0.23) and biscuits (-0.13). A 10% increase in the price of dairy products would lead to a decrease of fat intake of about 2.3%. The impact of alcohol prices on fat intake is positive, at just below 0.2: a 10% increase in the price of alcohol would lead to overall adjustments in the food consumption that increase fat intake by 2%.

The data for 2019 finds some differences with the intake of fat becoming more sensitive to the price of chilled convenience products (price elasticity changed from -0.12 in 2018 to -0.20 in 2019) and savoury home cooking (-0.06 to -0.19). Also, the elasticity with respect to the price of take-home soft drinks was found to be positive in 2019.

Intake of other nutrients

For completeness we show the results for all relevant nutrients in tables and graphs in the Appendix (Section 9). We summarise here some findings regarding intake of other nutrients, such as proteins, carbohydrate, and dietary fibre.

For intake of proteins, the largest negative elasticities are found for ambient bakery products, canned goods and dairy products. All are close to -0.2, for both 2018 and 2019. These results suggest that a 10% increase in the price of any of these items would lead to a 2% decrease in overall intake of proteins. In contrast, the protein elasticity is positive, around 0.2, with respect to the price of frozen confectionery and alcohol, as well as take-home soft drinks. This result suggests that a 10% increase in the price of these products would lead to a 2% increase in the intake of protein.

For intake of carbohydrates, the nutrient elasticities are mostly negative. These are most elastic in the case of chilled convenience products and packet breakfast products (around -0.2) which show that carbohydrate intake decreases in response to increases in prices of these products. We show positive values again for alcohol as well as frozen confectionary.

In case of fibre elasticities, we show a little more variation between positive and negative values. The largest estimated elasticities are found for canned goods and frozen prepared goods, which both close to -0.3 (in the case of the latter in 2018 only), and savoury home cooking (around -0.2). We find the largest positive values for elasticities in the case of alcohol and frozen confectionery (both around 0.4 in 2019) and take-home soft drinks (0.3). All expenditure elasticities are close to 0.9 with slightly larger values for sodium in 2018 (0.94).

Table 8. Selected nutrient elasticities 2018

	Alcohol	*Ambient Bakery Products*	*Biscuits*	*Canned Goods*	*Chilled Convenience products*	*Dairy Products*	*Fresh Meat*	*Frozen Confectionery*	*Packet Breakfast*	*Savoury Home Cooking*	*Sweet Home Cooking*	*Take-home Confectionery*	*Expenditure*
Energy kcal	0.15	-0.07	-0.09	-0.07	-0.09	-0.17	-0.03	0.08	-0.10	-0.06	-0.04	-0.06	0.91
Protein	0.11	-0.19	-0.02	-0.21	-0.03	-0.18	0.02	0.20	-0.04	-0.07	-0.01	-0.15	0.91
Carbohydrate	0.23	-0.11	-0.12	-0.08	-0.08	-0.12	-0.04	0.16	-0.13	-0.06	-0.08	-0.04	0.89
Sugar	0.25	0.07	-0.18	0.23	-0.21	-0.26	-0.16	0.01	-0.06	0.02	-0.16	0.08	0.90
Fat	0.19	0.01	-0.13	-0.02	-0.12	-0.23	0.01	-0.02	-0.07	-0.06	-0.01	-0.10	0.90
Saturates	0.20	0.05	-0.13	0.12	-0.21	-0.33	0.01	-0.08	-0.03	0.01	-0.01	-0.08	0.87
Fibre	0.22	-0.25	-0.12	-0.31	-0.04	-0.02	0.02	0.46	-0.14	-0.16	-0.03	-0.14	0.91
Sodium	-0.09	-0.20	-0.08	0.04	0.25	-0.35	-0.22	0.10	-0.11	-0.15	-0.01	-0.13	0.94

Source: Authors' calculations from Kantar's Grocery Market Share data.

Table 9. Selected nutrient elasticities 2019

	Alcohol	*Ambient Bakery Products*	*Biscuits*	*Canned Goods*	*Chilled Convenience products*	*Dairy Products*	*Fresh Meat*	*Frozen Confectionery*	*Packet Breakfast*	*Savoury Home Cooking*	*Sweet Home Cooking*	*Take-home Confectionery*	*Expenditure*
Energy kcal	0.20	-0.06	-0.06	-0.12	-0.19	-0.14	-0.03	0.03	-0.07	-0.13	-0.04	-0.05	0.91
Protein	0.22	-0.16	-0.05	-0.17	-0.19	-0.21	-0.01	0.21	-0.06	-0.13	-0.01	-0.05	0.91
Carbohydrate	0.35	-0.13	-0.03	-0.14	-0.19	-0.09	-0.03	0.01	-0.12	-0.08	-0.08	-0.12	0.91
Sugar	0.32	-0.10	-0.03	0.08	-0.20	-0.13	-0.05	-0.31	-0.09	0.11	-0.20	-0.04	0.89
Fat	0.17	0.06	-0.16	-0.09	-0.20	-0.18	-0.04	0.03	-0.01	-0.19	0.00	0.02	0.90
Saturates	0.22	0.01	-0.17	-0.01	-0.24	-0.25	-0.03	-0.14	0.02	-0.02	0.00	-0.08	0.89
Fibre	0.34	-0.21	-0.11	-0.28	-0.15	-0.09	-0.03	0.36	-0.14	-0.20	-0.04	-0.07	0.87
Sodium	-0.04	-0.10	-0.06	-0.14	-0.12	-0.08	-0.06	0.31	0.05	-0.53	0.02	-0.10	0.91

Source: Authors' calculations from Kantar's Grocery Market Share data.

6 Policy scenarios

This section explores the implication of our results through particular policy scenarios. We examine how selective taxation of specific product types (for instance, those that are high in their sugar or salt content) might affect overall intake of various nutrients. In particular, we examine the consequences of targeting the following products with a selective tax that leads to a 10% increase in their retail price:

(i) ambient bakery goods,
(ii) biscuits,
(iii) packet breakfast goods,
(iv) savoury carbohydrates and snacks,
(v) take-home confectionery,
(vi) frozen confectionery,
(vii) chilled bakery products and
(viii) chilled convenience products.[14]

6.1 Ambient bakery products

Consider the effects of a 10% tax in the price of ambient bakery products on demand and nutrient intake. A tax will make these products relatively more expensive and also affect a household's overall expenditure on food. Hence, we look at uncompensated elasticities of demand as they capture both the substitution and income effects. Table 10 reports the uncompensated elasticities and expenditure elasticities for the year 2019, where the first column shows the food groups whose quantities are affected as a result of a price change for ambient bakery products.

We find that a 10% increase in the price of ambient bakery products would decrease its consumption by about 10%. In addition, households would also decrease their consumption of chilled drinks, and by a larger proportion (16.86%). They would also decrease their consumption of hot beverages (by 10.75%), of canned goods (by 7.53%), and of chilled convenience products foods (by 3.85%). Due to the substitution effect, the consumption of chilled bakery products and take-home savouries would increase by as much as 20.94% and 17.19%, respectively.

[14] Strictly speaking, elasticities of demand measure the impact of small or infinitesimal changes in the underlying parameters, so the estimated values are better at predicting the outcome of small changes, such as a 1% increase in price rather than a 10% increase. Nonetheless extrapolation to more significant adjustments to prices may convey a clear impression of the scope of policy interventions.

Table 10. Ambient bakery products: Uncompensated elasticities (2019)

	Uncompensated price elasticities	Expenditure elasticities
Ambient Bakery Products	-1.002	0.652
Biscuits	0.727	0.894
Canned Goods	-0.753	1.020
Chilled Bakery Products	2.094	0.957
Chilled Convenience products	-0.385	1.054
Chilled Drinks	-1.686	0.947
Hot Beverages	-1.075	1.059
Take-home Savouries	1.719	0.881

To see how a change in the price of ambient bakery products would affect the intake of nutrients we investigate the relevant nutrient elasticities. Table 11 suggests that a hypothetical 10% increase in prices of ambient bakery products would lower intake of dietary fibre (down 2.1%) and proteins (down 1.6%). Additionally, sugar and sodium intake would decrease by 1%. Intake of fat and saturated fat would be relatively unaffected, both increasing slightly, by 0.6% and 0.1%, respectively.

