Are plant-based proteins perfect substitute for meat?

Abstract

There is a growing concern among policymakers and researchers about the negative health and climate impact of meat consumption. Consumers are being encouraged to re-evaluate their dietary choices in order to preserve our ecosystem and reduce the burden of diet related diseases. However, limited information is available about how price changes in animal protein sources affect plant-based protein demand and the consequences for nutrient intake and/or diet quality. The goal of the preset paper is to fill this gap by explaining how consumers react to prices changes in animal protein types and present the implications for nutrition or diet quality. The paper applied the Exact Affine Stone Index Implicit (EASI) Marshallian Demand System to the 2021 home scan panel data collated by Kantar Worldpanel to estimate both price and expenditure elasticities. Twelve food groups of seven animal-based protein products and five plant-based protein products were considered. The results reveal that dairy and eggs are daily necessities for the people of Scotland. The demand for fish and non-dairy milk are the most price sensitive. Estimates based on expenditure elasticities show that beef is considered a luxury and a highly substitutable product in the Scottish diet. Peas are relatively basic, essential foodstuff. In general, increasing the price of animal protein sources will shift demand towards plant protein. On the positive side, there will be a significant reduction in cholesterol and fat purchases. However, there would also be a significant reduction in the total amount of protein, carbohydrate, and healthy fats such unsaturated fatty acid purchases by the average household. This shows that increases in plant-based protein are not enough to compensate for the reductions in essential macro- and micro-nutrient purchases from animal protein. From the climate perspective, reduction in meat purchases could potentially reduce emission from production and consumption.

Keywords: Plant based protein, EASI demand system, Animal protein, Diet quality, Scotland

1. Background

Carbohydrate, fats, and protein are the three main important macronutrients derived from food. They supply 90 per cent of nutrients and all energy required for the smooth functioning of the body (Bhupathiraju & Hu, 2023). Although both plant and animal proteins form essential part of today's diet, animal protein is usually considered to be superior to plant protein for building muscle mass (Berrazaga et al., 2019; Gorissen & Witard, 2018; van Vliet et al., 2015).

Animal proteins are proteins derived from animal body tissues and include meat (e.g.

beef, pork, lamb), fish, dairy products (e.g. milk, cheese, yoghurt) and eggs. Animal proteins are usually rich in all the amino acids required by the body and are particularly high-quality proteins, the nutrients of which are more readily absorbed and utilised by the body (Day et al., 2022). Animal proteins also provide a rich source of nutrients such as vitamins (e.g., vitamin B12) and minerals (e.g., iron, zinc). On the other hand, plant proteins are proteins derived from plant tissues and the main sources of plant proteins include beans (e.g., soybeans, black beans, red beans), cereals (e.g. wheat, rice, maize) and nuts (e.g. walnuts, almonds, cashew nuts) (Stahmann, 1963). Plant proteins may be less absorbable and utilised by the body than animal proteins (Day et al., 2022). However, high levels of meat consumption poses significant risks for public health (Funke et al., 2022).

With growing concerns about climate change and sustainability, more and more consumers are recognizing the impact of animal protein production/consumption on climate change, soil and water resources (Moran & Wall, 2011) and are beginning to re-evaluate their dietary choices. In this context, plant-based proteins are of increasing interest to UK consumers as an alternative to animal proteins - 6 in 10 are willing to try plant-based products many of which are already on the market (Ibrahimi Jarchlo & King, 2022). Plant proteins are often rich in other nutrients such as dietary fibre (Dhingra et al., 2011), vitamins, minerals and antioxidants, as well as being low in saturated fat and cholesterol, which can help maintain heart health and reduce the risk of chronic diseases (Hertzler et al., 2020; Qin et al., 2022). Moreover, the production of plant-based proteins has a lower environmental impact and has a positive effect on reducing greenhouse gas emissions and conserving natural resources (Detzel et al., 2022). For instance, Springmann et al. (2018) found that replacing animal protein with plant protein in diets could help reduce the total greenhouse gas emission from diet. In addition, Ferrari et al., (2022) concluded that consumption of vegetable protein sources is associated with better health outcomes overall than animal-based product use. The intake of animal proteins, especially red meat, and poultry, was associated with weight gain, while there was no overall association between intake of plant proteins and weight change (Halkjær et al., 2011).

Many countries have been reluctant to consider taxes on meat and dairy products because of the strong social and political controversy that such taxes can cause (Cornelsen et al., 2019). Funke et al. (2022) noted that the only taxes on meat are value-added taxes, often at reduced rates. However, with the increasing severity of global climate change, researchers have emphasized that changing dietary pattern is one of the key areas to limit the impact of GHG emissions from livestock (British Nutrition Foundation, 2019; Nelson et al., 2016).

Therefore, in order to rapidly reduce carbon emissions from the agricultural sector to counter the threat of global warming and to try to limit global temperature increase to 1.5°C (Funke, 2022), one of the measures that the government and the international community may want to consider is to impose taxes on meat and dairy products. By raising taxes on these foods, people may be financially incentivised to reduce their consumption of high GHG-emitting foods and move towards more environmentally friendly and low-carbon dietary choices. From the health perspective, reducing the consumption of red and processed meat would result in 220,000 fewer deaths per year from chronic diseases such as coronary heart disease, stroke, cancer, and type 2 diabetes (Springmann, 2018). There is little research on how a tax on animal-based protein could nudge Scottish households to increase their consumption of plant protein.

However, consumers also face several challenges when switching from animal to plant-based proteins, one of which is price and supply and demand. Plant protein products are usually available in the market at relatively high prices, which may limit the choices available to some consumers. In addition, consumer preferences, cultural habits, product availability, price and taste may all influence their willingness and ability to switch from animal to plant-based proteins (Jeske et al., 2018). Similarly, Pohlmann, (2021) found that the choice between plant-based and animal-based protein is influenced by both consumer's characteristics and dietary preferences. Both Pohlmann, (2021) and Jeske et al., (2018) agreed that protein choice is influenced by a variety of interacting biological, situational, psychological, and economic factors. A survey conducted by the Plant Based Foods Association, in 2018 shows that the market for plant-based meat substitutes had grown by more than 20% (Plant Based Foods Association, 2018) compared to the previous year. However, it is believed that the rising cost of living is likely to push consumers away from healthier, less carbon-footprint plant-based protein to high carbon footprint and less healthy animal-based proteins. Demand studies suggest that consumers are very responsive to price changes which affect both their demand and preference for healthier food options. It is therefore necessary to access the extent to which consumers are sensitive to the prices of plant protein and a shift from animal-based protein to plant-based protein affects diet quality and vice versa.

Specifically, the main objectives of this study are 1) to explain consumers sensitivity to changes in the own-price of plant and animal proteins; 2) to understand how consumers perceive the relationship between plant and animal proteins i.e., as substitutes or complements; and 3) to estimate the extent to which a switch from animal to vegetable protein affect overall diet quality.

The rest of the paper is organised as follows: section 2 presents descriptive statistics relevant to the study and a summary of relevant research done by previous scholars. Section three presents the research methodology on how the above objectives were conducted. Section four presents and discusses the results of this study and the section 5 presents the conclusions and recommendations.

2. Literature Review

Trends in plant and animal proteins consumption

Figure 1 shows the average daily consumption of animal and plant protein per person in different countries and continents from 2018-2020. With the exception of Africa and China, per capita intake of animal protein is higher than plant protein. The US has the largest per capita share of animal protein intake, followed by Europe and the UK, Africa having the least. For plant protein, China has the largest per capita share, followed by Africa, and the US the least.

