Accounting for foods’ nutritional value when implementing a climate tax on food

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Abstract: A growing and increasingly more affluent world population leads to an increase in food demand putting pressure on the planet’s natural resources and contributing to anthropogenic climate change. At the same time, a large part of our population suffers from nutrition related non-communicable diseases. There is an urgent need to develop a food system which provides healthy and sustainable food for all. An increase of public policies and regulations within this area has been deemed important in this quest. However, climate impact and nutrient content can have an inverse correlation, if a climate tax which includes nutrition would be implemented this would need attention so that an increased consumption of unhealthy foods with low climate impact does not increase. Aim: The aim of this project is to evaluate different methods for accounting for food’s nutritional value when implementing a climate tax on food in order to avoid the risk of environmental fiscal policies leading to less healthy eating. The focus is on the use of nutrient indices, which concerns the characterizing of foods based on an assessment of their nutrient quality. The objective is to create a quantitative scoring arrangement based on nutritional information resulting in a composite index which could potentially be used to account for foods’ nutritional content when implementing a climate tax on food. Other methods to account for foods’ nutritional value in a climate tax are also evaluated such as Nyckelhålet, complementing the climate tax with a tax on single nutrients or food items or subsidies on healthy foods. Method: The different methods were evaluated according to the following criteria; capturing of ‘healthiness’, cost to implement the methods, practical concerns during implementation, transparency, credibility and scientific base, risk of driving undesirable consumption, risk for fraud and acceptance of the method among the general public. To investigate the possibility to use nutrient indices as a base for a health- and climate related food tax, a nutrient index applicable to Swedish conditions was designed. This index was called Swedish Nutrient Index [SNI] and when including foods climate impact, it was called Swedish Nutrient Index in relation to Climate Impact [SNICI]. Findings: Of the evaluated methods, nutrient indices capture ‘healthiness’ best but would be more complicated and costly to implement than using Nyckelhålet or a tax on single food items or nutrients. The acceptance and credibility might be higher for nutrient indices and Nyckelhålet than for the other methods and these methods would most likely lead to less unwanted consumption since a wider range of food items will be affected by the method. To create a nutrient index suitable for Sweden, like SNICI, is possible. It’s important that the method is objective, transparent and scientifically justifiable, something that can be difficult as there are so many choices to be made when designing a nutrient index. Conclusion: Nutrient indices captures ‘healthiness’ well and could be a useful yet complicated tool to include nutrition in a climate tax on food. When putting nutrition in relation to climate impact it is important that undesirable, unhealthy consumption does not appear caused by the fact that some foods high nutritional value can get offset by its large climate impact and that some foods with low nutritional value can get favoured if they have a small climate impact. Other methods for including food’s nutritional value such as Nyckelhålet, taxing single nutrients, single food items and/or subsidizing healthy food items could be a preferable option, mainly as it would be easier to implement. However, before introducing such a method in combination with a climate tax, a thorough assessments on the risk of undesirable consumption, health effects, practical implementation, cost, political- and public acceptance, scientific evidence, credibility and transparency would be needed.

Keywords: Sustainable Development, Nutrient profiling, climate tax, Sweden, Nutrition, Greenhouse gas emission

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Summary: Our world’s population is growing, this means that the need for food increases as well. To provide food for more and more people leads to a higher use of our planets’ natural resources. This results in climate change and global warming due to higher emissions of greenhouse gases. Alongside this, another universal problem is that diseases related to unhealthy food habits are increasing. A global goal is to have a sustainable development. To reach this we need to change the food system so it gives our population healthy and sustainable food. For this to happen it has been suggested that more policies and regulations for the food system needs to be introduced. One suggestion is to implement a climate tax on food which also considers foods’ nutritional value.

Aim: To investigate how this could be done, the aim with this thesis is to evaluate different methods which could be used to include foods’ nutritional value in a climate tax on food. The focus will be on creating a numerical score which is based on a food item’s nutritional content. This results in a final score telling you how nutritious a food item is. This type of method is called nutrient index. Other methods will also be evaluated such as the Swedish food label Nyckelhålet, a tax on single nutrients or single food items and subsidies on healthy food.

Method: The mentioned methods were evaluated to the criteria of how well they capture ‘healthiness’, how costly they would be to implement, how easy it would be to practically implement them, how transparent and credible the method would be, if there’s a risk that the method leads to undesirable consumption, if the method would have a good scientific base, if there would be a risk for fraud if the method was implemented and how well the method would be accepted by outside parties. To investigate the possibility to use nutrient index as a base for a climate tax on food, a nutrient index related to Sweden was designed. This index was called Swedish Nutrient Index.

Findings: Of the evaluated methods, nutrient indices are more complicated than other methods as they capture how healthy foods are in a good way. It would be more difficult- and costly to implement a nutrient index than to implement e.g. Nyckelhålet or a tax on single food items- or nutrients. The acceptance might be higher for nutrient indices and Nyckelhålet than for the other methods and would most likely lead to less unwanted consumption since a wider range of food items would be exposed to the tax if these methods were implemented. To create a nutrient index is possible, but it’s important that the method created and designed thoroughly. This can be difficult as there are so many choices to be made when designing a nutrient index.