Table 11. Nutrient elasticities for Ambient Bakery products

Nutrient	Nutrient elasticities
Energy (kcal)	-0.06
Protein	-0.16
Carbohydrate	-0.13
Sugar	-0.10
Fat	0.06
Saturated fat	0.01
Fibre	-0.21
Sodium	-0.10

6.2 Biscuits

Next, we investigate the effects of a 10% tax in the price of biscuits on demand and nutrient intake. Table 12 reports the uncompensated price elasticities and expenditure elasticities for the year 2019, where the first column shows the product groups whose quantities would be affected as a result of a price change in biscuits.

The estimated price elasticities suggest that a 10% increase in the price of biscuits would decrease their consumption by 9.94%. It would also decrease household consumption of canned goods, frozen prepared foods, take-home savouries and more strongly frozen confectionery and chilled bakery products. Extrapolating from the estimated cross-price elasticities, households facing a 10% higher price for biscuits would consume 24.78% less of chilled bakery products and 12% less of frozen confectionery.

Perversely, a 10% increase in the price of biscuits would increase the consumption of alcohol by 8.14%, that of ambient bakery products by 3.83%, that of frozen fish by 6.13%, that of savoury carbohydrates and snacks by 9.85% and that of sweet home cooking by 6.24%.

Table 12. Biscuits: Uncompensated elasticities (2019)

	Uncompensated price elasticities	Expenditure elasticities
Alcohol	0.814	1.679
Ambient Bakery Products	0.383	0.652
Biscuits	-0.994	0.894
Canned Goods	-0.745	1.020
Chilled Bakery Products	-2.478	0.957
Frozen Confectionery	-1.199	1.044
Frozen Fish	0.613	1.228
Frozen Prepared Foods	-0.344	1.101
Savoury Carbohydrates + Snacks	0.985	0.951
Sweet Home Cooking	0.624	0.945
Take-home Savouries	-0.768	0.881

As Table 13 shows, a 10% increase in the price of biscuits would reduce the overall consumption of fat (by 1.6%) and saturated fats (by 1.7%). It would also reduce the intake of sodium, carbohydrates and sugar, but by relatively smaller proportions (0.6%, 0.3% and 0.3%, respectively).

Table 13. Nutrient elasticities for biscuits

Nutrient	Nutrient elasticities
Energy (kcal)	-0.06
Protein	-0.05
Carbohydrate	-0.03
Sugar	-0.03
Fat	-0.16
Saturated fat	-0.17
Fibre	-0.11
Sodium	-0.06

6.3 Packet breakfast goods

We then turn to the investigation of the effects of a 10% tax on the price of packet breakfast[15] on demand and nutrient intake. Table 14 reports the uncompensated elasticities and expenditure elasticities for the year 2019, where the first column shows the group of products whose quantities are affected as a result of a price change in packet breakfast.

An increase of 10% in the price of packet breakfast goods would reduce its demand by 8.49%. In addition, it would also reduce household consumption of savoury carbohydrates and snacks by 5.97% and sweet home cooking by 6.17%. On the other hand, the demand for frozen confectionery would increase by 11.47% and the demand of take-home soft drinks by 5.36% as a consequence of the tax.

Table 14. Packet breakfast: Uncompensated elasticities (2019)

	Uncompensated price elasticities	Expenditure elasticities
Frozen Confectionery	1.147	1.044
Frozen Poultry+Game	-1.802	1.363
Packet Breakfast	-0.849	0.942
Savoury Carbohydrates+Snacks	-0.597	0.951
Sweet Home Cooking	-0.617	0.945
Take-home Soft Drinks	0.536	0.997

Table 15 below illustrates the extent to which the intake of several nutrients would be affected. We find that a 10% increase in the price of packet breakfast would lead to a decrease in the intake of fibre by 1.4%, of carbohydrate by 1.2% and sugar by 0.9%. It would have relatively little impact on the consumption of fat (which would be reduced by only 0.1%), on the intake of sodium (increase by 0.5%) and saturated fat (increases by 0.2%).

Table 15. Nutrient elasticities for Packet breakfast

Nutrient	Nutrient elasticities
Energy (kcal)	-0.07
Protein	-0.06
Carbohydrate	-0.12
Sugar	-0.09
Fat	-0.01
Saturated fat	0.02
Fibre	-0.14
Sodium	0.05

[15] Packet breakfast goods includes breakfast cereals, ambient pastes and spreads, ambient sandwich fillers, chocolate spread, honey, peanut butter, preserves and toaster pastries.

6.4 Savoury carbohydrates and snacks

We consider now the effects of a 10% tax on the price of savoury carbohydrates and snacks on demand and nutrient intake. Table 16 reports the uncompensated elasticities and expenditure elasticities for the year 2019, where the first column shows the food groups whose quantities are affected as a result of a price change in savoury carbohydrates and snacks.

A 10% tax on savoury carbohydrates and snacks would decrease its own demand and also the demand for canned goods, chilled bakery products, frozen prepared foods, packet breakfast and for frozen poultry and game, with the effect on the latter being the strongest. That is, a 10% increase in the price of savoury carbohydrates and snacks would decrease consumption of frozen poultry and game by 31.59%.

Increasing the price of savoury carbohydrates and snacks by 10% would increase the demand of biscuits by 4.31%, of chilled drinks by 8.92%, of frozen confectionery by 6%, of sweet home cooking by 3.49% and of take-home savouries by 2.76%.

Table 16. Savoury carbohydrates and snacks: Uncompensated elasticities (2019)

	Uncompensated price elasticities	Expenditure elasticities
Biscuits	0.431	0.894
Canned Goods	-0.431	1.020
Chilled Bakery Products	-1.313	0.957
Chilled Drinks	0.892	0.947
Frozen Confectionery	0.600	1.044
Frozen Poultry + Game	-3.159	1.363
Frozen Prepared Foods	-0.293	1.101
Packet Breakfast	-0.341	0.942
Savoury Carbohydrates + Snacks	-1.526	0.951
Sweet Home Cooking	0.349	0.945
Take-home Savouries	0.276	0.881

In Table 17 below we see the nutrient elasticities estimated in response an increase in the price of savoury carbohydrates and snacks. A 10% increase in these prices would mostly lead to a reduced intake of fibre (by 1.3%), protein (by 0.8%) and sodium (by 0.3%). The tax on carbohydrates and snacks would also lead to a rise in the consumption of sugar by 1%, saturated fat by 0.3% and fat by 0.1%.

Table 17. Nutrient elasticities for carbohydrates and snacks

Nutrient	Nutrient elasticities

Energy (kcal)	-0.02
Protein	-0.08
Carbohydrate	-0.04
Sugar	0.10
Fat	0.01
Saturated fat	0.03
Fibre	-0.13
Sodium	-0.03

6.5 Take-home confectionery

Next, we look at the effects of a 10% tax on the price of take-home confectionery on demand and nutrient intake. Table 18 reports the uncompensated elasticities and expenditure elasticities for the year 2019, where the first column shows the food groups whose quantities are affected as a result of a price change in take-home confectionery.

Table 18. Take-home confectionery uncompensated elasticities (2019)

	Uncompensated price elasticities	Expenditure elasticities
Alcohol	0.475	1.679
Ambient Slimming Products	-1.730	1.312
Biscuits	-0.187	0.894
Canned Goods	-0.278	1.020
Chilled Bakery Products	-0.340	0.957
Chilled Convenience products	-0.238	1.054
Chilled Drinks	-0.185	0.947
Dairy Products	-0.138	0.746
Fresh Fish	-0.177	1.181
Fresh Meat	-0.183	1.214
Frozen Confectionery	-0.385	1.044
Frozen Fish	-0.151	1.228
Frozen Poultry + Game	-1.100	1.363
Frozen Prepared Foods	-0.134	1.101
Hot Beverages	-0.222	1.059
Packet Breakfast	-0.205	0.942
Pickle + Tbl Sce + Condiment	-0.173	0.971
Savoury Carbohydrates + Snacks	-0.268	0.951
Savoury Home Cooking	-0.091	0.989
Sweet Home Cooking	0.109	0.945
Take-home Confectionery	0.826	0.857
Take-home Savouries	0.186	0.881
Take-home Soft Drinks	-0.118	0.997

Increasing the price of take-home confectionery by 10% would result in a decrease in demand for a range of products: ambient slimming products, biscuits, canned goods, chilled bakery products, chilled convenience products, chilled drinks, dairy products, fresh fish, fresh meat, frozen confectionery, frozen fish, frozen poultry and game, frozen prepared foods, hot beverages, packet breakfast, pickles, table sauces and condiments, savoury carbohydrates and snacks, savoury home cooking and take-home soft drinks. The largest impact is on ambient slimming products. Thus, a 10% in the price of take-home confectionery would decrease the demand for ambient slimming products by 17.3%.

