

# Essays on Economic Policy on Food Consumption

Environmental Taxes, Distribution and Health

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## Abstract

This thesis consists of four papers investigating the use of taxes on food consumption. The aim is providing policy information concerning what to eat from an environmental and health perspective. In Paper I the environmental damage costs of greenhouse gas emissions (GHG) and nutrient loads into the Baltic Sea from Swedish production of meat and dairy products are calculated. Costs are introduced as consumption taxes followed by estimations on the response in consumer demand and possible pollutant reduction levels. In Paper II, the distributional effects of the tax levels on Swedish produced meat, found in Paper I, are calculated for Swedish households. The incidence of taxes is calculated as the willingness to accept as compensation for taxes to be introduced, related to the households' total income and expenditure levels. The horizon is broadened in Paper III where consumption taxes on meat and dairy products in the whole of EU 27 are investigated. Three tax levels are introduced and by the use of the CAPRI model, changes in demand, supply, GHG emissions and welfare effects are estimated. In the last paper, Paper IV, most food commodities consumed in Sweden are included in a system of demand elasticities. The aim is to construct an economic incentive scheme to encourage the Swedish population to consume less meat and dairy products and increase consumption of fruit and vegetables. Reaching these consumption targets would not only reduce emission levels as was investigated in Paper I, but also improve public health. In Papers I, II and IV Marshallian, Hicksian and Income elasticities were estimated using the AIDS model. The overall results show that demand of food is in general inelastic, which implies that taxes have limited effects on demand and on pollutant levels.

*Keywords:* Environmental Taxes, Climate Change, Eutrophication, Meat and Dairy consumption, Sweden, EU, Distribution, Eating Healthy.

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Dedication

To Elva

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## List of Publications

This thesis is based on the work contained in the following papers, referred to by Roman numerals in the text:

- I Säll, S., Gren, I-M. (2015) Effects of an environmental tax on meat and dairy consumption in Sweden. *Food Policy* 55, 41-53.
- II Säll, S. Distributional effects of environmental meat taxes in Sweden- Can the poor still eat meat? (manuscript).
- III Jansson, T., Säll, S. Environmental consumption taxes on animal food products to mitigate greenhouse gas emissions from the European Union (manuscript).
- IV Säll, S. Health and Environment combined in Sweden- The cost of following dietary recommendations and reducing GHG emissions from food (manuscript).

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# 1 Introduction

The In this thesis the environmental, distributional and health aspects of economic policy implemented on food consumption, mainly meat and dairy products, are addressed. In paper I and III, environmental consumption taxes on meat and dairy products in Sweden and the EU 27 are analyzed. Paper II investigates the distributional effects an environmental tax on meat on Swedish households. Paper IV includes most food products consumed in Sweden, attempting to find out if an economic policy structure could shift consumption of food towards a combination where both environmental and health aspects are accounted for. Eating healthy and environmentally friendly food implies reduction of intake of animal products while increasing the share of vegetable products in the diet (WHO, 2015; NNR, 2012).

In the following, a brief background is given to why economic policies that reduce meat and dairy consumption can be important.

## 1.1 Livestock and the environment

The problems of greenhouse gas (GHG) emissions from livestock were highlighted after 2006 when FAO released a large study mapping the environmental concerns of raising animals for food (Steinfeld et al., 2006). In that study it was found that the global livestock production was responsible for 18% of total anthropogenic GHG emissions, which is more than from any other sector including transportation. The number has later been revised to 14.5% by e.g. Gerber et al, (2013). Even though Steinfeld et al, (2006) raise other environmental issues arising from livestock holdings such as nutrient leakages, soil degradation, deforestation and loss of biodiversity, these issues have not been in the spotlight as much as the

GHG emission levels. Several other papers have been published on the other environmental issues with focus on the agricultural impact on nitrogen and phosphorus leakages causing eutrophication (Machovina et al., 2015; Foley et al., 2011; Galloway et al., 2008).

