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ANALYSIS

Cost-neutral food tax reforms for healthier and more sustainable diets

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ABSTRACT

This study evaluates cost-neutral food tax reforms integrating climate and health objectives, compared with strictly climate- and health-focused reforms. Results indicate that a strict climate-focused reform risks negative health outcomes, while the strict health-focused reform achieves only 40 % of the climate benefit of the integrated reforms and adversely impacts animal welfare.

Integrated tax reforms, however, could reduce Sweden's food carbon footprint by an amount equivalent to an 8 % reduction in passenger car emissions, alongside co-benefits such as decreased pesticide and fertilizer use and lower ammonia emissions. In addition, the healthier diets simulated as a result of the integrated reforms are estimated to save more than twice as many lives as those lost to road traffic fatalities.

Furthermore, the strict climate- and health-focused reforms lead to higher food costs, disproportionately affecting low-income groups. The integrated reforms were designed to be cost-neutral by applying subsidies in the form of VAT exemptions on healthy foods or through the redistribution of tax revenues to all citizens. This study demonstrates that it is possible to design food tax reforms to achieve substantial environmental and health improvements while avoiding additional financial burdens on consumers, suggesting a promising pathway for policy development.

1. Introduction

To curb the negative health and environmental impacts associated with the food system, production-side improvements need to be accompanied by demand-side mitigation such as dietary changes (Clark et al., 2020; Willett et al., 2019). Several organizations call for public policy interventions to steer eating habits in a more positive direction (European Commission Research directorate, 2023; Mathijs et al., 2023; Nordic Council of Ministers, 2024).

Most currently implemented food consumption policies focus on soft interventions, including issuing dietary guidelines and voluntary food labeling. However, the current availability, marketing, and pricing of unhealthy and emission-intensive foods necessitate stronger interventions to make a change. For example, research has confirmed that food marketing exploits adolescent vulnerabilities, with substantial adverse impact on their dietary habits and overall health (Harris and Smith Taillie, 2024). These effects could be alleviated by regulations on the marketing and availability of unhealthy foods — as illustrated by the UK's ban on price promotions and favorable in-store placement of such items (UK Department of Health and Social Care, 2023). Additionally, the negative health and environmental costs of unsustainable foods are not reflected in their market price, making them cheaper than their true price (Hendriks et al., 2023). Taxes are a potential strong policy instrument which can be used to internalize the external health and environmental costs associated with current dietary patterns. Health-related costs include healthcare expenditure and work absenteeism, leading to lower gross domestic product (GDP) and reduced tax revenue, while environmental costs include the negative consequences of climate change, eutrophication and biodiversity loss (Harris and Smith Taillie, 2024).

Taxing agricultural greenhouse gas emissions from food production bears the risk of carbon leakage, which can negate environmental benefits and lead to domestic job losses (Ricci et al., 2024; Säll and Gren, 2015). Taxing the consumption of both domestically produced and

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imported foods can help circumvent these problems and avoid the need to measure emissions at the farm level, which can be challenging (Funke et al., 2022; Schmutzler and Goulder, 1997). No country has yet implemented environmental taxes on food. However, health-related taxes, primarily on sugar-sweetened beverages, have positively influenced consumption habits, through both consumer response and producer adjustments via reformulation (Andreyeva et al., 2022; Teng et al., 2019).

A number of modeling studies have demonstrated the potential health and environmental benefits of tax reforms (see review articles: Doro and Réquillart, 2020; Mészáros et al., 2024). However, low levels of public support, particularly for taxes on meat products (Grimsrud et al., 2020; Pechey et al., 2022), poses a critical barrier to political implementation. Negative perceptions of meat taxes may partly stem from consumers' strong cultural and emotional attachment to meat (Graça et al., 2020). Additionally, general resistance to taxation as a policy tool is often linked to concerns over increased personal financial burden (Kallbekken et al., 2013) and the regressive nature of taxes, which disproportionately impact low-income households (Maestre-Andrés et al., 2019). This regressivity arises because higher taxes on specific food items elevate overall food expenditures, with low-income households spending a relatively larger share of their disposable income on food (Funke et al., 2022).

To address this challenge, the present study focuses on cost-neutral food tax reforms. Research on policy acceptability suggests that cost-neutral approaches—such as allocating revenues from meat taxes to reduce the value-added tax (VAT) on other foods—are likely to gain greater public support (Ejelöv et al., 2025; Grimsrud et al., 2020; Siegerink et al., 2024). Another mechanism for achieving cost-neutrality involves redistributing tax revenues equally among citizens, an approach implemented for fossil fuel taxes in Canada (Government of Canada, 2024). While the acceptability of such schemes remains uncertain, evidence indicates that public approval can be significantly enhanced when individuals are made aware of the equitable distributional effects (Douenne and Fabre, 2022; Sommer et al., 2022).

This study aims to identify and evaluate fully cost-neutral food tax reforms that deliver both health and climate benefits. Some previous studies have included both taxes and subsidies, making the reforms more cost-neutral compared to using taxes alone (Briggs et al., 2013; Caillavet et al., 2019; Edjabou and Smed, 2013; Springmann et al., 2025; Springmann et al., 2017). For instance, Springmann et al. (2025) analyzed a near cost-neutral reform in which the highest VAT rate was applied to meat and dairy products, while a zero VAT rate was applied to fruits and vegetables, resulting in beneficial outcomes for both environmental sustainability and public health.

While most previous studies predominantly examine the effects of food taxes on a single environmental dimension, namely climate outcomes (Mészáros et al., 2024), this research incorporates ten sustainability dimensions. This multidimensional approach enables an evaluation of potential trade-offs among objectives, such as those related to climate, biodiversity, and animal welfare. This study also contributes to previous literature by analyzing a more extensive health approach, which not only subsidizes fruit and vegetables but also legumes and wholegrain foods, as well as excise taxes on sugar-sweetened beverages. The dimension of cost-neutrality is comprehensively addressed through the analysis of two distinct mechanisms: reducing value-added tax (VAT) on certain foods and redistributing tax surpluses among citizens.

Moreover, Doro and Réquillart (2020) highlighted that most food tax studies neglect the budgetary reallocation effects between food and non-food items, potentially overestimating emission reductions. This study addresses this gap by accounting for these reallocation dynamics, providing a more accurate assessment of the environmental impacts of food tax reforms.

This study also analyzes the distributional outcomes across different income groups. Previous research has found that climate-related food taxes tend to disproportionately affect low-income groups (García-Muros et al., 2017; Klenert et al., 2023; Säll, 2018). Caillavet et al. (2019) included subsidies for fruits and vegetables in their analysis, yet still found regressive effects, which they attributed to differences in baseline consumption patterns between low- and high-income groups.

The simulations were performed for Sweden, a country that shares many food-related challenges with other high-income countries, such as rising obesity rates (+200 % since 1980, The Public Health Agency of Sweden, 2024), a high red meat consumption (double the global average, FAO, 2023) as well as generally highly environmentally unsustainable eating patterns (Moberg et al., 2020). Moreover, the availability of comprehensive data for Sweden enables the simulation of tax adjustments for specific food categories across different income brackets.

2. Data and methods

This section begins with a description of the analyzed food tax reforms, followed by an overview of the food consumption data applied. Subsequently, the methods for estimating price sensitivity and analyzing environmental, health, and distributional effects are described.

2.1. Analyzed food tax reforms

The focus of this study is to evaluate cost-neutral food tax reforms that integrate both climate and health objectives, comparing them with strictly climate-focused and health-focused reforms. To achieve this, four distinct reforms were developed, incorporating different food items and tax levels: 1. Climate tax, 2. Health tax shift, 3. Integrated tax shift – redistribution, and 4. Integrated tax shift – subsidies.

A fundamental principle of the policy design process was to include only taxes targeted at driving consumption changes supported by robust scientific evidence of climate or health benefits. Additionally, the policy focused on a limited number of food categories with the greatest climate or health impacts to minimize administrative costs of the reform.

Reform 1 included excise taxes on beef, lamb, pork, fish and shellfish, and dairy products. These were identified as the top emitters of greenhouse gases (Moberg et al., 2019; Poore and Nemecek, 2018), and in our data they are responsible for 62 % of the climate impact of Swedes' food consumption.

Reform 2 involved changes to VAT from the current Swedish level of 12 % on food categories deemed most important from a health perspective (Blomhoff et al., 2023; Clark et al., 2019; Hankey, 2019). Lower VAT levels were applied to fruits, vegetables, legumes, wholegrains (in bread, pasta, muesli, and cereals), as well as fish and shellfish, while higher VAT levels were applied to energy-dense, nutrient-poor foods (sugar-sweetened beverages, sweets and chocolate, chips and salty snacks, and pastries), plus red and processed meats.

Reform 3 and 4 took an integrated approach to deliver both health and climate benefits, as well as to be cost-neutral for both the average consumer and public finances. In Reform 3, cost-neutrality is achieved by redistributing state revenue as a lump sum to all citizens, whereas in Reform 4, it is achieved by offsetting taxes on certain foods with decreased taxes on others. These reforms adopt most of the tax changes from Reforms 1 and 2, albeit with a few notable exceptions. For example, dairy products such as cheese, milk, and butter were included in the climate tax reform but excluded in the integrated reforms. The exclusion is based on the lower climate benefits of taxing dairy compared to red meat, as well as the fact that dairy products are not linked to negative health outcomes in the same way as red meat (WHO, 2023). Conversely, while fish were subsidized in the health tax reform, it was excluded in the integrated reforms due to the relatively high climate impact of fish and shellfish (see Appendix B).