In contrast, households facing a 10% higher price in take-home confectionery would increase their consumption of alcohol by 4.75%, sweet home cooking by 1.09%, take-home savouries by 1.86% and take-home confectionery by 8.26%.

Table 19 illustrates nutrient elasticities estimates for take-home confectionery. A 10% tax on take-home confectionary would result in decreases of fibre and sodium consumption of 1% and 1.1% respectively. In contrast, this would also lead to an increase in intake of sugar of 0.2%.

Table 19. Nutrient elasticities for take-home confectionery

Nutrient	Nutrient elasticities
Energy (kcal)	-0.05
Protein	-0.12
Carbohydrate	-0.04
Sugar	0.02
Fat	-0.08
Saturated fat	-0.07
Fibre	-0.10
Sodium	-0.11

6.6 Frozen confectionery

Next, we investigate the effects of a 10% tax on the price of frozen confectionery on demand and nutrient intake. Table 20 reports the uncompensated elasticities and expenditure elasticities for the year 2019, where the first column shows the foods whose quantities are affected as a result of a price change in frozen confectionery.

The cross-price elasticities show that households facing a 10% higher price for frozen confectionery would decrease their consumption of frozen confectionery by 48%. They would also reduce their consumption of alcohol, biscuits, chilled drinks, pickle, table sauces and condiment, sweet home cooking, take-home savouries, and take-home soft drinks.

However, an increase in the price of frozen confectionery would lead to an increase in the demand of a range of goods: canned goods, frozen meat, frozen poultry and game, frozen prepared foods, hot beverages, packet breakfast, savoury carbohydrates and snacks, and savoury home cooking. The largest impact is on frozen poultry and game, with a 10% increase in the price of frozen confectionery leading to an increase in the demand of frozen poultry and game of 64.55%.

Table 20. Frozen confectionery: Uncompensated elasticities (2019)

	Uncompensated price elasticities	Expenditure elasticities
Alcohol	-0.705	1.679
Biscuits	-0.577	0.894
Canned Goods	1.869	1.020
Chilled Drinks	-0.932	0.947
Frozen Confectionery	-4.800	1.044
Frozen Meat	1.404	1.330
Frozen Poultry + Game	6.455	1.363
Frozen Prepared Foods	1.052	1.101
Hot Beverages	0.541	1.059
Packet Breakfast Cereals	0.728	0.942
Pickle + Tbl Sce + Condiment	-1.803	0.971
Savoury Carbohydrates + Snacks	0.667	0.951
Savoury Home Cooking	1.624	0.989
Sweet Home Cooking	-0.467	0.945
Take-home Savouries	-0.432	0.881
Take-home Soft Drinks	-0.711	0.997

Table 21 illustrates changes to nutrients as a consequence of a price change affecting frozen confectionery. We see that saturated fat consumption would decrease by 1.4% and sugar intake by just over 3.1% after a 10% tax on these products. In contrast, this tax would lead to an increase in the consumption of fibre, sodium and protein, by 3.6%, 3.1% and 2.1%, respectively.

Table 21. Nutrient elasticities for frozen confectionery

Nutrient	Nutrient elasticities
Energy (kcal)	0.03
Protein	0.21
Carbohydrate	0.01
Sugar	-0.31
Fat	0.03
Saturated fat	-0.14
Fibre	0.36
Sodium	0.31

6.7 Chilled bakery products

Next, we focus on the effects of a 10% tax on the price of chilled bakery products on demand and nutrient intake. Table 22 reports the uncompensated price elasticities and expenditure elasticities for the year 2019, where the first column shows the food categories whose quantities are affected as a result of a price change in chilled bakery products.

We find that a tax on chilled bakery products decreases its own demand, and also the demand for biscuits, canned goods, frozen meat, frozen poultry and game, packet breakfast, savoury carbohydrates and snacks, savoury home cooking, and sweet home cooking. The impact is large for frozen meat, with a 10% increase in the price of chilled bakery products resulting in a reduction in demand for frozen meat by 6.77%.

Conversely, a 10% increase in the price of chilled bakery products would increase the demand of ambient bakery products by 1.73%, pickles, table sauces and condiment by 4.11% and take-home soft drinks by 2.88%.

Table 22. Chilled bakery products: Uncompensated elasticities (2019)

	Uncompensated price elasticities	Expenditure elasticities
Ambient Bakery Products	0.173	0.652
Biscuits	-0.394	0.894
Canned Goods	-0.330	1.020
Chilled Bakery Products	-0.302	0.957
Frozen Meat	-0.677	1.330
Frozen Poultry + Game	-0.760	1.363
Packet Breakfast	-0.166	0.942
Pickle + Tbl Sce + Condiment	0.411	0.971
Savoury Carbohydrts + Sncks	-0.479	0.951
Savoury Home Cooking	-0.259	0.989
Sweet Home Cooking	-0.277	0.945
Take-home Soft Drinks	0.288	0.997

Table 23. Nutrient elasticities for chilled bakery products.

Nutrient	Nutrient elasticities
Energy (kcal)	-0.06
Protein	-0.04
Carbohydrate	-0.07
Sugar	-0.07
Fat	-0.05
Saturated fat	-0.05
Fibre	-0.07
Sodium	-0.02

Table 23 below shows that the nutrient responses to a change in chilled bakery products are relatively more minor, compared to changes in other products. A 10% tax in chilled bakery products will decrease intake of sugar, carbohydrates, and fibre by 0.7%. Intake of fat and saturated fat would also decrease by 0.5%, consumption of protein by 0.4% and sodium by 0.2%.

6.8 Chilled convenience products

We investigate the effects of a 10% tax on the price of chilled convenience products foods on demand and nutrient intake. Table 24 reports the uncompensated elasticities and expenditure elasticities for the year 2019, where the first column shows the groups whose quantities are affected as a result of a price change of chilled convenience products foods.

Increasing the price of chilled convenience products by 10% would result in a decrease in household consumption of chilled convenience products, packet breakfast and take-home confectionery by around 5%. It would also reduce the demand for dairy products by 3.29%. However, the 10% tax in chilled convenience products would increase the demand of canned goods, chilled bakery products and savoury carbohydrates and snacks by 6.36%, 13.11% and 7.96%, respectively.

Table 24. Chilled convenience products: Uncompensated elasticities (2019)

	Uncompensated price elasticities	Expenditure elasticities
Canned Goods	0.636	1.020
Chilled Bakery Products	1.311	0.957
Chilled Convenience products	-0.502	1.054
Dairy Products	-0.329	0.746
Packet Breakfast	-0.515	0.942
Savoury Carbohydrates+Snacks	0.796	0.951
Take-home Confectionery	-0.533	0.857

Finally, a 10% tax in chilled convenience products would lead to sizeable decreases in intake of saturated fat and fats, sugar, carbohydrates, and protein, all by around 2% (Table 25). The consumption of fibre and sodium would also decrease by 1.5% and 1.2%, respectively.

Table 25. Nutrient elasticities for chilled convenience products

Nutrient	Nutrient elasticities
Energy (kcal)	-0.19
Protein	-0.19
Carbohydrate	-0.19
Sugar	-0.20
Fat	-0.20
Saturated fat	-0.24
Fibre	-0.15
Sodium	-0.12

7 Conclusions

This report provides econometric estimates of elasticities of demand for a range of food and drink products for UK households. These estimates of elasticity assess the sensitivity of demand for food and drink to prices and to consumers' overall expenditure, the latter as a proxy for their income. Our estimates are based on data for two years, 2018 and 2019, drawn from Kantar's Grocery Market Share database, which covers the grocery purchasing habits of more than 30,000 demographically representative households.

