The effects of a meat tax based on sustainability indicators: carbon footprint, biodiversity loss and animal welfare

Nora Lundin

Degree project/Independent project • 15 credits
Swedish University of Agricultural Sciences, SLU
Faculty of Natural Resources and Agricultural Sciences/Department of Economics
Business and economics - Sustainable development
Degree project/SLU, Department of Economics, 1742 • ISSN 1401-4084
Uppsala, 2026

The effects of a meat tax based on sustainability indicators: carbon footprint, biodiversity loss and animal welfare

Effekterna av en köttskatt baserad på hållbarhetsindikatorer: klimatavtryck, biologisk mångfald och djurvälfärd

Nora Lundin

Supervisor:	**Sarah Säll, Swedish University of Agricultural Sciences, Department of Economics**
Examiner:	Shon Ferguson, Swedish University of Agricultural Sciences, Department of Economics

Credits:	15 credits
Level:	Bachelor's level, G2E
Course title:	Independent project in Economics
Course code:	EX0903
Programme/education:	Business and economics - Sustainable development
Course coordinating dept:	Department of Economics
Place of publication:	Uppsala
Year of publication:	2026
Title of series:	Degree project/SLU, Department of Economics
Part number:	1742
ISSN:	1401-4084

Keywords:	Price elasticity, carbon footprint, biodiversity loss, animal welfare, Pigouvian tax, Almost Ideal Demand System

Swedish University of Agricultural Sciences

Faculty of Natural Resources and Agricultural Sciences

Department of Economics

Abstract

Two of the most pressing sustainability challenges today are climate change and biodiversity loss. The modern food sector, particularly meat production, is a major contributor to all two. In light of this, the need for policy measures to shift dietary patterns becomes clear. However, to only incorporate environmental challenges creates a risk for potential trade-offs regarding other sustainability indicators. Therefore, the indicator for animal welfare is included in this analysis as well, aiming to handle possible substitution effects between different types of meat. This study examines the design of a potential consumption tax on beef, pork and poultry based on these sustainability indicators, as well as the effects such a tax could have on consumption levels and the reduction of associated externalities. The carbon tax is designed as a Pigouvian tax based on carbon footprints, while the taxes related to animal welfare and biodiversity are simulated using price elasticities and targeted reductions in quantity demanded. The effects of these tax rates are then compared with those of a uniform tax rate applied across all three types of meat, using a targeted 10% reduction in quantity. The 10% target is chosen as it may represent a remarkable yet realistic potential change in meat consumption. The results suggest that both tax designs would have significant effects on the reduction of externalities. For the individual tax rates, the reductions for carbon footprint, biodiversity loss and animal welfare are estimated at approximately 4-20%, 8-10% and 4-10% respectively. The uniform tax rate was estimated to 20 SEK per kilogram of meat, which resulted in a reduction between 4-16% for each externality. Although a uniform tax is less cost efficient than a Pigouvian tax, arguments can still be made in its favour, as different sustainability indicators are difficult to compare directly and consequently, challenging to combine into a single, rational framework. The results do not however support the claim about potential trade-offs between different sustainability indicators, as all types of meat appear to be complements according to the estimated elasticities. One limitation is that taxes of this design would not provide incentives for individual producers to adopt more sustainable production systems, since a consumption tax does not account for the individual impact from a specific producer. Furthermore, existing evidence suggests that consumers are generally not highly supportive of taxes on food products, highlighting the need for additional measures to strengthen public support and enable implementation. Finally, the findings highlight the importance of assigning monetary values to externalities such as animal welfare and biodiversity loss in order to enable more accurate comparisons across sustainability indicators.

Keywords: Price elasticity, carbon footprint, biodiversity loss, animal welfare, Pigouvian tax, Almost Ideal Demand System

Table of contents

List of tables **6**

1. Introduction **8**
1.1 Food systems 9
1.1.1 Greenhouse gas emissions 9
1.1.2 Biodiversity loss 9
1.1.3 Animal welfare 10
1.2 Policy instruments 11
1.3 Price elasticities 12

2. Literature review **14**

3. Data and methodology **16**
3.1 Data 16
3.1.1 External impact 16
3.1.2 Price and quantity 17
3.2 Method 18
3.2.1 The Almost Ideal Demand System (AIDS) 19

4. Results **21**
4.1 Results from the Almost Ideal Demand System 21
4.2 Taxation and corresponding effects 22

5. Discussion **24**
5.1 Analysis of results 24
5.2 Policy implications 27
5.3 Limitations 28

6. Conclusion **30**

References **31**

List of tables

Table 1: Compensated elasticities 21
Table 2: Uncompensated elasticities 21
Table 3: Carbon footprint..22
Table 4: Biodiversity loss..22
Table 5: Animal welfare 22
Table 6:Uniform tax rate 23
Table 7: Data on consumer price index 35
Table 8: Data on consumption quantity (per capita) 36
Table 9: Hicksian elasticities 36
Table 10: External impact..37

List of figures

Figure 1: A Pigouvian tax 12

1. Introduction

During the last decades, climate change and biodiversity loss have become widely recognized as major environmental challenges connected to modern food systems. Greenhouse gas emissions, such as carbon dioxide, resulting from human activities are considered the main driver of climate change. The rise in average global temperature due to anthropogenic emissions has been estimated at approximately 0,2 degrees per decade compared to pre-industrial levels. In response, the 2015 Paris Agreement aimed to unite countries in limiting global warming to 1,5 degrees. This goal requires substantial action to reduce emissions at both the international and national levels (IPCC n.d). Meanwhile, biodiversity loss has reached critical levels. Approximately one million species are currently threated with extinction, while natural habitats continue to be destroyed (Pfenning-Butterworth et al. 2024). The practices in modern food systems have been shaped to produce large quantities of affordable food. This has required large-scale intensification in the agricultural sector, for example through increased use of fertilizers and the breeding of new higher-yielding crops. While these changes have improved agricultural productivity, they have also contributed to habitat destruction and biodiversity decline (Benton et al. 2021*)*. Within the food sector, meat production is proven to be the largest source of greenhouse gas emissions and is one of the leading drivers of biodiversity loss due to its major land-use requirements (WWF n.d). In addition to its environmental impacts, the industrialization of animal agriculture has raised ethical concerns regarding the treatment and living conditions of farm animals (Bonnet et al. 2020). Common welfare issues include overcrowded housing conditions and incapacity to perform natural behaviours due to restrictions (Nollkaemper 2023). Animal welfare is also increasingly recognized as an important policy concern for consumers. As Ammamm et al. (2023) argue, “animal welfare is one of the key agricultural policy goals and is considered extremely important by consumers”. Their findings further suggest that consumers continue to place considerable value on animal welfare even when it competes with other agricultural policy goals (Ammamm et al. 2023).

The impacts across these sustainability indicators – namely animal welfare, carbon footprint and biodiversity loss – vary substantially between different types of meat, highlighting the urgency of incorporating multiple sustainability indicators when analysing consumption and production levels. The database SAFAD from the Swedish University of Agricultural Sciences reports that the carbon footprint from 1 kg of beef is approximately 10 times higher than for 1 kg of poultry and 5 times higher than for 1 kg of piglet meat. In contrast, there is an opposite relationship regarding animal welfare, where SAFAD reports that the estimated animal welfare index is almost 80 times higher for poultry than for beef and 40 times higher than for pork, where a higher value indicates poorer welfare conditions (SAFAD 2026). Consequently, policies aimed at reducing the environmental impacts of meat production may cause trade-offs with animal welfare. First, consumers may substitute towards cheaper alternatives such as poultry if beef and pork become more expensive due to environmental taxation or other policy measures. Second, higher prices and hence lower demand for beef and pork could increase incentives for producers to intensify production in order to maintain profitability, potentially leading to poorer living conditions for farm animals. Therefore, it is essential to account for several indicators to prevent the risk of trade-offs.

Against this background, there is an urgent need for mitigation actions to decrease these effects, for example by new policy instruments. The aim of this paper is to estimate a potential tax rate for pork, beef and poultry based on their respective impact on animal welfare, biodiversity and carbon footprint. The effects of the taxes will then be examined by analysing the change in demanded quantity through price elasticities and the corresponding reduction in external impact. There is a large body of literature examining environmental taxation. However, few papers investigate potential tax rates based simultaneously on biodiversity loss, carbon footprint and animal welfare. Further, this study uses an updated dataset compared to similar research, for example the paper by Säll and Gren (2015), which therefore better reflects recent patterns in consumption and prices.