A key distinction between Reforms 3 and 4 lies in the treatment of sweets and chocolate, chips and salty snacks, and pastries. Reform 3 applies a higher VAT to these less healthy products, whereas Reform 4

Table 1

Changed taxes and subsidies in the four simulated food tax reforms. The tax-induced price changes listed under the altered VAT rates represent the average for the products included in our model; in practice, these changes would vary based on the specific price of each product. The excise taxes per kilogram or liter, however, remain the same regardless of whether the product is a cheaper or more expensive alternative. Empty cells indicate that the current 12 % VAT level remains unchanged.

	1. Climate tax	2. Health tax shift	3. Integrated tax shift - redistribution	4. Integrated tax shift - subsidies
Beef & lamb	Excise tax	25 % VAT	Excise tax	Excise tax
Absolute price change Relative price change	€ + 3.2/kg +25–30 %	€ + 1.3/kg +12 %	€ + 3.2/kg +25 to 30 %	€ + 2.7/kg +22 to 26 %
Pork	Excise tax	25 % VAT	Excise tax	Excise tax
Absolute price change Relative price change	€ + 0.5/kg +7 to 8 %	€ + 0,9/kg +12 %	€ + 0.5/kg +7 to 8 %	€ + 0.5/kg +6 to 7 %
Processed meat	Excise tax	25 % VAT	Excise tax	Excise tax
Absolute price change Relative price change	€ + (0.5)/kg[a] +5 to 6 %	€ + 1,0/kg +12 %	€ + (0.5)/kg[a] +5 to 6 %	€ + (0.4)/kg[a] +5 %
Fish & shellfish	Excise tax	0 % VAT		
Absolute price change Relative price change	€ + 0.7/kg +5 to 7 %	€-1.2/kg -10.7 %		
Cheese	Excise tax			
Absolute price change Relative price change	€ + 0.6/kg +6 %			
Wholegrain foods		0 % VAT	0 % VAT	0 % VAT
Absolute price change Relative price change		€-0.2 to −0.6/kg - 10.7 %	€-0.2 to −0.6/kg - 10.7 %	€-0.2 to −0.6/kg - 10.7 %
Vegetables, legumes, fruit		0 % VAT	0 % VAT	0 % VAT
Absolute price change Relative price change		€-0.3 to −0.4/kg - 10.7 %	€-0.3 to −0.4/kg - 10.7 %	€-0.3 to −0.4/kg - 10.7 %
Yoghurt & soured milk	Excise tax			
Absolute price change Relative price change	€ + 0.1/kg +5 to 6 %			
Cream, sour cream, cultured cream	Excise tax			
Absolute price change Relative price change	€ + 0.3/kg +6 %			
Milk	Excise tax			
Absolute price change Relative price change	€ + 0.1/kg +9 %			
Sugar-sweetened beverages		Excise tax	Excise tax	Excise tax
Absolute price change Relative price change		€ + 0.3/l + 16 to 18 %	€ + 0.3/l + 16 to 18 %	€ + 0.3/l + 16 to 18 %
Sweets & chocolate		25 % VAT	25 % VAT	
Absolute price change Relative price change		€ + 1.2/kg + 12 %	€ + 1.2/kg + 12 %	
Chips & salty snacks		25 % VAT	25 % VAT	
Absolute price change Relative price change		€ + 1,0/kg + 12 %	€ + 1,0/kg + 12 %	
Pastries		25 % VAT	25 % VAT	
Absolute price change Relative price change		€ + 0,8/kg + 12 %	€ + 0,8/kg + 12 %	
Butter	Excise tax			
Absolute price change Relative price change	€ + 0.7/kg +8 to 9 %			
Margarine	Excise tax			
Absolute price change Relative price change	€ + 0.4/kg +7 to 8 %			
Redistribution to all citizens			All state revenues	

[a] The tax level on processed meat is based on the carbon footprint of beef, lamb, and pork respectively and the average content of beef/lamb and pork in processed meat.

does not. This difference reflects the underlying design strategies of the two reforms. Reform 3 achieves cost neutrality through lump-sum redistribution of tax revenues to all citizens, while Reform 4 achieves it through subsidies in the form of VAT exemptions on healthier foods. Including VAT increases on the above-mentioned product categories in Reform 4 would have generated substantial tax revenues, making it difficult to identify a sufficient number of healthy food categories to offset those increases through tax reductions, thereby compromising cost neutrality. Table 1 outlines the specific price changes induced by taxes that were simulated for each reform. This study assumes that 100 % of the taxes are passed on to consumers, consistent with empirical research showing that both VAT reductions on food and new levies on sugar-sweetened beverages exhibit high pass-through rates (Andreyeva et al., 2022; Fuest et al., 2025).

The tax rates in Reform 1 and 3 are based on the carbon footprint per kg of food (Appendix B) and a carbon price of €100 per tonne of CO_2. This aligns with the current carbon tax on fossil fuels in Sweden and is consistent with recent estimates of the social cost of carbon (Rennert et al., 2022). To create an approach that is close to cost-neutral for the average consumer in Reform 4, the excise tax on beef, lamb and pork is calibrated to compensate for the removal of VAT on healthy foods. Reforms 2, 3 and 4 include an excise tax on sugar-sweetened beverages of €0.3 per liter, consistent with the highest tax of the UK model. For the health-related foods in Reforms 2, 3 and 4, no similar data on externalities for each food category exist. Therefore, the analyses used Sweden's highest current VAT level (25 %) on less healthy foods and zero VAT on foods with health benefits.

2.2. Purchasing data and categorization

While most modeling studies rely on purchasing data from households, this study utilizes data from retailers. This approach has distinct advantages and disadvantages. Retail data is generally more reliable, as it is sourced directly from centralized retail data systems. In contrast, household data, being self-reported, is prone to omissions and biases. Our dataset is also exceptionally rich, providing detailed information on sold quantities (kg) and prices for over 22,000 products, recorded weekly across 31 Swedish supermarkets over a period of 119 weeks from 2021 to 2023.

A potential drawback of using retail data is the absence of detailed household characteristics like socioeconomic status, which is used for analyzing health and financial disparities. To address this, we categorized the 31 supermarkets into three groups, based on the average personal income of the population residing near each store, to represent socioeconomic status. Our retail data was sourced in collaboration with ICA, Sweden's leading food retail chain, which operates 1300 stores and holds approximately half of the Swedish market share. From their medium-sized segment, we selected 31 stores that offer a full assortment of food products. These stores, with an average size of 1300 m^2, primarily serve nearby residents. In contrast, stores in the largest segment (>2500 m^2) attract many customers from outside the local area, while the smallest stores (average 500 m^2) were excluded from the analysis, as they are mainly used for supplementary shopping (ICA Fastigheter, 2024). The stores were chosen randomly from all the stores in the medium-sized segment, stratified by geographic area to represent the whole country.

For our analysis, average personal income data for the areas surrounding the stores were obtained from Statistics Sweden, covering 5984 designated "DeSO areas" (Statistics Sweden, 2024b). In the areas where the 10 stores classified as being in middle-income locations were situated, the average personal income after tax was €23,675. In comparison, the average income in low-income areas, where 11 stores were located, was €17,487 (26 % lower than the middle-income average). In high-income areas, where 10 stores were located, the average income was €28,098 (19 % higher than the middle-income average).

We deem retail data to be an adequate alternative to household data in our case. In addition, it enables nuanced analyses that account for differences in price sensitivity, as described in Section 3.1, as well as differences in price per kilogram of food in low-, middle-, and high-income areas. On average, prices for the different food categories were 3 % lower in supermarkets in low-income areas and 7 % higher in high-income areas compared to those in middle-income areas. This price variation could be due to differences in brand or product choices within the food category, as well as price differences for the same products. Furthermore, prices paid by consumers within each income group can vary - for example, between individuals purchasing the lowest-cost options and those selecting premium products. Nonetheless, the stratification into three distinct income groups with specific price levels represents an improvement over most studies, which typically rely on a single average price.

To facilitate the analysis of the demand system, the over 22,000 food items contained in the retail data were categorized into different food groups. To ensure robust estimates, the food groups were organized into three stages (see columns in Table 2). In the first stage, the categorization was guided by the principle of reflecting actual consumption behaviors, acknowledging that certain foods fulfill similar dietary roles, such as both pasta and potatoes fulfilling one's dietary need for carbohydrates (Seale Jr et al., 2003). This led to the following Stage 1 categories: 1) protein-rich foods, 2) cereals, grains & potatoes, 3) fruit, vegetables & legumes, 4) dairy foods, 5) beverages, 6) snacks, and 7) fats & spreads.

The categories for stages 2 and 3 were primarily developed based on policy relevance, aiming to enable evaluation of price changes targeting food categories with climate and health impacts (see Section 2.1), consistent with previous studies sharing a similar objective (Caillavet et al., 2019; García-Muros et al., 2017; Klenert et al., 2023). For example, in Stage 2 we distinguish between sugar-sweetened and sugar-free soft-drinks to be able to estimate the effect of a tax on sugar-sweetened beverages. In Stage 3, we further differentiate between for example bread (Stage 2 category) with no/little wholegrain and high wholegrain respectively.