For a range of items of food and drink at different levels of disaggregation we estimate own-price elasticities of demand, which measure the sensitivity of consumers' demand to the price of the good in question. We also estimate cross-prices elasticities, which measure the sensitivity of demand for a product to the price of closely-related products, thereby uncovering relationships of substitution and complementarity across products.

Large changes in the price of products, especially those that alter the price of goods that form a significant share of total expenditure, affect real disposable income. We estimate the size of these income elasticities, using total expenditure as a proxy. When computing price elasticities, we can either compute uncompensated price elasticities (which capture both the substitution effect and income effect of price changes) or compensated price elasticities (which focus on the substitution effect alone, by stripping out the effect of price changes on real incomes).

We find that the estimated demand elasticities in our data are very stable across the two years, 2018 and 2019, and that compensated and uncompensated elasticities are broadly similar. It is doubtful however that this stability will be maintained in the current setting where food price inflation has been significantly higher than in the past.

As we might expect, and in line with standard economic theory, the price elasticity of demand for most products is found to be negative: that is, the demand for most products falls when their price rises, but this sensitivity varies across products. Consumers' price responsiveness is high in the case of alcohol, so that an increase in price can lead to significant reduction in alcohol purchases. Price sensitivity is high also for product categories such as frozen confectionery, savoury home cooking, and take-home savouries.

Also, in line with expectations, price sensitivities differ across socio-demographic groups. The demand for alcohol is especially responsive to price changes for the group identified as 'skilled working-class families'. For the group identified as 'administrative clerks and professionals' demand is also quite sensitive to prices of other categories in the food basket, such as dairy products, consumed quite widely across households. Given the recent increase in food-price inflation, there is the possibility of worrying impact on the consumption basket for vulnerable groups.

We find that income or expenditure elasticities also vary across different items in the food and drinks consumption basket. The demand for alcohol is quite sensitive to income of households: as income increases, the demand for alcohol increases more than proportionately, which would lead alcohol to be classified as a 'luxury' good. Other products whose demand varies significantly with income include fresh lamb, smoked fish and fresh bacon joint. In contrast, we see that consumption of dairy products does not vary as much with incomes, fitting the standard description of 'necessities'.

We also estimate cross-price elasticities to examine how changes in prices of one good affect the demand for other goods. We find evidence of a small but complementary relationship between a range of goods that are relatively high in sugar. For instance, when the price of take-home confectionery increases there is a reduction in the quantity demanded of several products (biscuits, chilled bakery products, chilled convenience products, frozen confectionery, dairy products, frozen prepared foods, hot beverages, packet breakfast, take-home soft drinks – all goods that are also relatively high in sugar), though the impact on demand is small. The demand for dairy products is generally invariant to the price of other products.

We also investigate how pricing of various products affects the household intake of nutrients. There is growing policy concern that foods that are high in fat, salt or sugar (HFSS) foods contribute to obesity and increased incidence of cardiovascular disease. To the extent these specific nutrients – fat, salt and sugar – may be obtained from a variety of food and drink items, attempts to limit their intake requires us to consider the impact on prices on the entire consumption basket. For instance, a tax on a specific category of food or drink (such as the recently introduced levy on sugary soft drinks) will have only limited impact on overall sugar consumption if it induces substitution only away from sugary drinks to other sugar-dense foods. We compute nutrient elasticities to capture the overall effect of such specific taxes. These provide as useful guide to policy priorities. For instance, in our data the elasticity of overall sugar intake to the price of soft drinks is in the range of -0.02 to -0.11, which suggests that further increases in the prices of soft drinks will have relatively small effects on sugar consumption. Taxing take-home confectionery might even have a perverse effect, increasing overall sugar intake because of an induced substitution towards other sugar-dense products. In fact, among the range of products considered, a tax on frozen confectionary is likely to lead to the strongest reduction in overall consumption. Going beyond sugar consumption, our analysis of nutrient elasticities can provide a rough guide for limiting intake of other nutrients, such as salt and fat. One effective way to limit all three -- sugar, salt and fat – might be through taxing of chilled convenience products.

There is growing concern about the impact of food consumption choices on our physical environment. Every stage in the cycle of food production, distribution, and consumption has significant impact on the environment, with different categories of food varying in their overall impact. The production and distribution of meat, for instance, might have very different impact on patterns of land and water use, and emissions of harmful gases, from fruit and vegetable. Just as nutrient elasticities allow us to compute the overall impact of food price changes on the overall intake of nutrients of concern, our model can be adapted to evaluate the overall impact of food and drinks prices and choices on environmental variables of concern. A more complete analysis along these lines will enable us to develop a food strategy that prioritises health in the broadest sense, both for the population and the planet.

Acknowledgements

We would like to thank Prof. Martin Weale for valuable comments and suggestions on earlier drafts of this paper. We also acknowledge the financial support of the Department for Environment, Food and Rural Affairs (Defra). Any errors are our own.

8 References

Blundell, R., and J.M. Robin. (1999). Estimation in large and disaggregated demand systems: An estimator for conditionally linear systems. *Journal of Applied Econometrics*.

Deaton, A., and J. Muellbauer (1980). *Economics and Consumer Behavior*. Cambridge: Cambridge University Press.

Huang, K.S. (1996), 'Nutrient elasticities in a complete food demand system,' *American Journal of Agricultural Economics*, 78:21–29.

Huang, K.S. (1999), ‘Effects of food prices and consumer income on nutrient availability,’ *Applied Economics*, 31: 367–380.

Tiffin, R., Balcombe, K., Salois, M., and Kehlbacher, A. (2011). ‘Estimating food and drink elasticities’. *Reading: University of Reading*.

9 Appendices

9.1 The Almost Ideal Demand System

The Almost Ideal Demand System (AIDS) is often used in the literature to model consumer demand with household data. This study uses the AIDS model of Deaton and Muellbauer (1980) corrected to take into account the Iterated Linear Least Square (ILLS) developed by Blundell and Robin (1999). The AIDS model has the following attributes: (i) it is a first order approximation to any demand system; (ii) it satisfies the axioms of choice; and (iii) it aggregates over consumers.

The model allows us to compute budget, (un)compensated price elasticities and cross-price elasticities. In addition, socio-demographic characteristics can be added to the demand system to account for household heterogeneity, although this does not constrain the shares to lie between zero and one.

In the international trade literature, it is common to use a Poisson quasi-maximum likelihood or negative binomial models for over-dispersed count data and there are generalisations.[16] The shares data used in the AIDS model are not count data and strictly the model assumes no corner solutions at zero. AIDS also does not, as noted, constrain the predicted shares to lie in the zero one interval, though this is not a particular problem if the parameter of interest is the elasticity.

The starting point of the model is the expenditure function given by:

$$\ln m_t = \ln(p_t, U_t) = \alpha_0 + \sum_i \alpha_i \ln p_{it} + \frac{1}{2}\sum_i \sum_j {\gamma_{ij}}^* \ln p_{it} \ln p_{jt} + U_t\, \beta_0 \prod_i p_{it}^{\beta_i} \qquad (A.1)$$

where m_t is total expenditure at time t, p_{it} is the price of good i at time t, $\gamma, \beta,$ and α are coefficients. U_t is utility level at time t.

[16] A recent survey is Bellego, C., D. Benatia and L.-D. Pape. (2021), Dealing with logs and zeros in regression models, SSRN.