Conclusion: Nutrient indices could be a useful but also complicated method to use when including nutrition in a climate tax on. When putting nutrition in relation to climate impact it is important that undesirable, unhealthy consumption does not appear caused by the fact that some foods high nutritional value can get offset by its large climate impact and that some foods with low nutritional value can get favoured if they have a small climate impact. Methods such as Nyckelhålet, taxing single nutrients, single food items and/or subsidising healthy food items could be a preferable option since it would be easier to implement, mainly because it would be less complicated- and costly. However, before introducing any of these methods in a climate tax, a thorough assessment of uncertainties such as if there is a risk for undesirable consumption, how the method captures ‘healthiness’, how the method would be practically implemented, how much it would cost, the political and public acceptance, scientific evidence, its credibility and transparency would be needed.

Keywords: Sustainable Development, Nutrient profiling, Climate tax, Sweden, Nutrition, Greenhouse gas emissions

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Abbreviations

CO₂e – carbon dioxide equivalents
GHG – Greenhouse gas
LCA – Life cycle assessment
MRV – maximum recommended value
NCD – non-communicable diseases
NNR – Nordic nutritional recommendations
NRF – nutrient rich food index
PAL – physical activity level
RDA – recommended daily allowance
SNI – Swedish Nutrient Index
SNICI – Swedish Nutrient Index in relation to Climate Impact

Preface

This master thesis is a part of a larger project - *Effects of climate tax on food including recycling of the income* - funded by the Swedish Environmental Protection Agency led by project leader Elin Röös and engaging PhD Student Emma Moberg at the Swedish University of Agricultural Science. The main purpose of this larger project is to investigate the effects of implementing a consumption based, climate tax on food in Sweden. A part of this is to investigate which possible alternatives there are for taxes and it is here this thesis comes into the picture.

Life cycle assessments (LCAs) on the climate impact of the investigated food groups had already been collected within the project. The research in this thesis will contribute to valuable information within the study area of how the nutritional aspect can be included in a climate tax on food, with a focus on whether nutrient indices can be a useful tool.
1. Introduction

Humans have a clear influence on the climate and recent changes in climate have impacted the sensitive systems of nature and humans. Anthropogenic greenhouse gas (GHG) emissions are the dominant cause of the warming of the planet and needs to be decreased dramatically to reach international targets (IPCC, 2014). In the Paris Agreement at COP21 in December 2015 all countries agreed to work to limit global temperature to rise above 2 degrees Celsius, and to strive for maximum 1.5 degrees Celsius from 1995 years’ measurements (UN, 2015). One significant contributor to GHG emissions is the food system which accounts for about 20-30% of global GHG emissions (Vermeulen, Campbell, & Ingram, 2012). Professor in environmental studies Johan Rockström claims that it is up to food if we are going to reach this goal, and many of the other sustainable development goals, or not – because “everything has to do with food [...] If we get it right for food, we can get it right for the planet” Rockström argues. Additionally, at COP22 in Marrakech 2016, health and environment ministers gathered to sign a Ministerial Declaration on Health, Environment and Climate change. This declaration aims to create a drive for the intertwined nature of health and environmental challenges. They recognize the need for an integrated and inter-sectoral approach to do this, encouraging coherence in policies in the areas of health, food, environment and equity (WHO, 2016).

Besides climate impact, current Westernized diets are also unhealthy, contributing to non-communicable diseases (WHO, 2015; Stylianou et al., 2016). There is a need to identify healthy and price-worthy, sustainable foods and diets (Garnett, 2011; WHO, 2016; Rockström et al., 2017). Increased public awareness along with an overall understanding that the food system is a key element in the challenge of global environmental sustainability is needed (Garnett, 2011; Heller et al., 2013; Rockström et al., 2017).

As an attempt to decrease the environmental impact and reduce emissions from the food sector, researchers have focused on the need to reduce the consumption of products proven to emit high amounts of GHG, such as meat and dairy (Garnett, 2011; Wirsenius et al., 2011; Hedenus et al., 2014; Hallström et al., 2014). Some studies have presented that these types of diets, which emit less GHG, also can improve health and decrease the risk of getting non-communicable diseases, especially cardiovascular diseases (Scarborough et al., 2012). Challenges and possibilities of consumer based climate taxes on food have been assessed as to see if these types of policies could lead to changes in consumer purchases and hence reduction in emissions (Wirsenius et al., 2011; Edjabou & Smed, 2013; Säll & Gren, 2015; Springmann et al., 2017). Even if taxes of this kind have been estimated to improve health in some aspects, mainly due to reduced intake of red meat and saturated fat (Edjabou & Smed, 2013; Säll & Gren, 2015), they might lead to unwanted consumption of other less healthy foods due to an inverse relation between climate impact and nutritional quality for certain foods (Briggs et al., 2016). One way to prevent such consequences when implementing a tax on foods with a high climate impact could be to consider the nutritional value of food when creating policies aimed at reducing climate impact (van Dooren et al., 2017). This could be done by combining established nutrient profiling models with foods climate impact (Snedman et al., 2010; Drewnowski & Fulgoni, 2014; Röös et al., 2015; van Dooren et al., 2017) and using this as a base for the tax, or by using simpler strategies like taxing single nutrients or products proven bad for our health e.g. sugar or fizzy drinks or subsidising certain healthy foods in combination with the climate tax.

