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Modeling price sensitivity in food consumption

- a foundation for consumption taxes as a GHG mitigation policy.

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Abstract

In this paper we investigate the mitigation possibilities of climate impact weighted food taxes in Sweden. We include 52 food items in a demand system of elasticities, covering most food consumed by the Swedish population. Tax levels are based on the Swedish Carbon tax and would lead to price increases up to SEK 25 (close to EURO 2.5) per kilo product. The possible emission reductions would be just above 200 kilos of CO_2e emissions per person and year which corresponds to a 10% decrease from Swedish food consumption. Most important for the reductions are beef, other meats and dairy products. Almost 90% of reductions are from animal products.

1. Introduction

Reducing greenhouse gas (GHG) emissions from the food producing sector is necessary to reach the Paris agreement of maximum 2 degrees temperature increase relative to pre-industrial levels (IPCC, 2018). This has been discussed in a number of papers and several suggest economic directed policies to reduce the impact of food production (IPCC, 2018; Springmann et al, 2017; Jansson & Säll, 2018). Agriculture and the food producing sector are at large exempted from enforced economic policy (Markensten et al., 2018). As an example, the sector is not included in the EU-Emission Trading System (EU-ETS) and is exempted from paying full taxes on fuel consumption for machinery and energy used in production in some countries (e.g Swedish Tax Agency, 2020). It is to some extent understandable that the food producing sector is excluded from restricting policies, food security is too important to risk a decrease in production, especially in a longer time horizon (Wilett et al., 2019). However, it is still important to recognize aggregated emissions levels from agriculture and the fact that some food commodities, such as for example beef, are very emission intense in comparison to other goods such as legumes and other vegetable produce, even in relation to nutritional value (Clark & Tilman, 2017; Clune et al., 2017; Poore & Nemecek, 2018). Livestock stand out as the main emitting sector within agriculture, around 15% of global anthropogenic GHGs come from the production of animal products (Gerber et al., 2013). Hence much of the discussion around policy implementation on food and agriculture focus on livestock production and consumption.

In this study we focus on reduced GHG emission levels from food consumption in Sweden. According to Eker et al, (2019), social norms are the most important factor when changing consumption behavior regarding food. For the past three years consumption of meat in Sweden has declined (Swedish Board of

Agriculture, 2020). The global trend however show an increase driven by higher living standards and urbanization (i.e Xiong et al., 2020). Even though consumption of meat has decreased in Sweden, the rate is slow and it might be necessary to curb emission intense food consumption by the use of policy to increase the speed of change.

There are several alternative policies that could be implemented on the food producing sector. Economic instruments such as tradable permits (as in ETS) and pollution taxes are both cost efficient in abatement, thus leading to optimal reduction allocations between sectors or producers. For open economies where food is traded to a large extent, these instruments are however best in theory. Policy regulation that affect the production side of the economy, such that both permits and pollution taxes does, risk creating emission leakages in terms of increased import levels when production costs increase with policy, and might even offset national reductions (Pérez-Domínguez et al., 2016; Van Doorslaer et al., 2015). Or, as found in Lundgren et al, (2015), have close to no impact on the sector due to the low prices in EU-ETS. In addition, output related emission policies might create large social costs in terms of transaction costs measuring emissions on farm level together with other administrative cost, and at the same time not be cost efficient in practice (Schmutzler & Goulder 1997; Bakam et al, 2012).

As discussed in e.g Jansson & Säll, (2018) consumption taxes are at present the only realistic instrument to use if policy makers want to reduce emission levels from food in a set geographical area, without reducing the competitiveness of domestic producers and without increasing the risk of emission leakages. In addition, consumption taxes on food would assess external effects and environmental degradation caused by large pollution levels. Consumption taxes as a mitigation policy has both beneficial and negative implications. A tax on consumption in an open economy makes it possible to include imported goods such that domestic production do not suffer disproportional costs and disadvantages compared to international production, and thus reduces the risk of emission leakage by increased import levels. The negative effects of consumption taxes are mainly the disconnection to the emission source and the need to rely on consumer preferences for mitigation.

Several papers have discussed and simulated mainly consumption taxes on animal food products weighted by climate impact (e.g Wirsenius et al., 2011; Edjabou & Smed, 2013: Säll & Gren, 2015; Springmann et al., 2017). Springmann et al, (2017) found that a global charge on carbon emissions from food could reduce GHG emissions from the sector by close to 10% which is in line with what for example Säll & Gren, (2015) found in the case of Sweden by the use of meat and dairy taxes. Jansson & Säll, (2018) on the other hand found that taxes on livestock produce in the EU would not affect consumption levels by much and thus claimed that consumption taxes and price mechanisms might be viewed upon as a rather ineffective policy instrument and that proportionally large price increases would likely be necessary to shift dietary choices, resulting in large reductions in consumer surplus and high average costs per reduced ton GHG. Results from earlier studies on simulations of consumption taxes are spread and the main underlying differences come from estimated demand elasticities (see for example the differences in the results in Wirsenius et al., 2011 and Janson & Säll, 2018 who both simulate mitigation possibilities by a charge of EURO60 per ton CO_2e on animal products). Most find demand of food products to be inelastic with small own price elasticities, whereas the ones that find high elasticities on for example beef such as Wirsenius et al, (2011) indubitable find higher mitigation potential as results.