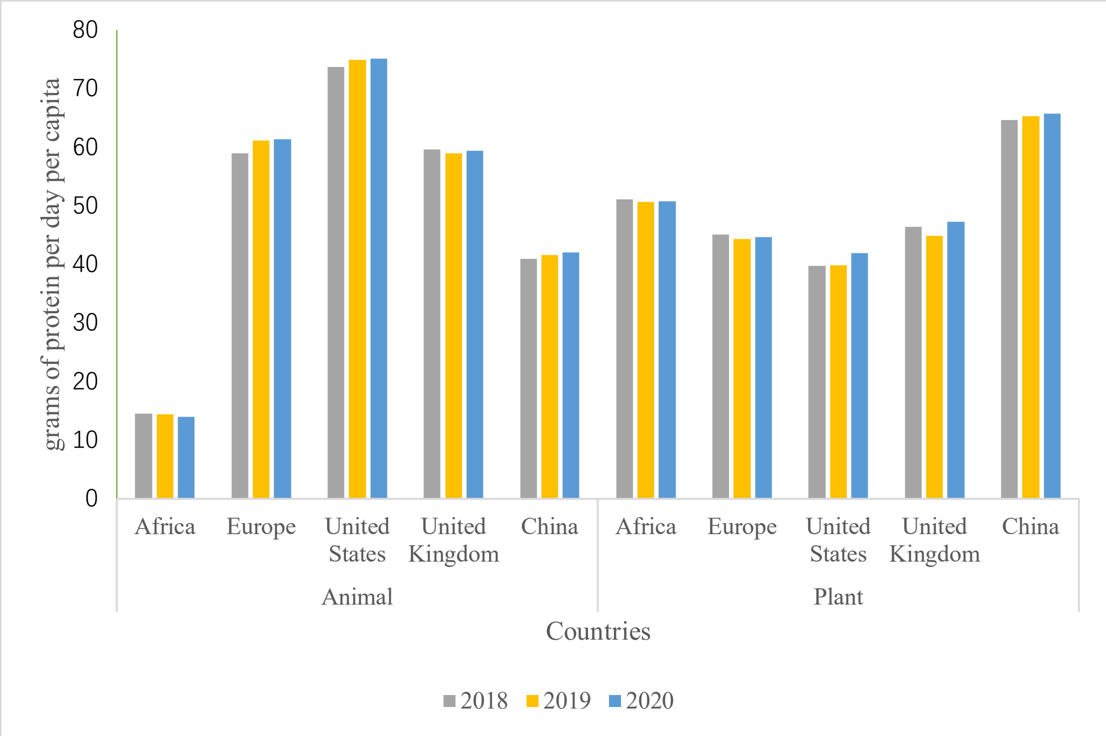

Figure 1. Animal protein vs. vegetable protein by regions
Source: Author's own computation, 2023

Fig. 2 also shows that chicken and fish are the most popular choice in the UK. Poultry is the best choice for British people, probably because it has a short production cycle (Yakovleva & Flynn, 2004). Fish is also popular, and the reasons is that the majority of UK cities are close to the coastline and have access to fresh fish, which is also relatively cheap. In addition, fish and chips are considered one of Britain's national dishes, is a traditional food that is very popular with the British. Across the regions in the UK, Scotland is the second largest consumer of beef and veal and the third largest consumer of poultry and fish. She is also the least consumer of mutton and lamb.

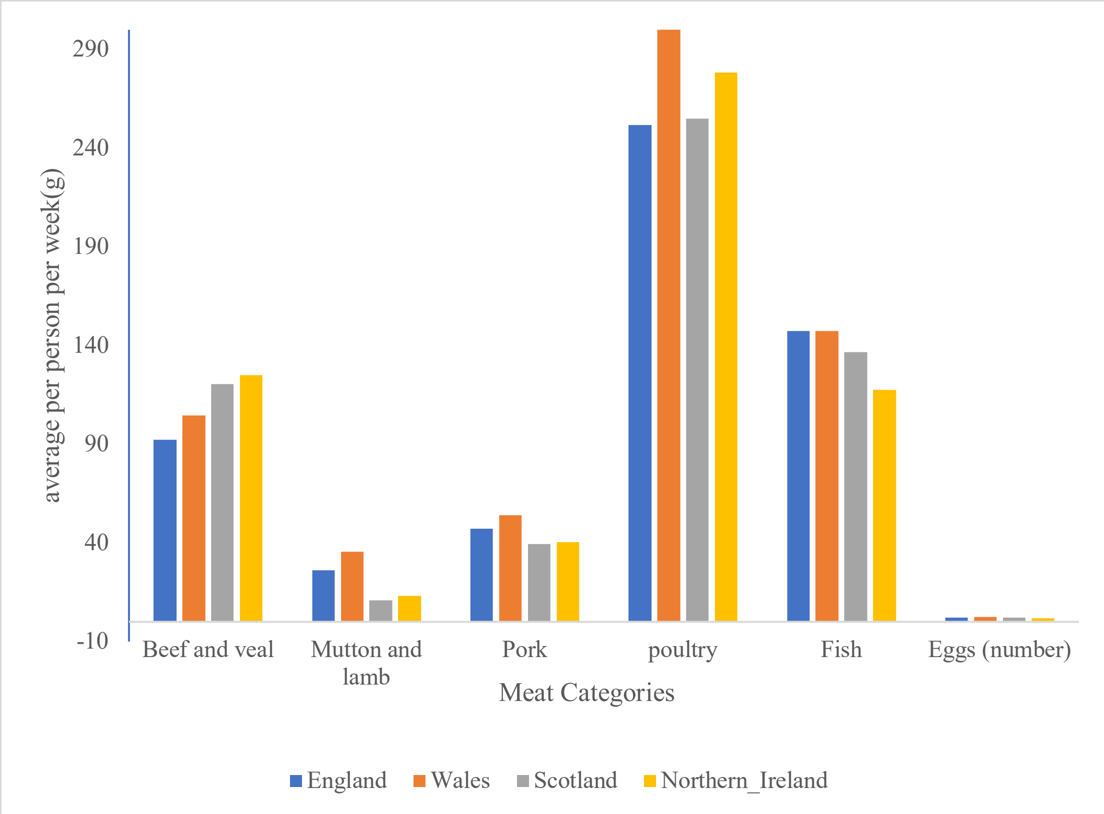

Figure 2. Meat consumption by region - average per person per week (UK)
Source: Author's own computation, 2023

Figure 3 shows the importance of plant protein as one of the main sources of protein in the UK diet. Beans is the dominant plant protein consumed in the UK whilst dried pulses are the least important plant protein. The importance of beans in the British diet could be due to having a higher protein content than peas and providing a wide range of essential amino acids and dietary fibre in the diet (Geil & Anderson, 1994). Across the regions, Scotland is the second largest consumer of peas, and non-dairy milk substitutes. However, it is the least consumer of dried pulses.

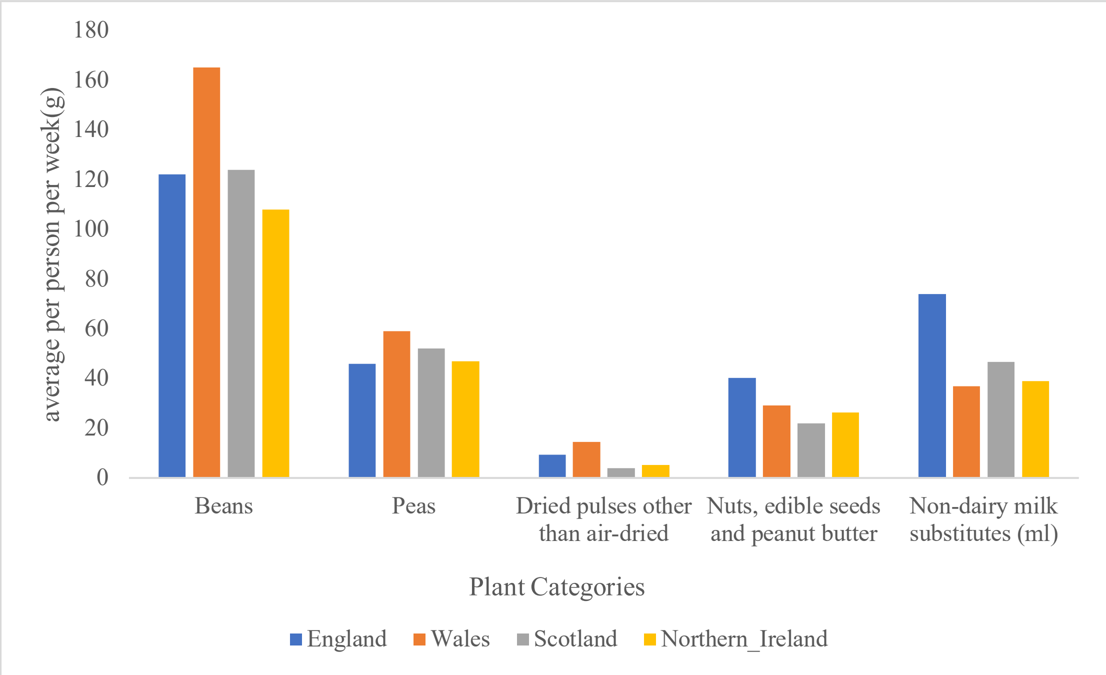

Figure 3. Plant consumption by region - average per person per week (UK)
Source: Author's own computation, 2023

Drivers of animal and plant protein consumption

Health reasons: Red meat (e.g. beef, pork and lamb) is associated with an increased risk of diseases such as cardiovascular disease, type 2 diabetes and certain cancers (Abete et al., 2014; Barnard et al., 2014). Larsson & Wolk (2006) found that an increase in red meat intake of 100-120 g/day caused increased risk of colorectal cancer. Tilman & Clark (2014) found that replacing meat intake with plant-based protein substitutes reduced the risk of coronary heart disease by 20-26% and type II diabetes by 16-41%. Furthermore, the Eatwell guidelines recommend a shift from animal-based foods to more plant-based foods, reducing red meat intake and highlighting the importance of fruit, vegetables, and complex carbohydrates (such as brown rice and wholemeal bread) in the diet (NHS, 2022). As concerns about health and diet increase, many people are choosing to reduce their meat intake. Stewart et al. (2021) using a multiple linear regression model found that per capita meat consumption decreased by approximately 17.4 g from 2008-2019, with the proportion of meat consumers decreasing over time, while the proportion identifying as vegetarians and vegans increased.