2.3. Baseline food consumption

Data on baseline (current) consumption were obtained from the Swedish Board of Agriculture (2024), using averages from 2021 and 2022. This was the latest available data (note that the 2022 data are preliminary and may be slightly adjusted in future database updates). These data include total quantities of food sold to consumers and large-scale kitchens (including food waste) per capita (kg/year).

The baseline data described above is not differentiated for consumers of differing socio-economic backgrounds. To analyze the price sensitivity, health, and distributional effects for low, middle, and high-income consumers, we differentiated the Swedish Board of Agriculture's consumption data using the sales data. To estimate the baseline consumption for low, middle, and high-income groups, the consumption data from the Swedish Board of Agriculture was weighted by how much the quantities sold by supermarkets in each income area deviated from the total quantities sold from all supermarkets (see equation below). Using the category *beef & lamb* for high-income supermarkets as an example, a value of 1 indicates that there is no difference between supermarkets in high-income areas and the average supermarket in terms of the relative share of *beef & lamb* within the total consumption of protein-rich foods. A value greater than 1 suggests that beef & lamb have

Table 2
Categories and baseline consumption per income group per person per year. Note: kg = kilograms; l = liters.

Stage 1	Stage 2	Stage 3	Income group			
			Low	Middle	High	Average
Protein-rich foods	Beef & lamb		11.9 kg	10.6 kg	15.2 kg	12.5 kg
	Pork		12.8 kg	14.2 kg	10.7 kg	12.6 kg
	Processed meat		18.7 kg	19.2 kg	16.5 kg	18.2 kg
	Poultry		22.2 kg	19.0 kg	23.3 kg	21.5 kg
	Fish & shellfish		7.94 kg	7.45 kg	8.02 kg	7.80 kg
	Plant-based protein products		1.97 kg	1.91 kg	1.67 kg	1.85 kg
	Egg		11.2 kg	12.6 kg	10.3 kg	11.4 kg
	Cheese		18.1 kg	18.3 kg	19.8 kg	18.7 kg
Cereals, grains & potatoes	Bread & flour	Bread - no/low wholegrain	42.7 kg	44.5 kg	44.8 kg	44.0 kg
		Bread - high wholegrain	10.8 kg	10.0 kg	10.4 kg	10.4 kg
		Flour	8.14 kg	7.46 kg	7.07 kg	7.56 kg
	Muesli, cereal & porridge oats	Muesli & cereals - no/low wholegrain	1.60 kg	1.71 kg	1.76 kg	1.69 kg
		Muesli & cereals - high wholegrain	0.46 kg	0.53 kg	0.53 kg	0.50 kg
		Porridge oats - no/low wholegrain	0.13 kg	0.08 kg	0.07 kg	0.09 kg
		Porridge oats - high wholegrain	1.42 kg	1.29 kg	1.25 kg	1.32 kg
	Rice, pasta & potatoes	Pasta - no/low wholegrain	10.1 kg	10.2 kg	10.6 kg	10.3 kg
		Pasta - high wholegrain	0.21 kg	0.22 kg	0.23 kg	0.22 kg
		Rice & potatoes	61.3 kg	61.1 kg	60.4 kg	61.0 kg
Fruits, vegetables & legumes	Vegetables & root vegetables		65.8 kg	64.3 kg	62.3 kg	64.1 kg
	Legumes		3.16 kg	2.71 kg	2.42 kg	2.76 kg
	Fruit		58.5 kg	60.0 kg	61.8 kg	60.1 kg
Dairy foods	Yoghurt & soured milk		24.0 kg/l	25.3 kg/l	27.4 kg/l	25.5 kg/l
	Cream, sour cream, cultured cream		6.44 kg/l	6.67 kg/l	6.40 kg/l	6.50 kg/l
	Milk		64.6 kg/l	63.7 kg/l	59.9 kg/l	62.8 kg/l
	Plant-based dairy alternatives		5.93 kg/l	4.93 kg/l	6.34 kg/l	5.73 kg/l
Beverages	Sugar-sweetened soft drinks		62.9 l	59.4 l	52.0 l	58.1 l
	Sugar-free soft drinks		40.8 l	45.3 l	47.4 l	44.5 l
	Beer (0–3.5 % alc.)		11.4 l	11.0 l	10.8 l	11.1 l
	Juice		14.8 l	14.8 l	16.7 l	15.4 l
	Coffee, tea & cocoa		10.2 kg	10.8 kg	9.3 kg	10.1 kg
	Mineral water		4.67 l	4.50 l	5.22 l	4.80 l
Snacks	Sweets & chocolate		15.6 kg	15.9 kg	16.8 kg	16.1 kg
	Chips & salty snacks		5.34 kg	5.76 kg	5.73 kg	5.61 kg
	Pastries		22.5 kg	20.4 kg	19.0 kg	20.6 kg
	Nuts & seeds		2.91 kg	3.13 kg	3.28 kg	3.11 kg
Fats & spreads	Butter		2.48 kg	2.68 kg	3.02 kg	2.72 kg
	Margarine		10.1 kg	10.8 kg	10.0 kg	10.3 kg
	Vegetable oils		2.05 l	1.53 l	1.75 l	1.78 l

Notes. The categorization of bread, muesli & cereals, porridge oats, and pasta in terms of low or high wholegrain content is based on the minimum values specified by the Swedish "keyhole" front-of-pack label system requirements (Swedish food agency, 2024). Ready-made meals were omitted from this analysis.

a higher share of protein-rich foods in high-income supermarkets than in the average market. A value less than 1 indicates that beef & lamb have a lower share of protein-rich foods in high-income supermarkets compared to the average market.

$$\frac{\textit{Sales of beef\&lamb from low income supermarkets}}{\textit{Sales of all proteinrich foods from low income supermarkets}} \Big/ \frac{\textit{Sales of beef\&lamb from all supermarkets}}{\textit{Sales of all proteinrich foods from all supermarkets}}$$

This deviation is then applied to the baseline consumption that is obtained from the Swedish Board of Agriculture (2024). For example, the sales of beef and lamb as a share of protein-rich foods are 22 % higher in stores in high-income areas compared to the average across all supermarkets. The average consumption of beef and lamb, as estimated by the Swedish Board of Agriculture, is 12.5 kg, and the estimated baseline consumption among high-income households is 15.2 kg per person per year.

The Swedish Board of Agriculture's consumption data does not include volumes of plant-based protein products, legumes, and plant-based dairy alternatives. Therefore, to estimate the baseline consumption of these foods, we used the sales data from supermarkets to relate sales of these foods to sales of other foods measured by the Swedish Board of Agriculture. For example, the Swedish Board of Agriculture consumption data shows that the consumption of protein-rich foods is 102.7 kg per year. However, this figure does not include plant-based protein products. To estimate the consumption of these products, we used our sales data, where plant-based protein products accounted for 1.8 % of all protein-rich food sales. Based on this proportion, we estimated the average consumption of plant-based protein products to be 1.9 kg per year (i.e., 1.8 % of 102.7*100/98,2).

In the same way, we used data from supermarkets to estimate the shares of sugar-sweetened and sugar-free soft drinks, as well as the shares of no/low and high wholegrain foods.

2.4. Analyses of price sensitivity

The price elasticities were estimated using a Linear Approximation of the Almost Ideal Demand System (LA-AIDS) model with the Stone price index (Deaton and Muellbauer, 1980) using the software R package micEconAids (see Henningsen, 2017 for detailed information on the setup of the LA-AIDS model). Demand systems were estimated separately for each income group. We used a three-stage budgeting model, with demand functions estimated separately at each stage (Table 1) assuming that expenditure allocation occurs in independent stages. Marshallian price elasticities from all three stages were then combined into a matrix of total elasticities, using the approach described by Edgerton (1997). We first combine elasticities from Stages 1 and 2, and then (when applicable) combine these with Stage 3 elasticities to obtain the final elasticities.

To estimate the change in quantity and total expenditure between baseline consumption and the different tax reforms, we used the approach outlined in Blakely et al. (2020). We did so because introducing price changes in a conditional demand system where starting consumption is estimated separately from price elasticities can yield unrealistic changes in total expenditure such as total food expenditure decreasing after a tax is introduced. Blakely et al. (2020) suggest accounting for the total food expenditure elasticity and average change in food price index *after* the tax or subsidy, when estimating total expenditure. In summary, the first step involves scaling the estimated quantity changes so that, when multiplied by post-tax/subsidy prices, the total expenditure remains unchanged. In the second step, change in total expenditure is then estimated using the total food expenditure elasticity and average change in food price index, allocated across different foods using expenditure elasticities. For the full two-step calculation, see Blakely et al. (2020). To calculate total food expenditure after a tax or subsidy, we used a total food expenditure elasticity of 0.61, which is a weighted average of a European food expenditure elasticity (Salotti et al., 2015).

To calculate price elasticities, we utilized the dataset over sales (in monetary terms) and sold quantities (in kg) for different food products at 31 stores over 119 weeks. The price for each food category was calculated by dividing the total sales for the category with the total quantity sold. Data points with implausible values (negative sales values and unreasonably high prices, such as kilo prices for Juice over € 4511) were omitted from the analysis due to a high probably of erroneously inserted data. Data on sales of local and deli products were omitted as quantities for these categories could not be reliably calculated, due to store variabilities in data entry. Holiday weeks (such as Christmas, and Easter and Midsummer) were omitted from most demand systems due to major sales variations. Ice-cream was further omitted from the Snacks category due to strong seasonal effects.