Introducing consumption taxes on food products to cover the costs of emissions would place the cost on consumer prices, hence the need for a demand system for food products. In this study we advance the knowledge as regards to consumption taxes on food by extending the demand and climate consumption tax analysis in the case of Sweden as done in e.g Säll & Gren, (2015). The extension in this paper show the expenditure flows between 52 commodities when prices change, by the estimation of demand and income elasticities, as contrast to previous studies done on Swedish demand of food that show aggregated expenditure flow from meat or meat and dairy to other aggregated food groups, but not to specific commodities (Edgerton, 1997; Lööw & Widell, 2009; Säll & Gren, 2015).

We continue our analysis by simulating emission mitigation possibilities for a climate impact weighted tax on food consumption for a given year. Tax levels are based on Life Cycle Analysis (LCA) calculations of GHG emissions per kilo or liter of output. As a metric for GHG emissions we use Global Warming Potential for a 100 year time span (GWP_{100}), including Land Use and Land Use Change (LULUC), calculated for all included food products in Moberg et al, (2019). GWP_{100} is the most commonly used climate metric used in similar papers, such making it easier to compare results. There are however disagreements on what metric to use when discussing climate change, thus a sensitivity analysis using Global Temperature Potential for a 100 year time span (GTP_{100}) as weights for tax levels, is included in the analysis (Shine, 2009).

2. Data

2.1 Data for demand analysis

The dataset of Swedish food consumption runs from 1980-2015 and is a combination of quantities consumed per person and year, and consumer price indexes (CPI) for the same commodities (Statistic Sweden, 2018; Swedish Board of Agriculture, 2018; FAOSTAT, 2018). The 52 included items cover most food groups consumed in Sweden such as animal products, grain products, fruit and vegetables, fats, drinks and snacks. To match as many food groups as possible some approximations are necessary. For example were the official calculations of fresh fish and seafood stopped in 1999, thus a linear estimation of consumption has been included in the dataset for the years 2000 to 2015.

The included products are divided into groups and within each group we assume similar purpose for the included commodities, such as meat, fruit and hot drinks. These groups are shown in Table 1 in the Middle Stage. In the Lower Stage, all included commodities are presented and then all groups are aggregated into the Upper Stage. The upper stage aggregated groups are separated by usage.

Table 1: Commodities and groups of commodities included in the demand system. Sweden 1980-2015

Upper Stage	**Animal products**	**Grain products**	**Fruit and vegetables**	**Fats**	**Drinks**	**Snacks**
Middle Stage	Meat Other protein sources Dairy	Hot carbs Sweet bread Bread and grain	Fruit Fibrous vegetables Kitchen vegetables	Fats	Hot drinks Cold drinks	Snacks Sweeteners
Lower Stage	**Meat:** Beef Pork Chicken Other meats	**Hot carbs:** Rice Pasta Potatoes and root vegetables	**Fruit:** Pear Apple Orange Banana Exotic fruit Small citrus	**Fats:** Butter Vegetable oils Margarine Low fat margarine	**Hot drinks:** Coffee Tea Chocolate	**Snacks:** Ice cream Confectionary Crisps
	Other protein sources: Eggs Fish and seafood Cheese	**Sweet bread:** Buns Cookies Pastries	**Fibrous vegetables:** Carrots Brassica Onions Leek		**Cold drinks:** Mineral water Soft drinks and ciders Juice and squash Milk	**Sweeteners:** Sugar Honey Syrup
	Dairy: Fermented products Cream products Cream fraiche and sour cream	**Bread and grain:** Soft bred Hard bread Flours Grains	**Kitchen vegetables:** Tomatoes Cucumber Lettuce Avocado Lemon			

Consumption data come from the Swedish Board of Agriculture Statistical Database, (2018) and include both "Direktkonsumtion" and "Totalkonsumtion" as well as FAOSTAT, (2018). The mix has been necessary to be able to combine consumption levels with price indexes.

Milk and cheese are often estimated together with dairy products, while we here use them as a drink and a lacto vegetarian substitute for meat. Data on vegetarian meat substitutes such as processed soy products (e.g. burgers, sausages), and vegetarian protein sources such as pulses are not available, thus we allow for switches to meat substitutes by the use of cheese.