1.1 Food systems

1.1.1 Greenhouse gas emissions

Within the food sector, meat production poses the largest threat to climate change (WWF n.d) The average carbon footprint of beef exceeds 30 kg CO_2 per kilogram (SAFAD 2026). In contrast, the average carbon footprint of plant-based products is only around 4 kg CO_2 per kilogram (Van Rysselberge and Röös 2021). In a biological food chain, energy is lost at each trophic level – which is the main reason that meat yields more emissions per unit of energy compared to plant-based foods (Godfray et al. 2018). Meanwhile, the global consumption of meat is currently increasing (WWF n.d).

1.1.2 Biodiversity loss

Our dietary patterns have a significant effect on the growing threat of biodiversity loss, and yet again, the production of livestock is an issue of concern. Consumption of animal products has a significant impact on biodiversity both in Sweden through domestic production and on an international level through imported meat or feed (Wallman et al. 2013). Machovina et al. (2015) reports that this type of production is the "single largest driver of habitat loss", in which the main problem is the large amount of land that has been and continues to be converted into cropland for feed production and pasture. This has resulted in loss of natural forests and grassland. When accounting for the production of livestock as well as feed production, agricultural land use consists of approximately 75% land for animal production (Machovina et al. 2015). It is however important to note that animal production not only consists of meat but also products like milk and egg. Regarding the production of meat specifically, the production of ruminants generally requires larger areas of land than for example pigs and chickens, since ruminants are less effective in converting feed (Wallman et al. 2013).

However, livestock contributes to biodiversity in other ways. The positive effects on biodiversity from animal production is primarily through grazing. Land for agricultural production could either be cropland or semi-natural grasslands, where the latter is neither plowed nor fertilized (Wallman et al. 2013). Semi-natural grasslands require grazing (Ahlgren et al. 2024) and active animal production to preserve biodiversity and the ruminants in animal production thus plays an important role (Wallman et al. 2013). However, the share of the total ruminants that grazes on semi-natural grasslands during their lifetime is quite small (WWF n.d), and the overall effects on biodiversity are therefore predominantly negative (Wallman et al. 2013).

1.1.3 Animal welfare

When investigating the impacts from meat production across different sustainability indicators, social dimensions such as animal welfare should not be overlooked. As meat production continues to increase, animal production systems have become increasingly industrialized in order to maximize output per animal. Such systems often involve small cages and overcrowded living areas (Nollkaemper 2023). At the same time, animal welfare is considered highly important by many consumers and may therefore influence changes in dietary patterns and be a main driver for behaviour change (Ammann 2023). Further, welfare conditions also vary substantially between animal species, with poultry production often being identified as one of the most severe concerns from an animal welfare perspective.

Based on the environmental impact data from SAFAD (2026), taxation based solely on environmental sustainability indicators will almost certainly shift consumption away from beef and towards poultry, particularly because the estimated carbon footprint of beef is considerably higher. A policy framework focusing exclusively on environmental indicators would therefore favour increased poultry consumption. However, poultry production raises substantial concerns regarding animal welfare. Röös et al. (2025) suggest that more efficient animal production systems generally have lower environmental impacts but also involve trade-offs between carbon efficiency and animal welfare – particularly when comparing red meat and poultry production. Focusing only on environmental sustainability dimensions therefore risks oversimplification of the consequences of livestock production (Röös et al. 2025). Poultry production today is generally characterized by relatively few but highly industrialized large-scale farms, where animal management is heavily optimized for efficiency. These production conditions may result in stress and restricted ability to perform natural behaviours (Nollkaemper 2023). According to animal welfare data from SAFAD (2026), the animal welfare index for poultry is estimated to be almost 80 times higher than that for beef. It is therefore not without challenges to recommend dietary shifts from beef to poultry, although it may be advantageous from an environmental perspective.

The different characteristics of beef, pork and poultry production systems also raise important questions regarding food security– an issue of growing importance in light of recent events such as the war in Ukraine. Although poultry production generally has a lower environmental impact than beef and pork production, the conditions under which production takes places may create challenges not only for animal welfare but also for food security. Poultry production in Sweden today is concentrated in relatively few but very large farms. Furthermore, these systems are generally highly automated which require substantial energy inputs, making production vastly dependent on other stages of the supply chain (Swedish Board of Agriculture 2024). This creates systemic vulnerability, as national consumption becomes highly reliant on a limited number of production facilities. Risks such as outbreaks of diseases on individual farms could therefore have substantial effects on total production volumes, potentially creating significant challenges for Swedish food security.

Against this background, the desired production and consumption levels for different types of meat may differ when analysing several indicators of sustainability – namely carbon footprint, biodiversity loss and animal welfare in this case. Policies based only on environmental indicators may unintentionally favour production systems associated with poor animal welfare and vulnerabilities regarding food security. The aspect of animal welfare could also, due to its value for consumers, be of great importance regarding public support for a potential policy. Consequently, it is highly relevant to incorporate all of these indicators in an analysis of policy instruments and consumption quantity.

1.2 Policy instruments

Against this background, the need for policy measures to change this pattern becomes clear. Mitigation actions on the production side will not be sufficient to tackle the environmental challenges, which is why a dietary transformation is urgent (Röös et al. 2025). Policy measures are therefore important tools since one cannot rely on the individual will to change behaviour and shift toward more sustainable alternatives. Many economists support the idea of a Pigouvian tax as a strategy to internalize externalities in market prices. In this case, the externality is incorporated into the supply curve as the marginal external cost in the standard supply and demand framework. The tax rate is set equal to the marginal external cost at the equilibrium and is imposed on each unit of the good. By combining the marginal external cost with the marginal cost of production, a new optimum emerges with a lower quantity and higher price that better reflects the true social cost of production (Kallbekken 2013). This relationship is illustrated in Figure 1:

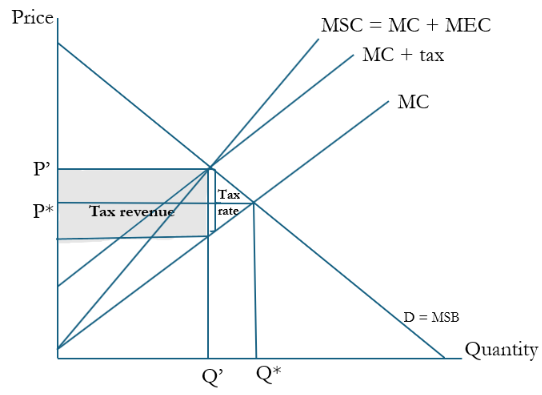

Figure 1: A Pigouvian tax

Where P* and Q* is the equilibrium price and quantity without the tax, and P' and Q' represents the new equilibrium that emerges. MSC stands for the marginal social cost, which incorporates both the marginal cost of production and the marginal external cost. MSB stands for the marginal social benefit, which constitutes the demand curve.

With a Pigouvian tax, tax revenues are substantially larger than the net benefits. Net benefits refer to the difference between the reduction in external costs and the loss in consumer surplus. This implies that how governments choose to allocate tax revenues has significant implications for how the tax is received in public eyes, raising important questions about political feasibility. Furthermore, whether the revenue is used to enhance social welfare will also affect the overall efficiency gains from the tax (Kallbekken 2013). A Pigouvian tax is considered to have several good features from an economic perspective. Andersson (2019) states that "To reach the mitigation targets put forward by each country, it is important to rely on environmentally and economically efficient measures such as carbon pricing.". Setting a tax rate based on the external cost of a specific good is often more practical than monitoring emissions at the firm level (Andersson 2019). This report focuses on the implications of a consumption tax. While arguments can be made for both consumption and production taxes, one advantage of consumption taxes is that they reduce the risk of substitution toward imported goods. Since all similar goods sold within the same country are subject to the same tax, domestic producers are not disadvantaged relative to foreign competitors (Säll and Gren 2015).