Nutrient leakages and eutrophication have been of concern for environmental policy for decades. The intergovernmental organization HELCOM was formed in 1974 for the purpose of reducing pollutant levels in the Baltic Sea. The Baltic Sea is one of the most polluted oceans in the world, much due to intensive farming in the catchment area resulting in excessive algae blooming and oxygen depletion (ECA, 2016; SMED, 2014; Helcom, 2011). The narrow passage to the Atlantic Ocean between Sweden and Denmark also keep pollutants in the ocean allowing for stocks to build up.

With a long coastal zone, Sweden is one of the main nutrient emitting countries surrounding the Baltic Sea (Helcom, 2011). Most of the nutrients discharged into the sea, lakes and other water compounds originate from the agricultural sector (SMED, 2014). Much can be done, and has been done with technological improvements in the agricultural sector to reduce nutrient leakages. For example, there are regulations on how to keep and spread manure aiming to reduce nutrient leakage and on the use of catch crops (Swedish board of Agriculture, 2013a). However, even though measures are in place the levels of nutrient concentrations in the Baltic Sea have increased since 2009 (SMED, 2014). Of course, Sweden is not alone in polluting the Baltic Sea and measures are needed in all the surrounding countries to reduce eutrophication. In this thesis however, only Sweden is the focus regarding nitrogen and phosphorus emissions (Paper I).

In comparison to other protein food sources such as legumes, meat and dairy products are nitrogen use intensive per kilo output and in relation to protein content (Pierer et al., 2014; Rööös et al., 2013). Also, livestock production requires substantial area of agricultural land. Worldwide 33% of arable land and 70% of agricultural land is used for livestock production, Steinfeld et al, (2006). By decreasing livestock production in favour of e.g. legumes, the need for land and fertilizers could decrease and reduce nutrient leakages.

Loss of biodiversity from eutrophication in water basins is due to the oxygen depletion resulting from excess algae blooming (e.g. McKinnon &

Tyler, 2012; Shaw et al., 2009). Much of the decrease in water biodiversity can thus be linked to agriculture. However, livestock has both negative and positive effects on terrestrial biodiversity. Machovina et al, (2015) point out the negative impacts of deforestation caused by livestock in tropical areas such as the Amazons. Steinfeld et al, (2006) claim that the five major drivers of biodiversity loss are i) habitat change, ii) climate change, iii) invasive alien species, iv) overexploitation and v) pollution, all on which livestock have direct or indirect effects. The conclusion that livestock have a large negative impact on biodiversity can however be balanced by the positive effects animals can have on biological diversity in grazing areas. In Sweden the traditional agricultural landscape include non-fertilized grazing fields rich in both animal and plant life, which are in risk of disappearing if the number of grazing animals decrease (Kumm, 2011; Swedish Environmental Protection Agency, 2016a).

## 1.2 Eating healthy

The WHO and the Swedish Food Agency identify the same commodity groups as problematic, with respect to human health (WHO, 2015; NNR, 2012). Apart from ‘junk food’ such as fast food and salt/ sugar, meat and dairy products are the primal food commodities causing disease. Large consumption levels of food from livestock can lead to cancer, cardiovascular disease, high blood pressure, obesity and diabetes type 2 (see e.g. Bjerselius et al., 2014; Larson & Wolk, 2012; WCRF, 2015; Aune et al., 2009; Pan et al., 2013). These diseases can to some extent all be labelled as welfare diseases, where the negative impacts can be lessened by increasing the share of vegetable products in the diet (WHO, 2015). The nutritional recommendations thus emphasize the need to decrease consumption per capita of red and processed meat and saturated fats found in dairy products (NNR, 2012). People are also encouraged to increase consumption of fruit and vegetables, whole grain and vegetable oils. The Nordic recommendations that are quantified are “maximum of 500 grams per week” of red meat with “as little as possible” from processed meats and “minimum of 500 grams per day” of fruit and vegetables (NNR, 2012). These recommended levels are far from the average Swedish consumption of today. The amount of red meat consumed is too high, and the amount of

vegetables and fruit is much too low especially among men (Swedish Board of Agriculture, 2016a; Amcoff et al., 2012).