2.2 Emission data and tax scenarios

Data on climate impact for the included commodities were calculated by Moberg et al., (2019) based on LCA. The motivation for using the dataset is the unique standardisation in calculation method over all commodities. The dataset show several emission scenarios depending on methodological choices in LCA, which affect the resulting climate impact of the different commodities. The methodological choices include for example how to account for emissions from land use and land use change (LULUC) and where to draw system boundaries.

The dataset in Moberg et al. (2019) include scenarios of the climate impact where emissions of GHGs are shown both individually as well as with the climate impact of different GHGs weighted with climate metrics such as GWP_{100} and GTP_{100}. The main difference between the two measures GWP and GTP would, in relation to food, be the impact of methane (CH_4) which has a short life span (~12 years), thus decreasing the importance of reducing products from ruminants.

For the reference scenario in our tax scheme, we have chosen the GWP_{100} as climate metric, as GWP_{100} is the most commonly used metric of choice in many LCAs and policies (Shine, 2009). We include LULUC in the reference scenario to allow for carbon sequestration/ release from agricultural land as well as taking land use change into account. Additionally, the reference scenario include all emissions up to retail gate, hence all emissions on the farm as well as those from subsequent processes to retail gate such as processing of foods, packaging and transportation. Included gases are carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4) as well as the hydrochlorofluorocarbon R22 (HCFC-22) which arise from the use of refrigerants in the fishing industry.

In Table 2 we present emission levels calculated as GWP_{100} in CO_2e , as well as the total tax level per kilo of output of each commodity and the average group tax per kilo (used for calculating the flow of money from one group in the middle level in Table 1 to another and further to each commodity). The tax levels are based on the Swedish Carbon tax of SEK 1.15 per kilo CO_2, such that the tax can be said to be cost efficient in Sweden. Assuming linear demand curves for all commodities (which is explained in more detail in Section 3), we test for one tax level per kilo of emissions. Simulating for different tax levels will change demand in proportion to the tax change, and not alter the relative importance of each good.

In the included scenarios climate impact is calculated per kilo of output with the exception of meat (calculated per kilo carcass weight), fish and seafood (calculated per kilo of edible weight) and drinks (per litre), all which correspond to the presentation of consumption data used in the demand analysis.

Table 2: All emission scenarios included in the emission reduction analysis and allocated tax levels per kilo of produce in each scenario. Emission calculations are based on average Swedish consumption in the year 2013 (Moberg et al., 2019; Moberg et al., 2020).

Per kilo	GHG	Tax in SEK		GHG	Tax in SEK		GHG	Tax in SEK
Beef	23,5	27,03	Hard bread	1,1	1,27	Butter	12,7	14,61
Pork	4,6	5,29	Soft bread	1,0	1,15	Vegetable oils	2,4	2,76
Chicken	4,2	4,83	Flours	1,0	1,15	Margarine	2,4	2,76
Other meats	22,3	25,65	Grains	1,0	1,15	Low fat margarine	1,3	1,50
Average		**12,82**	**Average**		**1,16**	**Average**		**4,31**
Eggs	2,5	2,88	Pear	0,4	0,46	Coffee	6,4	7,36
Fish and seafood	6,1	7,02	Apple	0,4	0,46	Tea	6,4	7,36
Cheese	10,5	12,08	Orange	0,7	0,81	Chocolate	2,8	3,22
Average		**7,30**	Banana	0,7	0,81	**Average**		**6,52**
			Exotic fruit	1,2	1,38			
Fermented products	1,5	1,73	Small citrus	0,7	0,81	Mineral water	0,3	0,35
Cream products	6,5	7,48	**Average**		**0,77**	Soft drinks / ciders	0,4	0,46
Cream fr. / sour cr.	5,7	6,56				Juice and squash	1,2	1,38
Average		**3,21**	Carrot	0,3	0,35	Milk	1,4	1,61
			Brassica	0,5	0,58	**Average**		**1,02**
Rice	3,6	4,14	Onion	0,4	0,46			
Pasta	1,8	2,07	Leek	0,4	0,46	Ice cream	2,8	3,22
Potatoes / root veg.	0,4	0,46	**Average**		**0,44**	Confectionary	5,1	5,87
Average		**1,06**				Crisps	2,9	3,34
			Tomato	1,4	1,61	**Average**		**4,71**
Buns	1,4	1,61	Cucumber	0,7	0,81			
Cookies	1,1	1,27	Lettuce	0,3	0,35	Sugar	1,4	1,61
Pastries	1,4	1,61	Avocado	1,1	1,27	Honey	1,8	2,07
Average		**1,54**	Lemon	0,5	0,58	Syrup	1,4	1,61
			Average		**1,02**	**Average**		**1,66**
Sum kilo	**2107,00**							

Tax levels are recalculated to percent change on initial prices. Initial prices are collected from online grocery stores as averages values on the included commodities, and revalued to 2015 price levels. The prices that are available in the Agriculture Statistical Yearbooks are used when available as a control measure (Statistics Sweden, 2019).