1.3 Price elasticities

To evaluate the effects a Pigouvian tax would achieve, the concept of price elasticities becomes relevant. Estimates of the own price elasticity of demand help measure how quantity demanded responds to changes in price. Demand is inelastic when the price elasticity is greater than -1, meaning that the percentage change in quantity demanded is smaller than the percentage change in price. Conversely, if the price elasticity is less than −1, demand is elastic, and quantity demanded responds more than proportionally to price changes. The most commonly used measure of price elasticity is the Marshallian price elasticity, in which the change in quantity demanded reflects both the substitution effect, where consumers switch to alternative goods when prices change, and the income effect, which arises from changes in purchasing power (Snyder and Nicholsen 2018:145-147).

There are mainly three types of elasticities. First, *own price elasticity of demand* is, as mentioned, an estimate of how the estimated demand changes in percent when a good's own price changes by one percent (Snyder & Nicholsen 2018: 159).

$$e_p = \frac{\partial x(P_x, P_y, I)}{\partial P_x} * \frac{P_x}{x}$$

Second, the *cross-price elasticity of demand* measures how the demanded quantity of one good changes when the price of another good changes. A negative cross price elasticity implies that the goods are complements – meaning that the demand for the second good decreases when the price of the first good increases. Meanwhile, the goods are substitutes if the cross-price elasticity is positive, implying an opposite relationship. However, the goods are independent if the cross-price elasticity is zero (Snyder & Nicholsen 2018: 160)

$$e_p = \frac{\partial x(P_x, P_y, I)}{\partial P_y} * \frac{P_y}{x}$$

Last, *income elasticity* of demand estimates the percentage change in demand of a good in response to a change in a consumer's income. If the good is classified as "normal", the value of the income elasticity will be positive – implying that demand increases as income increases (Snyder & Nicholsen 2010: 159).

$$e_p = \frac{\partial x(P_x, P_y, I)}{\partial I} * \frac{I}{x}$$

2. Literature review

There is a large body of literature examining taxation policies targeting externalities. Larsson et al. (2026) analyse cost-neutral tax reforms based on their effects on climate and health, finding that such reforms can generate positive outcomes from both environmental and public health perspectives. Unlike most previous studies, their analysis incorporates ten sustainability indicators, including animal welfare, climate and biodiversity. This comprehensive approach allows for the identification of trade-offs across different indexes. For example, they highlight that "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" (Larsson et al. 2026).

Moberg et al (2021) analyse the environmental impacts of taxation on Swedish food consumption and assess potential conflicts between environmental objectives. This approach involves weighting multiple environmental indicators and adjusting value added tax rates accordingly. Several scenarios indicate reduced beef consumption, leading to positive international environmental effects due to decreased land use. However, they also identify potential domestic trade-offs, as ruminant grazing contributes to biodiversity in semi-natural grasslands in Sweden. This highlights the importance of comparing several sustainability aspects, such as in this paper. Moberg et al (2021) uses the Swedish carbon tax for the monetary valuation of carbon dioxide, which is the approach used in this study as well.

Andersson (2019) provides a detailed analysis of the Swedish carbon tax introduced in 1991. Andersson found an average reduction of almost 11 % in CO_2 emissions from the transport sector after the implementation of the tax. Importantly, the study shows that consumer responses to carbon taxation are significantly larger than responses from regular market driven price changes. He states that future analysis of effective mitigation actions should consider that the responses from carbon taxation will likely be larger than calculations from existing estimates of price elasticities (Andersson 2019).

The OECD (2025) further explores biodiversity-related taxes and highlights key policy lessons. They emphasize the importance of stakeholder engagement in tax design to mitigate resistance and improve implementation. Furthermore, they state that public support is a critical factor and that earmarking tax revenues could be a strategy to enhance acceptance while potentially contributing further to environmental benefits. Effective enforcement and continuous evaluation are also highlighted as essential for maintaining the effectiveness of such taxes (OECD 2025).

Säll and Gren (2015) evaluate the effects of a Pigouvian environmental tax by estimating demand systems using the Almost Ideal Demand System (AIDS) and damage costs for dairy and meat based on the Swedish carbon tax. Their findings suggest that such a tax could reduce greenhouse gas emissions by approximately

12 %, with beef identified as the most important product to regulate. Similar to Säll and Gren, this paper will use the Almost Ideal Demand System to estimate demand. Their findings regarding beef further highlight the importance of examining this specific type of meat. However, this paper differs from their research in several aspects – primarily in terms of the sustainability indicators included in the analysis. Säll and Gren base their taxation framework on four different pollutants: greenhouse gas, nitrogen, ammonia and phosphorus. In contrast, this paper will only account for greenhouse gas in terms of pollutants but also incorporates social sustainability indicators – specifically animal welfare. Furthermore, this analysis differs from that of Säll and Gren through its use of a more recent dataset. Säll and Gren used data from 1980 to 2012, which therefore also captured consumption patterns before Sweden's entry into the European Union, which may no longer be relevant. Consequently, this analysis better reflects recent consumption patterns and price levels, as it uses data between 1995 and 2024.

Previous research has primarily focused on environmental sustainability indicators. Relatively few papers examine taxation that simultaneously accounts for greenhouse gas emissions, biodiversity loss and animal welfare, highlighting the relevance of this paper. Previous research, such as Andersson (2019) and Moberg et al (2021), has extensively analysed taxes on greenhouse gas emissions, consistently demonstrating significant effects. In contrast, taxation based on biodiversity loss and animal welfare remains more unexplored, partly due to challenges in assigning these indicators a monetary value.

To address this gap, this study adopts the Swedish carbon tax as a monetary benchmark, following the approach of Moberg et al. (2021) and Säll and Gren (2015). As noted by Röös et al. (2025), social aspects of sustainability, such as animal welfare, are often overlooked despite their importance (Röös et al 2025). This paper therefore contributes to the literature by estimating potential tax levels that incorporate animal welfare, carbon footprint and biodiversity loss, and by comparing how these taxes vary across different types of meat based on the three sustainability indicators. The effect on these indicators may vary substantially between beef, pork and poultry as the underlying drivers of these externalities in production systems are often weakly connected or not connected at all between indicators. A multidimensional analysis is therefore of great interest and importance.

3. Data and methodology

3.1 Data

3.1.1 External impact

The data on external impact is retrieved from the Sustainability Assessment of Foods and Diets (SAFAD) - tool, distributed by the Swedish University of Agricultural Sciences. The tool is based on data from nine European countries and assesses the effects of 1804 food items and diets on environmental and social aspects. The foods are analysed with respect to different key indicators, such as biodiversity loss, animal welfare and carbon footprint and are calculated per one kilogram of food, or bone-free edible weight for meat, fish and seafood specifically. When measuring carbon footprint, the estimates include greenhouse gas emissions from all stages in the primary production process, including fuel and electricity, packaging, transport, preparation, farming and fishing. Emissions from transports are calculated based on total distance and vehicle specific emission factors. Methane and nitrous oxide emissions are converted into carbon dioxide equivalents by using estimates from the IPCC AR6-report by Forster et al. (2021), based on the properties of the specific emissions, for example how long the emissions exist in the atmosphere. Both national and international data from websites such as FAOSTAT and Eurostat are used as inventory data for the calculations (Röös et al. 2025).

This paper analyses the impact from meat consumption, for which SAFAD uses country specific factors for calculations, such as livestock diets and production aspects. For beef, they consider the different systems for beef production and corresponding environmental impact. This includes systems like meat from culled dairy cows and meat from dairy calves, where the average carbon footprint for beef from dairy systems is lower since the emissions are distributed between both milk and meat in this case. A fact worth considering is that beef will always be a byproduct from the dairy industry (Röös et al. 2025).

The different production systems are also accounted for when calculating the index for animal welfare. Based on data such as slaughtering statistics, the amounts of meat coming from each respective production system is established. Animal welfare is generally considered to be better for food items produced in Sweden due to stricter regulations concerning the treatment of animals (Röös et al. 2025). The index itself is designed to capture the level of suffering during production, the species' ability to acknowledge negative conditions based on expert assessment and the number of animals affected per kilogram of meat. The estimates of suffering include factors such as conditions during slaughter, the duration of suffering and the spread of disease (Larsson et al. 2026).