Healthy eating is also related to the availability of food. With an increasing global population the pressure on agricultural land increase. As mentioned in the previous section, global livestock production use 33% of the available arable land (Steinfeld et al., 2006). The assumed increase in demand of meat and dairy products (discussed further in section 1.3) will thus increase demand of arable land for feed production. For the sake of food security, for example UNEP, (2009) express concern regarding consumption of meat and dairy products.

### 1.3 Consumption of meat and dairy products in Sweden

Globally, the demand for meat and dairy products has increased by 245% and 70% respectively, between 1961 and 2001, and the increase will most likely continue in the foreseeable future (forecasted to 68% and 57% increase from the year 2000 until 2030) driven by increasing living standards (Steinfeld & Gerber, 2010). Between 1980 and 2012, per capita consumption of beef, pork and chicken in Sweden increased by almost 36%. The main increase was in chicken consumption, which more than tripled, followed by beef, which increased by almost 37%. Consumption of pork remained rather constant, see Figure 1.

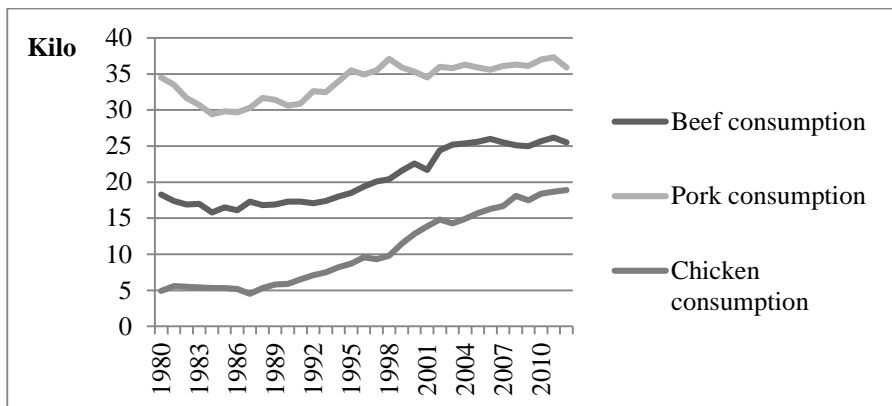


Figure 1. Per capita consumption (kg carcass weight) of beef, pork, chicken and all meat in Sweden 1980-2012. Per capita consumption, kilo' on y axis. Source: Swedish Board of Agriculture, (2016a).

Part of the increase in demand can be explained by a relatively small price increase on meat, compared to other goods and an increase in disposable income. The Swedish meat price index decreased in the early 1990's and has still not reached consumer price index on other commodities. The relative decrease in prices can partly be explained by Sweden entering the European Union in 1995, opening up for larger import volumes at prices lower than what Swedish producers can compete with (Swedish Board of Agriculture, 2013b).

Since 1995 when Sweden joined the European Union, the shares of domestically produced meat has decreased rapidly. The shares of beef have decreased from 89% to 53% and the share of pork from 98% to 68%. The share of chicken consumption has decreased from levels where Sweden was a net exporter and 104% of consumption was produced domestically, to 66% of total consumption being produced in Sweden in the year 2012 (Swedish Board of Agriculture, 2013b).

The increasing trend in consumption was also found for most dairy products, with the exception of milk where consumption decreased during the entire time period. In 1980, the average Swede used 162 litres of milk per year. In 2012 this number had decreased to less than 90 litres. In figure 2, the consumption of milk, fermented products, cream and cheese are presented. Consumption of fermented products and cream increased by almost 50% per person from 1980 to 2012, and cheese consumption with 34% during the same time period.