All demand systems were checked for autocorrelation and heteroskedasticity, using Durbin-Watson and Breusch-Pagan tests. When autocorrelation was present, we tested lagged price or total expenditure variables. For all demand systems, autocorrelation was present for some equations even after using lagged variables (see Supplementary). As a decision-making rule, we retained the demand systems which had the fewest autocorrelated equations and in which our economic assumptions held. For example, own-price elasticities being greater than cross-price elasticities, and negative Marshallian and Hicksian own-price elasticities.

2.5. Environmental impact methodology

The analysis of environmental impacts from various food tax reforms utilizes the SAFAD (Sustainability Assessment of Foods and Diets) tool, accessible at www.safad.se. The following indicators are used: carbon footprint, cropland use, biodiversity impact from land use, pesticide use, blue water use, ammonia emissions, new nitrogen input, and new phosphorus input, plus antibiotics use and animal welfare in livestock production. The sustainability indicators in SAFAD reflect the Swedish Environmental Objectives (Moberg et al., 2020) and were further included in SAFAD based on recommendations in Ran et al. (2024). Information on the methods and main data sources for all indicators is summarized in Appendix A.

The animal welfare index reflects the number of animals affected per kilogram of product, each species' capacity to experience negative states, and the level of suffering in typical production systems. Suffering was estimated based on indicators such as mortality rates, disease prevalence, spatial restrictions, and the duration of slaughter, thereby capturing key aspects of animals' living and dying conditions. The species-specific capacity to experience negative states was derived from expert assessments rather than neurological proxies, in order to account for variation related to age, domestication, and sentience across a wide range of species. This approach is conceptually based on the framework developed by Scherer et al. (2018) and follows the structured assessment steps outlined by Richter et al. (2024).

The outcome in terms of the animal welfare index, in descending order, is as follows: Poultry (80.4), Fish and shellfish (72.2), Eggs (8.59), Processed meat (7.08), Pork (3.95), and Beef and lamb (0.25), while dairy and all other food categories have negligible index values (see Appendix B). As an illustration of how the index works, that beef and lamb have a better score on the animal welfare index than for example poultry has to do with the production of 1 kg poultry affecting more animals and having a higher level of suffering in the productions system compared to the production of 1 kg of beef.

The indicators reflect impacts associated with the primary production of 1 kg (including waste), and account for the impacts of domestic production and imports. In addition to emissions from primary production, the carbon footprint includes emissions associated with transport (excluding consumer transport), processing and packaging.

Indicator values representative of the Swedish market were calculated by weighting country-specific values according to import shares (Moberg et al., 2019). For example, the indicator values for beef on the Swedish market comprise the values of beef from Sweden (57 %), Ireland (11 %), Germany (8 %), and so on, reflecting countries of origin.

Sold quantities for the food categories used in the environmental analysis in this study were calculated as weighted averages of the 20 most sold (by weight) food items in each category (see Appendix B). For example, the four top-selling fruits — bananas, oranges, mandarins, and apples — together account for 86 % of total fruit sales, indicating that covering the 20 most sold fruits captures a very high share of this category.

To ensure a comprehensive assessment of the climate impact in reform 3 the calculations include the effect on emissions from non-food consumption. The emission intensity associated with this consumption was calculated by dividing the total household greenhouse gas emissions (Swedish EPA, 2024c) by the total expenditure in monetary terms (Statistics Sweden, 2024a). The non-food emission intensity was 0.18 kg CO_2e per €. According to previous research, emissions from marginal consumption are typically 20 % lower than the average consumption (Nässén and Larsson, 2014). Consequently, an emission factor of 0.15 kg of CO_2e per € was applied for marginal non-food consumption. For Reform 3, we assume that 3.2 % of the redistributed tax surplus is allocated to food purchases. This assumption is based on a linear approximation derived from current food expenditure patterns across the three income groups and is incorporated into the estimated food consumption. The climate calculations also include the carbon footprint from the other 96.8 % of the money which is assumed to be used for non-food consumption.

2.6. Health impact assessment methodology

To estimate the effects on health outcomes, we used the WHO Diet Impact Assessment model (WHO, 2023), which uses a comparative risk assessment methodology. The model calculates the number of premature deaths—occurring between the ages of 30 and 70—that would theoretically have occurred if the population had followed the counterfactual reform. If the reform has a positive impact on health, the outcome is expressed as the number of premature deaths avoided. The dietary factors related to mortality risks were intakes of wholegrains, red meat, processed meat, fruits, vegetables, legumes, and nuts and seeds, and the diseases are cancer (primarily colorectal), stroke, coronary heart disease and type 2 diabetes. By applying established relative risk ratios for specific diet factor–disease pairs (e.g., fruit intake and type 2 diabetes mortality), reductions in population-level mortality risk due to improved dietary intake can be estimated (WHO, 2023). The calculations were based on Swedish population and mortality data from 2018, the reference year used in the tool. These diet–disease associations are independent of changes in body weight; therefore, total energy intake was not calculated (see justification in Section 4.2).

Nonetheless, to assess potential changes relevant to body weight, we estimated changes in energy intake from a specific subgroup of foods associated with excess calorie consumption and weight gain, namely, energy-dense, nutrient-poor foods. These foods have particularly low satiating effects and are easily consumed in large quantities alongside other foods. While our analysis of calories from energy-dense, nutrient-poor foods provides an indication of possible health impacts, it does not necessarily reflect changes in total energy intake.

The analysis includes an estimation of changes in calorie intake from key categories of energy-dense, nutrient-poor foods: sugar-sweetened soft drinks, sweets and chocolate, chips and salty snacks, and pastries. To estimate changes in calorie intake, we calculated a weighted average caloric value based on the 20 top-selling products within each category.

2.7. *Distributional effect methodology*

How tax reforms impact the private finances of low, middle, and high-income groups can be analyzed in various ways. One metric evaluates how much individuals' "utility level" (consumer surplus) decreases due to tax-induced changes in dietary patterns. However, this measure has been criticized as it optimizes short-term utility. This is questionable, given that current dietary patterns contribute to illness and reduced long-term well-being (Funke et al., 2022).

The metric employed in this study is the direct quantification of changes in food expenditures as a proportion of disposable income. The change in total expenditure before and after the tax reform was divided by the median disposable income level for each income group. For details on median income across various income brackets, see Section 2.1.

3. Results

First, the results regarding consumption changes for various food categories are presented (3.1), followed by the outcomes in terms of environmental impacts (3,2), health (3.3) and distributional (3.4) effects for different income groups.

3.1. *Consumption changes*

The basis for simulating the impact of tax reforms on consumption changes is price elasticities. We find that, on average, across the three income groups, the own-price elasticity for beef and lamb is −0.85, for pork −1.12, for legumes −0.84, and for fruit −0.84 (all own- and cross-price elasticities for the three income groups are found in the Supplementary). We compared our elasticities with those reported in a meta-study covering 424 studies (Bouyssou et al., 2024). The meta-study found average elasticities for the European Union of −0.75 for beef, −0.79 for pork, and − 0.85 for a broader food category that includes fruit, vegetables, pulses, and tubers. This indicates that the elasticities calculated and used in our study are well aligned with previous research.

The own-price elasticities were, on average for the 38 food categories, 14 % higher for the low-income group compared to the middle- and high-income groups. This indicates that the low-income group's consumption is more susceptible to price changes, relative to the middle and high-income groups. The largest difference was observed in fruit and vegetables, where the price elasticity was 42 % higher in the low-income group.

Table 3 presents the results of the simulations for each reform, focusing on the tax-induced consumption changes and covering the most relevant food categories. These results are based on both own-price and cross-price elasticities. Detailed consumption changes across all 38 food categories by income group are found in Supplementary. The results assume that VAT and excise tax changes are fully transferred to the consumer.

3.2. *Effects on environment, animal welfare and antibiotics use*

All reforms show carbon footprint reductions (Fig. 1). As anticipated, the strongest effect is in Reform 1 (5.9 % lower carbon footprint from

Table 3
Selected consumption changes in kg (or liters) per capita per year, and percent.