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1.1. Aim

The aim of this study was to evaluate different methods for accounting for food’s nutritional value when implementing a climate tax on food. The focus is on using nutrient profiling such as nutrient indices, aimed at taxing a wide range of nutrients and food products or food groups (i.e. bread, fruit, vegetables), but alternative methods will also be discussed such as using Nyckelhållet (which also can be classified as a nutrient profiling model) to exempt foods from the climate tax or using a tax on single nutrients (i.e. saturated fat, sugar, sodium), tax on single food items (i.e. Sweetened/sugary beverages) and subventions on healthy food items in combination with a climate tax on food.

1.2. Research question

What method is most suitable to use when accounting for food’s nutritional value in a climate tax on food?

To answer this research question and to fulfill the aim, the following questions need to be addressed:

- What methods are there to account for food’s nutritional value in a climate tax? What are the pros and cons of these different methods?
- Is nutrient profiling in the form of a nutrient index an appropriate way of including nutrition in a climate tax?
- How can a nutrient index relevant for Sweden be designed? What are important design decisions? Are there big differences in the results depending on how the index is designed?

1.3. Structure of the report

Section 2 of this report provides a background on climate change and the food system, the nutritional status in Sweden and policies for a healthy and sustainable food consumption.

The theory section (section 3) consists of a discussion on what a healthy diet is, including different methods which could be used to include the nutritional aspect in a climate tax on. This section also discusses how the climate impact of food can be related to food’s nutritional quality based on existing research on the combination of nutritional- and environmental impact.

Section 4 describes the methods and data used in this thesis while section 5 includes the results, starting with the evaluation of the different methods which could be used to include the nutritional aspect in a climate tax on food and then results from the newly created nutrient index combined with climate data is presented.

In section 6 the results are discussed, limitations with this work are outlined in section 7 while overall conclusions are drawn in section 8.
2. Background

2.1. Climate change and the food system

A great challenge for accomplishing a sustainable food system is to reduce GHG emissions and still produce enough nutritious food for the global population (Abadie et al., 2015). The food system includes agriculture, fisheries and food production with transport, processing, packaging, marketing, sales, purchasing as well as cooking of food and waste disposal (Garnett, 2011; Vieux et al., 2012; Kehlbacher et al., 2016).

The food system emits GHG in different stages, and the emission rates vary between countries. Of the GHG emissions associated from agriculture, the main part - around 80-86% - come from the on-farm activities while the rest arise in different pre- and post-farm activities (Vermeulen et al., 2012). Pre-farm emissions are dominated by the production of animal feed and fertilizers. On farms, there are emissions from soils, enteric fermentation, biomass burning, rice cultivation and manure management – these are called direct emissions. Indirect emissions come from land-cover change, deforestation, forest degradation and peat land degradation. Post production emissions comes from processing, packaging, transportation, refrigeration, retail activities, catering, domestic food management and consumer waste (Vermeulen et al., 2012).

While the food system emits GHG which lead to climate change, naturally, climate change will also affect the food system. There is enough evidence to prove that climate change will affect yields, fisheries, food quality, food safety and a lot of other activities. Climate change’s effect on the food system will vary between regions and between different social groups in the population. The largest effect will be on agriculture due to its sensitivity to climate variability, which will in turn affect many vulnerable populations which depend on agriculture for their livelihoods. However, effects from climate change on nutrition, poverty and health are complicated to predict (Vermeulen et al., 2012). How to reach a sustainable food system is in many ways a political issue and to adapt to- and mitigate climate change, policies which aim at decreasing GHG emissions and make the food system more resistant to climatic changes are needed (Vermeulen et al., 2012).

According to FAO, sustainable diets are “those diets with low environmental impacts which contribute to food and nutrition security and to healthy life for present and future generations. Sustainable diets are protective and respectful of biodiversity and ecosystems, culturally acceptable, accessible, economically fair and affordable; nutritionally adequate, safe and healthy; while optimizing natural and human resources” (FAO, 2010). Different actors have varying views on what a sustainable food systems entails and what the solutions to reach it are (Garnett, 2013). Many attempts to achieve a sustainable diet can be seen world-wide, unfortunately, an agreement on how to cooperatively reach this is missing.