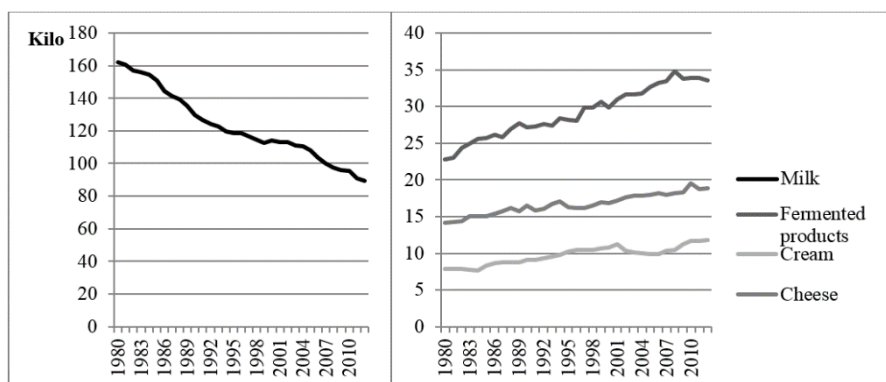


Figure 2: Per capita consumption of milk, fermented dairy products, cream and cheese in Sweden 1980-2012. Per capita consumption, kilo' on y axis. Source: Swedish Board of Agriculture, (2016a).

## 1.4 Demand of animal food products and modeling framework

One argument for decreasing consumption or production of livestock by the use of economic incentives is found in e.g. Hedenus et al, (2014) and Bajželj et al, (2014) who argue that without reducing the intake of meat, mainly from ruminants, the target of global warming not to exceed 2 degrees cannot be reached. The argument is based on the assumption that technological approaches to reduce emissions from livestock are limited. Leip et al, (2010) find that a reduction by 15-19% of total GHG emissions from livestock is plausible within the EU by improving only the production systems. Gerber et al, (2013) find that the corresponding improvement worldwide is close to 30%. However, Van Dorslaer et al, (2015) find that subsidizing mitigation measures in EU agriculture could result in more modest reductions of approximately 4.5%. Technological improvements of cattle production could include improved feed quality, such as high energy and protein crops, which reduce the release of methane per kilo of final output. However, increasing the amount of high protein crops given to livestock could raise the sectors demand for arable land, which is already high (Steinfeld et al., 2006).

The limitations of technical improvements to reduce GHG emissions from meat and dairy point out the need of other policy measures. If consumers change their food consumption patterns to include a larger share of vegetables, the potential of reducing per capita food related GHG emissions could be between 22% and 40% (Berners-Lee et al., 2012; Scarborough et al., 2014). However, the difficulties of changing preferences by only information might call for the implementation of economic policies to reduce emissions from livestock by affecting consumption pattern (Löow et al., 2013; Rööös et al., 2014).

Steinfeld & Gerber, (2010) mention targeting the demand of livestock products to reduce consumption levels, but focus on emission reductions from the production side. They emphasize the need to intensify production of monogastric animals (such as pigs and chickens) to curb the environmental impact from the livestock sector. A switch from production of ruminants such as cattle, sheep and goats, to pigs and chicken would decrease emission of GHG and nutrients. However, animal products and especially red meat are more emission intense than food based on vegetables.

Also, although not related to the environmental topic, intensifying production to reduce emission levels might have a negative impact on animal welfare.

While agreeing with Steinfeld & Gerber, (2010) on the need to reduce emission levels from the livestock sector, their focus on the production side can be discussed. In a perfect world, where all producers could be included in a mitigation scheme, the production side would be the best focus for curbing pollutant emissions. If all producers worldwide could be included in one reduction scheme, the emission reductions would be efficient from an economic point of view because producers face the same incentive to improve production methods. This can be problematic in practice as demonstrated by e.g. United Nations Climate Change Conferences where the difficulties of reaching agreements on worldwide reductions are highlighted. Countries desisting the agreement can have a comparative advantage in production of agriculture commodities, which create a risk of emissions leakages when demand of the unrestricted, hence cheaper, products increases.

The papers in this thesis focus on average consumption taxes for reducing pollutant emissions. When regulating the demand side it would be efficient to introduce differentiated taxes based on the actual emissions from each animal. Cederberg et al, (2009) estimate GHG emissions from Brazilian beef and find levels to be 30% to 40% higher than from the average European produced beef. One kilo of carcass weight beef produced in Brazil was found to emit on average 28 kilo of CO<sub>2</sub>/e at the farm gate, while Leip et al, (2010) find that the corresponding value for one kilo beef produced in e.g. The Netherlands was 11.5 kilo of CO<sub>2</sub>/e, which is the least emission intense production in the EU. The differences are much due to production methods, where Brazilian production is based on extensive farming, while the European system is more intensive. An efficient tax scheme would thus include high taxes on Brazilian beef and the lowest tax level on beef from The Netherlands. This is difficult to implement in practice and there can be large transaction costs identifying the different production methods used on each farm in each exporting country (see for example Schmutzler & Goulder, 1997). Leip et al, (2010) show that the newer eastern member states in the European Union (for example Slovenia, Bulgaria and Romania) produce beef more emission intensely than the