3. Empirical approach- QAIDS

The first step of the analysis is to estimate Marshallian uncompensated demand elasticities. This is done by the use of a three stage QAIDS model (Quadratic Almost Ideal Demand System) by Deaton & Muellbauer, (1980) and extended by Banks et al., (1997) The three stages in the demand system presented in Table 1 are included to find final elasticities that show how consumption of commodities in the Lower stage change when prices increase, including consumption shifts to other similar goods and other groups of food (Edgerton, 1997).

The QAIDS model is set up as the expenditure share s_i of commodity i ($i = 1 \dots n$) is regressed on prices of all included commodities, p_j where $j = 1 \dots n$ and total expenditures $X = \sum_{i=1}^{n} p_i\, q_i$. The shares are thus $s_i = p_i\, q_i / X$ and

$$s_i = \alpha_i + \sum\nolimits_{j=1}^{n} \gamma_{ij} \ln p_j + \beta_i (\ln X - \ln P) + \frac{\mu_i}{Q} (\ln X - \ln P)^2 \qquad (1)$$

Where P is the aggregated price index for the non-linear version of the AIDS model.

$$\ln P = \alpha_0 + \sum_{i=1}^{n} \alpha_i \ln p_i + \frac{1}{2} \sum_{i}^{n} \sum_{j}^{n} \gamma_{ij} \ln(p_i + p_j) \qquad (2)$$

And Q is defined as follows.

$$Q = \prod_{i}^{n} p_i^{\beta_i} \qquad (3)$$

All parameter are estimated at the average level for each variable and need to fulfil restrictions of symmetry and homogeneity. α_i is the logarithmic share of initial consumption and thus sums to 1 $\sum_i^n \alpha_i = 1$, β_i shows the reaction to changes in total expenditures and add to 0 $\sum_i^n \beta_i = 0$ thus the parameter for the quadratic term also add to 0 $\sum_i^n \mu_i = 0$. γ_{ij} are the changes in budget shares s_i when prices changes. Homogeneity restriction requires that $\sum_{j=1}^{n} \gamma_{ij} = 0$. Symmetry conditions imply that a change in price of good i has the same marginal effect on the budget share of good j as a price change of good j has on the marginal change of budget shares of good i, i.e. that $\gamma_{ij} = \gamma_{ij}$. Weak separability is assumed for the demand system, with three stages this implies that the budget for overall food consumption is assumed to be a constant share of consumer's total budget.

The above analysis presented in equations (1) - (3) is set up for each group including individual commodities thus fourteen systems are set up for the lower stage. For the second stage where intermediate food groups are included (Middle Stage) one system is estimated for each group, thus six systems are estimated. Lastly, one system is estimated for the overall food consumption (Upper Stage). For the groups in the middle stage, index r and u are used, where $r = 1 \dots k$ and $u = 1 \dots k$. For the overall consumption, index a and b are used, where $a = 1 \dots c$ and $b = 1 \dots c$.

Elasticities for each stage are calculated as $\varepsilon_i^I = 1 + \beta_i / s_i$ and $\varepsilon_{ij}^M = \left[\left(\gamma_{ij} - \beta_i s_j \right) / s_j \right] - \delta_{ij}$ with superscript I for income elasticities and M for Marshallian elasticities. The Kronecker delta $\delta = 1$ if $i = j$, $r = u,\ a = b$ and 0 otherwise. Homogeneity of degree zero requires that restrictions on elasticities are $\varepsilon_i^I + \sum_{i=1}^{n} \varepsilon_{ij}^M = 0$. Elasticities of each stage are combined into uncompensated elasticities that take all levels of the demand system into account, such that $\varepsilon_i^{I*} = \varepsilon_i^I \varepsilon_r^I \varepsilon_a^I$ for the uncompensated income elasticities for each commodity i and ε_{ij}^{M*} for the uncompensated own price and cross price elasticities (Edgerton, 1997).

$$\varepsilon_{ij}^{M*} = \delta_{ab}\delta_{ru}\varepsilon_{ij}^{H} + \delta_{ab}s_j\varepsilon_i^I\varepsilon_{ru}^H + s_j s_r \varepsilon_i^I \varepsilon_r^I \varepsilon_{ab}^M \qquad (5)$$

ε_{ij}^{H} are the compensated Hicksian elasticities for each stage, capturing the price/ substitution effect of price changes on consumption choices, calculated as $\varepsilon_{ij}^{H} = \varepsilon_{ij}^{M} + s_j\varepsilon_i^I$.