Research indicate that diets could both meet dietary recommendations and have low GHG emissions. This is not to say that all healthy diets are more climate friendly than more unhealthy variants. The type of food products that the diet contains is of high importance, and it is important to point out that there is no single sustainable diet (Macdiarmid et al., 2012). For example, the diet’s protein sources can come from either animal or plant based foods and still give us enough protein, but the amount of emitted GHG will vary substantially between these different sources of protein, with animal based food causing greater GHG emissions than plant-based variants (Macdiarmid, 2013).
2.2. Nutritional status of the Swedish population

In Sweden, unhealthy food habits are one of the largest risk factors for disease and premature deaths. Since 1980 the prevalence of obesity has tripled, and every other Swede is now overweight or obese (Public Health Agency of Sweden, 2017). Intake of nutrients such as saturated fat, sugar and sodium should be decreased while the consumption of other healthy nutrients should be improved (Riksmaten, 2012; Mensink et al., 2013). The average intake level of protein in the EU is more than 50% higher than required (Westhoek et al., 2014) and overconsumption of protein has large impact on the environment as it demands more resources in its production than plant-based foods (Ranganathan et al., 2016). Moreover, in the Nordic countries, the intake of Vitamin D is quite low, mainly due to the lack of Vitamin D derived from the sun during the winter months. The intake of Iron (Fe) in women of a fertile age is also low (Mensink et al., 2013) as well as the intake of folate (Riksmaten, 2012).

Moreover, only 21% of the Swedish population consume the recommended intake of 500 g of fruits and vegetables per day (Riksmaten, 2012). Despite the low intake of these nutrients and foods, many people get an adequate intake of micro-and macro nutrients indicating that there is room to move towards more sustainable diets in Sweden and still ensure adequate intake of essential nutrients as the most relevant problem associated with nutrition in Sweden is the consumption of unhealthy nutrients and food products and overconsumption of calories. In a study of the Swedish population’s eating habits called Riksmaten 2010-11 (Riksmaten, 2012), it was found that 57% of the men and 42% of the women were overweight or obese and on an average 15% of the total energy came from soda, candy and pastries. Moreover, the intake of saturated fat was high: 13 E%, where the recommendation is that maximum 10% of the energy consumed in one day should come from saturated fat. Added sugar contributed to almost 10% of the energy, which is the maximum recommended level of intake of sugar and the salt intake was 7.5 g per day which is higher than recommendations (Riksmaten, 2012). When trying to improve peoples’ eating habits it is important to look at diets in a holistic way, and put the whole diet in focus as dietary patterns play an important role in preventing diet-related chronic disease (Nordic Council of Ministers, 2014). However, to focus on diets is a great challenge when for example implementing a tax on food since we cannot know which specific diets people eat and will eat. What can be done then, is to study the nutrient content in single food items. A tax with focus on the nutritional value of single food items instead of diets would aim at making it easier and more affordable to consume food items which are nutritious and sustainable. Moreover, this could lead to a consumption of healthy and sustainable diets.

2.3. Policies for healthy and sustainable food consumption

Policies aimed at changing behavior are generally more accepted if they are less intrusive, such as information for example. However, in a review by Garnett et al. (2015) evidence suggest that information about healthy and sustainable food as a policy intervention has limited effectiveness. An acceleration of the implementation of more effective policies on food is needed and care must be taken that these ascribe to both a sustainable food system and a healthy, nutritious diet (Garnett, 2011; EAT, 2016). Substantial research efforts have been made to understand food’s environmental impact but the nutritional aspect is usually not included in environmental assessments of food (Stylianou et al., 2016; Saarinen et al., 2017). Vice versa, nutritional research does not often include environmental impacts of food production (van Dooren et al., 2014; Stylianou et al., 2016). Nonetheless, financial policies, e.g. tax on food with the purpose of steering food consumption could aim at both mitigating GHG emissions and improve public health.

Some products, services and other consumable goods are currently subject to so called excise duties. The purpose of excise duties is to affect the consumption in some direction. For example, in Sweden alcohol, tobacco, road traffic, energy and carbon dioxide have excise duties aimed at reducing consumption, or in the case of carbon dioxide, emissions (Swedish Tax Agency, 2017). Sweden has had a charge on carbon dioxide emissions since 1991 and an excise duty on carbon dioxide emissions since 1995. Taxable fuels are gasoline, oil, natural gas, coal and coke. Household waste that is
incinerated for heating is also taxed (Swedish Tax Agency, 2014). In Europe, Denmark, Finland, Ireland, the Netherlands, Norway, Slovenia, Sweden, Switzerland, and the UK have carbon taxes. Currently, Sweden has the highest carbon tax in the world with a rate of 131 US dollars/t carbon dioxide equivalents (hereafter CO₂e.) Switzerland coming in second with 86 US dollars (World Bank, 2016). A tax on carbon covers part of the food system as the transportation, - processing and packaging part of food production and consumption is covered in the tax and therefore some of the emitted GHG within the food system are paid for.

Excise duties serve a large source of income for Sweden. For excise duties, the destination principle is applied, this means that the tax is inactive until the product reaches the country in which it is going to be consumed. This decreases the risk for skewed competition but demands border controls (Swedish Tax Agency, 2013). The excise duty can be a positive driving force when it comes to creating an awareness about health issues and environmental impact as it usually puts a higher price on things that are unhealthy for people- and/or planet (Taxclimate.com, 2017). It can also be seen as negative since it can create an ambition to find detours to avoid it (Verksamte.se, 2017). The implementation of a tax on food will require resources which will need to be weighed with the reduced societal costs, lower healthcare costs and an increasing health status of the population (Smed, 2012). With already existing excise duties on products and services with negative effect on health and/or the environment, an extra excise duty on food’s climate impact and nutritional value seems in line with Sweden’s current policy to correct for market failures.