	1. Climate tax		2. Health tax shift		3. Integrated tax shift - redistribution		4. Integrated tax shift - subsidies	
Beef & lamb	−2.5 kg	−20 %	−0.9 kg	−6.7 %	−2.7 kg	−22 %	−2.4 kg	−19 %
Pork	0.8 kg	6.2 %	−0.7 kg	−6.3 %	0.2 kg	1.7 %	−0.1 kg	−0.7 %
Processed meat	−0.7 kg	−4.0 %	−2.1 kg	−12 %	−1.2 kg	−6.3 %	−1.0 kg	−5.5 %
Poultry	1.5 kg	7.1 %	0.0 kg	−0.1 %	0.5 kg	2.3 %	0.3 kg	1.2 %
Fish & shellfish	−0.2 kg	−2.6 %	0.4 kg	4.6 %	−0.2 kg	−2.2 %	−0.2 kg	−3.0 %
Plant-based protein products	0.2 kg	11 %	0.1 kg	7.6 %	0.1 kg	8.4 %	0.1 kg	6.3 %
Egg	1.2 kg	10 %	0.0 kg	0.0 %	0.5 kg	3.9 %	0.3 kg	2.6 %
Cheese	−1.8 kg	−10 %	−0.7 kg	−3.9 %	−1.2 kg	−6.2 %	−1.0 kg	−5.1 %
No/low wholegrain foods[a]	4.0 kg	7.2 %	6.6 kg	12 %	7.9 kg	14 %	8.5 kg	15 %
Wholegrain foods[a]	0.6 kg	4.8 %	1.2 kg	9.4 %	1.4 kg	11 %	1.3 kg	10 %
Flour	0.4 kg	5.2 %	−0.3 kg	−3.6 %	−0.2 kg	−2.2 %	−0.3 kg	−3.7 %
Rice & Potatoes	3.8 kg	6.3 %	7.2 kg	12 %	8.4 kg	14 %	8.4 kg	13.7 %
Vegetables, Legumes & Fruit	−12 kg	−10 %	6.7 kg	5.3 %	4.3 kg	3.4 %	5.6 kg	4.4 %
Dairy foods	2.6 kg/l	2.7 %	4.4 kg/l	4.7 %	6.5 kg/l	6.8 %	4.0 kg/l	4.2 %
Plant-based dairy alternatives	0.2 kg/l	3.9 %	0.0 kg/l	0.8 %	0.1 kg/l	2.2 %	0.0 kg/l	0.7 %
Sugar-sweetened soft drinks	0.5 l	0.9 %	−14 l	−23 %	−14 l	−24 %	−14 l	−24 %
Other beverages	1.5 l	1.7 %	−3.0 l	−3.4 %	−2.5 l	−3.0 %	−3.2 l	−3.8 %
Sweets & chocolate	0.3 kg	2.1 %	−1.3 kg	−7.9 %	−1.2 kg	−7.5 %	−0.1 kg	−0.6 %
Chips & salty snacks	0.2 kg	2.9 %	−0.3 kg	−4.6 %	−0.2 kg	−3.9 %	0.0 kg	−0.7 %
Pastries	0.9 kg	4.2 %	−0.7 kg	−3.3 %	−0.5 kg	−2.3 %	−0.1 kg	−0.5 %
Nuts & seeds	0.1 kg	3.9 %	0.1 kg	4.4 %	0.2 kg	5.7 %	0.0 kg	−0.5 %
Butter	−0.1 kg	−2.4 %	0.2 kg	6.6 %	0.2 kg	8.0 %	0.2 kg	5.4 %
Margarine	−0.4 kg	−3.7 %	1.5 kg	15 %	1.6 kg	16 %	1.3 kg	12 %
Vegetable oils	0.2 l	11 %	0.1 l	3.6 %	0.1 l	4.8 %	0.1 l	2.9 %

[a] No/low wholegrain foods, and wholegrain foods include bread, muesli & cereals, porridge oats, and pasta.

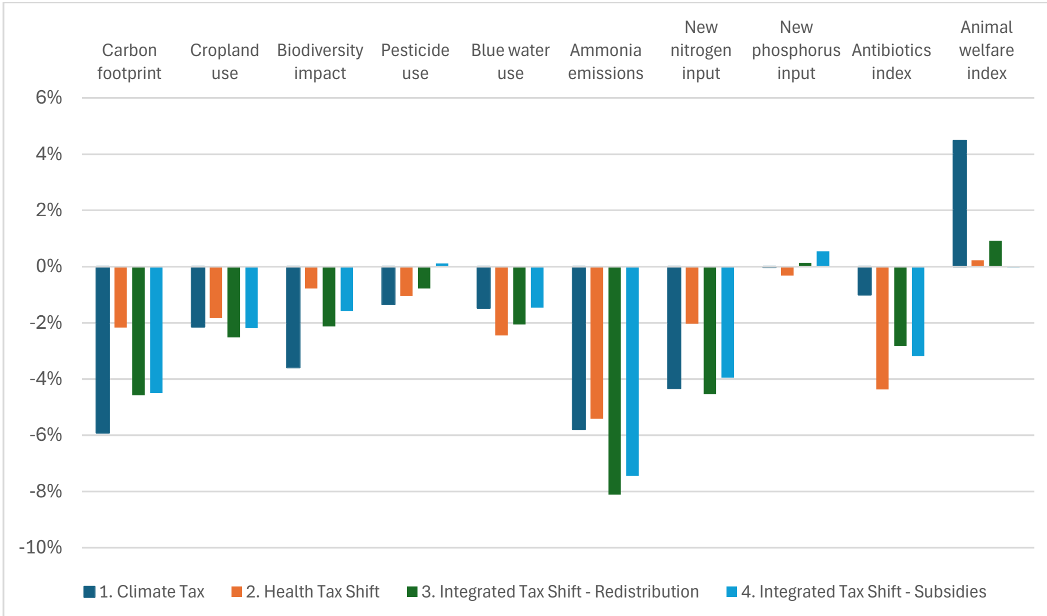

Fig. 1. Environmental effects of the four food tax reforms.

total food consumption) as most emission-intense foods are taxed in this reform. However, integrated tax Reforms 3 and 4 showed similar effects (−4.5 % to −4.6 %) despite dairy products and fish not being taxed. Reform 2, which was designed to achieve health benefits, showed a smaller reduction in the carbon footprint (−2.2 %), due to a more modest price increase for beef and lamb (Table 3). In all reforms, most of the carbon reductions were due to reduced beef consumption (approximately 75 % in Reforms 1, 3 and 4, and 40 % in Reform 2).

The majority of the other environmental indicators showed beneficial outcomes. This can be largely attributed to the reduced demand for beef, lamb and cheese, and hence reduced demand for animal feed which diminishes the need for croplands, pesticides, water and fertilizers (Poore and Nemecek, 2018). Ammonia emissions stem mainly from manure management and are also reduced substantially in all reforms due to decreased meat consumption. Antibiotic use decreases most in Reform 2 due to a larger reduction in pork and processed meat compared to the other reforms (Table 3).

All the aforementioned environmental effects align with climate benefits. The only substantial trade-off concerns animal welfare, which in Reform 1 is negatively affected by a substantial increase in poultry consumption (+1.5 kg/person/year). Poultry has the most adverse animal welfare index among all meat types, primarily due to the conditions under which chickens are typically raised (Panel et al., 2023).

3.3. Health effects

The potential health impact of each reform was quantified as changes in the number of premature deaths. Positive numbers in Fig. 3 represent

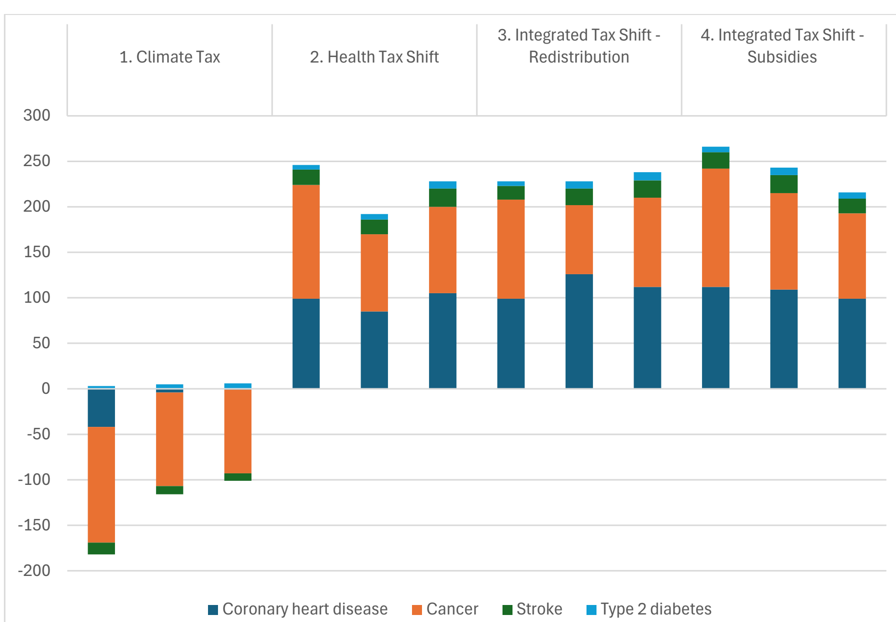

Fig. 2. Avoided premature deaths per year. The results are displayed segmented into three income groups, each assumed to contain an equal number of citizens. For each of the four scenarios, the effects are shown for low-income (left bar), middle-income (center bar), and high-income (right bar) earners.

the number of avoided deaths per year occurring between the ages of 30 and 70.

Aligned with the objective of achieving health benefits, Reforms 2, 3, and 4 demonstrate positive health outcomes, with around 700 avoided premature deaths each per year (combined for the three income groups in Fig. 3) if the population had adhered to the dietary changes modeled in the simulations of the various food tax reforms (Table 3). Interestingly, the integrated reforms achieved health benefits comparable to those of the strictly health-focused alternative. Furthermore, Reform 4 demonstrates more pronounced health benefits for low-income groups, which is particularly important given existing health inequalities and the limited effectiveness of measures like provision of dietary guidelines and health labeling on foods in changing dietary patterns among low-income groups (Løvhaug et al., 2022).