Marshallian (uncompensated) demand functions can be derived from the expenditure function above by applying Shephard's Lemma and replacing the unobservable utility level by the indirect utility function that corresponds to the expenditure function (Deaton and Muellbauer 1980):

$$x_{it}(p_t, m_t) = \frac{m_t}{p_{it}}\left(\alpha_i + \sum_j \gamma_{ij} \ln p_{jt} + \beta_i \ln(m_t/P_t)\right) \qquad \text{(A.2)}$$

where x_{it} is the consumed quantity of good i, $\gamma_{ij} = \gamma_{ij}{}^{*} + \gamma_{ji}{}^{*}$, and P_t is a translog price index.

$$\ln P_t = \alpha_0 + \sum_i \alpha_i ln\, p_{it} + \tfrac{1}{2}\sum_i \sum_j \gamma_{ij} \ln p_{it} \ln p_{jt} \qquad \text{(A.3)}$$

The demand equations of the AIDS model can be simplified by expressing them as expenditure shares:

$$s_{it}(p_t, m_t) = \alpha_i + \sum_j \gamma_{ij} \ln p_{jt} + \beta_i \ln(m_t/P_t) \qquad \text{(A.4)}$$

where $s_{it} = x_{it} p_{it}/m_t$ is the expenditure share of good i.

Several restrictions are imposed on the coefficients, given microeconomic household theoretical considerations. An adding up restriction ensures that expenditures shares always sum up to 1, that is, $\sum_i s_i$ This is ensured if the following conditions are met:

$$\sum_i \alpha_i = 1;\ \sum_i \beta_i = 0\,;\ \sum_i \gamma_{ij} = 0 \ \ \forall j$$

For the econometric estimation of such model, we substitute the observed (stochastic) budget shares w_{it} for the (unobservable) deterministic budget shares s_{it} and add disturbance terms (u_{it}). We arrive at a system of equations that can be econometrically estimated:

$$w_{it}(p_t, m_t) = \alpha_i + \sum_j \gamma_{ij} \ln p_{jt} + \beta_i \ln(m_t/P_t) + \sum_k \mu_{i,k} d_{i,k} + u_{it} \qquad \text{(A.5)}$$

where $d_{i,k}$ is the k-th demographic characteristic.

9.2 Computing Nutrient Elasticities

This section describes the technical steps that allow us to translate elasticities of demand for products (both price and expenditure elasticities) into elasticities of demand for nutrient contained in those products. The steps build on the methodology developed by Huang (1996).

Consider a list of L nutrients, with typical nutrient l. These nutrients may be obtained from any of *n* possible items of food, with typical food item denoted by *i.* Let $a_{l,i}$ be the amount of the l^{th} nutrient obtained from consumption of each unit of the i^{th} food item. The total amount φ_l of nutrient l obtained from various foods, is given by:

$$\varphi_l = \sum_{i=1}^{n} a_{l,i}\, q_i \tag{A.6}$$

where q_i is the quantity good i and $a_{l,i}$ is the density of nutrient l in one unit of good i.

Define $s_{l,i}$ to be the mean share of nutrient l obtained from good i.

$$s_{l,i} = \frac{a_{l,i} q_i}{\varphi_l} \tag{A.7}$$

Let S be the matrix of nutrient shares from various sources: this is of order Lxn.

$$S = \begin{bmatrix} s_{1,1} & \cdots & s_{1,n} \\ \vdots & \ddots & \vdots \\ s_{l,1} & \cdots & s_{l.n} \end{bmatrix} \tag{A.8}$$

$$\sum_{i=1}^{n} s_{l,i} = 1 \tag{A.9}$$

Each row of matrix S captures the shares of that nutrient from various food sources, with the elements of the row adding to 1.

Let D be a matrix of uncompensated demand elasticities, estimated for the demand system. D is a matrix of order n x $(n+1)$ containing all own-price and cross-price elasticities for n goods, plus a column vector that captures the expenditure elasticities $d_{i,m}$ for the n goods.

$$D = \begin{bmatrix} d_{11} & \cdots & d_{1,n} & d_{1,m} \\ \vdots & \ddots & \vdots & \vdots \\ d_{n,1} & \cdots & d_{n,n} & d_{n,m} \end{bmatrix} \qquad (A.10)$$

The nutrient elasticity matrix N, for the case of L nutrients and n food products can then be obtained as a product of the two matrices S and D:

$$N = S * D \qquad (A.11)$$

The matrix N of nutrient elasticities is of order L x $(n+1)$, where $e_{l,i}$ denotes the nutrient elasticity of demand for the l-th nutrient with respect to the price of the *i*-th item of food, and $e_{l,m}$ denotes the nutrient elasticity for the *l*-th nutrient with respect to expenditure m.

$$N = \begin{bmatrix} e_{1,1} & \cdots & e_{1,n} & e_{1,m} \\ \vdots & \ddots & \vdots & \vdots \\ e_{l,1} & \cdots & e_{l,n} & e_{l,m} \end{bmatrix} \qquad (A.12)$$

9.3 B: Tables

Table A1: Categories codes

Category 0		**Category 2**			
1	Total Alcohol	1	Ambient Rice+Svry Noodles	31	Frozen Other Meat & Offal
2	Total Ambient Groceries	2	Ambient Vgtrn Products	32	Frozen Pork
3	Total Fresh+Chilled	3	Butter	33	Frozen Ready Meals
4	Total Frozen	4	Canned Vegetables	34	Frozen Sausages
Category 1		5	Chilled Burgers+Grills	35	Frozen Vegetables
1	Alcohol	6	Chilled Prepared Fish	36	Frozen Vegetarian Prods
2	Ambient Bakery Products	7	Chilled Prepared Frt+Veg	37	Fruit
3	Ambient Slimming Products	8	Chilled Prepared Salad	38	Margarine
4	Biscuits	9	Chilled Processed Poultry	39	Mineral Water
5	Canned Goods	10	Chilled Ready Meals	40	Nuts
6	Chilled Bakery Products	11	Chilled Vegetarian	41	Shellfish
7	Chilled Convenience products	12	Cooked Meats	42	Sugar
8	Chilled Drinks	13	Cooked Poultry	43	Total Bread
9	Dairy Products	14	Cooking Oils	44	Total Cheese
10	Fresh Fish	15	Dry Pasta	45	Total Milk
11	Fresh Meat	16	Eggs	46	Vegetable
12	Frozen Confectionery	17	Flour	47	Wet/Smoked Fish
13	Frozen Fish	18	Fresh Bacon Joint	48	Yoghurt
14	Frozen Meat	19	Fresh Bacon Rashers		
15	Frozen Poultry+Game	20	Fresh Bacon Steaks		
16	Frozen Prepared Foods	21	Fresh Beef		
17	Hot Beverages	22	Fresh Cream		
18	Packet Breakfast	23	Fresh Lamb		
19	Pickle+Tbl Sce+Condiment	24	Fresh Other Meat & Offal		
20	Savoury Carbohydrts+Sncks	25	Fresh Pork		
21	Savoury Home Cooking	26	Fresh Poultry		
22	Sweet Home Cooking	27	Fresh Sausages		
23	Take-home Confectionery	28	Frozen Bacon		
24	Take-home Savouries	29	Frozen Beef		
25	Take-home Soft Drinks	30	Frozen Lamb		

Table A.2. Share of total nutrients accounted for by each product, in percentages (%), 2018.