A part from excise duties, value added taxes are also added to consumer goods. There are three different rates for value added taxes (VAT) in Sweden. Most commodities have a 25% VAT rate. Food, restaurant visits and hotels etc. have 12% VAT rates. Books, magazines, concerts, taxi, bus, flight and train trips within Sweden etc. have a 6% VAT rate.
3. Theory

3.1. Healthy diets and foods

The Nordic Nutrition Recommendations from 2012 (hereafter NNR 2012) (Nordic Council of Ministers, 2014) will be used in this study as a theoretical framework for evaluating and defining what constitutes healthy foods. NNR has been adopted as the official recommendations in Sweden and is one of the most thoroughly researched and comprehensively documented nutritional science works in the world. It is an important basis when developing food, nutrition and health policy. NNR 2012 consists of recommendations for intake of certain foods, nutrients and energy.

These are the most important recommendations from the Swedish National Food Agency, based on NNR 2012:

- Eat many fruits and vegetables, over 500 g per day
- Choose whole grain when eating bread, cereal, grains, pasta (whole-grain rice obtains much arsenic and is therefore not recommended)
- Choose food items labelled with Nyckelhålet
- Do not eat more than 500 g of red meat per week
- Choose foods with less salt, use less salt when you cook, use salt with Iodine
- Eat less candy, pastries, ice-cream and other sugary products, consume less soda
- Eat fish two to three times per week
- Use liquid margarine or oil when you cook – look for Nyckelhålet

NNR 2012 is created for the general healthy population and its guidelines are not meant for individuals with diseases. The goal with recommended amounts of nutrients is to prevent diseases, not to cure them. The guidelines in NNR should not be understood as definitive since nutritional research keeps advancing. A diet based on the guidelines in NNR should:

- “satisfy the nutritional needs, i.e. cover the physiological requirements for normal metabolic functions and growth, and
- support overall good health and contribute to a reduced risk of diet-associated diseases” (Nordic Council of Ministers, 2014, p.16).

Even though the descriptions above sound accurate, to decide what is a healthy diet for everyone is almost unmanageable since what is ‘healthy’ varies on an individual level due to genes, lifestyle, health status, socioeconomic conditions, physical activity, use of tobacco and alcohol, exposure to toxic substances and more. Bioavailability, the amount of the consumed nutrient which can be made available for the body to process in the metabolism, is also an important factor (Nordic Council of Ministers, 2014). In conclusion, the definition of a healthy diet used in this thesis is a diet which aims at meeting the recommended intake of macro- and micronutrients. Hopefully this will contribute to a reduced risk for illnesses related to diet, however, this cannot be guaranteed.

3.2. Health related food taxes and subsidies

The rising prevalence of food related illnesses and non-communicable diseases caused by unhealthy eating habits have increased the need for interventions aimed at stimulating healthier food choices. Health related food taxes have been an area of increased attention (Cornelsen et al., 2014; WHO, 2015; Waterlander et al., 2016). To my knowledge there are no formalised criteria to consider when designing an excise duty. How easy an implementation of the tax would be, naturally must be taken into consideration. A ‘lump sum’ tax is usually advocated in models (Andersson, J, pers. Comm. 2017). A ‘lump sum’ tax is a tax based on a fixed amount even if the taxed entity would change in circumstance, it means that all taxable parties pay the same amount of tax regardless of their income.
This means that the tax will become regressive as it would affect people with lower incomes more as they put a larger percentage of their income on the tax than people with higher income. Usually, assessments are done based on already existing taxes, and how wide the tax base is, is usually taken into consideration. Issues such as practical implementation, cost, transparency, credibility, scientific base, if the tax could lead to unwanted consequences, if there is risk for fraud and if the tax will be accepted are usually discussed before implementation (Cnossen, 2005).

In a report from WHO (2015) advice is given on what to consider before implementing a health-related food tax:

- Estimate potential health effects before implementation. Measure and document health and consumption effects after implementation.
- Consult health professionals and organisations
- Analyse welfare effects of the economy
- Analyse anti-competitiveness to avoid lawsuits
- Design the tax in a clear and logical way based on public health recommendations

WHO (2015) claims that health related interventions should improve diet, decrease the consumption of calorie-dense foods, address obesity and diabetes, and that the most important interventions are fiscal policies in the form of taxation and subsidies. Denmark, Ecuador, Egypt, Finland, France, Hungary, Mauritius, Mexico, Philippines, Thailand and some states in the US have implemented different sorts of health-related fiscal policies in the forms of a tax and/or subsidy (WHO, 2015). These countries have applied different kind of taxes such as a tax on sugar, salt, saturated fat, trans fat, and/or sugar sweetened beverages (WHO, 2015). Most countries that introduced health related food taxes, only on single food products or nutrients however, have used an excise duty as it is deemed to be the most effective type of tax to change consumer behaviour (WHO, 2015). In some countries, the health-related excise duty is increasing gradually after its introduction to allow consumers to adjust to the changing prices. Some countries adjust the excise duty annually to inflation. As mentioned above, one issue is the risk of the tax becoming regressive, if subventions are not introduced as well, low income citizens would pay a greater proportion of their money on the taxes than people with higher income would (Cornelsen & Carreido, 2015).