The reductions in deaths were primarily attributed to decreases in cancer (mainly colorectal cancer) and coronary heart disease, followed by reductions in stroke and type 2 diabetes. The dietary changes underpinning the benefits in these reforms (Table 3) include reductions in processed meat consumption (−5.5 % to −12 %), coupled with increases in wholegrain foods (+10 to +11 %) and increased consumption of fruit, vegetables and legumes (+3.4 % to +4.6 %). For Reforms 2 and 4, the beneficial health outcomes are slightly more favorable for the low-income group due to their relatively larger increase in fruit and vegetable consumption in these reforms.

Furthermore, the simulations result in reductions in sugar-sweetened beverages (−23 % to −24 % for the different income groups), sweets and chocolate (−0.6 % to −7.9 %), pastries (−0.5 % to −3.3 %) and chips and salty snacks (−0.7 % to −4.6 %). While these reductions are not captured by the health impact model, the decrease in the consumption of these energy-dense, nutrient-poor foods can be expected to further improve health outcomes under Reforms 2–4, as they result in a reduction in calorie intake from these groups by 6–7 % for Reforms 2 and 3, and by 2–5 % for Reform 4, compared to baseline consumption.

Fig. 2 also shows that Reform 1 can have negative health effects, primarily due to an increased risk of cancer, as the reduction in red meat consumption coincides with a 10 % decrease in fruit and vegetable consumption. According to the cross-price elasticities, fruit and vegetables are complementary to pork and beef, indicating that consumers want both product types in a varied food basket. However, cross-price elasticities should in general be interpreted with caution (Chen et al., 2016; Cornelsen et al., 2015). In addition, the calculations of calorie intake from energy-dense, nutrient-poor foods in Reform 1 show an increase of 2–4 % compared to baseline consumption.

3.4. Distributional effects

Table 4 illustrates that climate taxes in Reform 1 result in an increase in food expenditures of 4–5 euros per month per person (average across all ages). In Reform 2, some of the tax increases are offset by subsidies which limits the monthly expenditure increase. Reforms 3 and 4 are specifically designed to be cost-neutral and both reforms result in monthly effects of less than 1 euro per person. In Reform 3, food expenditures are almost as high as in Reform 1. However, in this reform, the state surplus is redistributed to all citizens. After accounting for the increased food costs and a monthly lump-sum transfer of 3.7 euros, this reform is effectively cost-neutral. Reform 4 was specifically designed to be a cost-neutral tax reform through subsidies, and this goal was nearly achieved.

While the changes in food expenditures in absolute terms are similar for the low- and high-income groups, their impact differs substantially due to the substantial variation in median disposable income (Table 4). This is further illustrated by the fact that, in our sample, the low-income group allocates 14 % of their disposable income to food, compared to 11 % for the middle-income group and 10 % for the high-income group. As a result, food taxes are generally regressive, disproportionately affecting low-income households. This regressive nature is also evident in Fig. 3, which highlights how the increasing food expenditures in Reforms 1 and 2 disproportionately impact low-income households.

4. Discussion

The overall results align with previous research and indicate that it is possible to design cost-neutral tax reforms that provide both substantial environmental and health benefits (Caillavet et al., 2019; Springmann et al., 2025; Springmann et al., 2017). More specifically, the two integrated health and climate reforms generate climate benefits that are nearly as substantial as those achieved by the specific climate reform. Removing climate taxes on dairy and fish only reduces the overall climate benefits to a small extent. For the entire Swedish population, the climate benefit of the integrated reforms is estimated at approximately 700,000 tons of CO2e, which corresponds to a reduction of Swedish passenger car emissions by about 8 % (Swedish EPA, 2024a, 2024b). The simulations also indicate that these reforms lead to additional environmental improvements, such as reduced use of pesticides and fertilizers, as well as lower ammonia emissions. From an animal welfare perspective, it is crucial to ensure that a reduction in red meat consumption does not lead to a compensatory increase in poultry consumption.

However, the estimated emission reductions are contingent on the assumption that decreased demand will eventually lead to a corresponding reduction in production. This assumption represents a simplification, as reduced demand may instead contribute to lower international prices and, in turn, increased consumption in other countries. Analyzing such market dynamics would require economic modeling beyond the scope of this study. In addition, the extent to which emissions are reduced within Sweden versus abroad depends on whether the share of imported meat changes in response to the proposed food tax reforms.

Our simulations indicate that a reform aimed solely at climate benefits may lead to adverse health outcomes, as reductions in red meat consumption are accompanied by simultaneous declines in fruit and vegetable purchases. This occurs because these products are complementary and often purchased together. While such effects, derived from cross-price elasticities, should be interpreted with caution, the finding is supported by previous studies (e.g. Briggs et al., 2013; Springmann et al., 2025; Springmann et al., 2017). However, those studies generally reported positive or neutral health impacts from climate-related food taxes. This discrepancy is largely explained by their findings that such taxes reduced overall energy intake, thereby contributing to improvements related to overweight and obesity. These weight-related effects were not included in our demand system due to the lack of robust

Table 4
Disposable income and change in expenditure. euro per person and month.

	Disposable income	1. Climate tax	2. Health tax shift	3. Integrated tax shift – redistribution	4. Integrated tax shift – subsidies
Low	€1460	+ €4.4	+ €2.2	- €0.4 (after €3.7 in lumpsum transfer)	+ €0.8
Middle	€1970	+ €4.3	+ €2.1	- €0.8 (after €3.7 in lumpsum transfer)	+ €0.5
High	€2340	+ €4.9	+ €2.1	- €0.4 (after €3.7 in lumpsum transfer)	+ €0.6

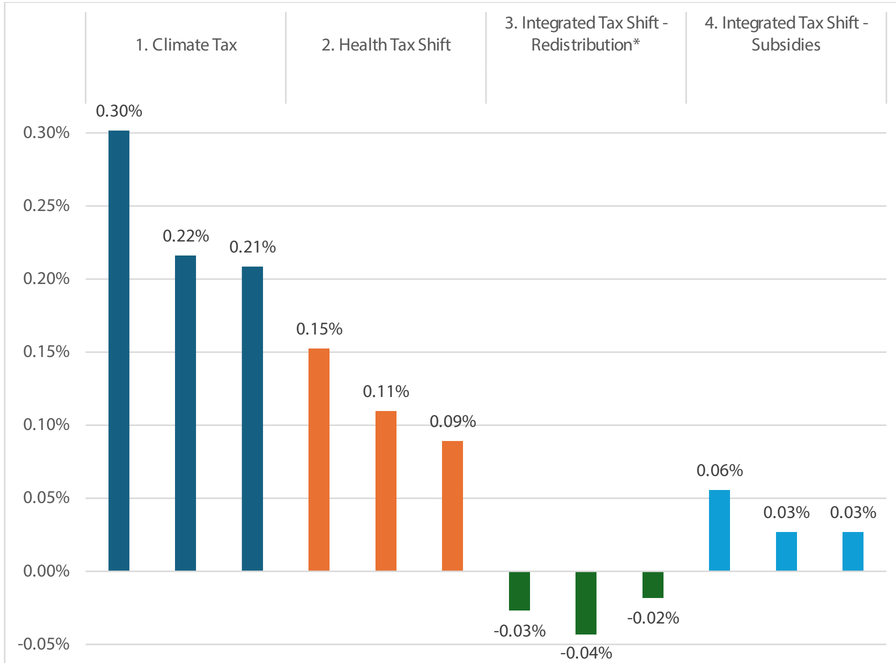

Fig. 3. Change in food expenditure for different income groups. For each of the four scenarios, the effects are shown for low-income (left bar), middle-income (center bar), and high-income (right bar) earners.
*The net effect after redistribution: The result indicates that all groups have more money left for other expenses after food costs are paid and the redistribution is implemented.

methods to account for the differing satiety effects of calories from various food types (e.g., meat vs. bread; see Section 2.6).

Our simulations of a reform strictly aimed at achieving health benefits show that it delivers less than half the climate benefits compared to the other reforms. These results, together with those from the climate-focused reform, suggest that assuming health and climate benefits naturally align is overly simplistic.

Previous research has demonstrated that potential trade-offs between health and climate objectives can be mitigated through careful tax policy design (Briggs et al., 2013; Caillavet et al., 2019; Springmann et al., 2025). Our findings reinforce this by showing that integrated policy reforms, combining climate-related taxes with subsidies for fruits and vegetables, can deliver substantial health gains without compromising climate outcomes. Furthermore, we show that health benefits can be amplified through a more comprehensive policy package that includes subsidies for whole-grain foods and targeted levies on sugar-sweetened beverages, as well as red and processed meat.

These integrated reforms are estimated to prevent approximately 700 premature deaths annually among adults aged 30 to 70. While this number represents yearly potential, the benefits would take many years to materialize, as dietary changes take time to influence chronic disease risk. For context, the simulated dietary changes could result in more than twice as many lives saved as would be achieved by eliminating all road traffic fatalities in Sweden (in 2023, there were 232 road traffic fatalities, according to the Swedish Transport Agency, 2024).