The key indicator for biodiversity is referred to as "biodiversity impact from land use". This indicator accounts for both the amount of land required and the geographic location of crop production – where feed production is the most relevant component in the case of meat (Röös et al. 2025). It is calculated by comparing species richness on agricultural land with that of the same area under natural conditions (Röös et al. 2024). The impact on biodiversity varies considerably depending on the location of production. Estimates for beef and lamb suggest that production in Northern Europe may have positive effects on biodiversity when based on semi-natural grasslands, which supports species-rich environments, as discussed in section 1.1.2. In contrast, ruminant meat production in countries such as Greece, Spain and Italy is associated with a greater negative impact on biodiversity, largely due to the extensive land requirements (Röös et al. 2025)

3.1.2 Price and quantity

The price data is obtained from The Swedish Board of Agriculture and consists of a consumer price index rather than absolute price levels. The dataset includes a range of agricultural foods (Swedish Board of Agriculture. n.d). To obtain reliable results, it is crucial to include a sufficiently long time series. This presents a challenge when using data from the Swedish Board of Agriculture, as the available consumer price index (CPI) data is reported in several separate tables, each with a different base year and a limited number of observations. To construct a consistent dataset, these series must therefore be merged and converted to the same base year.

In this study, 1995 is chosen as the reference year, as this was the year when Sweden entered the European Union. As a consequence of the new trade agreements that Sweden became part of, Swedish trade experienced a severe increase which also led to different consumption patterns (European Commission n.d). It is therefore most relevant to analyse the years after 1995. A conversion factor is constructed to convert all series to the base year of 1995. The factor is obtained by calculating the ratio between overlapping years in two series at a time, thereby linking them together. This process is applied likewise on all datasets, such that each new conversion factor builds on the previous. The conversion factors are then used to rescale their respective datasets with alternative base years to the 1995 baseline, yielding a consistent CPI across the full time period. The final dataset will contain data between the years 1995 and 2024.

The consumption data is also collected from the Swedish Board of Agriculture and provides information on direct consumption for a range of food products. The term *direct consumption* refers to the total quantity of a food item supplied from producers to households and catering services, including the producer's own consumption. This can be contrasted with *total consumption,* which refers to the total quantity actually consumed by humans. In the case of meat, consumption is measured in kilograms per capita per year (Swedish Board of Agriculture. n.d).

3.2 Method

The aim of this paper is to estimate the potential tax levels for beef, pork and poultry when accounting for externalities in production – specifically animal welfare, biodiversity and carbon footprint – as well as how much consumption of the three chosen types of meat and the associated externalities would be reduced if taxes were imposed.

Price elasticities are estimated by specifying demand systems for each type of meat. The model used in this paper is the Almost Ideal Demand system (AIDS), which is described in detail in section 3.2.1. Estimating price elasticities is necessary to assess how the quantity demanded responds to changes in prices, and thus what the effects of the tax will be.

When evaluating the results from the demand system, several conditions must be satisfied. Income elasticities should be positive, indicating that the goods are classified as normal. Own price elasticities of demand should be negative, otherwise suggesting errors in the estimations. Cross-price elasticities may either be positive or negative, as they indicate whether goods are substitutes or complements – something that is not known beforehand. Furthermore, the estimated elasticities should be statistically significant, as there is otherwise a high risk that the results only occurred by chance and not by causality (Angrist and Pischke 2015: 21). Another important aspect is the lack of autocorrelation, meaning that residuals close in time should not be too similar. If autocorrelation exists, the residuals are correlated, which may exaggerate the statistical significance of the results (Angrist and Pischke 2015:205).

The tax level for greenhouse gas emissions can be calculated by estimating a Pigouvian tax equal to the marginal external cost, as discussed in section 1.2. The monetary value for this external effect can be approximated by using the existing Swedish carbon tax, which is currently a value of 1,52 SEK per kilogram CO_2 (Government Offices of Sweden n.d). The Pigouvian tax level will thus be calculated by multiplying the average carbon footprint per kilogram of meat, obtained from SAFAD (2026), with 1,52 SEK.

The monetary value for animal welfare and biodiversity is more difficult to determine and not as extensively researched. Consequently, this paper does not apply a Pigouvian tax approach to these sustainability indicators. Instead, it simulates tax rates designed to achieve a targeted 10% reduction in quantity demanded. The 10% target is chosen as it represents both a meaningful yet likely realistic reduction. Based on the estimated price elasticities, the price increases required to achieve this reduction can be calculated and consequently the appropriate tax level can be determined. In addition, a uniform tax rate is estimated using the same methodology – namely, to achieve a 10% reduction in quantity demanded. The results obtained from the uniform tax are then compared with those of the tax rates based on individual externalities in order to assess the relative effects of the different tax designs.

3.2.1 The Almost Ideal Demand System (AIDS)

The Almost Ideal Demand (AIDS) is a method used to estimate demand systems and price elasticities. The method is based on a specific set of preferences, known as Price-Independent Generalized Logarithmic (PIGLOG) preferences. The PIGLOG preferences can be represented by either a cost function or an expenditure function, which describes the minimum expenditure required to achieve a given level of utility at a given set of prices. The AIDS model allows for the analysis of aggregate market demand as if it were generated by a rational representative consumer. This is made possible by using the cost function as a starting point, which allows exact aggregation across consumers. The cost function is derived using Shephard's lemma, which yields demand functions expressed in budget shares. The budget share for good *i* is given by

$$w_i = \alpha_i + \sum \gamma_{ij} \log p_j + \beta_i \log(x/P)$$

where w_i is the budget share of good i, p_j is the price of good *j*, *x* is total consumers expenditure and *P* is a price index defined by the model parameters. The parameters α, β and γ are estimated and require interpretation. The parameter γ_{ij} captures the effect on the budget share of good *i* from a change in the price of good *j*, holding real expenditure *(x/P)* constant. The parameter β_i indicates whether a good is a luxury, in which the value is positive, or a necessity, in which the value is negative, as real expenditure changes (Deaton and Muellbauer 1980). In this analysis, only data on the expenditures on beef, pork and poultry are used and x therefore represents the total expenditures on these types of meat only. The obtained budget shares, w_i, thus reflect the share of the “meat budget” used for good *i.*

One advantage of the AIDS model is that it allows for testing of whether consumer behaviour follows economic theory through linear restrictions on the parameters. These restrictions include the assumption that the sum of the budget shares is 1, homogeneity of degree zero – suggesting that proportionate changes in prices and income do not affect demand - and symmetry – meaning that the compensated cross price effect between good *i* and good *j* is symmetric. If these assumptions hold, budget shares remain constant when relative prices and real expenditure remain unchanged (Deaton and Muellbauer 1980). In this paper, the linear version of the AIDS model is used, called LA AIDS. In this version, the final step of estimation is simplified by substituting the complex nonlinear price index P with a linear approximation instead. A common approach is to use an existing price index, such as Stone’s price index, instead of the exact index which depends on the model’s parameters. This allows estimation using standard econometric methods such as ordinary least squares (OLS). To conclude, the AIDS model provides a flexible yet theoretically consistent framework for analysing how households allocate their expenditures across different goods in response to changes in prices and income (Deaton and Muellbauer 1980).

3.1.2 Elasticities

Both Hicksian and Marshallian elasticities will be estimated in the demand system. Marshallian elasticises, as discussed in section 1.3, are however the most commonly used and thus also the approach used in this paper in order to capture both income and substitution effects (Snyder and Nicholsen 2010:126). Furthermore, the estimation of cross-price elasticities is of importance as the effect on other goods when the price of one good changes needs to be captured. Through the Marshallian elasticities, here called compensated, the cross-price effect is however only captured within the group of commodities. Therefore, the uncompensated elasticises will also be calculated, to control for the change in allocation of expenditure between groups of commodities (Edgerton 1997). The general formula can be written as follows:

$$e_{ij} = \delta_{rs} e_{(r)ij} + E_{(r)i} w_{(s)j} [\delta_{rs} + e_{(r)(s)}]$$

In which e_{ij} is the uncompensated elasticity. δ_{rs}, called Kronecker's delta, is equal to 1 if the goods are part of the same group – as in this case – or zero otherwise. $e_{(r)ij}$ is the compensated price elasticity, $E_{(r)i}$ is the compensated income elasticity and $w_{(s)j}$ is the budget share. $e_{(r)(s)}$ represents the uncompensated elasticity for the group (Edgerton 1997). The value for $e_{(r)(s)}$ is in this analysis obtained from Säll et al. (2020).