There are some uncertainties about the success of health-related food taxes, many are due to the lack of high quality evidence and the uncertainty of whether a tax on saturated fat for example will increase the consumption of other unhealthy foods with high levels of sugar or salt for example. The tax may also affect the consumption of healthy foods in a desirable or undesirable way. Furthermore, concerns such as if the tax should be levied on raw ingredients or the final product, how much of the ingredient the product can contain before it is taxed are also issues which needs be addressed before a tax is introduced (Mytton et al., 2012). Moreover, if the tax is introduced along with related information which raise awareness of the health effects of consuming the taxed food/nutrient as well as consuming other healthier alternatives, it may contribute to a positive dietary behavior change (Mytton et al., 2014). WHO concludes in a report from 2015 that there are strong economic and health rationales for using health related food taxes and that this should be a key instrument for preventing NCDs and promoting healthy diets. It is just important that ongoing evaluation and assessment of the taxes after and before implementation is conducted (Thow et al., 2014; WHO, 2015; Waterlander et al., 2016).

Denmark implemented a tax on saturated fat, and noticed, that it increased cross-border purchases of products containing the taxed nutrient, which might prevent the expected health outcomes (Cornelsen et al., 2014). Moreover, the tax was designed so that products containing more than 2.3 g saturated fat per 100 g was affected, with this level, drinking-milk was not affected by the tax (Jensen & Smed, 2013). Denmark proposed a higher rate at first where both meat and milk was affected by the tax, but this was rejected by the European Union Commission since they claimed that the exclusion of milk was not in line with EU state aid rules since it can be beneficial for certain age groups to consume milk. The excise tax amounted to 16 Danish crowns (2.15€) per kilogram of saturated fat (Smed,
Moreover, Danish produced and imported foods consumed in Denmark were taxed equally, while foods produced for export were not affected by the tax. The taxable party needed to be able to document the weight of saturated fat in the food. To decide this for meat, standard rates of fat in different products was used, or it could be calculated from food composition data, the same method needed to be used for one year. For non-meat products, nutrition labelling or technical analysis could be used to determine the content of saturated fat. For imported foods, it was sometimes difficult to determine the amount of saturated fat, in these cases the total amount of fat needed to be taxed, or if that could not be established, the products’ net weight was taxed (Smed, 2012).

It’s suggested that a tax rate on food or nutrients needs to be 10-20% for the changes to even be noticeable (Mytton et al., 2012). However, small changes in consumption can lead to very meaningful changes in nutritional intake which decrease risk factors across the whole population and result in improved health (Mytton et al., 2012). This supports a tax based on nutrient profiling in the form of nutrient indices which would affect all food products, the tax rate would however most likely not be 10-20% on all products.

According to economic theory a tax should reflect the external costs caused by the product being taxed. A food tax should reflect the avoided profits that a healthier consumption could offer or the economic costs of an unhealthy food consumption. Because the individual’s choice to (over)consume certain products might impose costs on other people than the individual decision-maker, for example, publicly funded medical treatments for conditions related to a specific consumption. Taxes that corrects the external costs which the individual consumer will not pay for could be argued to be introduced (Chosenen et al., 2009). However, in Sweden there is (to my knowledge) no available estimate of what the economic gains would be from a healthier food consumption. Data does exist on how much obesity and overweight cost the society and the individual (Public Health Agency of Sweden, 2017). However, the reasons for the gained weight in our population is a complicated web caused by structural reasons and individual choices (Andersson & Fransson, 2011) and would therefore not be sufficient to use as basis. Some other basis would be necessary to decide how large the yearly tax revenues ought to be. Moreover, it’s difficult to get information on which health outcomes and diseases that derives from which foods and nutrients. Norway has in a report concluded that if the Norwegian population would follow the Norwegian dietary guidelines the societal benefits would be a total sum of 154 billion Norwegian crowns (approximately 16,8 billion €). This sum contains of the accumulated health profits (longer life and better life quality), reduced costs for healthcare and reduced loss of production (increased tax revenue due to reduced absenteeism, disability and death) (Sælensminde et al., 2016).

Another policy option could be to introduce subsidies for unprocessed fruit and vegetables, or other products proven to be healthy for us (Cornelsen et al., 2014; WHO, 2015). Generally, it would be assumed that the subsidies would make consumers buy more of the subsidised food. However, this theory may not be the actual outcome. When something is subsidised it means that the consumer’s disposable income increases and they can buy something else instead. What the consumer chooses to buy decides whether the outcome of the subsidy will be positive or negative (Cornelsen et al., 2014). This issue was lifted in a review by Epstein et al. (2012) as well, who found that subsidies tend to result in an overall increase of purchased energy. This is due to the money saved by the consumer from the subsidies.