Social concerns: An increasing number of consumers and citizens are beginning to consider animal welfare as a choice among purchasing factors. Alonso et al. (2020) based on data from the Eurobarometer surveys comparing consumer concerns about animal welfare in 2006 and 2016 found a 20% increase for European citizens and a 68% increase for UK residents. In addition, the public are becoming increasingly aware of the possible risk or quality or safety issues associated with meat consumption. Yamoah & Yawson, (2014) examined the reactions of different groups of shoppers to the UK horsemeat scandal through a paired t-test study. In the six consecutive weeks following the announcement of the first horsemeat scandal, all meat markets experienced weekly declines in retail sales and volume. However, this led to increase in the sales of vegetarian meat alternatives (Butler, 2013)

Emission: Another reason why people may choose to stay away from animal proteins is the high carbon footprints associated with production and consumption. Greenhouse gases such as methane (25%), carbon dioxide (CO_2) (32%), and Nitrous Oxide (N_2O) (31%) are the main consequences of animal production (Moran and Wall, 2011). In addition, population growth and limited land resources can drive farmers or herders to overgraze their limited land, causing damage to the land and ecosystems. (Abril & Bucher, 1999; Zou et al., 2006) found that overgrazing caused a reduction in soil fertility, water retention. In addition, Sy et al. (2015) found through different satellite images that 71% of the rainforest in South America was converted into pasture for farmed animals and 14% was used for commercial cultivation. The destruction of natural habitat for many plants and animals affects biological interdependence and may lead to a decrease in the stability of the entire ecosystem. A study by Goldstein et al. (2017) found that the widespread adoption of plant-based beef alternatives could significantly reduce greenhouse gas emissions, water consumption, and agricultural land use in the United States. Similarly, Stehfest et al. (2009) found that by switching to a meat-free diet, in which all protein is derived from plants, CO_2, CH_4 and N_2O emissions were reduced to varying degrees globally.

The mutual substitutability of animal and plant proteins

Different scholars have different views on the substitutability and complementarity of animal and plant proteins. Some scholars believe that plant proteins are unlikely to completely replace animal proteins in meat and poultry products in general. Sha & Xiong (2020) argue that meat will continue to be the main source of protein in North America in the future and that meat substitutes cannot completely replace animal meat, and that the term "meat substitutes" should be used instead of "meat analogues" to avoid misleading consumers into thinking that these products can completely replace traditional animal meat. Similarly, in terms of nutrition, Clegg et al. (2021) found that plant-based dairy alternatives (PBDAs) products were at risk of nutritional deficiencies through ANOVA using a linear model and pairwise comparisons, and that many PBDAS were not fortified with micronutrients and therefore could not replace milk.

Some scholars believe that there is complementarity between animal and plant proteins and that both can be consumed to obtain a more complete nutrition. Vainio et al., (2016) after conducting structural equation modelling (SEM) found that most beef eaters were not opposed to eating plant proteins. Almost half of the respondents had established a pattern of combining beef consumption with the consumption of beans and/or soy products. However, a limitation of the article is that the sample studied was only Finnish consumers, who consume fewer beans in their diet. This may lead to differences in the applicability of the study results across regions.

Some academics consider animal and vegetable proteins as complete substitutes. This may be due to their concern for issues such as animal welfare, environmental protection, and sustainable development. In addition, plant protein intake is associated with a lower risk of disease. However, some consumers avoid dairy products for a variety of reasons, including medical reasons such as lactose intolerance, milk allergy, lactase deficiency, cholesterol problems and phenylketonuria. The main treatment is to avoid lactose-containing foods and to replace milk and dairy products with lactose-free dairy products or dairy-free alternatives (Mäkinen et al., 2015), which include plant-based milk alternatives. Salomé et al. (2021) using ANOVA, multiple comparisons, Kruskal-Wallis nonparametric and post hoc Dwass-Steel-Critchlow-Fligner tests found that plant-based protein alternatives had minimal alterations and legumes were largely perfect substitutes for animal protein in terms of nutrition.

Factors limiting plant protein consumption

Meat substitutes are often more expensive than traditional meat products because they use different ingredients and production techniques, some fortified with micronutrients (Clegg et al., 2021). The authors also found that plant-based dairy alternatives (PBDAs) cost much more than their dairy equivalents and predicted that if a household switched to a plant-based protein diet, the cost of dairy consumption would be three times higher than before. Axworthy (2022) found that the current price of plant-based meat far exceeds that of animal meat, and that higher prices would reduce the likelihood of consumption. However, surprisingly, the average retail sales of plant-based meat increased by 45% in 2020. Similarly, Tosun et al. (2020) found the negative impact of price changes to be minimal, accounting for only 4% of participants in the survey. Although the current market environment is still favourable, as the market develops and competition increases, the price of some meat alternatives may gradually decline and be priced at parity with conventional meat. Finally, Axworthy (2022) predicts price parity in 2023 for meat substitutes made from soy, peas, and other leguminous plant-based proteins.

3. Methodology

Data

This study relies on 2021 home scanner data collated by Kantar Worldpanel. The data included household food purchases and demographic data. Every household participating in the data gathering procedure received a scanner to record the Universal Product Code (UPC) details for all items. This study was conducted on a sample of

1,589 Scottish households that had been observed for at least 40 weeks. Information from the consumer side included the type of animal protein products and plant protein products purchased, and the price (£) and weight (kg) of the products. Information on household characteristics included weekly expenditure obtained by aggregating the daily expenditure of the household on different products. Household location, age, gender, employment status of household members, number of people of different ages, marital status, access to the internet or not, number of diabetics, smokers, and vegetarians in the household. For this study, seven animal protein products: dairy, beef and veal, Mutton and lamb, pork, poultry, fish and egg, and four plant protein products: peas; beans and pulses; nuts, seeds and peanut butter; and non-dairy alternatives were considered for the analysis. All other products bought by the household was summed under "all other product" or miscellaneous products.

3.1.1 Summary of data

Table 1 presents the weekly consumption of the different types of animal and plant protein products bought by Scottish households. Dairy products had the largest average weekly purchase of approximately 3.83 kg, followed by eggs at about 3.19 kg, while mutton and lamb were the least purchased meat with weekly per capita purchase of about 0.02 kg. In terms of expenditure, dairy products had the highest weekly expenditure (£5.14), followed by pork (£1.71) and fish (£1.67). among the meat group, mutton and lamb had the lowest weekly average expenditure (£0.19). In terms of share of expenditures, dairy products had the largest share and lamb the least.

Overall, plant protein consumption is much lower than animal protein. Beans and pulses had the largest average weekly quantity purchase at around 0.26 kg per capita, while non-dairy substitutes are the lowest at just 0.05 kg per capita. This is reflected in the average weekly expenditure. In terms of expenditure shares, plant protein products have a very small share compared to animal protein products indicating relatively less importance of the these groups among Scottish consumers.

Table 1. Household food consumption statistics

	Weekly expenditure per capita (£)		Weekly quantity per capita (Kg)		Budget shares		Prices		Total Expenditure	
Categories	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev	Mean	Std. Dev
Dairy	5.14	3.06	3.83	2.67	0.08	0.04	4.35	4.02	67.79	32.43
Beef and veal	1.49	1.63	0.20	0.20	0.02	0.02	8.48	4.91		
Mutton and lamb	0.19	0.47	0.02	0.04	0.00	0.01	3.88	5.52		
pork	1.71	1.47	0.29	0.25	0.02	0.02	7.23	3.17		
poultry	1.53	1.53	0.32	0.34	0.02	0.02	6.04	3.00		
Fish	1.67	1.60	0.33	0.35	0.02	0.02	9.76	5.44		
Eggs	0.48	0.48	3.19	3.18	0.01	0.01	0.20	0.72		
Peas	0.20	0.43	0.10	0.16	0.00	0.01	2.94	5.36		
Beans and pulses	0.39	0.35	0.26	0.25	0.01	0.01	2.58	2.86		
Nuts, seeds and peanut butter	0.41	0.55	0.09	0.16	0.01	0.01	7.53	4.73		
Non-dairy substitutes	0.07	0.27	0.05	0.27	0.00	0.00	1.11	4.02		
All other expenditure	54.50	27.02	33.98	17.88	0.80	0.06	7.41	6.54		

Source: Author's own computation, 2023

Table 2 displays the demographic characteristics included in the probit and EASI demand model: Gender, Number of kids, Scottish Index of Multiple Deprivation Quintiles, Rural-urban classification, Income decile, Life stage, Employment status, and Marital status.