Changes in consumed quantities q_i are the differences between the initial consumption levels with superscript 0 and the demanded level after taxes are introduced with superscript 1 $\Delta q = q_i^1 - q_i^0$. Demand is for simplicity assumed to be linear functions of own prices and cross prices $q_i = k_i p_i + m_i + \Delta h_i$ where k_{ij} is the negative slope found in the elasticities $\varepsilon_{ij}^{M*} = \frac{\Delta q_i}{\Delta p_j}\frac{p_j^0}{q_i^0} = k_{ij}\frac{p_j^0}{q_i^0}$ when $i = j$. The initial intercept is m_i and the sum of shifters in the demand curve is denoted as Δh_i which is zero before taxes are introduced.

$$\Delta h_i = \sum \Delta p_j \frac{\varepsilon_{ij}^{M*} q_i^0}{p_j^0} + \sum \Delta p_r \frac{\varepsilon_{ru}^{M} q_u^0}{p_r^0} s_u + \sum \Delta p_a \frac{\varepsilon_{ab}^{M} q_b^0}{p_a^0} s_b \qquad (6)$$

Shifts are due to price changes of the other within group commodities ($i \neq j$) as well as the other total group elasticities (from the Middle Stage and Upper Stage). Assuming constant budget shares within each group of commodities and each commodity, expenditures flows between groups are divided accordingly.

4. Mitigation possibilities of taxes on food consumption

All elasticities are presented in Appendix (Table A.1) while here in the result section we show the possible reductions of GHG emissions, by the use of consumption taxes (shown in Table 2) in Sweden.

4.1. Mitigation possibilities of consumption taxes on food in Sweden, reference scenario.

In the reference scenario aggregate reductions per person would be 220 kilo of CO_2e annually, which corresponds to 10.5% of total emissions from food consumption. 88 % of the reductions are from reduced consumption of animal products. In Figure 1, we show the relative changes in commodity prices and consumed quantities of animal products when taxes are introduced. The most prevalent price changes are for beef and dairy products such as cream fraiche for which initial prices are low in relation to emission intensities.

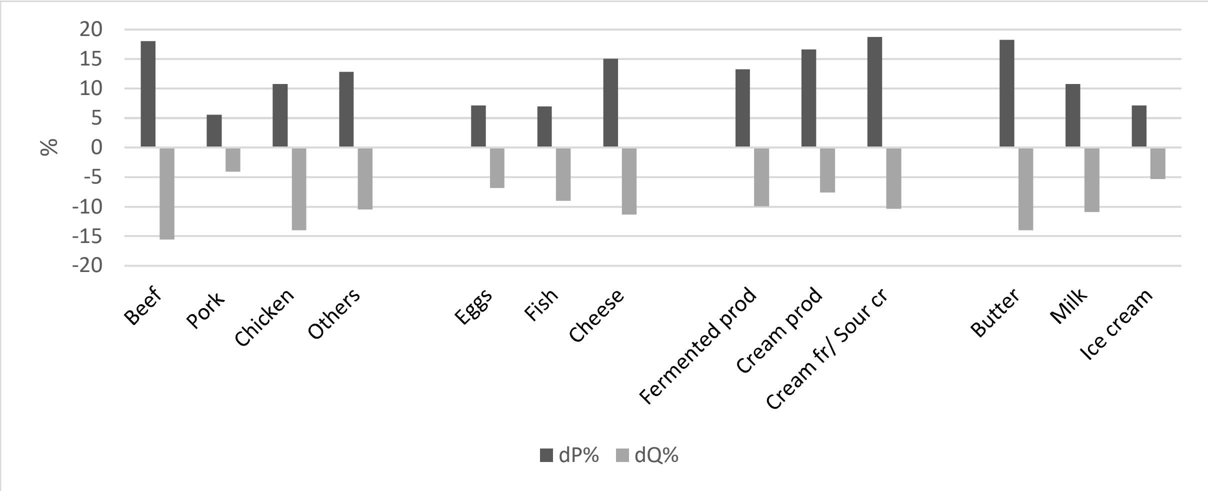

Figure 1: Reference scenario. Figure 1 show the percentage changes in prices and consumption on animal products, after taxes based on GWP100 are introduced. 2015 year levels are used as a base line. Price data for the calibrations are included from (Statistics Sweden, 2019) and collected from online grocery stores, where averages for each products are used. Price indexes for the elasticity estimations are from CPI, Statistics Sweden.

Beef is the one commodity most affected by weighted climate taxes. Reductions are just above 15% or 4 kilos per person, which would reduce volumes to the levels consumed in the beginning of the millennia. Following beef reductions, taxes have the largest effect on butter and chicken consumption. Emissions levels from butter are large due to the amount of milk that goes into production and both own price elasticities are found to be relatively large.