	Energy kcal	***Protein***	***Carbo-hydrate***	***Sugar***	***Fat***	***Saturates***	***Fibre***	***Sodium***
Alcohol	3.05	0.27	0.90	1.37	0.02	0.02	0.01	0.15
Ambient Bakery Products	14.60	14.46	21.22	9.96	7.54	6.96	23.37	9.36
Ambient Slimming Products	0.02	0.03	0.02	0.02	0.01	0.01	0.05	0.01
Biscuits	7.53	3.61	8.99	8.62	7.50	9.59	7.09	2.60
Canned Goods	2.40	5.34	2.43	2.39	1.32	1.00	8.80	3.36
Chilled Bakery Products	0.78	0.50	0.84	0.69	0.87	1.12	0.49	0.25
Chilled Convenience products	6.67	9.60	4.78	2.99	8.55	8.24	6.99	5.67
Chilled Drinks	0.73	0.42	1.33	2.90	0.09	0.12	0.52	0.08
Dairy Products	18.02	26.75	7.07	15.44	30.66	39.55	1.40	9.29
Fresh Fish	0.21	0.76	0.06	0.02	0.24	0.11	0.06	0.21
Fresh Meat	3.12	9.66	0.33	0.18	4.79	4.92	0.80	3.97
Frozen Confectionery	2.44	1.11	2.65	4.71	2.80	4.84	1.40	0.38
Frozen Fish	0.66	1.69	0.43	0.05	0.67	0.23	0.42	0.62
Frozen Meat	0.14	0.33	0.05	0.01	0.22	0.23	0.08	0.16
Frozen Poultry+Game	0.04	0.25	0.00	0.00	0.03	0.02	0.01	0.04
Frozen Prepared Foods	6.62	8.47	6.66	1.50	6.15	4.52	13.47	4.29
Hot Beverages	0.56	0.62	0.80	1.30	0.34	0.69	2.07	0.31
Packet Breakfast	6.78	5.19	10.36	7.65	3.04	1.88	14.68	1.47
Pickle+Tbl Sce+Condiment	1.73	0.33	1.27	2.42	2.82	0.67	1.25	2.98
Savoury Carbohydrts+Sncks	2.68	2.67	4.48	0.30	0.63	0.45	3.68	0.54
Savoury Home Cooking	5.94	2.63	4.32	1.61	9.39	3.94	4.43	18.22
Sweet Home Cooking	4.05	0.76	7.76	16.52	0.96	1.22	1.52	0.54
Take-home Confectionery	5.18	1.88	6.47	12.31	5.11	7.75	2.30	0.59
Take-home Savouries	4.49	2.43	3.85	0.71	6.19	1.86	4.74	2.74
Take-home Soft Drinks	1.55	0.24	2.94	6.33	0.05	0.05	0.38	32.16
TOTAL	100	100	100	100	100	100	100	100

Source: Authors' calculations from Kantar's Grocery Market Share data.

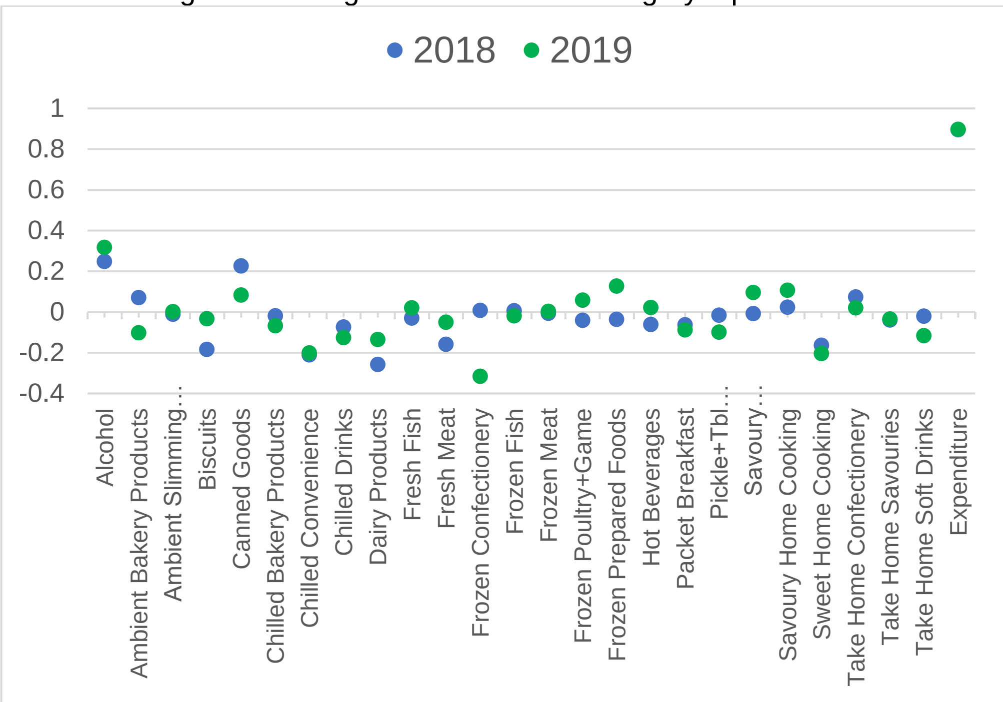
Table A.3. Share of total nutrients accounted for by each product, in percentages (%), 2019.

	Energy kcal	***Protein***	***Carbo-hydrate***	***Sugar***	***Fat***	***Saturates***	***Fibre***	***Sodium***
Alcohol	3.03	0.26	0.94	1.47	0.03	0.03	0.01	0.21
Ambient Bakery Products	14.57	14.60	21.22	9.98	7.41	6.78	23.04	12.21
Ambient Slimming Products	0.02	0.03	0.02	0.02	0.01	0.01	0.04	0.01
Biscuits	7.76	3.74	9.29	9.04	7.70	9.76	7.23	3.45
Canned Goods	2.41	5.33	2.44	2.38	1.31	0.98	8.79	4.30
Chilled Bakery Products	0.72	0.46	0.77	0.62	0.79	0.97	0.46	0.30
Chilled Convenience products	6.65	9.52	4.86	3.03	8.40	8.16	6.80	7.25
Chilled Drinks	0.71	0.42	1.31	2.90	0.08	0.11	0.50	0.10
Dairy Products	18.00	26.65	6.92	15.32	30.75	39.84	1.43	11.89
Fresh Fish	0.23	0.80	0.07	0.02	0.28	0.12	0.07	0.30
Fresh Meat	3.05	9.55	0.30	0.18	4.64	4.82	0.76	4.93
Frozen Confectionery	2.27	1.03	2.50	4.46	2.56	4.47	1.37	0.49
Frozen Fish	0.64	1.65	0.42	0.05	0.65	0.22	0.38	0.82
Frozen Meat	0.14	0.31	0.05	0.01	0.20	0.21	0.08	0.19
Frozen Poultry+Game	0.04	0.22	0.00	0.00	0.03	0.02	0.01	0.05
Frozen Prepared Foods	6.82	8.66	6.92	1.56	6.30	4.61	13.60	5.72
Hot Beverages	0.57	0.64	0.79	1.30	0.35	0.71	2.31	0.41
Packet Breakfast	6.76	5.22	10.35	7.60	3.04	1.87	14.38	1.84
Pickle+Tbl Sce+Condiment	1.72	0.32	1.25	2.42	2.80	0.66	1.30	3.88
Savoury Carbohydrts+Sncks	2.66	2.65	4.46	0.31	0.64	0.47	3.76	0.72
Savoury Home Cooking	6.02	2.60	4.34	1.65	9.54	4.06	4.46	22.89
Sweet Home Cooking	3.97	0.74	7.60	16.46	0.96	1.21	1.66	0.66
Take-home Confectionery	5.31	1.91	6.67	12.88	5.24	7.98	2.54	0.81
Take-home Savouries	4.56	2.46	3.94	0.75	6.25	1.87	4.68	3.63
Take-home Soft Drinks	1.36	0.21	2.56	5.59	0.04	0.04	0.35	12.96
TOTAL	100	100	100	100	100	100	100	100

Source: Authors' calculations from Kantar's Grocery Market Share data.