Around 27 percent of the participants in the dataset were men. Married respondents made up a higher proportion of the data, at about 21 per cent. More than half of the households had two children. The percentage of households living in the most deprived areas is 17.94 per cent. The largest proportion of respondents, around 45 per cent, had annual income of £29,999 and under. More than half of the households aged 45 and over have no children. Around 0.06 percent of the respondents chose not to disclose their employment status. The largest percentage of heads of households, 43.30 per cent, worked more than 30 hours per week.

Table 2. Descriptive statistics of household composition and characteristics.

Variable	Percentage
Gender	
Female	72.56
Gender	27.44
NA	3.11
Number kids	21.46
	60.42
	13.03
	4.15
	0.76
	0.13
	0.06
Scottish Index of Multiple Deprivation Quintiles (SIMD)	
SIMD 1 （Most deprived areas）	17.94
SIMD 2	20.52
SIMD 3	20.20
SIMD 4	22.84
SIMD 5 (Least deprived areas)	17.81
NA	0.69

Table 2. Descriptive statistics of household composition and characteristics cont'd

Variable	Percentage
Rural-urban classification	
Lg. Urb. Areas	30.84
Oth. Urb. Areas	39.65
Ac. Sm. Towns	7.11
Rm. Sm. Towns	3.21
Ac. Rural	11.20
Rm. Rural	5.54
NA	2.45
Income decile	
£0 - £29,999	44.87
£30,000 - £39,999	13.09
£40,000 - £49,999	10.70
£50,000 - £59,999	5.98
£60,000 - over	5.79
NA	19.57
Life stage	
Pre-family	15.73
Young family	11.26
Middle family	9.00
Older family	8.68
45+ no children	55.32
Employment status	
Over 30 Hours	43.30
8 - 29 Hours	19.89
Under 8 Hours	2.01
Unemployed	2.89
Retired	18.44
Full Time Education	1.13
Not Working	12.27
NA	0.06
Marital status	
Married	21.71
Single	5.54
Widowed/Divorced/Separated	4.34
Unknown	68.41

Source: Own computation based on Kantar Worldpanel data, 2023

The percentage of zero purchases for household food consumption is shown in Table 3. The lower the percentage of zero purchasers indicate that more consumers bought the product. Milk is a daily necessity for Scottish residents, while fish products are second only to dairy. These two categories have become the main food items consumed by the population. Fish consumption varies geographically, and for Scotland, the region has a vast coastline and abundant marine resources. As a result, Scots have easy access to fresh seafood and fish is an essential part of their diet. Over 60% of the population did not consumed mutton and lamb for at least 40 weeks and similarly over 75% did not consumed non-dairy milk substitutes for at least 40 weeks. This suggests that the consumption of Mutton and lamb and Non-dairy milk substitutes is infrequent and not an essential part of the daily diet of Scottish residents.

Table 3. Households reporting zero consumption.

Categories	**Total sample**	**Percentage of zero purchases (%)**
Dairy	1589	0.06
Beef and veal	1589	6.92
Mutton and lamb	1589	64.07
pork	1589	3.84
poultry	1589	5.60
Fish	1589	0.69
Eggs	1589	5.60
Peas	1589	17.31
Beans and pulses	1589	3.46
Nuts, seeds and peanut butter	1589	10.51
Non-dairy milk substitutes	1589	77.85

Source: Author's own computation of Kantar Worldpanel data, 2023

Conceptual Framework

In this research, the Exact Affine Stone Index (EASI) demand model of Lewbel & Pendakur (2009) was employed to estimate the demand of animal protein products and plant protein products. The EASI demand system establishes a connection between the budget share w_i and the polynomials of real expenditure on food (y_i), the vector of demographic characteristics (z_i), and the vector of prices (p_i).

The budget share equation of each food in the LA/EASI demand system is indicated by:

$$w_i = \sum_{r=0}^{5} b_r y_i^r + C z_i + \mathrm{D} z_i y_i + A p_i + B p_i y_i + \epsilon_i \qquad (1)$$

Where y the real food expenditure is specified as:

$$y_i = \ln(x_i) - p_i' w_i \qquad (2)$$

In equation (2), the variable x_i represents the overall weekly household spending, and the parameter matrices that need to be estimated are $A, B, C, D, and\ b_i$.

The satisfaction of the following constraints is necessary to ensure the cumulatively and homogeneity of the cost function:

$$1_n' A = 1_n' B = 0_n' \ ; \ 1_n' C = 1_n' D = 0n \qquad (3)$$

$$1_n' b_0 = 1, 1_n' b_r = 0 \qquad \forall r \neq 0 \qquad (4)$$

A and B symmetry ensures Slutsky symmetry. The EASI demand system produces an implicit Marshallian demand equation rather than a traditional Marshallian demand function. Therefore, the Marshallian demand elasticity is derived indirectly from the Hicksian price elasticity and expenditure elasticity via the Slutsky equation (Lewbel & Pendakur, 2009).

Given the prevalence of households with high reported zero expenditures on food categories, we utilize a censored equation system and apply a consistent two-step estimation procedure (Shonkwiler and Yen, 1999). This technique involves two steps: (1) estimating the probit or sample selection equation; and (2) estimating the EASI demand system.

In the initial step, a general sample selection model is specified, comprising 12 equations, each corresponding to a specific food group, respectively dairy, beef and veal, mutton and lamb, pork, poultry, fish and eggs, peas, beans and pulses, nuts, seeds and peanut butter, non-dairy milk substitutes, or all other foods considered in the analysis. The probit equation for the $i-th$ food group is expressed as follows:

$$w_i^* = X_i' \beta_i + \varepsilon_i \ ; \ d_i^* = Z_i' v_i + u_i \qquad (5)$$

$$di = \begin{Bmatrix} 1 \ if d_i > 0 \\ 0 \ if \ d_i < 0 \end{Bmatrix} \quad w_i = d_i w_i^* \qquad (6)$$

w_i and d_i are the observed dependent variables, w_i is the latent variable for the budget share, d_i is the latent variable for the probit equation, X_i and Z_i are vectors of exogenous variables determining level and participation, respectively, β_i and v_i are parameter vectors, and ε_i and u_i are error terms. Using the vectors of parameter estimated, a set of cumulative density functions (CDF) and probability density functions (PDF) $(Z_i' v_i)$ were calculated and included in the final demand model.

3.3.2 The demand model

The standard Linear Approximate Exact Affine Stone Index (LA/EASI) with censorship is specified as follows:

$$w_i^* = \hat{\Phi}_i \left(\sum_{r=0}^{5} b_r y_i^r + C z_i + D Z_i y_i + A p_i + B p_i y_i \right) + \delta \hat{\phi}_i + \epsilon_i \qquad (7)$$

where $\hat{\Phi}_i$ and $\hat{\phi}_i$ represent nxn identity matrices with ones replaced by cdf and pdf values, respectively. Additionally, δ is an n-vector of parameters that need to be estimated. It is important to note that economic theory does not provide specific guidance on the selection of socio-demographic variables to be included in the probit model (x_i vector) and demand equation (z_i vector) for the sample section (Castellón, Boonsaeng, and Carpio, 2015). However, to mitigate potential multicollinearity concerns in the censored model outcomes, additional demographic factors were included in the x_i vector.

The final LA/EASI demand system, accounting for zero purchases, price, and spending endogeneity, and excluding interactions, is represented as follows:

$$w_i = \hat{\Phi}_i \left(\sum_{r=0}^{5} b_r y_i^r + C z_i + A p_i \right) + \delta \hat{\phi}_i + \tau \pi_i + \epsilon_i \qquad (8)$$

Lewbel & Pendakur (2009) suggest that the presence of y on the right-hand-side of equation (8) and the left-hand-side of equation (2) introduces endogeneity in the demand model. Authors suggested using the log of real expenditure estimated from the mean budget shares ($\overline{w}$) (i.e., $\overline{y_i} = \ln(x_i) - p_i' \overline{w}_i$) as instrument to correct for this form of endogeneity. The final $n - 1$ equations were estimated using iterative three-stage least squares (3SLS) using $\overline{y_i}$ as instrument to correct for the endogeneity.