Notable in the results are the increase in consumption of sweeteners and the almost non-existent reduction in sweet breads and crisps and other foods high in carbohydrates. These items are in general cheap and in the demand system we find substitution between these aggregated groups and other major groups (see Upper Stage in Table 1). Consumers view for example animal products and fruit and vegetables as complements, while food rich in carbohydrates is something the average person switch to when the general price level increase.

In figure 2, we show total and marginal effects of taxes. Total effects are when all taxes are introduced simultaneously, while the marginal effects are the contribution to mitigation from each individual commodity tax. When all taxes are introduced, consumption of almost all goods will decrease, however due to cross price effects some individual taxes might result in increased emission levels. Introducing taxes on e.g chicken meat and egg could increase emission levels due to the substitution in cross prices with beef and cheese. In Figure 2 we show selected commodities where the results show the highest reduction possibilities in total and marginal effects, as well as the commodities where taxes might increase emission levels.

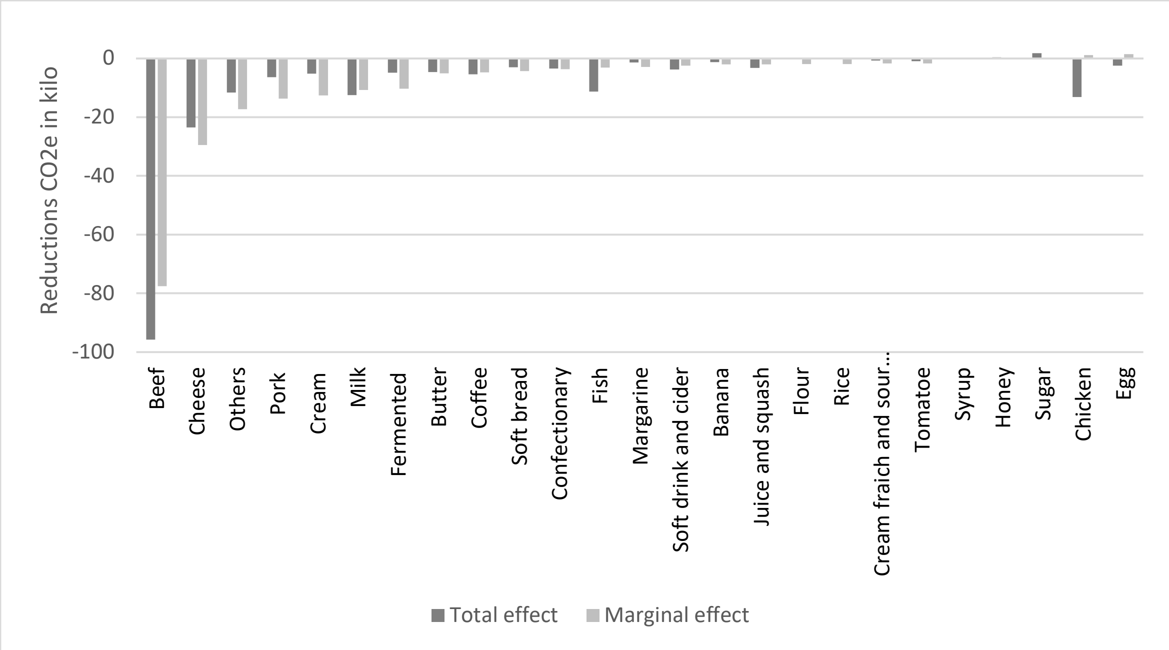

Figure 2: Marginal and total effects of taxes, the most affected commodities.

Beef has the highest reduction potential of all food products. 96 of total 220 kilo reduced CO2e are from reductions in beef consumption, while 78 kilos are due to the beef tax. The difference are cross effects from other taxes such as pork and other meats. Second to beef, cheese is most valuable to regulate, followed by other meats, pork and dairy products.

4.2 Sensitivity analysis

In the sensitivity analysis we weigh carbon taxes by GTP100 instead of GWP100. Using GTP over a 100 year time period decrease the importance of methane emissions from food and climate taxes. Initial total emission levels per person and year are thus reduced from 2107 kilos to 1509 kilos when GTP is used. Tax levels are the same, 1.15 SEK per kilo of CO_2e per kilo produce. In Figure 3, we see that the reduction weight for beef reduce, while at the same time the weight for other meats and other animal products increase.