In addition to the positive environmental and health outcomes driven by consumer adaptations to tax changes, these effects may be further amplified as producers adjust their product compositions to minimize excise taxes and VAT. For example, the excise tax on sugar-sweetened beverages in the UK prompted the Coca-Cola Company to halve the sugar content of Sprite sold in the UK compared to Sweden (Arthur, 2018). Producer adaptations may also occur in other food categories. For instance, removing VAT from wholegrain bread could incentivize the bread industry to alter its recipes. Similarly, tax adjustments could encourage the food and hospitality industry to reduce taxed foods (like decreasing the amount of beef while using more legumes in sausages). In addition, the effects of policy changes like tax reforms could be further increased by societal discussions leading to normative shifts.

The simulation results on private finances show that the reform focused solely on climate taxes would increase annual food expenditures by over €200 for a four-person household—an impact that could be considered substantial. The health tax reform also increases food expenditures, but by only half as much as the climate reform. These rising food expenditures disproportionately impact low-income households, a finding consistent with previous research demonstrating the regressive nature of food taxes (García-Muros et al., 2017; Klenert et al., 2023; Nnoaham et al., 2009; Säll, 2018). Rising food costs in general, and especially when they disproportionately affect low-income households, are likely to reduce public support for such a reform.

Our results show that it is possible to design cost-neutral reforms that avoid these drawbacks. This contradicts Caillavet et al. (2019) who found that greenhouse gas taxes combined with subsidies of fruit and vegetables, were regressive. Both studies account for differing baseline consumption patterns between low- and high-income groups, and the contradictory results could be a result of the specific policy designs.

4.1. Policy implications

The acceptability of food tax reforms remains a potentially critical barrier to widespread implementation of food tax reforms, despite their possible health and environmental benefits. Historically, food taxes have largely been limited to sugar-sweetened beverages, with broader applications facing resistance due to, among other, public concerns about financial burden and perceived unfairness (Graça et al., 2020; Kallbekken et al., 2013). This hesitancy underscores the importance of carefully designing tax policies to increase public support (Grimsrud et al., 2020).

The specific choice of food items to tax or subsidize can influence public support. Swedish research highlights that a strong majority supports higher taxes on sugar-sweetened beverages and unhealthy snacks, and subsidies for healthy foods, such as fruits, vegetables, and whole grains (Ejelöv et al., 2025). However, there is notable opposition toward higher taxes on meat. Interestingly, public acceptance improves substantially when revenues from meat taxes are used to subsidize healthy foods (Ejelöv et al., 2025; Siegerink et al., 2024), underscoring the importance of designing cost-neutral reforms. In terms of acceptability, scenarios 3 and 4 might potentially differ. In Scenario 4, both the price increases and decreases are directly visible to consumers at the time of purchase through taxes and subsidies. In contrast, Scenario 3 features visible price increases through taxes, while the lump-sum redistribution may be less noticeable when it appears in the consumer's bank account. While both scenarios are cost-neutral, scenario 4 might therefore be perceived as more cost-neutral given that price increases and decreases are presented every time a consumer purchases food. Future research might directly compare these two cost-neutral designs in terms of public support. Building on previous research findings (Dominioni and Heine, 2019), one possible policy design would be to initiate lump-sum payments prior to the implementation of the fees, in order to enhance the transparency of both cost increases and decreases and possibly also public acceptance.

While tax adjustments can lead to environmental and health improvements, they would only be one piece of the puzzle in achieving a sustainable food system. Additional food and agriculture policies targeting both supply and demand, along with voluntary initiatives from consumers, farmers, retailers, and industry, are needed. Combining a food tax reform with other policy instruments could enhance public acceptability through increased understanding achieved by information campaigns and mandatory health and carbon labeling on food products, or by simultaneously introducing production-side policies, further amplifying the total effect (Fesenfeld et al., 2020).

Policy packages may also address important additional trade-offs that might arise from the tax reform. For example, in Sweden, the preservation of semi-natural pastures is important for conserving local biodiversity (Eriksson, 2021), and a tax on beef, lamb, and dairy could reduce the need for these pastures (Moberg et al., 2021). However, using semi-natural pastures in ruminant production is best incentivized through direct payments to farmers (Larsson et al., 2020). Such production-side policies targeting farmers could also be included in a policy package to mitigate economic consequences and hence increase acceptance among producers, and to potentially achieve additional environmental benefits by supporting ecosystem services (Gren et al., 2021).

When designing tax reforms, a key aspect involves the distinction between implementing excise taxes (levied per kilogram of food) and applying VAT differentiation (calculated as a percentage increase based on the price of the food). These create different outcomes. Excise tax on meat creates a relative price advantage for high-quality and high price meats, instead of the price disadvantage that would result from higher VAT rates on these meats.

Administrative cost is an additional important factor to consider when implementing tax changes. Both cost-neutral reforms include excise taxes, which would initially pose an administrative burden for companies such as domestic slaughterhouses and meat importers. However, this implementation is likely to integrate smoothly, similar to existing excise taxes on alcohol, tobacco, sugar-sweetened beverages, and fuels already established in many countries. Limiting excise taxes to a small number of food items further reduces the administrative burden. Both reforms also employ differentiated VAT levels, a system already in use in many countries. For instance, supermarkets in Sweden effectively manage three existing VAT levels, suggesting that extending this system to new product categories is unlikely to result in substantial additional administrative costs.

Reforms 3 and 4 are constructed to be revenue-neutral for the government. In Reform 3, this can be arranged by basing the monthly redistributed amount on the surplus from the preceding year. Reform 4 is designed such that subsidies and tax increases shall balance out for the state. However, this study only estimates consumer adaptations and not producer adaptations, such as product reformulation to minimize levy payments, which has been observed when a tiered levy on sugar-sweetened beverages was introduced (Andreyeva et al., 2022; Teng et al., 2019). This tends to amplify health benefits but also reduces tax revenues. To maintain fiscal neutrality, recurring adjustments would be needed either in the levels of excise taxes or in the number of food categories subject to the zero or full VAT rate.

Legal aspects are crucial for policy decisions. The tax adjustments in the cost-neutral reforms are presumed to comply with EU regulations. In 2022, the EU introduced greater flexibility, allowing the complete removal of VAT on up to seven categories and the application of reduced VAT rates (minimum 5 %) on up to twenty-four categories (EU, 2022). Food items are among the goods eligible for these VAT modifications, with specific emphasis on items beneficial to public health (European Commission, 2024). Both VAT changes and excise taxes must adhere to EU state aid rules. However, as domestically produced and imported goods are treated equally under consumption tax regulations, there are no clear reasons why such measures would not be accepted.

4.2. Limitations related to data and methodology

The calculations of price elasticities in this study are subject to some uncertainties. One risk is the use of store data rather than household data. Because households may purchase their food from multiple stores (due to variations in price and selection), using data from a single retail chain may affect price sensitivity estimates. Moreover, as stores conduct promotional campaigns featuring both advertising and reduced prices, our estimates of price elasticities may capture both effects, potentially leading to an overestimation of price elasticities. While own-price estimates tend to be relatively more robust, cross-price elasticities tend to be small and vary across countries and income groups (Chen et al., 2016; Cornelsen et al., 2015), suggesting that the substitution effects should be interpreted with more caution. Another consideration is that price elasticity may differ between food purchased in supermarkets and food consumed in large-scale kitchens (e.g., restaurants). Currently, there are no Swedish data available on the share of food sold through large-scale kitchens. This introduces additional uncertainty, as the results assume that tax changes affect consumption in large-scale kitchens in the same way as food purchased directly by consumers. Furthermore, all demand systems exhibited some issues with autocorrelation (see Supplementary material).

There are also uncertainties related to the analyses of environmental, health and distributional effects. For the distributional effects, we captured only consumption in stores and not food consumed at other venues such as restaurants and market halls. As the consumption patterns at these other venues may differ between income groups, there may be slight differences in the distributional effects of the tax reforms, if these additional expenditures are considered.

The uncertainty related to the environmental assessment varies across indicators. For carbon footprint, ammonia emissions, and cropland use, data are reasonably available, and methods range from simple (cropland use) to well-established (carbon footprint and ammonia emissions). However, for pesticide use, data availability is a major limitation. The biodiversity impact considered here is solely from land use and is based on a coarse methodology with global coverage, which is necessary in dietary assessments where foods are sourced from various locations. For more limitations related to the environmental assessment and indicators, see Ran et al. (2024).

One limitation related to the health impact assessment is that the food consumption statistics we have used include both consumed food and food waste. This is not an issue when analyzing environmental impacts or distributional effects, as the outcome is the same regardless of whether the food is eaten or not. However, it does present an issue when analyzing health effects as it overestimates consumption. Still, the health assessments performed in this study are based on changes (grams more/less per day) and not on absolute consumption (total grams/day) and are therefore less affected by this limitation. The impact on total health is underestimated as only the change in mortality in the age group 30–70 years is considered, and not morbidity. Certain consumption changes for foods consumed in small amounts (such as nuts) were too small to be included in the model. Thus, some impacts are slightly underestimated. Some food groups known to negatively affect health, such as sugar-sweetened beverages, are not currently implemented in the WHO model used. We anticipate that this will lead to an underestimation of the positive health impacts of Reforms 2–4. It was also necessary to assume that the baseline mortality risk for each income group was the same as for the general population, whereas low-income groups often actually have poorer health outcomes. This is because such factors as obesity, smoking and physical activity levels are known to differ by income (The Public Health Agency of Sweden, 2023).