Price and expenditure elasticities were derived from Equation 8. The matrix of own and cross price elasticities were recovered from the censored LA/EASI demand system:

$$\xi = \varpi^{-1}\Phi(A + Bu) + \Omega\varpi - I \qquad (9)$$

where, ξ represents an $n\ x\ n$ matrix of compensated demand elasticities, while ϖ is an identity matrix with the budget share of each food group replacing the original elements. Additionally, Ω is an $n\ x\ n$ matrix of ones, and I denotes an identity matrix.

Similarly, the elasticity of expenditure (η_i) derived from the implicit Marshallian equation of demand is:

$$\eta = \varpi^{-1}(I + \Phi\mathfrak{b}\mathrm{p}')^{-1}\Phi\mathfrak{b} + 1_n \qquad (10)$$

where η denotes the J X 1 vector of estimated expenditure elasticities, ƀ represents the expenditure semi-elasticity coefficients, p is the vector of mean prices, and 1_j stands for a J x 1 vector of ones.

The matrix of uncompensated Marshallian elasticity (ε) was derived from the Slutzky equation:

$$\varepsilon = \xi - \varpi\eta \qquad (11)$$

Changes in average weekly consumption (ΔQ_i) are estimated through the following:

$$\Delta Q_i = \varepsilon_{i,j} * Q_{av} * \Delta P_i \qquad (12)$$

If a 10 per cent increase in the original price is applied, the change in weekly nutrient intake (Δq_n) is estimated through the following:

$$\Delta q_n = \Delta Q_i * q_{av} \qquad (13)$$

where $\varepsilon_{i,j}$ refers to estimated own- and cross-price elasticities, Q_{av} refers to the average weekly consumption, q_{av} refers to average weekly nutrient intakes.

Simulation scenarios

Table 4 illustrates price rise scenarios adjusted by the current level of inflation. Scenario 1 prices of all meat & meat product (i.e. dairy, beef and veal, Mutton and lamb, pork, poultry, fish and eggs) increased by 10 percent from its current level; In scenario 2 prices of red meat (beef and veal, Mutton and lamb, pork) were made to increase by 10 per cent. Under scenario 3 prices of white meat (poultry, fish) were made to increase by the current inflation rate (10 per cent) from initial level; and finally, scenario 4 considers rise in eggs and dairy prices by 10 per cent from its level.

Table 4. Description of tax scenarios

Food groups	All Meat & Product	Red Meat	White Meat	Eggs & Dairy
Dairy	T			T
Beef and veal	T	T		
Mutton and lamb	T	T		
Pork	T	T		
Poultry	T		T	
Fish	T		T	
Eggs	T			T
Peas				
Beans and pulses				
Nuts, seeds and peanut butter				
Non-dairy milk substitutes				

T is 10 per cent price increase

Source: Author's own computation of Kantar Worldpanel data, 2023

4. Results and discussion

Results

Table 5 shows that all the estimated own price elasticities are significant and negative. Own-price elasticity can be used to measure the sensitivity of quantity demand to changes in the price of a good (Davidson & Hellegers, 2011). The own price elasticity of a good can be elastic (when the coefficient is greater than 1), inelastic (when the coefficient is less than 1) or unit elastic (when the coefficient is equal to 1). Table 5 shows that dairy product and eggs are price inelastic. A 1 % price increase in dairy product will cause the quantity demanded to decrease by 0.89 %. Similarly, if the price of eggs increases by 1 %, the quantity demanded falls by 0.75 %. This indicates that these two products have low price sensitivity and are a necessity for consumers.

The own price elasticities of beef and veal; mutton and lamb; pork; poultry; and fish are greater than 1. The demand for fish is most sensitive to price; if the price increases by 1 %, demand will decrease by 1.583%. The own price elasticity of plant protein products is greater than 1, especially for non-dairy milk substitutes, for which demand is most sensitive to price; a 1 per cent increase in price would result in a 1.633 per cent decrease in demand. The above data indicates that these products are highly price sensitive. Therefore, consumers can easily choose other substitutes.

Table 5 shows that among the animal-based proteins, dairy is a substitute for all meat products; beef and veal are substitute for dairy, fish, and eggs, and complementary with other meats. Similarly, mutton and lamb are substitute for dairy and complementary with other meats. The results for pork and poultry are similar, with demand for dairy and eggs rising when prices rise by 1 per cent each. fish can be substituted with dairy and beef and veal, and eggs can be substituted with mutton and lamb, and fish.

To address the relationship between animal and plant proteins, the results suggest that peas are substitutes for dairy, beef and veal, and pork. For instance, when the price of peas increases by 1 %, the demand for dairy, beef and veal and pork increases by 0.01 %, 0.03 % and 0.02 %, respectively. On the other hand, peas are a complement to mutton and lamb, poultry, fish and eggs. Beans and pulses are weakly complementary to pork; when the price of beans and pulses increases by 1%, the demand for pork decreases by 0.003%. Otherwise, Beans and pulses are substitutable with other animal protein products to varying degrees. For example, when the price of beans and pulses increases by 1 %, the demand for dairy, beef and veal, mutton and lamb, and poultry, fish and eggs increase by 0.008 %, 0.01 % and 0.01 %, 0.004 %, 0.02 % and 0.01 %, respectively. Also, Nuts, seeds and peanut butter are complemented to mutton and lamb indicating that when the price of nuts, seeds and peanut butter increases by 1 %, the demand for mutton and lamb decreases by 0.005 %. Similarly, non-dairy milk substitutes can complement beef and veal and mutton and lamb, and they are substitutes for other animal protein products.

Table 5. Uncompensated elasticity of demand for animal protein plant protein in Scottish households.

Demands	Products												
	Dairy	**Beef and veal**	**Mutton and lamb**	**Pork**	**Poultry**	**Fish**	**Eggs**	**Peas**	**Beans and pulses**	**Nuts, seeds and peanut butter**	**Non-dairy milk substitutes**	**Miscellaneous**	**Expenditure**
Dairy	**-0.890**	0.046	0.026	0.040	0.019	0.039	0.008	0.012	0.008	0.001	0.007	0.363	0.925
	(0.031)	(0.013)	(0.008)	(0.013)	(0.014)	(0.018)	(0.006)	(0.014)	(0.004)	(0.007)	(0.011)	(0.036)	(0.027)
Beef and veal	0.158	**-1.526**	-0.072	-0.087	-0.038	0.122	0.015	0.030	0.018	0.068	-0.034	-0.432	1.145
	(0.046)	**(0.025)**	(0.018)	(0.026)	(0.023)	(0.031)	(0.014)	(0.025)	(0.011)	(0.016)	(0.026)	(0.064)	(0.041)
Mutton and lamb	0.292	-0.186	**-1.318**	-0.177	-0.161	-0.102	-0.059	-0.080	0.018	-0.005	-0.030	-0.586	0.634
	(0.078)	(0.047)	**(0.103)**	(0.050)	(0.042)	(0.052)	(0.020)	(0.064)	(0.012)	(0.020)	(0.041)	(0.164)	(0.176)
Pork	0.113	-0.072	-0.058	**-1.308**	-0.031	-0.015	0.027	0.022	-0.003	0.046	0.029	-0.309	1.096
	(0.041)	(0.023)	(0.016)	**(0.028)**	(0.026)	(0.026)	(0.019)	(0.023)	(0.011)	(0.016)	(0.026)	(0.061)	(0.038)
Poultry	0.055	-0.036	-0.060	-0.036	**-1.286**	-0.015	0.017	-0.038	0.004	0.006	-0.000	-0.456	1.112
	(0.049)	(0.022)	(0.016)	(0.029)	**(0.034)**	(0.030)	(0.016)	(0.026)	(0.015)	(0.016)	(0.027)	(0.079)	(0.048)
Fish	0.122	0.108	-0.035	-0.013	-0.010	**-1.583**	-0.028	-0.012	0.027	0.007	0.025	-0.387	0.993
	(0.056)	(0.026)	(0.017)	(0.026)	(0.026)	**(0.047)**	(0.014)	(0.024)	(0.014)	(0.018)	(0.021)	(0.065)	(0.040)
Eggs	0.097	0.050	-0.063	0.096	0.056	-0.088	**-0.750**	-0.040	0.012	0.007	0.032	0.523	0.811
	(0.059)	(0.040)	(0.021)	(0.063)	(0.047)	(0.047)	**(0.044)**	(0.036)	(0.030)	(0.026)	(0.026)	(0.104)	(0.055)
Peas	0.288	0.184	-0.174	0.161	-0.223	-0.074	-0.083	**-1.102**	0.040	-0.047	0.664	0.773	0.768
	(0.310)	(0.153)	(0.139)	(0.158)	(0.155)	(0.169)	(0.077)	**(0.463)**	(0.044)	(0.075)	(0.280)	(0.760)	(0.537)
Beans and pulses	0.108	0.066	0.021	-0.010	0.016	0.114	0.014	0.023	**-1.316**	-0.008	0.029	0.066	0.982
	(0.055)	(0.038)	(0.016)	(0.047)	(0.054)	(0.057)	(0.037)	(0.026)	**(0.032)**	(0.029)	(0.021)	(0.097)	(0.042)
Nuts, seeds and peanut butter	0.023	0.237	-0.009	0.191	0.028	0.031	0.009	-0.027	-0.007	**-1.511**	0.057	0.148	0.790
	(0.086)	(0.053)	(0.025)	(0.063)	(0.057)	(0.072)	(0.031)	(0.043)	(0.027)	**(0.030)**	(0.039)	(0.133)	(0.071)
Non-dairy milk substitutes	0.096	-0.137	-0.044	0.130	-0.003	0.111	0.043	0.442	0.032	0.066	**-1.633**	0.023	1.134
	(0.161)	(0.101)	(0.059)	(0.120)	(0.111)	(0.093)	(0.036)	(0.183)	(0.025)	(0.046)	**(0.169)**	(0.260)	(0.145)
Miscellaneous	0.030	-0.008	-0.009	-0.007	-0.010	-0.012	0.003	0.003	0.000	-0.000	0.001	**-1.013**	1.005
	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.003)	(0.001)	(0.001)	(0.002)	**(0.008)**	(0.005)