### 3.3. Climate tax on food

This social cost caused by the emissions of GHG from food production is not currently included in the price of food and is therefore not visible for the consumer nor paid for (Briggs et al., 2016). A climate tax on food would reflect the cost of the GHG emissions caused by the production of different types of foods. Several studies have modelled how such consumer based taxes on food’s GHG emissions could reduce emissions from food consumption (Wirsenius et al., 2011; Edjabou & Smed, 2013; Säll & Gren, 2015; Springmann et al., 2017). Wirsenius et al. (2011) concluded in a study that a climate tax
on animal products could reduce GHG emissions in EU agriculture with up to 7%, and that a tax on foods from ruminants would be the most important to tax in order to decrease GHG emissions. Edjabou & Smed (2013) looked at mitigation opportunities in Denmark and found that a climate tax on 23 food categories could decrease GHG emissions from food products with 8.8%. A study by Säll & Gren (2015) showed that a tax on meat and dairy in Sweden could decrease GHG emissions and they found that a reduction of up to 12% could be obtained if all products of meat and dairy would be taxed. A study by Springmann et al. (2017) suggest that positive health outcomes and decreased GHG emissions could be obtained if a properly designed GHG tax on food would be implemented. They also found that the reduced amount of obese people and reduction in red meat consumption could outweigh negative consequences such as that the tax could lead to an increased number of underweight people. Moreover, health gains would weigh up health losses that could occur due to a decreased consumption of healthy food groups as they would be more expensive as well.

It might be problematic to get acceptance for a climate tax on food as certain nutrients and food products which would be penalised by such a tax (i.e. saturated fat, meat, dairy products) may not have a negative impact on our health if we eat it in small or restricted amounts (Edjabou & Smed, 2013) for example, milk can be beneficial for children to consume (Kehlbacher et al., 2016). Nonetheless, some food products which cause large GHG emissions during production are also foods which have been proven to be associated with negative health effects if you eat too much of it, e.g. red meat. Due to the non-coherent relation between healthiness and emissions of GHG, a tax could also lead to an increased consumption of some unhealthy food items, low in GHG emissions. This problem could be avoided if the climate tax is designed to considers foods nutritional value or if additional health related taxes are introduced in parallel e.g. a tax on sugar (Briggs et al., 2016). Other challenges with introducing a climate tax on food include administrative costs, the risks of cross-border trading (Abadie et al., 2015), the possible lack of political will to introduce taxes (Edjabou & Smed, 2013) and the risk of the tax being regressive and therefore affect weak social groups more (García-Muros et al., 2017). Another issue is that ideally the tax rates needs to be non-static so that they can be adjusted if technology would improve and reduce the environmental impact from food production (Edjabou & Smed, 2013). A tax which penalises foods that contains nutrients with limited positive health outcomes, and rewards foods with less GHG emissions and proven positive health outcomes could be beneficial for the environment and peoples’ health (Markandya et al., 2016).

3.4. Nutrient profiling as an instrument in food taxes

Fiscal policies designed to improve public health and/or decrease GHG emissions may benefit from nutrient profiling (Rayner et al., 2009). One way of introducing a health-related food tax could be with nutrient profiling as an assessment tool and instrument to base the tax on. This section introduces the concept of nutrient profiling and shortly describes some different methods for calculating nutrient density indices.

3.4.1. Nutrient profiling

Nutrient profiling concerns the characterizing of foods based on an assessment of their nutrient quality. The objective is to create a scoring arrangement based on nutritional information resulting in a composite index (Drewnowski, 2009; WHO, 2011; Arsenault et al., 2012; Drewnowski & Fulgoni, 2014). Examples of common uses of nutrient profiling are in food labelling schemes aimed at helping consumers to better understand which foods that are healthier (WHO, 2011; Drewnowski & Fulgoni, 2014). In a report from 2015, WHO (2015) concludes that for health related food taxation to be successfully introduced, there is a need for a sound nutrient profiling model and that they now aim to prepare a global nutrient profile model to be used for fiscal policies amongst other things.

Ranking foods according to their nutritional quality poses many challenges, both conceptual and technical (Drewnowski, 2009). Challenges lies within the selection of nutrients to encourage to include and nutrients to limit, the basis of calculations (grams, kcal or serving size), the choice of
reference daily values and whether the nutrients should be capped at 100% of recommended daily allowance of nutrients or not (WHO, 2011). To cap nutrients at 100% of RDA means that if 100 g (or 100 kcal if that’s your basis of calculations) of a food item contains more than the recommended daily allowance of a nutrient, it doesn’t get extra high scores, but is capped at the value which is 100%. In addition, to calculate a composite numerical index, an algorithm that is scientifically justifiable, enforceable, objective and transparent is needed (Drewnowski, 2009; Fulgoni et al., 2009; Drewnowski & Fulgoni, 2014). Nutrient profile models can be based on nutrients known to be beneficial for health, nutrients which should be limited, or a combination of both (Drewnowski et al., 2009). Nutrient profiles which captures both nutrients to encourage and nutrients to limit have been shown to perform better than those only capturing one of these (Drewnowski & Fulgoni 2014). Most models use sodium (Na), sugar and saturated fat as nutrients to limit, and protein and fiber as two macronutrients* to be encouraged and furthermore a range of micronutrients** to be encouraged as well (Drewnowski & Fulgoni 2008; Fulgoni et al., 2009; van Dooren et al., 2017).