older member states such as France and Great Britain, due to the differences in production technology methods. The distributional effects of differentiated taxes on beef would thus imply a disadvantage for producers in poorer countries. Given the subsequent problems with differentiated and production based measures, average consumption taxes can be a reasonable choice when imposing economic policies on food commodities.

Not only has consumption of meat and dairy products increased in Sweden the last decades but import levels have increased and crowded out part of the domestic production (Swedish Board of Agriculture, 2016b). This indicates that Swedish consumers are more sensitive to prices than to other values provided by domestically raised animals, such as a profitable domestic agricultural sector and grazing fields providing a unique fauna for biodiversity in the traditional Swedish agricultural landscape (Kumm, 2011). The latter is a major field of discussions in the public debate where it is claimed that restrictions such as taxes on meat and dairy consumption would seriously threaten the use of grazing land and thus biodiversity in Sweden (see e.g. Swedish Meat, 2015). On the other hand, the grazing areas have decreased since 2005 without any regulations on consumption (Olsson, 2013).

Using consumption taxes to improve public health has been tried in practice in for example Denmark, where a tax on saturated fats was introduced in 2011. The tax was however abolished only 15 months later, due to public resistance (Bødker et al., 2015). The tax implication on Danish health was studied in Smed et al, (2016), where it was found that a small but positive effect on health could be detected due to changes in consumption patterns during the time the tax was in place. The very few practical examples of health and environmental taxes on food products make it difficult to make a conclusive remark on the final effects of taxes. However, model simulations confirm the results from Smed et al, (2016) showing that taxes and subsidies have potential of both reducing emission levels and prevent chronic diseases (see reviews done by e.g. Thow et al., 2014 and Powell & Chaloupka, 2009).



The costs of consumption taxes as a means of achieving environmental targets should also be compared with the cost of other policies for emission reductions. A consumption tax may have a relative advantage because of its effects on several pollutants and thereby environmental targets.

In general, cost-effective solutions for achieving environmental targets are calculated for one target at a time, without much consideration of the eventual effects of these measures on other environmental targets, such as studies on the costs of reaching EU climate targets (e.g. Böhringer et al., 2009) and Baltic Sea international agreements (e.g. Elofsson, 2003). When accounting for the multi-pollutant effects of a consumption tax on meat and dairy, it can have a relative cost advantage in particular for environmental targets where livestock products account for a relatively large share of the total emissions. Including the positive health effects of reducing consumption levels of red and processed meat and saturated fats, the possible benefits from consumption taxes would be even larger.



## 2 Summaries of the appended papers

Common to all papers in this thesis is the foundation of consumption taxes and demand elasticities that are estimated to calculate the consumer response to taxes. Elasticities in Papers I, II and IV are estimated by the use of the AIDS model (Deaton & Muellbauer, 1980). In Paper I, environmental tax levels on meat and dairy products are calculated. Accurate tax levels would include all external effects, such as costs and benefits of the environmental impact as well as the positive or negative health effects of consuming the same commodities. However, the quantification and measurement of all these effects in monetary terms is difficult. In Paper III, different tax levels are tested for to estimate the change in demand, supply, welfare changes and GHG emission reductions, by the use of the CAPRI model (see Britz & Witzke, 2012). In Paper IV, simulations on consumer demand from one tax level is conducted and an attempt to find optimal tax levels given targets on demand and emission reductions is made.

The main finding in the included papers is that consumption taxes on food and primarily meat and dairy products might not be an efficient policy method to implement for reducing emissions. Consumer responses to higher prices on food are small and income elasticities are high, implying that improved living standards increase demand of the most emission intense commodities. However, the findings in Paper IV was that taxes combined with subsidies on fruit and vegetables would decrease meat consumption, increase the consumed quantities of fruit and vegetables to recommended levels and reduce GHG emissions substantially.