Note: Standard errors in parentheses.
Source: Author's own computation of Kantar Worldpanel data, 2023

Figure 8 shows household expenditure elasticities for 11 different types of animal and plant protein products for Scottish households, with expenditure elasticities ranging between 0.634 and 1.145. In the animal protein product types, mutton and lamb are the least responsive to changes in expenditure. Dairy and eggs expenditure elasticity are less than 1, which shows that they are necessities, while beef and veal are the most responsive to changes in spending and may be considered as luxury foods by Scottish households. Among the plant protein types, peas are less responsive to changes in total expenditure, indicating that peas or pea products are a relatively basic, essential food item for consumers. And non-dairy milk is the most responsive to changes in spending.

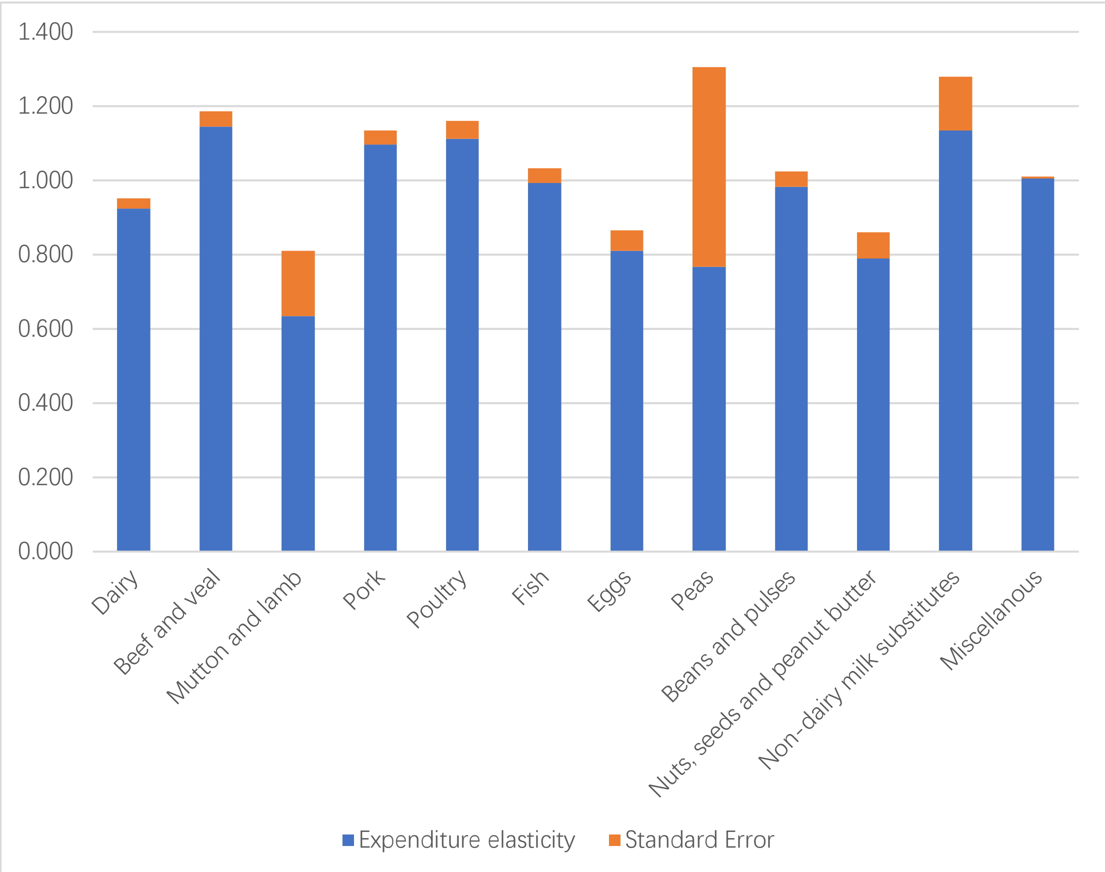

Figure 2. Expenditure elasticity for animal and plant protein products consumed in the Scottish household.

Source: Author's own computation of Kantar Worldpanel data, 2023

Effect of price increases in animal protein on demand for plant protein

Figure 9 shows the potential effect a 10 % price increase for all meat and meat products on the demand for animal and plant protein products. The demand for mutton and lamb decreased the most, 17.10 per cent, while the demand for eggs decreased the least, 5.99 per cent. Consumers are very sensitive to changes in the price of mutton and lamb and the increase in price has a greater impact on their purchasing decisions. While eggs are a more essential everyday item in Scottish households, the demand for this product has a more stable impact even if the price increases. Among the plant protein products, Nuts, seeds, and peanut butter has the highest increase in demand (5.13 %), which indicate that consumers may be more willing to buy nuts, seeds and peanut butter when the price of animal protein increases, whereas peas have the lowest increase in demand (0.82 %) among the plant protein products. It can be inferred that the impact of consumer demand for peas is more stable.

From Figure 9, when red mealy alone is taxed, consumer demand for the remaining untaxed animal protein products would still decrease, except for dairy, fish and eggs. This could translate into reduce impact on the environment, animal welfare and health. Positively, the demand for plant protein products would increase, except for non-dairy milk substitutes. This result could be potentially helpful for government policymaking.

When the price of white meat rises by 10 per cent, demand for dairy, and beef and veal increased by 0.58 per cent and 0.84 per cent, respectively, indicating a substitution effect. However, the demand for the remaining animal protein products fell by varying degrees, for instance, fish and poultry, which fell by 15.92 per cent and 13 per cent, respectively. Price increase for white meat only results in the demand increase for all vegetable proteins, except for peas, for which the demand decreased (-2.95%).

When the prices of eggs and dairy increase by 10 per cent, the demand for the remaining animal and plant proteins rose. The largest increase was estimated for mutton and lamb whilst the least was recorded for poultry. The results show that consumers consider the remaining plant animal and plant proteins as substitutes for eggs and dairy. The implication is that any policy that increases the prices of eggs and dairy would cause an increase in all other animal proteins.