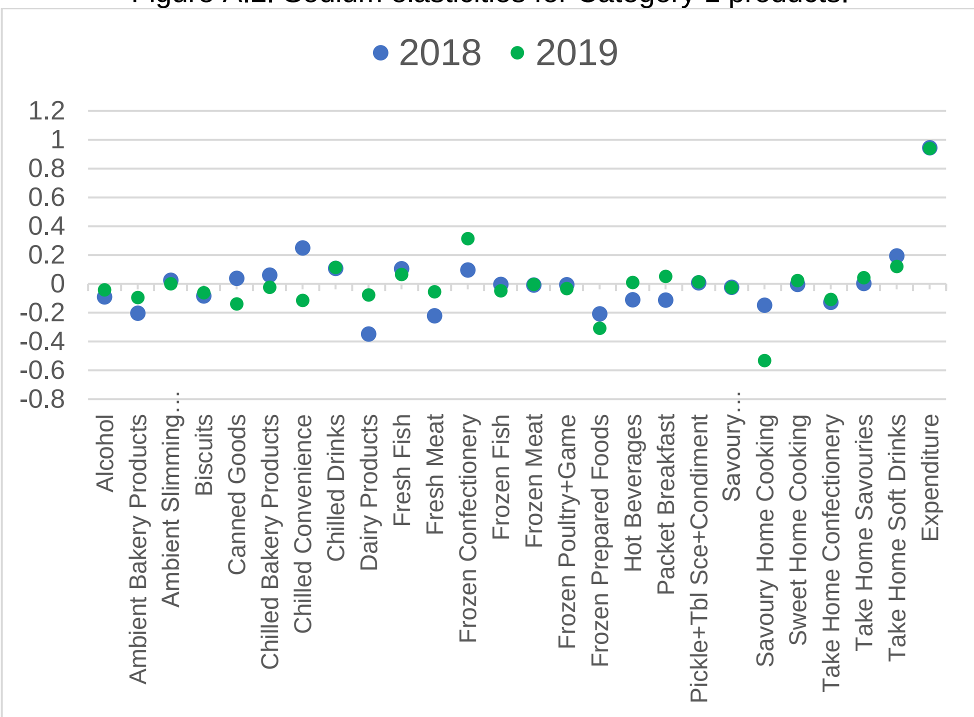
9.4 C: Graphs

Figure A.1. Sugar elasticities for Category 1 products.



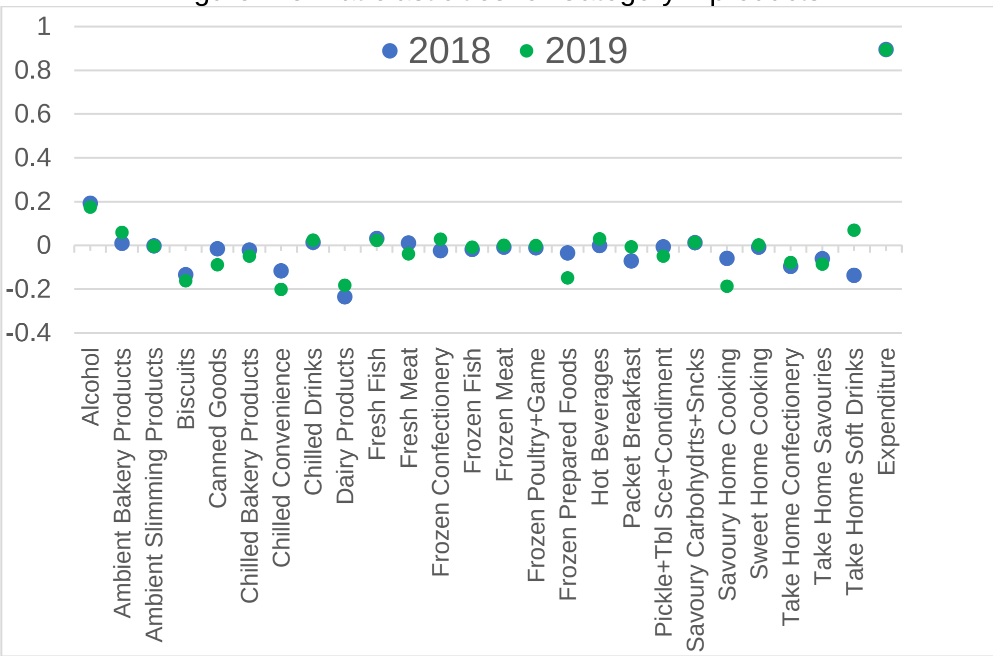
Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure A.2. Sodium elasticities for Category 1 products.



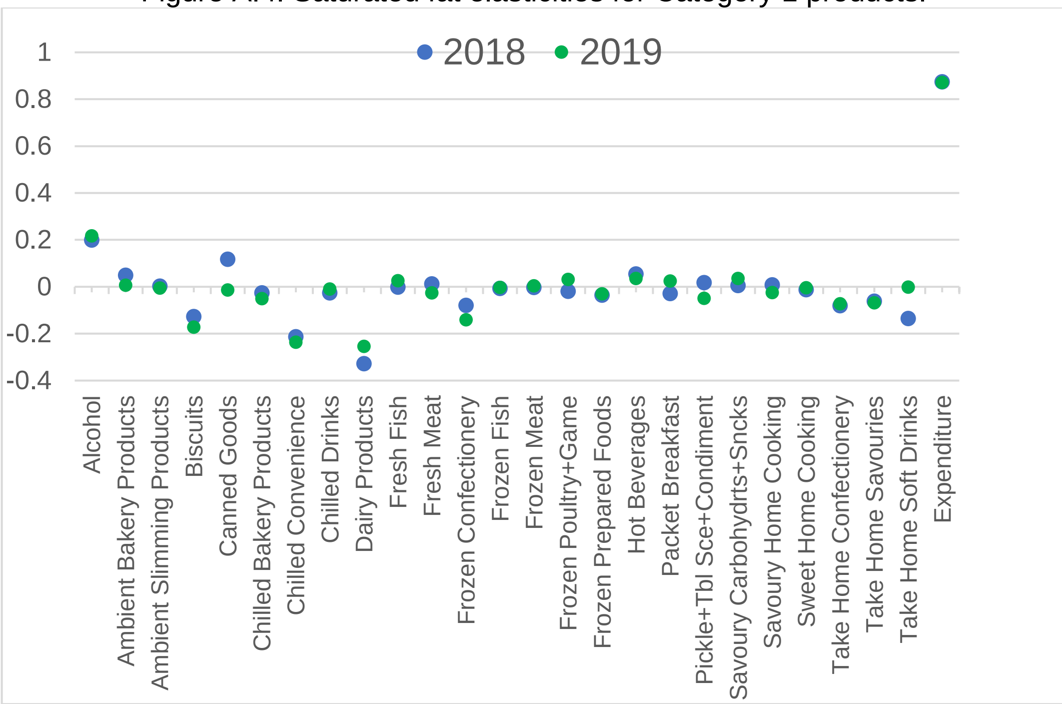
Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure A.3. Fat elasticities for Category 1 products.



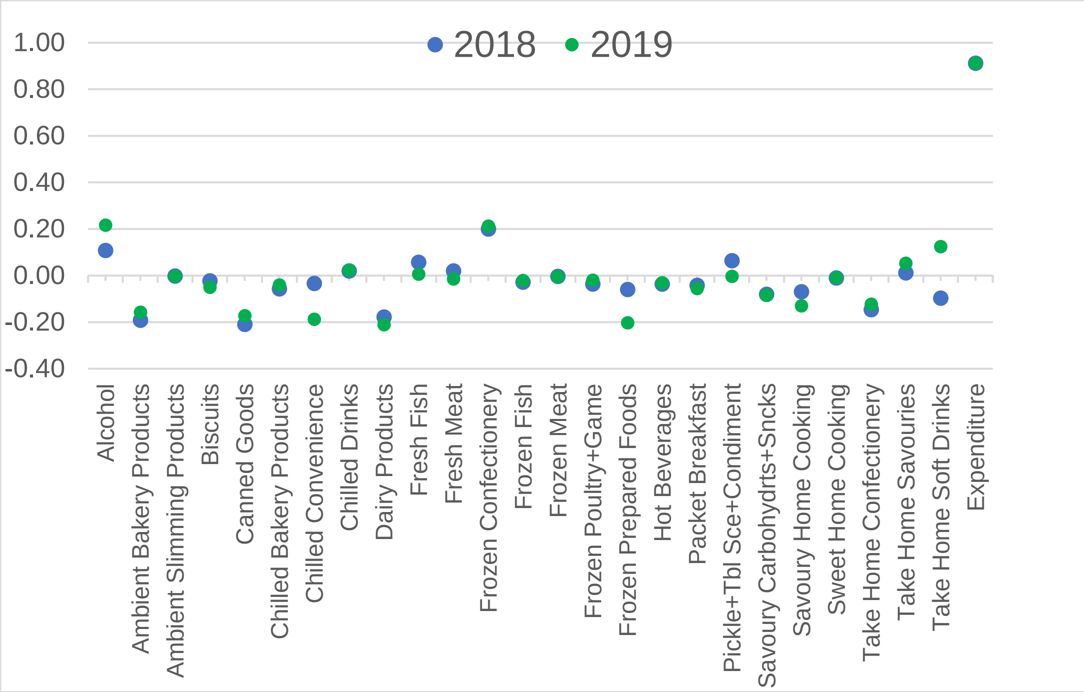
Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure A.4. Saturated fat elasticities for Category 1 products.