## 2.1 Summary of Paper I

One way of managing environmental problems arising from livestock production is to introduce Pigouvian taxes determined by the marginal damage costs (Pigou, 1957). In this way social costs of pollution are internalized in the prices paid by the final consumers of the goods. In paper I, the impacts of introducing such a tax on seven different products (beef, pork, chicken, milk, fermented products, cheese, and cream) in Sweden, in terms of emissions of four pollutants (GHG, nitrogen, ammonia and phosphorus) were calculated. The main novelty of this paper was the consideration of a tax on food that includes damage costs of several pollutant and not only GHG emissions as has been analysed in e.g. Edjabou & Smed, (2013) and in Wirsenius et al, (2011). It was found that the emission costs of Swedish meat and dairy products from the four included pollutants vary between 1.8 and 32.5 SEK per kilo produce, which corresponded to 8.9% and 33.3% of initial prices.

The effects of the taxes on demand and hence emission levels were calculated by estimating a non-linear demand system for the seven products based on time series data from 1980. The results revealed relatively low own price elasticities and higher income elasticities. Meat products were found to be more sensitive in prices and income than dairy products.

Taxing all seven products simultaneously could result in reductions up to 1.5% of the included emissions in Sweden, and up to 12.1% from only the livestock sector. The taxes investigated would also contribute with approximately 2.5% to an achievement of the Swedish Baltic Sea phosphorus reduction target of 530 ton (Helcom, 2013), and to 6.5% of the national commitment to reduction of nitrogen emissions in the reference case and up to 14.8% when costs of CO<sub>2</sub>/e increased from 1 SEK/ kilo to 2.8 SEK/ kilo (Swedish Environmental Protection Agency, 2016b). Emission reduction possibilities are thus found to be limited and it can be argued that consumption taxes are expensive as reduction measures, per unit emission reduction. However, when taking all of the pollutants into account, the multipollutant reductions possible from meat and dairy products could give consumption taxes a relative cost-advantage compared with policies directed towards a single pollutant.

## 2.2 Summary of Paper II

The distributional effect of environmental taxes on meat in Sweden, obtained from Säll & Gren, (2015), was calculated in Paper II. The distributional effects were measured as the amount households are willing to accept as compensation if a tax was introduced, to maintain the utility level experienced prior to the taxes. Willingness to accept as compensation was measured as the compensating variation (CV) for multiple price changes, based on Hicksian demand and constant utility levels for consumers (Huang, 1993). When several taxes are introduced simultaneously, compensating variation measures welfare changes in monetary terms, in relation to the initial expenditure level of all the included commodities.

Environmental taxes on meat have been a topic in the Swedish public debate since the Board of Agriculture issued a report on sustainable meat consumption, the contribution of livestock to greenhouse gas emissions in Sweden and possible mitigation actions (Lööv et al., 2013). One of the suggested actions was a tax to reduce meat consumption, which has increased rapidly since the early 1980's (Swedish Board of Agriculture, 2016a). Despite a large increase in consumption and the known environmental impact from livestock production, taxes on meat were dismissed by politicians with the consideration that such a tax would be regressive (HD, 2013).

In this paper it was found that the households with the smallest income levels would need to be compensated with 945 SEK per person and year to be able to adjust their consumption bundles and reach the same utility as before taxes. The households with the highest income levels need to be compensated with 1174 SEK. This corresponds to 0.77% and 0.80% of total expenditures for the low and high income group respectively. Environmental meat taxes were thus almost neutral when expenditures were used as a comparison measure, with a peak for the middle income group where a compensation of 0.85% of total expenditures was needed to maintain utility levels. On the other hand, if compensations were related to income levels the tax was found to be regressive. The lowest income group would then need compensation of 1.04% of the income while the highest income group would need a compensation of 0.52%.

A limitation of this paper was the focus on the consumer side of welfare changes from the environmental tax on meat. The supply side would most likely face welfare changes if demand of meat decrease. The change in demand is however small because of low price elasticities. If the decrease in consumption affects imported meat, the change in production in Sweden would be very small. Nevertheless, this is a topic that need further investigation.