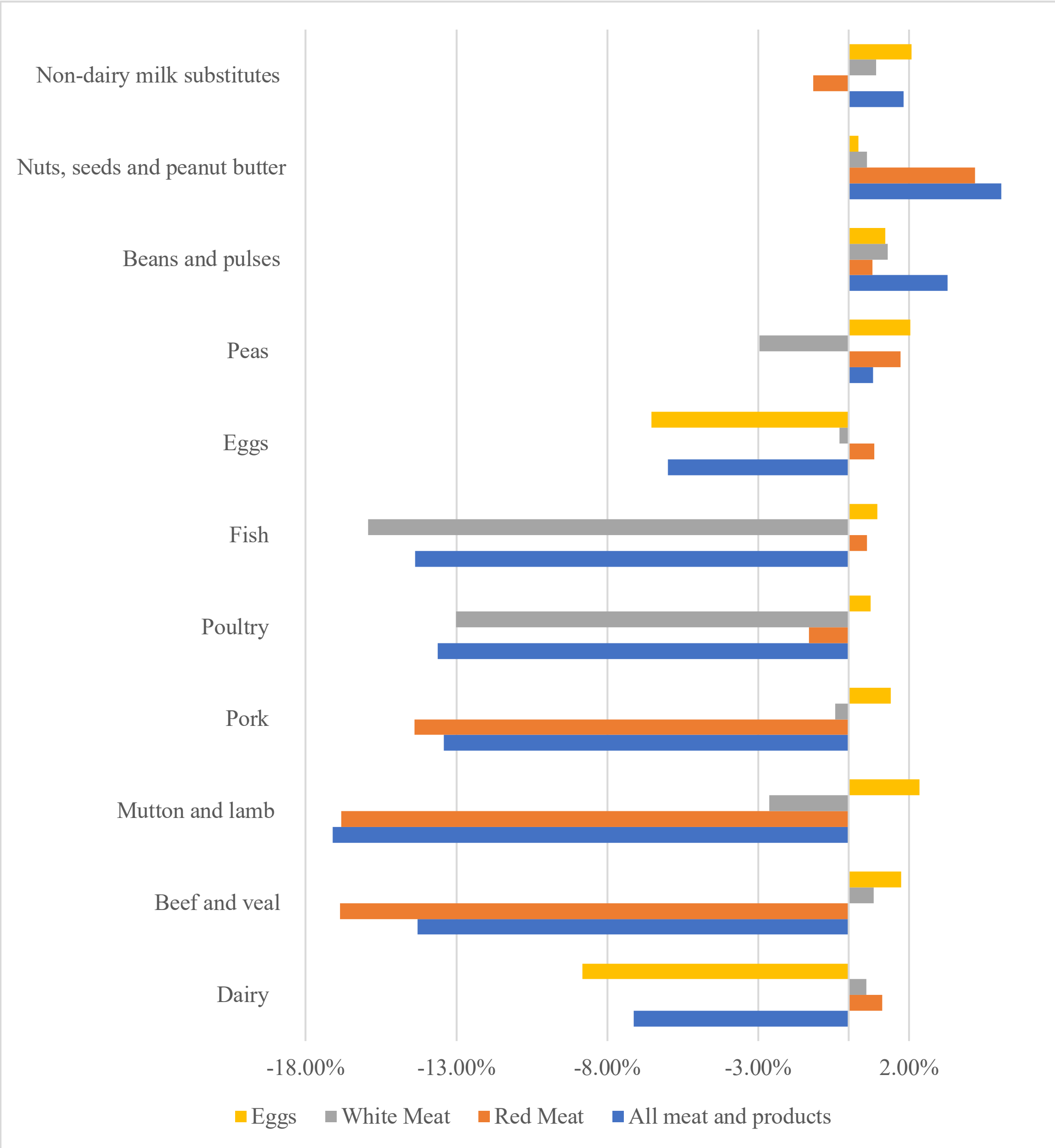

Figure 3. Percentage Change in Quantities
Source: Author’s own computation of Kantar Worldpanel data, 2023

Implication for nutrient demand

Figure 10 shows the potential impact of the different policy scenarios on macro- and micro-nutrient purchases. The discussion would focus on the following: protein, fat, energy (kcal), total sugar, carbohydrate, and cholesterol.

When the price of all meat and product rises by 10 per cent overall nutrients demand will be reduced, especially for cholesterol (11%), followed by calories (9%) and fat (8 %). Even though Figure 9 shows an increase in plant protein demand, the net effect is negative for calorie and total fat intake. This impact is positive as the average calorie intake in the UK is currently higher than recommended levels and the UK tops the European obesity league table (Sky News, 2018). Such nutritional findings can be explained by the fact that, firstly, meat is usually high in cholesterol and fat, so a decrease in cholesterol levels is to be expected when people reduce their meat consumption. Secondly, meat is one of the high-fat, high-calorie food sources, so reducing meat intake also means that people cut down on energy-dense foods. This helps to control weight and reduces the risk obesity and associated health problems. Finally rising meat prices may prompt people to pay more attention to their eating habits and health. Having realised that meat intake may have a negative impact on health, people may be more inclined to choose healthier food alternatives to meat, thus improving their overall nutritional intake.

When the price of only red meat rises by 10%, the figure shows that all nutrient intake decreases, except for carbohydrates and total sugars, which increase (1%). The increase in the price of red meat may encourage people to choose lower-priced alternatives to red meat, such as foods that are higher in carbohydrates and sugar. This resulted in a slight increase in carbohydrate and total sugar intake. In addition, higher red meat prices may encourage people to try a variety of other protein sources, such as poultry, pulses, and soya products, to maintain dietary diversity. This leads to a decrease in total protein and energy intake, as these alternative protein sources may contain less fat and energy.

When only white meat prices increased by 10 per cent, all nutrient intake decreased except for total sugars, which did not change. Typically, white meat is considered a relatively healthier source of protein because they usually contain less saturated fat and cholesterol. However, when prices rise, people may look for a more economical source of protein, something low in energy density or low in fat, to balance their diet.

Finally, when only the price of eggs and dairy rose by 10 per cent, all nutrient intakes declined, with total sugars falling the most at 7 per cent. This may be due to the fact that eggs and dairy are often used in the preparation of many processed foods, such as desserts and pastries, which may be high in sugars. When prices rise, people may consume less of these processed foods, leading to lower intake of nutrients such as sugar.

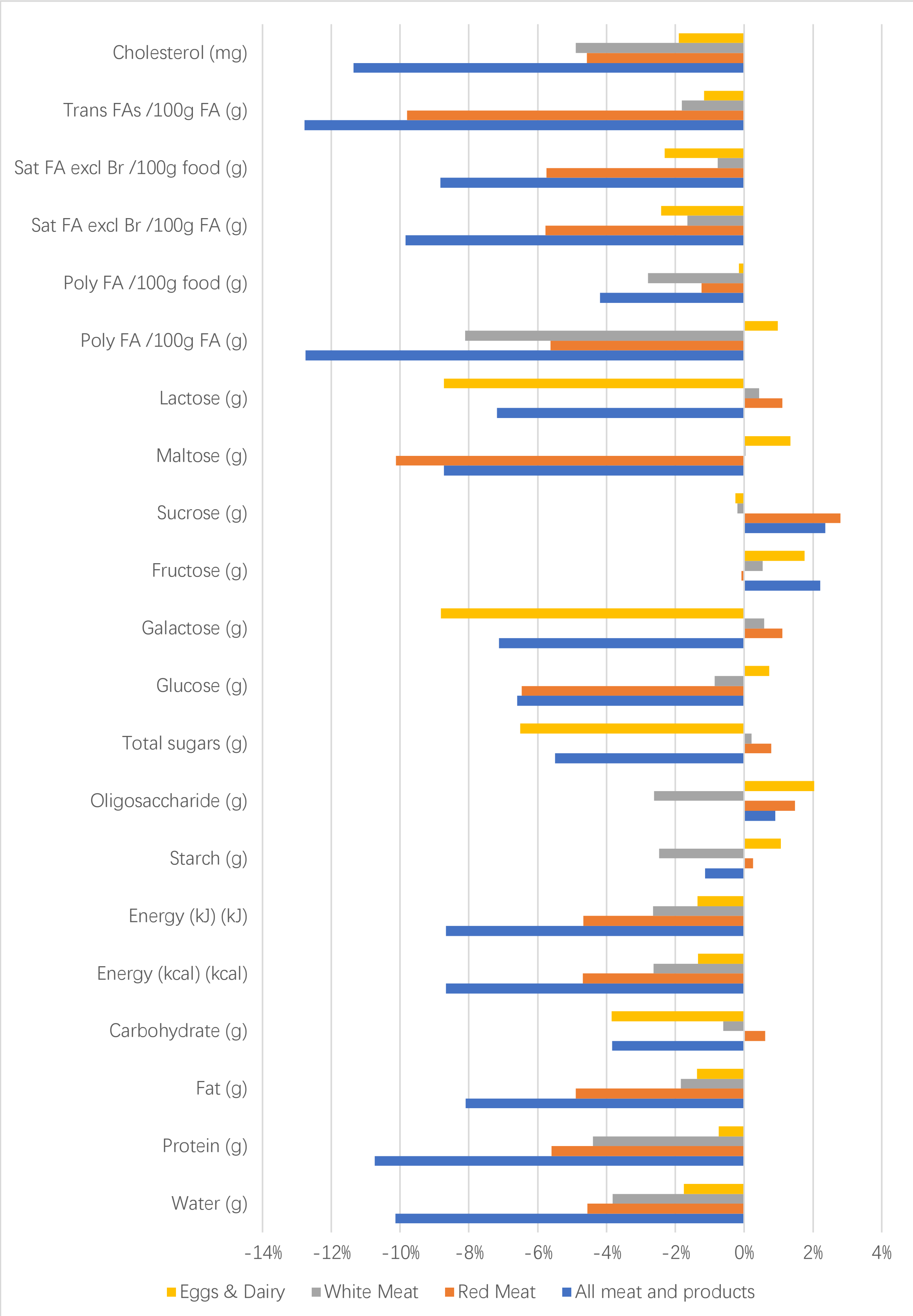

Figure 4. Percentage Change in Weekly Nutrient intake

Source: Author's own computation of Kantar Worldpanel data, 2023

Discussions

From the above results, if the price of animal protein increases, many consumers turn to plant protein products. This will in turn have a positive effect on the environment, and animal welfare. However, this shift may lead to a reduction in overall nutrient intake, which is consistent with Mariotti & Gardner (2019) who found that nutrient intake from plant proteins is low, and that there is the need to recognize the nutritional challenges involved and to take appropriate measures to ensure access to a complete and balanced nutrition.