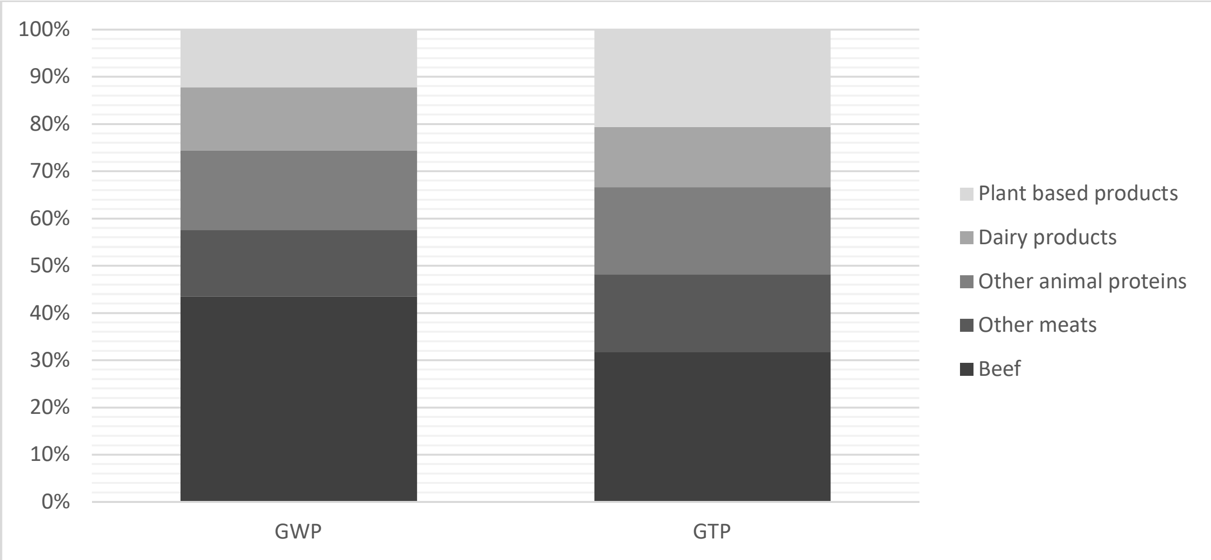

Figure 3: Reduction weights for the reference scenario with taxes based on GWP100, compared to taxes based on GTP100.

Under the GTP scenario, reductions per person are 99 kilos of CO_2e per person and year, or 6.6% of total emissions under the GTP calculations (220 kilo and 10.5% in the reference scenario). In the GWP scenario reductions from beef are close to 43% of total levels, followed by reductions from cheese (10.5%). Beef has the same weight as all other animal based products combined. In the GTP scenario, beef reductions account for 32 % of possible reductions while the weight of fish and seafood increase to 14% and total reductions of all other animal products account for 47% of total reductions. Notable is however that regardless of which metric is used to calculate emissions from food, animal products in general are the most important for emissions reductions. Between 12 and 20% of total reductions in our results are from plant based foods.

The results in the sensitivity analysis show that it might not be most important to regulate beef which has been the result of most previous studies. It is of equal importance to implement policies on other animal food products.

Summary and discussion

In this study we have estimated demand elasticities for 52 different food commodities consumed in Sweden. The found elasticities were used to simulate the effect on GHG emissions by the use of consumption taxes on food. The results show that Swedish consumers might reduce food related GHG emission levels by approximately 10% by changes in dietary choices, due to taxes. This corresponds to an annual reduction of 2 kton from Swedish consumption. The past three years Sweden has experienced a reduction in meat consumption which has taken place without any economic policies. Information, an increasing awareness of environmental related issues connected to food production, and a broader range of vegetarian food has likely made Swedish consumers change patterns. The demand system set up in this paper can only capture consumer's reactions to prices though we see in for example Eker et al, (2019) that norms are the most important factor for dietary shifts. It is however impossible to say if the ongoing changes in meat consumption in Sweden is a trend, or if consumption levels will increase in the future. Price related policies will however support a shift in consumption and we cannot deny that prices are an important factor when consumers make dietary decisions.

To expand the analysis conducted in this study the inclusion of plant based products would be necessary. Without an analysis on how meat consumption is substituted for vegetarian options, the possibilities of taxes as an instrument to curb emission levels from food consumption are not fully investigated. Additional research that could expand the picture of policies implemented on food consumption are the inclusion of organic products and country of origin, which would allow for analyses on a wider range of sustainability targets.

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Appendix

A.1: Marshallian price elasticities for 52 food commodities and aggregated food groups consumed in Sweden.