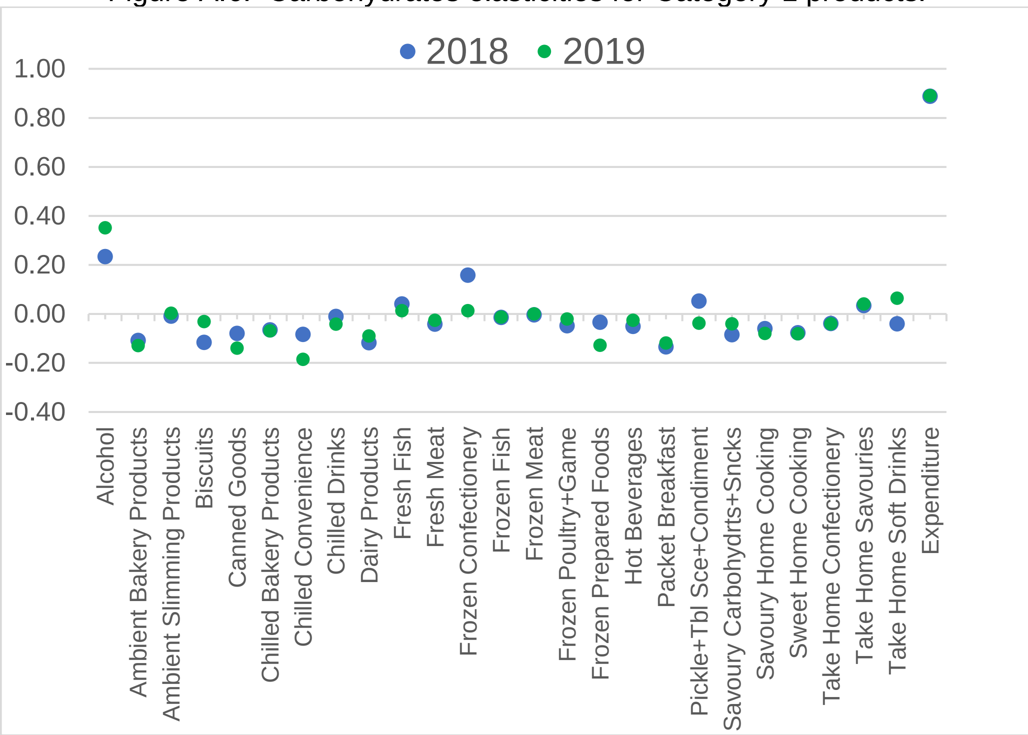
Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure A.5. Protein elasticities for Category 1 products.



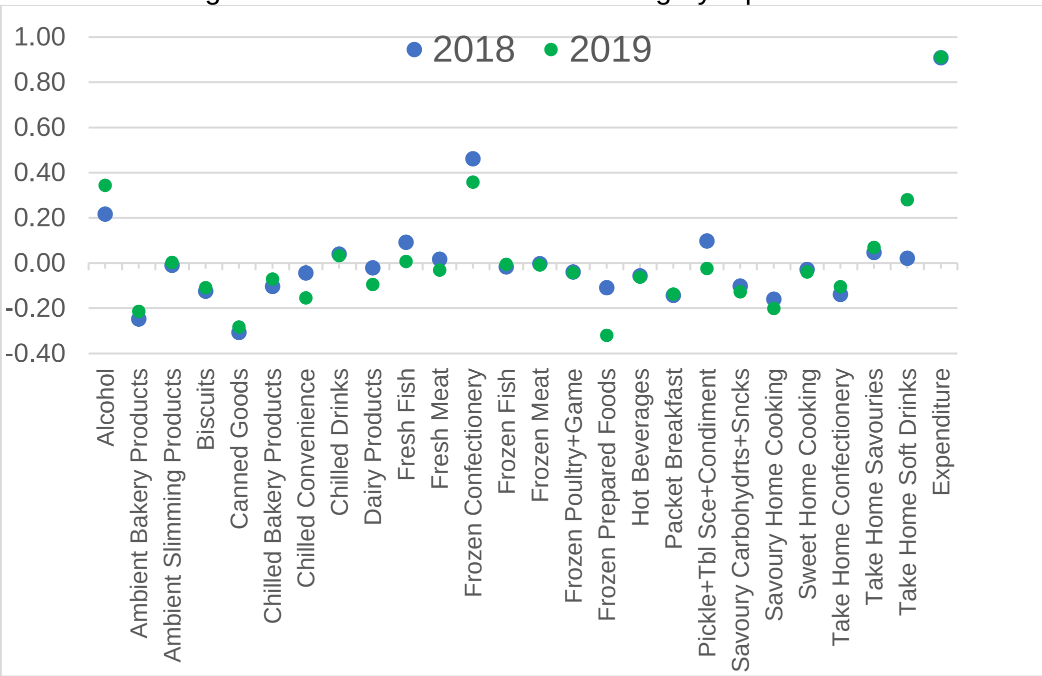
Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure A.6. Carbohydrates elasticities for Category 1 products.



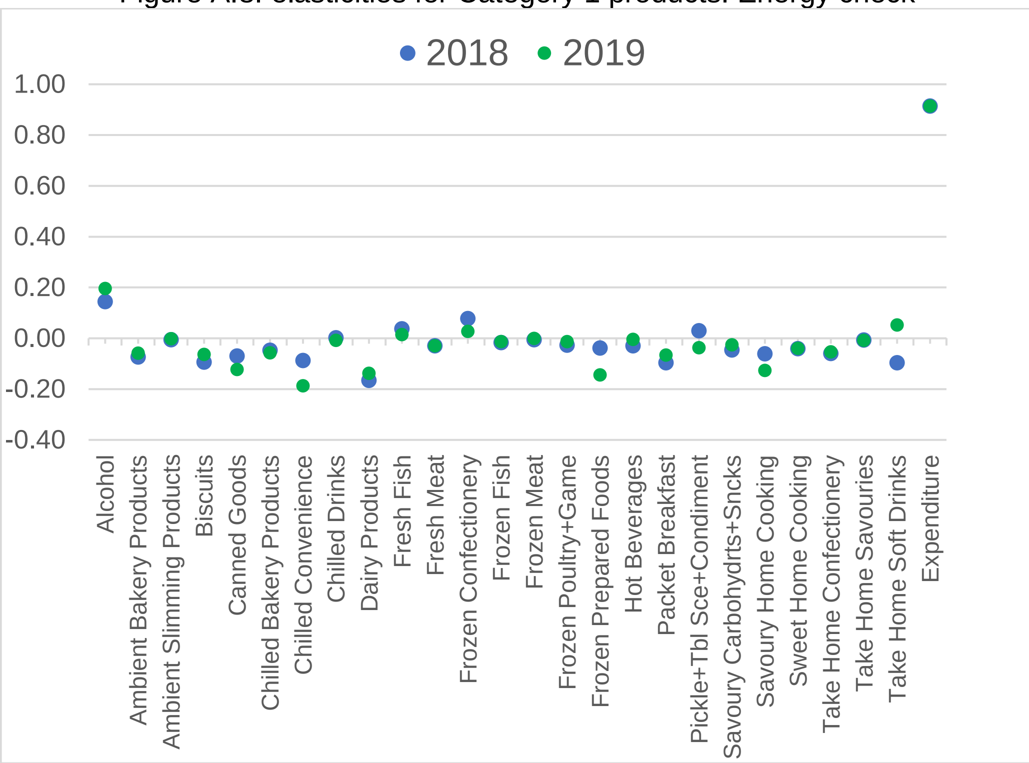
Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure A.7. Fibre elasticities for Category 1 products.



Source: Authors' calculations from Kantar's Grocery Market Share data.

Figure A.8. elasticities for Category 1 products. Energy check



Source: Authors' calculations from Kantar's Grocery Market Share data.