### 2.3 Summary of Paper III

In this paper we have estimated the GHG emission reductions of introducing average consumption taxes on animal food products in the EU-27. It was done by applying various tax levels per ton of CO<sub>2</sub>-equivalent on meat and dairy products and conducting agricultural GHG emission estimations for each tax level using the agricultural trade and production model CAPRI (for an overview of the CAPRI model see e.g. Britz & Witzke, 2012). We included three different tax scenarios in our estimations; 16 Euro per ton GHG emissions, 60 Euros per ton and 290 Euros per ton. The results showed that the largest tax level of 290 Euro per ton GHG emission is the only scenario where we would see substantial emission reductions. Final emission reductions within the agricultural sector of the EU-27 would then be close to 4.9%. We also examined the case of beef, which was found to be the most important commodity to regulate. The regional results showed that the old member states in the union, such as France and Great Britain, are most important to include in a mitigation scheme, compared to the newer Eastern member countries.

The approach is similar to a study by Wirsenius et al, (2011) where consumption taxes on beef, pork, poultry, dairy and eggs are introduced, weighted to each commodity's emissions of GHG measured in Carbon Dioxide equivalents (CO<sub>2</sub>/e). However, instead of the AIDS model which is used to estimate demand elasticities in Wirsenius et al, (2011), we used the CAPRI model. This model includes regional supply and demand parameters, as well as cross price effects on complements and substitutes such as feed production and other agricultural produce, and finally welfare changes, allowing us to see the whole picture of a tax.

In the three tax scenarios the average cost of the policies becomes 223 Euro/ton, 275 Euro/ton and 448 Euro/ton reduced GHG emissions, respectively. Since the average cost per ton increases with increasing tax and abatement levels, one may conclude that the marginal cost is even higher than the average cost. One may also note that the average costs is higher than the underlying carbon tax rates of 16 Euro/ton, 60 Euro/ton and 290 Euro/ton, indicating that if there were a market for agricultural CO<sub>2</sub> emission rights, and the consumption taxes were set equal to the emission prices, then the tax would be relatively inefficient since it gives a cost of reduction which is higher than the emission price.

## 2.4 Summary of Paper IV

The possibilities of promoting environmental friendly and healthy Swedish food consumption by means of consumption taxes/subsidies were examined in this paper. The average Swede consumes too much red and processed meat and too little fruit and vegetables, in contrast to recommended consumption levels (WHO, 2015; NNR, 2012). Health recommendations that were quantified were “minimum of 500 grams per day” of fruit and vegetables, and “maximum of 500 grams per week” of red and processed meats, where processed meats should be as little as possible (NNR, 2012). These recommendations are in place to reduce the risk of cancer, cardiovascular disease, and other welfare diseases in the population, caused by wrongfully combined food consumption (WHO, 2003; WCRF, 2015; NNR, 2012). From an environmental perspective, the recommendations are consistent with how consumption ought to change to reduce GHG emissions from food and other environmental problems linked to agriculture production.

Three different tax scenarios were investigated. Two scenarios were based on simulations where commodities were taxed by the level of the Swedish carbon tax, which is 1 SEK per kilo CO<sub>2</sub>/e emitted. It was found that such a tax has limited impact on emission and health. Taxing for example cheese could even increase emissions due to cross price effects with red meat. Taxes on vegetables and fruit decrease the consumed level of these products and increase consumption of red meat.

The final scenario was an optimization problem, where optimal tax and subsidy levels were found by minimizing reductions in consumer surplus under restrictions on consumption and emission levels. The result from the optimization show that a combination of subsidies and taxes would be the most efficient way to reach all quantified restrictions. A subsidy of close to 9 SEK per kilo of fruit and vegetables combined with a tax of 1.6 SEK per kilo GHG emissions on commodities such as grain products, fats, processed meat, beef, pork and milk would help reallocate consumption of food to the recommended levels. However, this tax/ subsidy scheme would increase the consumption of snacks and sugar.

There are some major limitations to this study, which need to be investigated to be more conclusive about policies that could be implemented on Swedish food consumption. The two main problems are the missing data on substitutes to animal protein, such as legumes and soy/ gluten products and price index availability.



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