Research shows that it is possible to reduce the demand for meat by increasing the price of meat protein without fully eliminating meat or dairy products from diet. This is consistent with the findings by Bonnet et al. (2018). Reducing the pressure of livestock farming on the environment and thus contributing to the reduction of greenhouse gas emissions, Westhoek et al. (2014) found that halving meat, dairy and egg consumption in Europe would reduce nitrogen emissions by 40 per cent and greenhouse gas emissions by 25-40 per cent. In addition, reducing the demand for meat reduces the demand for water resources and land, with positive impacts on combating climate change and environmental sustainability (Almeida et al., 2023; Bimbo, 2023; Moberg et al., 2021). In addition, by reducing the consumption of meat in response to pricing policies, farmers and livestock farmers may be encouraged to improve animal welfare by improving the conditions and treatment of animals. For example, the provision of larger grazing areas, improved animal husbandry (Michalk et al., 2019).

The nutritional implications show that the shift to plant protein products could lead to a decrease in overall nutrient intake. In terms of protein, in order to ensure adequate protein intake, consumers can contribute to balancing and diversifying their diets by increasing the supply of plant protein types such as pulses, grain, nuts and seeds, which promotes good health and nutrition (WBSD, 2020). As stated by Mariotti & Gardner (2019), the transition to a 100% plant proteins can be considered to involve little risk of inadequate protein intake when animal proteins are replaced with mixtures of protein-rich plant foods (i.e., legumes, nuts, and seeds). In addition, the shift in consumption will help in the adjustment of overall fat, cholesterol and calorie intake, a shift that is good for the obese population and encourages healthier eating habits. At the same time, plant protein products tend to be combined with healthier foods such as more vegetables, fruits and whole grains (Hu, 2003), which helps to provide more nutrients, fibre and antioxidants while lowering the intake of high-fat and high-calorie foods.

In terms of health, replacing animal sources with plant proteins can modestly improve glycaemic control in diabetic patients. Viguiliouk et al. (2015) found significant improvement in fasting blood glucose and fasting insulin levels in diabetic patients after replacing some of the animal protein with plant protein. Similarly, plant protein intake instead of animal protein reduces cancer risk. Although the risk of developing cancer is influenced by a number of factors such as genetic predisposition, environment, diet and lifestyle habits, Andersen et al. (2019) found that high meat intake was associated with a higher risk of colorectal cancer in carriers of certain genes compared to those with the same genetic predisposition but consuming a lower meat intake diet. Finally, there are also studies linking protein intake to mortality. For instance Huang et al., (2020) found that replacing animal proteins with plant proteins reduced the overall mortality by 10 per cent in both men and women.

5. Conclusion

This paper applies the Exact Affine Stone Index Implicit Marshallian Demand System (EASI model) proposed by Lewbel and Pendakur (2009) to 2021 home scan data collated by Kantar Worldpanel to investigate the nutritional impact of trade-offs between animal and plant proteins because of the recent price inflation. Twelve food groups of seven animal-based protein products and five plant-based protein products were considered. The results are important for understanding cross-category relationships and relevant policy makers.

The results of the study show that dairy and eggs in animal proteins are necessities for the people of Scotland. The demand for fish and non-dairy milk substitutes are the most price-sensitive among animal and plant proteins, respectively. This implies that the demand for these two types of goods is more responsive to price changes, and price fluctuations may directly affect consumers' purchasing decisions in these markets. As for cross-price elasticities, the results show that substitution is highest between eggs and dairy and other food categories. Estimates based on expenditure elasticities show that beef is considered a luxury or highly substitutable product in the Scottish diet. Peas are relatively basic, essential foodstuff.

In general, increasing the price of animal protein products increases the demand for plant protein products. This translates into changes in nutrition nutrient demand which cannot be ignored. By taxing all meat products, red meat, white meat, eggs, and dairy separately, consumers would increase their intake of plant proteins. This result in significant reduction in cholesterol, calorie, and fat purchases. The results also show that by increasing the price of meat sold, especially red meat, buyers will reduce their consumption of red meat, thereby reducing the environmental impact, improving the conditions and treatment of animals, and encouraging healthier dietary choices.

This study has certain limitation which would affect the interpretation of the results. First, it focuses on common meat and plants protein products and does not touch on how artificial products such as cultured meat and plant-based meat, for example, may affect consumers' choices. Second, the impact of the taxes on the supply of animal proteins were not factored in the simulation. Tax policies may lead consumers and producers to make different choices, such as finding alternatives or changing production methods. Understanding these behavioural changes is essential to assess the impact of tax policies on environmental impacts. It is therefore important to conduct careful supply chain analyses to predict possible responses and to take these predictions into account in the policymaking process.

Appendix

A1: Percentage Change in Quantities

Food products	All meat and products	Red Meat	White Meat	Eggs
Dairy	-7.12%	1.12%	0.58%	-8.82%
Beef and veal	-14%	-16.85%	0.84%	1.73%
Mutton and lamb	-17%	-16.82%	-2.63%	2.35%
Pork	-13%	-14.38%	-0.45%	1.40%
Poultry	-14%	-1.32%	-13.00%	0.72%
Fish	-14%	0.61%	-15.92%	0.94%
Eggs	-6%	0.84%	-0.29%	-6.53%
Peas	1%	1.73%	-2.95%	2.03%
Beans and pulses	3%	0.78%	1.29%	1.21%
Nuts, seeds and peanut butter	5%	4.20%	0.61%	0.33%
Non-dairy milk substitutes	2%	-1.18%	0.91%	2.08%

A2: Percentage Change in Weekly Nutrient intake

Nutrients	All meat and products	Red Meat	White Meat	Eggs & Dairy
Water (g)	-10%	-5%	-4%	-2%
Total nitrogen (g)	-11%	-6%	-4%	-1%
Protein (g)	-11%	-6%	-4%	-1%
Fat (g)	-8%	-5%	-2%	-1%
Carbohydrate (g)	-4%	1%	-1%	-4%
Energy (kcal) (kcal)	-9%	-5%	-3%	-1%
Energy (kJ) (kJ)	-9%	-5%	-3%	-1%
Starch (g)	-1%	0%	-2%	1%
Oligosaccharide (g)	1%	1%	-3%	2%
Total sugars (g)	-5%	1%	0%	-7%
Glucose (g)	-7%	-6%	-1%	1%
Galactose (g)	-7%	1%	1%	-9%
Fructose (g)	2%	0%	1%	2%
Sucrose (g)	2%	3%	0%	0%
Maltose (g)	-9%	-10%	0%	1%
Lactose (g)	-7%	1%	0%	-9%
NSP (g)	2%	2%	0%	1%
AOAC fibre (g)	1%	1%	-1%	1%
Satd FA /100g FA (g)	-13%	-9%	-4%	0%
Satd FA /100g fd (g)	-9%	-5%	-1%	-3%
n-6 poly /100g FA (g)	-6%	-5%	-2%	1%
n-6 poly /100g food (g)	-2%	-1%	-1%	0%
n-3 poly /100g FA (g)	-11%	-2%	-9%	1%
n-3 poly /100g food (g)	-13%	-2%	-10%	0%
cis-Mono FA /100g FA (g)	-10%	-5%	-4%	-1%
cis-Mono FA /100g Food (g)	-8%	-5%	-2%	-1%
Mono FA/ 100g FA (g)	-14%	-10%	-5%	1%
Mono FA /100g food (g)	-8%	-5%	-2%	-1%
cis-Polyu FA /100g FA (g)	-6%	-2%	-4%	0%
cis-Poly FA /100g Food (g)	-3%	-1%	-2%	0%
Poly FA /100g FA (g)	-13%	-6%	-8%	1%
Poly FA /100g food (g)	-4%	-1%	-3%	0%
Sat FA excl Br /100g FA (g)	-10%	-6%	-2%	-2%
Sat FA excl Br /100g food (g)	-9%	-6%	-1%	-2%
Branched chain FA /100g FA (g)	-12%	-9%	-1%	-2%
Branched chain FA /100g food (g)	-14%	-15%	0%	1%
Trans FAs /100g FA (g)	-13%	-10%	-2%	-1%
Cholesterol (mg)	-11%	-5%	-5%	-2%

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