Previous research on the health effects of climate-related food taxation (Briggs et al., 2013; Springmann et al., 2025; Springmann et al., 2017) included body weight-related effects based on changes in total energy intake. However, we did not attempt this as the methods for translating calorie intake into weight change are not widely used. These methods require numerous assumptions and often fail to account for factors such as the varying satiating effects of different food types. For instance, calories from protein-rich foods typically produce a longer-lasting sense of fullness compared to calories from bread (Gerstein et al., 2004).

5. Conclusions

Our findings reveal that while a climate tax reform on food improves most environmental indicators, it would negatively impact health outcomes. The health-focused reform provides substantial health benefits but yields much smaller environmental gains and was also found to have some adverse effects on animal welfare. Furthermore, both reforms lead to higher food costs, disproportionately affecting low-income groups.

However, the design of integrated cost-neutral tax reforms demonstrates that it is possible to structure food tax reforms to achieve dual benefits—environmental and health improvements—while avoiding additional financial burdens for both low- and high-income groups. These cost-neutral reforms, achieved through subsidies or tax redistribution, suggest a promising pathway for policy development that can generate substantial improvements while also being relatively likely to be received positively by the public. This study sets a framework for policymakers aiming for a multifaceted approach to the challenges at the intersection of public health, environmental sustainability, and economic inequality. The results are disseminated broadly through the website www.foodtaxshift.com.

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CRediT authorship contribution statement

Jörgen Larsson: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Edvin Månsson:** Writing – review & editing, Methodology, Investigation, Formal analysis, Data curation. **Elin Röös:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Sarah Säll:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Emma Patterson:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Liselotte Schäfer Elinder:** Writing – review & editing, Methodology, Conceptualization. **Jonas Nässén:** Writing – review & editing, Investigation, Formal analysis. **Emma Ejelöv:** Writing – review & editing, Software, Methodology, Investigation, Formal analysis, Data curation.

Declaration of competing interest

We, all authors, do not have any financial and personal relationships with other people or organizations that could inappropriately influence or bias our work. We have nothing to declare.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ecolecon.2025.108822.

Appendix B. Environmental indicators

Indicators	Unit per kg of product	Explanation/sources
Carbon footprint	kg CO_2e	A carbon footprint is the total amount of greenhouse gases, including carbon dioxide, nitrous oxide, and methane, emitted directly and indirectly during the production of a food item. The measurement is in carbon dioxide equivalents (CO_2e), in which the gases are weighed using global warming potential (GWP) over 100 years (AR6). For crops and terrestrial livestock production, carbon footprints were calculated based on methodology from IPCC and official data sources. For more details, see Röös et al. (2025). For seafood, data was taken from Gephart et al. (2021).
Cropland use	m^2*year	The use of cropland, calculated as the inverse of the yield for crops and of all feed crops used in livestock production. Yield data was taken from (FAO, 2024).
Biodiversity impact from land use	E/MSY	Extinction rate as extinctions (E) per million species years (MSY), (see Moberg et al., 2020 for details). This is calculated based on potentially disappeared fraction of species data from Scherer et al. (2023), with adjustment for the positive value of use of semi-natural pastures (Ahlgren et al., 2023).
Pesticide use	g active ingredient	Pesticide use as grams of active ingredient, using data from Eurostat (2023) and Statistics Sweden (2024c) as primary sources.
Blue water use	m^3	Use of groundwater and surface water bodies like rivers and lakes, with data from Mekonnen and Hoekstra (2011).
Ammonia emissions	kg NH3	Emissions of ammonia from manure and fertilizer use (EMEP/EEA, 2019).
New nitrogen input	kg N	Added N as mineral fertilizer and biological fixation, see Ran et al. (2024) for more information.
New phosphorus input	kg P	Added P as mineral fertilizer, see Ran et al. (2024) for more information.
Antibiotics use	mg	Approximate amount of antibiotics used in livestock production (in mg), assessed from aggregated national statistics of antibiotics use, and allocated across animal species based on typical species requirements (Rydhmer and Röös, 2025).
Animal welfare index	Index	An index of negative impact on animal welfare, accounting for the number of animals affected, the ability of animals to perceive their environment and the level of animal welfare standards (Rydhmer and Röös, 2025).

Appendix C. Environmental impact per kg or liter of food

	Carbon footprint, total (kg CO2e)	Cropland (m2*year /kg)	New N input (kg N/ kg)	New P input (kg P/kg)	Water (m3/ kg)	Pesticides (g active ingredient /kg)	Biodiversity (E/MSY/kg)	Ammonia (kg NH3/kg)	Animal welfare (index)	Antibiotics (mg/kg)
Beef & lamb	31.4	30.2	0.62	0.02	0.21	1.29	6E-12	0.17	0.25	22.0
Pork	5.69	15.0	0.15	0.02	0.30	1.58	2E-12	0.07	3.95	57.6
Processed meat	6.70	15.0	0.16	0.02	0.27	1.50	2E-12	0.07	7.08	52.9
Poultry	2.33	7.29	0.08	0.01	0.03	0.82	1E-12	0.04	80.4	25.2
Fish & shellfish	7.33	3.58	0.05	0.01	0.03	0.02	8E-13	0.00	72.2	50.9
Plant-based protein products	1.22	4.74	0.10	0.01	0.29	0.81	1E-12	0.00	0.10	0.00
Egg	1.26	4.92	0.06	0.01	0.02	0.38	4E-13	0.00	8.59	0.24
Cheese	6.21	8.89	0.10	0.01	0.02	0.33	9E-13	0.00	0.05	11.6
Bread - no/low wholegrain	1.16	2.57	0.04	0.01	0.01	0.25	2E-13	0.00	0.00	0.00
Bread - high wholegrain	1.34	2.58	0.03	0.00	0.03	0.25	4E-13	0.00	0.00	0.00
Flour	1.04	2.87	0.04	0.00	0.01	0.26	2E-13	0.00	0.00	0.00
Muesli & cereals - no/low wholegrain	2.45	4.03	0.04	0.01	0.19	1.93	1E-12	0.00	0.00	0.12
Muesli & cereals - high wholegrain	1.90	4.78	0.03	0.01	0.14	1.38	9E-13	0.00	0.00	0.00
Porridge oats - no/low wholegrain	1.08	3.07	0.04	0.00	0.00	0.26	2E-13	0.00	0.00	0.00
Porridge oats - high wholegrain	1.19	5.21	0.04	0.01	0.00	0.24	1E-13	0.00	0.00	0.00
Pasta - no/low wholegrain	1.49	4.38	0.04	0.00	0.03	0.27	2E-12	0.00	0.01	0.00
Pasta - high wholegrain	1.10	2.25	0.03	0.00	0.00	0.20	2E-13	0.00	0.00	0.00
Rice & potatoes	0.62	0.91	0.01	0.00	0.03	0.18	8E-14	0.00	0.00	0.22
Vegetables & root vegetables	0.84	0.24	0.00	0.00	0.02	0.19	6E-14	0.00	0.00	0.00
Legumes	0.68	4.94	0.03	0.00	0.07	0.81	9E-13	0.00	0.00	0.00
Fruit	0.76	0.57	0.01	0.00	0.13	1.21	2E-12	0.00	0.00	0.00
Yoghurt & soured milk	1.17	1.65	0.02	0.00	0.00	0.06	2E-13	0.00	0.01	1.90
Cream, sour cream, cultured cream	3.07	4.66	0.05	0.00	0.01	0.17	5E-13	0.00	0.02	5.38
Milk	1.10	1.57	0.02	0.00	0.00	0.06	2E-13	0.00	0.01	1.82
Plant-based dairy alternatives	0.42	0.41	0.00	0.00	0.00	0.15	2E-13	0.00	0.00	0.00
Sugar-sweetened soft drinks	0.40	0.17	0.00	0.00	0.05	0.08	8E-14	0.00	0.00	0.00
Sugar-free soft drinks	0.32	0.03	0.00	0.00	0.01	0.01	1E-14	0.00	0.00	0.00
Beer (0–3.5 % alcohol)	0.61	0.36	0.00	0.00	0.00	0.02	8E-15	0.00	0.00	0.00
Juice	1.36	1.23	0.02	0.01	0.19	0.73	6E-13	0.00	0.00	0.00
Coffee, tea & cocoa	8.41	11.0	0.14	0.03	0.12	4.76	1E-11	0.01	0.00	0.00
Mineral water	0.29	0.00	0.00	0.00	0.00	0.00	0E+00	0.00	0.00	0.00
Sweets & chocolate	2.05	5.64	0.04	0.01	0.25	2.70	2E-12	0.00	0.02	1.84
Chips & salty snacks	1.69	3.75	0.05	0.02	0.06	0.56	4E-13	0.00	0.00	0.20
Pastries	2.35	4.65	0.05	0.01	0.15	0.96	8E-13	0.00	0.30	1.88
Nuts & seeds	1.77	7.17	0.05	0.01	0.43	2.37	2E-12	0.00	0.00	0.00
Butter	7.31	10.9	0.12	0.01	0.02	0.40	1E-12	0.00	0.06	12.6
Margarine	4.50	6.79	0.07	0.01	0.07	0.57	2E-12	0.00	0.02	3.55
Vegetable oils	2.82	9.93	0.09	0.03	0.41	1.08	3E-12	0.01	0.00	0.00

Data availability

The authors do not have permission to share data.

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