	Beef	Pork	Chicken	Other meats		
Beef	-0,594	-0,185	0,081	-0,079		
Pork	0,054	-0,272	-0,015	0,025		
Chicken	0,011	-0,571	-0,999	0,267		
Other meats	-0,150	0,112	0,645	-0,903		
	Eggs	Fish and seafood	Cheese			
Eggs	-0,628	-0,619	0,241			
Fish and seefood	-0,416	-0,491	-0,065			
Cheese	0,456	0,185	-0,947			
	Fermented products	Cream	Cream fraiche and sourcream			
Fermented products	-0,399	-0,072	0,010			
Cream	-0,081	-0,169	-0,003			
Cream fraiche and sourcream	0,390	-0,019	-0,616			
	Rice	Pasta	Potatoes			
Rice	-0,179	-0,078	0,093			
Pasta	-0,050	-0,161	0,109			
Potatoes	0,005	0,003	-0,213			
	Sweet bread	Cookies	Pastries			
Sweet bread	-0,394	0,676	-0,435			
Cookies	0,610	-1,018	0,341			
Pastries	-0,360	0,207	-0,155			
	Hard bread	Soft bread	Flour	Grain		
Hard bread	-0,762	-0,138	0,052	0,069		
Soft bread	-0,081	-1,244	-0,259	-0,031		
Flor	0,053	0,086	-0,550	0,085		
Grain	0,157	0,454	0,434	-1,292		
	Pear	Apple	Orange	Banana	Exotic fruits	Small citrus
Pear	-0,372	-0,076	0,334	-0,141	-0,016	-0,175
Apple	-0,014	-0,406	0,045	0,032	-0,008	-0,073
Orange	0,111	0,116	-0,698	-0,066	0,039	0,246

Banana	-0,022	0,016	-0,070	-0,318	0,013	-0,076
Exotic fruits	-0,046	-0,193	0,016	-0,084	-0,734	0,076
Small citrus	-0,083	-0,131	0,496	-0,165	0,081	-0,308
	Carrot	Brassica	Yellow onion	Leek		
Carrot	-0,195	-0,014	-0,266	0,016		
Brassica	0,032	-0,525	0,180	-0,013		
Yellow onion	-0,357	0,155	-0,154	-0,082		
Leek	0,192	-0,047	-0,364	-0,031		
	Tomato	Cucumber	Sallat	Avocado	Lemon	
Tomato	-0,147	0,041	-0,040	0,022	0,005	
Cucumber	0,068	-0,033	-0,166	-0,039	0,010	
Sallat	-0,070	-0,128	-0,063	0,074	-0,053	
Avocado	0,089	-0,266	0,407	-0,768	0,082	
Lemon	0,004	0,022	-0,177	0,052	-0,066	
	Butter	Vegetable oil	Margarine	Light margarine		
Butter	-0,455	-0,197	-0,365	0,345		
Vegetable oil	-0,326	-0,687	0,173	0,153		
Margarine	-0,095	0,025	-0,478	-0,154		
Light margarine	0,163	0,044	-0,302	-0,611		
	Coffee	Tea	Chocolate			
Coffee	-0,365	-0,004	-0,026			
Tea	-0,021	-0,481	0,216			
Chocolate	-0,208	0,039	-0,317			
	Mineral water	Soft drink and cider	Juice and squash	Milk		
Mineral water	-0,402	-0,303	0,041	0,294		
Soft drink and cider	-0,041	-0,133	-0,016	-0,169		
Juice and squash	0,019	-0,061	-0,142	-0,196		
Milk	0,027	-0,068	-0,022	-0,212		
	Ice cream	Confectionary	Crisps			
Ice cream	-0,590	0,017	0,079			
Confectionary	0,032	-0,426	-0,068			
Crisps	0,986	-0,545	-0,571			
	Sugar	Honey	Syrup			
Sugar	-0,690	-0,005	0,002			

Honey	-0,243	-0,479	-0,158			
Syrup	0,254	-0,305	-0,434			
	Meat	Other proteins	Dairy			
Meat	-0,541	0,055	-0,118			
Other proteins	0,043	-0,796	0,021			
Dairy	-0,165	0,082	-0,406			
	Warm carbs	Sweet bread	Bread and grain			
Warm carbs	-0,193	-0,022	-0,169			
Sweet bread	-0,038	-0,185	-0,048			
Bread and grain	-0,174	-0,026	-0,199			
	Fruit	Fibrous vegetables	Kitchen vegetables			
Fruit	-0,403	-0,006	-0,107			
Fibrous vegetables	0,100	-0,403	-0,006			
Kitchen vegetables	-0,176	-0,012	-0,149			
	Warm drinks	Cold drinks				
Warm drinks	-0,406	0,245				
Cold drinks	0,013	-0,315				
	Snacks	Sweeteners				
Snacks	-0,462	0,205				
Sweeteners	0,468	-0,698				
	Animal products	Grain products	Fruit and vegetables	Fats	Drinks	Snacks
Animal products	-0,606	-0,132	-0,151	-0,023	-0,186	-0,051
Grain products	0,056	-0,378	0,018	0,032	-0,139	0,033
Fruit and vegetables	-0,387	-0,138	-0,431	-0,022	-0,093	-0,082
Fats	-0,232	0,172	-0,083	-0,698	-0,008	0,018
Drinks	-0,574	-0,396	-0,133	-0,016	-0,288	-0,011
Snacks	-0,289	0,155	-0,244	0,021	0,103	-0,249

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