4. Results

4.1 Results from the Almost Ideal Demand System

To control for autocorrelation, a LM test is performed in connection with the estimation of the demand systems. The p-values for this test are 0,479 and 0,207, indicating no statistically significant autocorrelation. This is favourable for the interpretation of the results. Income elasticities are positive as expected, implying that the goods are normal goods. That all own price elasticities are negative was expected, as this indicates that the goods are classified as normal and that the demand curves slope downward. However, whether the cross-price elasticities would be negative or positive was unknown beforehand. The estimated results therefore imply that all goods are complements. Several of the estimated compensated elasticities, although not all, are significant at least at the 10% level, indicating relatively robust results. The uncompensated elasticities were calculated manually, and corresponding p-values are therefore unavailable.

Table 1: Compensated elasticities

	Beef	**Pork**	**Poultry**	**Income**
Beef	-0,580797***	-0,223820*	-0,239745*	1,04436***
Pork	-0,190942**	-0,671833***	-0,297604**	1,16038***
Poultry	-0,103212	-0,155846	-0,561621***	0,820679***

p < 0.10, ** p < 0.05, *** p < 0.01.

Table 2: Uncompensated elasticities

	Beef	**Pork**	**Poultry**	**Income**
Beef	-0,520003	-0,14285	-0,148791591	0,8790908
Pork	-0,123226	-0,581833	-0,197684345	0,9767676
Poultry	-0,055032	-0,092184	-0,489585213	0,6913157

4.2 Taxation and corresponding effects

Table 3: Carbon footprint

	Tax rate (dP per kg)	Change in quantity (dQ per kg)	%dQ	Percentage change in externality
Beef	46,88	-1,4898628	-14,72%	-19,51%
Pork	8,61	-0,8048365	-6,49%	-9,27%
Poultry	3,36	-0,6461229	-2,954%	-4,36%

Table 4: Biodiversity loss

	Tax rate (dP per kg)	Change in quantity (dQ per kg)	%dQ	Percentage change in externality
Beef	26	-1,153668	-11,03%	-9,93%
Pork	16	-1,27121	-10,66%	-9,63%
Poultry	20	-1,916926	-9,30%	-8,51%

Table 5: Animal welfare

	Tax rate (dP per kg)	Change in quantity (dQ per kg)	%dQ	Percentage change in externality
Beef	18	-0,977906	-9,20%	-4,34%
Pork	13	-1,208459	-10,08%	-5,37%
Poultry	27	-2,384536	-11,84%	-10,59%

Table 6:Uniform tax rate

	Tax rate (dP per kg)	Change in quantity (dQ per kg)	%dQ	Percentage change in carbon footprint	Percentage change in biodiversity loss	Percentage change in animal welfare index[1]
Beef	20	-1,02	-9,59%	-13,30%	-8,75%	-4,51%
Pork	20	-1,40	-11,84%	-16,09%	-10,58%	-6,20%
Poultry	20	-1,93	-9,36%	-13,01%	-8,56%	-8,56%

[1] In which a higher value implies lower animal welfare

5. Discussion

5.1 Analysis of results

The uncompensated elasticities are generally lower than the compensated estimates, suggesting that consumers are less sensitive to price changes when they are able to substitute meat with other food products, which is reasonable. In the context of this study, this implies that the reduction in externalities will be smaller, as consumers do not reduce their meat consumption to the same extent.

According to the results, the Pigouvian tax based on carbon footprint is estimated at 46.88, 8.61 and 3.36 per kilogram for beef, pork and poultry respectively. These values therefore reflect the marginal external costs associated with each type of meat. The estimated change in quantity demanded, together with the corresponding reduction in externalities, indicates that these taxes would have a considerable impact. The percentage reduction in carbon footprint is estimated between 4-20% for the different types of meat. Beef shows the largest reduction, which is unsurprising given its considerably higher carbon footprint and associated marginal external cost. Estimating taxation levels for biodiversity and animal welfare is more complex, as the existing literature does not provide established monetary values for these externalities. Consequently, this study adopts an alternative approach by simulating tax levels that would achieve a targeted 10% reduction in quantity demanded. The tax levels reported in Table 4 and Table 5 therefore represent the estimated price increases required to produce a reduction in demand as close to 10 % as possible. However, these estimates are sensitive to the assumed elasticities. In particular, there is some uncertainty surrounding the cross-price elasticities, implying that the estimated tax rates and the corresponding reduction in quantity demanded should be interpreted with some caution. Nevertheless, these estimated values should not be interpreted as optimal tax rates. Given the difficulties associated with assigning monetary values to biodiversity loss and animal welfare impacts, the simulations are better understood as illustrations of the potential effects of a tax designed around these sustainability indicators. For the same reason, the tax rates estimated for carbon footprint should not be directly compared in absolute values with those estimated for animal welfare and biodiversity loss, as the underlying methodologies differ. As mentioned, while the carbon tax is based on the estimated marginal external costs, the biodiversity and animal welfare taxes are calculated to achieve a targeted reduction in demand.

Nevertheless, the estimated tax levels for both biodiversity and animal welfare show substantial effects on demanded quantities and on the reduction of externalities. The estimated reduction in the biodiversity index is approximately between 8-10%, and the estimated reduction in the animal welfare index is approximately between 4-10% for the different types of meat. According to these results, a taxation policy designed in this way could therefore serve as an effective policy instrument for shifting dietary patterns toward more sustainable options. Andersson (2019) also found that taxation aimed at enhancing sustainability could generate a stronger consumer response than estimates based only on price elasticities would suggest. One possible explanation is that sustainability-related taxes may influence behaviour not only through higher prices, but also by increasing awareness of these issues.

Since different indicators are used to measure each externality, direct comparisons between their values are difficult to interpret. A uniform tax rate applied to all types of meat, regardless of their respective impacts on the three externalities, may therefore constitute an alternative approach. The value of 20 SEK per kilogram was selected in this analysis using the same approach as that applied to biodiversity and animal welfare – namely, to achieve a targeted 10% reduction in quantity demanded. A uniform meat tax rate was also examined by Röös et al. (2021), who suggest that such an approach may be a practical way of taxing meat consumption. While external costs are ideally addressed through targeted policy instruments, implementing such instruments often involve complicated procedures and complexity (Röös et al. 2021). A uniform tax rate may therefore represent a feasible alternative, particularly given the limited research currently available for designing taxes that accurately reflect the external costs associated with biodiversity loss and animal welfare. The results of this analysis of a uniform tax rate of 20 SEK per kilogram are presented in Table 6. According to the results, a uniform tax rate of 20 SEK per kilogram would have substantial effects on quantity demanded and the associated externalities. The estimated percentage reduction in carbon footprint, biodiversity loss and animal welfare impacts range from approximately 13-16%, 8-11% and 4-9% respectively.

When comparing the individual tax rates presented in Table 3, 4 and 5 with the results of the uniform tax rate presented in Table 6, the results vary depending on the externality and type of meat considered. The reduction in carbon footprint is greater for poultry and pork but smaller for beef. In contrast, the reductions in biodiversity loss and animal welfare impacts are relatively similar – unsurprisingly, given that all of these tax rates were designed to achieve the same target of a 10% reduction in quantity demanded. The largest differences are consequently observed between the uniform tax rate and the tax rate based on carbon footprint; in other words, the only tax specifically designed as a Pigouvian tax and therefore the most efficient instrument for addressing that particular externality. Nevertheless, a uniform tax rate of 20 SEK per kilogram would still generate considerable improvements. These findings suggest that, although a uniform tax may not be the most cost-efficient policy instrument, it could however generate substantial reductions in these externalities and contribute to improved sustainability outcomes.

The estimated relationships between poultry and beef, and poultry and pork, do not support the claim that an environmental tax would result in trade-offs regarding animal welfare, as consumers do not appear to substitute pork and beef for poultry when their respective prices increase. The finding that beef, pork and poultry appear to be complementary goods further suggests that there are no essential conflicting goals when designing a tax based on these sustainability indicators. According to these results, it would be possible to implement a tax that simultaneously reduces all three externalities, thereby leading to positive outcomes for both environmental and social sustainability. However, while substitution effects could not be fully captured within the framework of this analysis, the possibility of consumers substituting towards poultry, and the associated trade-offs, cannot be entirely ruled out. It is possible that such behavioural responses are not sufficiently reflected in the model, even if they occur in reality.

The results of this paper align relatively well with those of previous literature on the same subject. As Andersson (2019) demonstrated, taxation based on carbon footprint appears to generate substantial reductions in emissions. Furthermore, Säll and Gren (2015) also reported considerable reductions when estimating taxation levels using the Almost Ideal Demand System and the Swedish carbon tax. This paper presents even larger reductions, which is most likely partly due to the higher level of the Swedish carbon tax today compared to 2015, when their analysis was conducted.

The estimated reductions in externalities are calculated under the assumption that reduced domestic demand also leads to lower domestic production and thereby a decline in negative environmental and social impacts. However, Larsson et al. (2026) note that "this assumption represents a simplification, as reduced demand may instead contribute to lower international prices and, in turn, increased consumption in other countries."

The analysis in this paper raises the question of how a consumer tax on meat would affect international trade. As outlined in section 1.2, such a tax would be applied to the final consumer price of meat, implying that domestic and imported products would be treated equally. This is consistent with Article III of the General Agreement on Tariffs and Trade (GATT), administered by the World trade organization, which requires that imported and domestic goods be treated equally with respect to taxation and regulation (National Board of Trade Sweden 2019). Article 110 of the Treaty on the Functioning of the European Union claims that the same principle applies within the European Union as well (European Union n.d). The Swedish consumption of animal products currently depends on imports from other countries within the European union, both for final food products and production inputs. While Sweden's domestic capacity to produce animal products is generally well functioning, foreign producers are typically better equipped to compete in prices. Domestic beef production increased by 1,0 percent in 2024; however, total per capita consumption rose by 2,1 percent, leading to higher import volumes and a decline in self-sufficiency rate. A similar development can be observed in the market for pork (Swedish Board of Agriculture 2025). In light of this, the effects of a consumption tax on imports are uncertain. On one hand, reduced demand following the tax could increase the domestic sector's ability to meet consumption needs. The relative domestic prices would also decrease as Swedish meat currently is more costly – hence, leading to a smaller percent change with unit taxes. On the other hand, foreign producers may still have better ability to compete in prices – resulting in an unchanged trade pattern, as both domestic and imported prices would increase by the same amount after the tax implementation. In the context of this study, it is not possible to determine which of these outcomes is more likely to occur.

5.2 Policy implications

The question of public support is highly relevant, as it is crucial in determining whether a tax of this kind would be politically feasible to implement. As discussed in Section 1.2, the allocation of tax revenues has significant implications for how such a policy is perceived in public eyes. Maestre-Andrés et al. (2021) argue that support is strengthened by perceptions of justice, for example through compensations to low-income households. Public acceptance may also increase when revenues are allocated to sustainability-related purposes, such as funding climate initiatives (Maestre-Andrés et al. 2021). Another possibility is to allocate revenues to the agricultural sector, in order to prevent negative effects on farmers' income (Röös et al. 2021). However, this effect appears to be weaker in the context of food than for environmental taxes on other goods, since food taxes are more directly connected to consumers' everyday lives and household expenditure (Lindahl 2026). Furthermore, the tax design employed in this analysis is based on the average impacts from production systems in Sweden. This may reduce public acceptance, as perceptions of fairness are likely to be weaker when differences between individual production systems are not considered (Röös et al. 2021). Nevertheless, the different sustainability indicators may have various supports. For example, animal welfare is identified as a dimension many consumers value, and the implementation of such a tax would thus potentially be easier (Ammann 2023).

Another finding is that individuals tend to be less supportive of consumption taxes than towards production taxes, which suggests additional challenges in the context of this study. One likely explanation is that consumers generally oppose food policies that increase their financial burden. Public attitudes toward environmental taxes are often negative overall, although taxes designed to reflect environmental externalities may receive greater support among individuals with stronger environmental concerns (Lindahl 2026). There is also evidence that meat taxes experience low support overall, which may partly depend on the strong cultural role of meat in our society (Larsson et al. 2026). Unsurprisingly, lower tax levels are generally viewed more favourably by the public (Lindahl 2026). Lindahl further argues that gradual implementation may be an effective strategy for increasing public acceptance, as evidence suggests that support for such policies could increase after implementation. To summarize, the implementation of a tax of this kind may be difficult from an acceptance perspective, but factors such as gradual implementation and allocation of revenues with regard to justice may strengthen the support.

Furthermore, consumer prices for individual food items become increasingly important as overall price levels rise, particularly during times of crisis. A recent example is the war in Ukraine, during which food price inflation in Sweden increased from just over 2% to 8,6% in Sweden (Swedish Food Agency 2025). As average food prices rise rapidly, consumers face stronger incentives to adjust their dietary patterns toward more affordable food options. Within the context of this paper, this may also encourage a shift toward more sustainable alternatives associated with lower negative externalities and, consequently, lower sustainability-related taxes. However, public opinion is likely to be more negative toward such a tax during periods when food prices are already high. Consequently, an externality-based tax may lack public support in these situations and be more difficult to implement.

The analysis only accounts for the average effect on household consumption. However, the effects of such a policy are likely to vary across households depending on factors such as income. Consequently, the analysis is unable to capture the potential distributional effects of implementing the tax. Nevertheless, the distributional effects are likely to follow certain patterns. Röös et al. (2021) argue that environmental taxes are likely to have the greatest impact on low-income households, as these households allocate a larger share of their income to food expenditures. One possible way to mitigate concerns regarding these distributional effects would be to introduce compensation measures targeted at these groups. On the other hand, Säll (2018) found that the effects are distributed similarly across all household types when expenditure, rather than income, is used as the welfare indicator. Expenditures may be a more reliable measure of welfare as household can smooth their expenditure levels through borrowing and savings, making expenditure less volatile over time than income (Säll 2018).

5.3 Limitations

One limitation with the SAFAD tool is that it relies on several assumptions, for example regarding farming practices. As a result, there may be some degree of uncertainty in the data. Furthermore, due to limited data availability in some cases, several approximations were necessary, which makes detailed comparisons between food items more difficult (Röös et al 2025).

Furthermore, the results do not reflect the most cost-efficient tax levels due to challenges associated with assigning monetary values to biodiversity loss and animal welfare. Consequently, the estimated tax levels for animal welfare and biodiversity cannot be interpreted as Pigouvian taxes, but rather as simulations based on a targeted reduction in quantity demanded. This approach introduces challenges regarding the reasonable size of the targeted reduction, since the different sustainability indicators are constructed differently and are therefore not directly comparable. The uniform tax rate is examined as a response to this limitation, as discussed in section 5.2. In addition, the animal welfare index may be difficult to interpret in real terms, due to the lack of an index unit.

Another limitation with the method used in this study is that the environmental impact data does not account for variation between individual production systems but instead reflects average impact in Sweden across each key indicator and type of meat. It is reasonable to assume that these differences can be substantial, particularly regarding animal welfare – for example when comparing conditions in large-scale industrial systems with small scale poultry production. This presents a challenge not only because the tax may not be optimally designed for its intended purpose, but also because individual improvements in production practices are not rewarded.

A consumption tax could be an effective instrument for promoting more sustainable dietary patterns, which is essential for addressing modern sustainability challenges. However, other policy instruments may be more effective in encouraging the development of more sustainable *production* systems. One commonly used instrument in the transition to a more sustainable society is the subsidy. A subsidy is a financial incentive provided by the government to encourage certain activities and can take the form of direct payments, grants or tax reductions (Corporate finance team, 2019). Subsidies thus stimulate changes on the production side by making green investments more profitable. In contrast, a sustainability-related consumption tax primarily stimulates behavioural change on the consumption side through shifts in dietary choices. However, it may provide weaker incentives for individual producers to adopt more sustainable practices, since the tax is based on average impact rather than sustainability performance at individual firms. Consequently, consumption taxes are unlikely to drive technological innovation or improvements in production practices. Nevertheless, designing effective subsidy schemes for animal production that incorporates all of the sustainability indicators addressed in this paper may be challenging, and a consumption tax could therefore be a better alternative in this specific scenario.

Several tests were conducted in order to obtain the most reliable results possible. First, total consumption was used instead of direct consumption in the estimation of the demand system. However, this specification did not lead to any notable improvement in the significance of the elasticities and instead resulted in a higher value of significance for the LM test. Second, different time lags were tested to determine how many previous years should be included in the calculations. A lag length of two or three years was ultimately selected for real expenditure and for the price of pork, while a lag length of one year was chosen for the remaining variables, as it produced the most reliable results.

To enable more efficient taxation with respect to indicators such as animal welfare and biodiversity, one should further explore the gap in the literature on how to assign these indicators a monetary value. A monetary value would enable comparisons between sustainability indicators and may also make discussions about these externalities more comprehensible.

6. Conclusion

Modern meat production represents a major challenge in relation to climate change, biodiversity loss and animal welfare. In this context, a sustainability-related tax on meat could serve as an important policy instrument for shifting dietary patterns toward more sustainable food options. When designing such a tax, it is essential to integrate both social and environmental dimensions of sustainability in order to minimize trade-offs between different sustainability objectives. While it is possible to estimate a Pigouvian tax based on carbon footprints, greater challenges arise when designing tax rates for animal welfare and biodiversity loss, as monetary valuations of these externalities are absent from the existing literature. Nevertheless, the results of this analysis indicate that both a tax based on carbon footprint and taxes designed to achieve a targeted 10% reduction in quantity demanded for biodiversity loss and animal welfare would have substantial effects in reducing these externalities, with estimated reductions in the associated externalities of 4-20%, 8-10% and 4-10% respectively. In addition, a uniform tax rate of 20 SEK per kilogram, calibrated to achieve the same 10% reduction in quantity demanded, is examined. The estimated results of such a tax indicate reductions of 4-16% across all externalities. Such a tax could represent a feasible alternative, as direct comparisons between different sustainability indicators are difficult, making the design of a multidimensional tax framework more challenging. Furthermore, differentiated tax rates based on individual sustainability indicators could require complex administrative procedures and may therefore be more difficult to implement. Although a uniform tax does not account for the varying impacts associated with different types of meat and is therefore less cost-effective than a differentiated tax, the results suggest that it could nevertheless generate substantial reductions in externalities. Consequently, there are arguments in favour of a uniform tax rate rather than separate tax rates based on individual externalities.

Furthermore, the findings of this analysis do not support the claim that taxation based on environmental indicators would necessarily create trade-offs between environmental objectives and animal welfare, particularly in relation to poultry consumption. However, this potential risk should not be entirely dismissed in future analysis. The implementation of a tax aimed at reducing the three sustainability indicators examined in this study may also face challenges related to public acceptance. Such a policy may therefore require additional measures to increase public support, including strategic allocation of tax revenues, as suggested by Lindahl (2026). Finally, a consumer-based tax alone does not create direct incentives for individual producers to adopt more sustainable production practices.

References

Ahlgren, S., Wirsenius, S., Toräng, P., Carlsson, A., Seeman, A., Behaderovic, D., Kvarnbäck, O., Parvin, N., Hessle, A. (2024) *Climate and biodiversity impact of beef and lamb production – A case study in Sweden.* Agricultural systems. Volume (219). https://www.sciencedirect.com/science/article/pii/S0308521X24001975

Ammann, J., Mack, G., Irek, J., Finger, R., El Benni, N. (2023*). Consumers' meat commitment and the importance of animal welfare as agricultural policy goal.* Food quality and preference. Volume (112). https://www.sciencedirect.com/science/article/pii/S0950329323002045

Andersson, J. (2019) *Carbon Taxes and CO2 Emissions: Sweden as a Case Study.* American Economic Journal: Economic Policy. Volume (11) (4), pp. 1–30**.** https://www.aeaweb.org/articles?id=10.1257/pol.20170144#:~:text=This%20quasi-experimental%20study%20is%20the%20first%20to%20find,a%20value-added%20tax%20on%20transport%20fuel%20in%20Sweden.

Angrist, J., Pischke, J. (2015) *Mastering Metrics. The path from cause to effect*. First edition. Princeton University Press.

Benton, T., Bieg, C., Harwatt, H., Pudasaini, R., Wellesley, L. (2021). *Food system impacts on biodiversity loss. Three levers for food system transformation in support of nature.* Energy, Environment and Resources Programme. 2021-02-03-food-system-biodiversity-loss-benton-et-al.pdf

Bonnet, C., Bouhamra-Mechemache, Z., Réquillart, V., Treich, N. (2020). *Viewpoint: Regulating meat consumption to improve health, the environment and animal welfare*. Food policy. Volume (97). https://www.sciencedirect.com/science/article/pii/S0306919220300312

Corporate finance team. (2019). *Subsidy.* https://corporatefinanceinstitute.com/resources/economics/subsidy/

Deaton, A., Muellbauer, J. (1980). *An Almost Ideal Demand System.* https://www.aeaweb.org/aer/top20/70.3.312-326.pdf

Edgerton. (1997). *Weak Separability and the Estimation of Elasticities in Multistage Demand Systems*. American Journal of Agricultural Economics. Volume (79). https://www.jstor.org/stable/1243943?seq=6

European Commission. (N.d). *Sverige och EU medlemskapet.* Sverige och EU-medlemskapet - Representationen i Sverige [2026-05-02]

European Union. (N.d) CONSOLIDATED VERSION OF THE TREATY ON THE FUNCTIONING OF THE EUROPEAN UNION. EUR-Lex. [2026-06-05] EUR-Lex - 12012E110 - EN - EUR-Lex

Forster, P., Storelvmo, T., Armour, K., Collins, W., Dufresne, J., Frame, D., Lunt, D., Maruitsen, T., Palmer, M., Watanabe, M., Wild, M., Zhang, H. (2021). *The earth's energy budget, climate feedback, and climate sensitivity.* Climate Change 2021 – The Physical Science Basis Working Group I Contribution to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University

Press. The Earth's Energy Budget, Climate Feedbacks and Climate Sensitivity (Chapter 7) - Climate Change 2021 – The Physical Science Basis

Godfray, J., Garnett, T., Hall, J., Key, T., Lorimer, J., Pierrehumbert, R., Scarborough, P., Springman, M., Jebb,S. (2018). *Meat consumption, health and the environment. Science*. Volume (361). Meat consumption, health, and the environment | Science

Governement Offices of Sweden. (N.d). *Sweden's carbon tax.* Sweden's carbon tax - Government.se [2026-05-12]

IPCC (n.d). *Global warming of 1.5 ºC.* Global Warming of 1.5 ºC — [2026-05-02]

Kallbekken, S. (2013). *Pigouvian Tax Illusions.* Encyclopedia of Energy, Natural Resource, and Environmental Economics. Chapter ENVIRONMENT. Pigouvian Tax - an overview | ScienceDirect Topics

Larsson, J., Månsson, E., Röös, Elin., Säll, Sarah., Pattersson, E., Schäfer Elinder, L., Nässén, J., Ejelöv, E. (2026). *Cost-neutral food tax reforms for healthier and more sustainable diets. Ecological economics.* Volume (240). Cost-neutral food tax reforms for healthier and more sustainable diets - ScienceDirect

Lindahl, T. (2026). *Citizen support for policy interventions implemented to achieve more sustainable food consumption: The role of policy design and presentation*. Current research in Environmental Sustainability. Volume (11). https://www.sciencedirect.com/science/article/pii/S2666049026000149#bb0250

Machovina, B., Feeley, K., Ripple, W. (2015). *Biodiversity conservation: The key is reducing meat consumption. Science of the Total Environment.* Volume (536). Biodiversity conservation: The key is reducing meat consumption - ScienceDirect

Maestre-Andrés, S., Drews, S., Savin, I., van der Bergh, J. (2021) *Carbon tax acceptability with information provision and mixed revenue uses.* Nature Communications. Volume (12). Carbon tax acceptability with information provision and mixed revenue uses | Nature Communications

Moberg, E., Karlsson Potter, H., Wood, A., Hansson, P., Röös, E. (2020). *Benchmarking the Swedish Diet Relative to Global and National Environmental Targets—Identification of Indicator Limitations and Data Gaps*. Healthy Sustainable Diets. Volume (12). Benchmarking the Swedish Diet Relative to Global and National Environmental Targets—Identification of Indicator Limitations and Data Gaps

Moberg, E., Säll, S., Hansson, P. Röös, E. (2021). *Taxing food consumption to reduce environmental impacts – Identification of synergies and goal conflicts. Food Policy*. Volume (101). Taxing food consumption to reduce environmental impacts – Identification of synergies and goal conflicts - ScienceDirect

National Board of Trade Sweden. (2019). *Gatt reglerar handeln med varor.* Gatt reglerar handeln med varor | Kommerskollegium [2026-05-02]

Nollkaemper, A. (2023) *International law and the agony of animals in industrials meat production.* European Journal of International Law. Volume (34). https://academic.oup.com/ejil/article/34/4/939/7334485

Pfenning-Butterworth, A., Buckley.L., Drake, J., Farner, J., Farrell, M., Gehman, A., Mordecai, E., Stephens, P., Gittleman, J., Davies, J. (2024) *Interconnecting global* *threats: climate change, biodiversity loss, and infectious diseases.* The Lancet Planetary Health. Volume (8). https://www.sciencedirect.com/science/article/pii/S2542519624000214

Röös, E. Jacobsen, M., Karlsson, L., Wanecek, W., Spångberg, J., Mazac, R., Rydhmer, L. (2025). *Introducing a comprehensive and configurable tool for calculating environmental and social footprints for use in dietary assessments.* Journal of Cleaner Production. Volume (519). Introducing a comprehensive and configurable tool for calculating environmental and social footprints for use in dietary assessments - ScienceDirect

Röös, E., Ran, Y., Moberg, E. (2024). *Mat, miljö och hållbarhet*. SLU Future Food Reports. Volume (14). Mat, miljö och hållbarhet - Hur påverkar den mat vi svenskar äter planeten?

Swedish Board of Agriculture. (N.d). *Direktkonsumtion av vara*. Direktkonsumtion efter Vara, Variabel och År. PxWeb [2026-05-03]

Swedish Board of Agriculture. (2024). *Företagens förmåga att leverera varor och tjänster under höjd beredskap.* Företagens förmåga att leverera varor och tjänster under höjd beredskap

Swedish Board of Agriculture. (N.d). *Prisindex.* Statistik - välj tabell [2026-05-03]

Swedish Board of Agriculture. (2025). *Vi åt mer kött, ägg och mejeriprodukter 2024 men en minskad andel kom från Sverige.* På tal om jordbruk och fiske – fördjupning om aktuella frågor. https://jordbruksverket.se/download/18.448459fe1958aa6ee5927c4c/1742369994661/Pa-tal-om-jordbruk-och-fiske-mars-2025-tga.pdf

Swedish Food Agency and Swedish board of Agriculture. (2025). *Livsmedelsförsörjningen i siffror.* Livsmedelsförsörjningen i siffror

Swedish University of Agricultural Sciences. (2026). SAFAD: Sustainability Assessment of Foods and Diets. Version: 1.301. SLU SAFAD | Sustainability Assessment of Foods and Diets [2026-05-11]

Snyder, C., Nicholsen, W. (2018) *Microeconomic theory*. 12th edition. Cengage learning.

Säll, S. (2018) *Environmental food taxes and inequalities: Simulation of a meat tax in Sweden.* Food Policy. Volume (74). Environmental food taxes and inequalities: Simulation of a meat tax in Sweden - ScienceDirect

Säll, S., Gren, I. (2015). *Effects of an environmental tax on meat and dairy consumption in Sweden*. Food Policy. Volume (55). Effects of an environmental tax on meat and dairy consumption in Sweden - ScienceDirect

Säll, S., Moberg, E., Röös, E. (2020). *Modeling price sensitivity in food consumption - a foundation for consumption taxes as a GHG mitigation policy.* Swedish University of Agricultural Sciences. Microsoft Word - working paper

OECD. (2025*). Scaling Up Biodiversity-Positive Incentives*. Scaling Up Biodiversity-Positive Incentives | OECD.

Van Rysselberge, P., Röös, E. (2021*). Carbon footprint of meat, egg,* *cheese and plant-based protein sources - compilation of data and discussion of assessing the climate impact in the WWF Swedish Meat Guide.* Swedish University of Agricultural Sciences. https://media.wwf.se/uploads/2021/11/carbon-footprint-of-meat-egg-cheese-and-plant-based-protein-sources_slu-v11.pdf

Wallman, M., Berglund, M., Cederberg, C. (2013). *Miljöpåverkan från animalieprodukter – kött, mjölk och ägg.* Swedish Food Agency. Rapportmall - svensk.

Wong, J. De Bruyn, J., Bagnol, B., Grieve, H., Li, M., Pym, R., Alders, R.G. (2017). *Small-scale poultry and food security in resource-poor settings: A review*. Global Food Security. Volume (15). Small-scale poultry and food security in resource-poor settings: A review - ScienceDirect.

WWF. (N.d). *Nöt*. Nöt - Världsnaturfonden WWF. [2026-04-25]

WWF. (N.d). *Mer om kött.* Mer om kött - Världsnaturfonden WWF [2026-05-25]

Appendix

Table 7: Data on consumer price index

Year	Beef	Pork	Poultry
1995	7,05	12,87	8,22
1996	8,71	14,72	8,72
1997	9,01	15,01	8,46
1998	9,03	15,65	8,90
1999	9,56	15,04	10,44
2000	10,70	15,08	11,77
2001	9,93	14,96	12,81
2002	10,12	13,76	13,48
2003	10,27	14,97	12,98
2004	10,53	15,22	13,52
2005	9,88	15,16	14,22
2006	10,21	14,35	14,77
2007	10,19	15,16	15,05
2008	10,86	15,08	16,51
2009	11,31	15,82	16,00
2010	12,20	16,19	16,88
2011	12,72	17,23	17,23
2012	12,46	15,65	17,57
2013	12,50	15,03	18,76
2014	13,07	14,77	19,89
2015	12,73	15,25	20,77
2016	12,69	15,06	21,94
2017	12,05	14,77	21,59
2018	11,74	14,76	20,57
2019	11,56	12,98	20,81
2020	11,00	12,65	20,26
2021	11,04	12,71	21,48
2022	11,48	12,91	21,18
2023	11,28	11,99	21,72
2024	11,61	13,20	22,52

Table 8: Data on consumption quantity (per capita)

Year	Beef	Pork	Poultry
1995	100,00	100,00	100,00
1996	88,50	92,40	93,30
1997	83,40	93,90	91,40
1998	84,20	88,00	90,70
1999	83,60	83,60	93,10
2000	85,10	87,10	93,40
2001	92,02	98,33	94,66
2002	91,81	99,20	96,89
2003	93,49	98,22	93,90
2004	92,32	98,61	94,21
2005	96,88	100,08	93,10
2006	102,29	103,45	92,59
2007	104,32	104,84	91,23
2008	120,57	112,04	100,87
2009	122,06	116,40	101,81
2010	124,42	115,27	102,40
2011	127,73	116,17	103,25
2012	133,27	119,01	104,33
2013	139,74	122,95	107,47
2014	138,69	121,88	104,02
2015	139,98	121,50	109,13
2016	145,47	123,67	110,01
2017	149,02	125,32	108,99
2018	151,81	127,38	110,56
2019	151,47	128,19	115,66
2020	161,94	136,18	113,72
2021	168,83	138,82	115,05
2022	190,89	149,23	138,50
2023	204,27	162,86	146,27
2024	206,91	176,96	140,14

Table 9: Hicksian elasticities

	Beef	Pork	Poultry
Beef	-0,311647*	0,15025	0,161397
Pork	0,108108	-0,256207*	0,1481
Poultry	0,108291	0,138105	-0,246396**

Table 10: External impact

	Carbon footprint (kg per kg of meat)	**Biodiversity loss (MSY per kg of meat)**	**Animal welfare (per kg of meat)**
Beef	30,845	5,8e-12E	0,34
Pork	5,665	1,7e-12E	3,8
Poultry	2,21	1,3ee-12E	80

Publishing and archiving

Approved students' theses at SLU can be published online. As a student you own the copyright to your work and in such cases, you need to approve the publication. In connection with your approval of publication, SLU will process your personal data (name) to make the work searchable on the internet. You can revoke your consent at any time by contacting the library.

Even if you choose not to publish the work or if you revoke your approval, the thesis will be archived digitally according to archive legislation.

You will find links to SLU's publication agreement and SLU's processing of personal data and your rights on this page:

- https://libanswers.slu.se/en/faq/228318

☒ YES, I, Nora Lundin, have read and agree to the agreement for publication and the personal data processing that takes place in connection with this

☐ NO, I/we do not give my/our permission to publish the full text of this work. However, the work will be uploaded for archiving and the metadata and summary will be visible and searchable.