As mentioned earlier, calculations can be based on 100 kcal, 100 g or serving size. There are advantages and disadvantages with all three bases. Models based on 100 g are more consistent with EU food labelling and the way e.g. recipes are structured, but do not consider the fact that different foods are eaten in varying amounts. It may penalize foods which are generally consumed in small amounts such as nuts, dried fruit, and cheese. With a 100 g basis, adjustments would be preferable for the calculations of beverages so that they don’t get favoured due to their high content of water. Using the basis of 100 kcal means that you calculate the ratio of nutrients to calories and this reflects well the fact that foods’ nutrient density usually is measured as kcal, and can be easily compared with nutrient guidelines. However, it tends to favour salad greens such as spinach and cabbage because of their low-energy-density and high nutrient content. To use serving size as a basis benefits foods which are often consumed in amounts above 100 g and foods eaten in amounts less than 100 g gets lower scores. It has been proposed that measuring nutrient density per serving size is easier to communicate to consumers, however it is difficult to use this within the EU since there are no standardized serving sizes for each food item (Drewnowski, 2009; Rayner et al., 2009; Drewnowski et al., 2009; Drewnowski & Fulgoni 2014; Sluik et al., 2015).

Some studies of nutrient indices have added a weighting factor in the calculations to make the index more context specific for the population in the country where the index will be used. That is, the included nutrients in the index are weighted according to different criteria, such as how a certain country’s population eat. For example, Arsenault et al. (2012) added a weighting factor as they applied a statistical approach, using linear regression of nutrient intakes of the population in the US to predict the quality of the populations’ diet measured by the Healthy Eating Index (HEI). Katz et al. (2010) weighed all their nutrient entries “based on their health effects for the prevalence of relevant conditions, the severity of the relevant conditions, and the strength of association between the nutrient and relevant conditions”.

3.4.2. Nutrient profiling models

Choosing the best nutrient profile model from among multiple alternatives is a challenge. Only a handful published, fully transparent models have been validated, some of them are: NRF (nutrient rich food index) by Drewnowski (2005) and Drewnowski & Fulgoni (2008) which later has been developed to the NRF9.3 index, one of many NRF variations (Fulgoni et al., 2009; Drewnowski & Fulgoni, 2014). The French SAIN/LIM (Darmon et al., 2005; Maillet et al., 2007; Darmon et al., 2009), the British FSA-Ofcom model (Rayner et al., 2009), ONQI, Overall Nutrient Quality Index proposed by Katz et al. (2010) and the WNDS, Weighted Nutrient Density Score, proposed by Arsenault et al. (2012). The characteristics of these nutrient profiling models are shown in Table 1.

---

* Energy-giving nutrients; fat, protein, carbohydrates, fiber, alcohol
** Non-energy giving nutrients; vitamins, minerals
Out of the methods shown in Table 1, there are three of which could be preferable to use if one wanted to include the nutritional value in the form of a nutrient index in a climate tax. These are NRF9.3, SAIN/LIM and WNDS (with a weighted factor suitable for the country the index will be used in). The ONQI includes many nutrients and has a weighted factor but is unfortunately complicated to replicate due to a complex and non-transparent algorithm (Katz et al., 2010). The British-Ofcom method is aimed at quantifying nutrition in food products which may be subject for commercials for kids and aims at excluding non-nutritious food products from commercials (Rayner et al., 2009). In the British-Ofcom, the inclusion of fruit, vegetables and nuts as a “nutrient” to encourage would be a bit problematic since it would exclude healthy food items which does not entail fruits, vegetables or nuts, and moreover it would be a more suitable method to use for processed and composite food products than single, non-processed food items. All methods could be adjusted to better reflect the health status of the population in which the tax is to be implemented, e.g. the number of included nutrients could be different and a weighting factor which suits the population could be included.

---

**Table 1. Summary of some nutrient profiling models**

<table>
<thead>
<tr>
<th>Model</th>
<th>Nutrients to encourage</th>
<th>Nutrients to limit</th>
<th>Basis for calculations</th>
<th>Nutrients are capped at 100% of RDA</th>
<th>Scores are Arithmetic means or sum</th>
<th>Index shown as score or div. in groups</th>
<th>Weighted factor included</th>
</tr>
</thead>
<tbody>
<tr>
<td>NRF9.3</td>
<td>Protein, fibre, Vit A, E, C, Ca, K, Mg, Iron</td>
<td>Sodium, Saturated fat, Added Sugar</td>
<td>100 g or 100 kcal for all nutrients (not a mix as in SAIN/LIM)</td>
<td>Yes</td>
<td>Sum (arithmetic means in some studies)</td>
<td>Score</td>
<td>No</td>
</tr>
<tr>
<td>SAIN/LIM</td>
<td>Protein, fibre, Vit C, Iron and Ca</td>
<td>Sodium, Saturated fat, Added Sugar</td>
<td>100 kcal for nutrients to encourage and 100 g for nutrients to limit</td>
<td>No</td>
<td>Arithmetic means</td>
<td>Divided into 4 groups</td>
<td>No</td>
</tr>
<tr>
<td>WNDS</td>
<td>Protein, fibre, Ca, unsaturated fat, Vit C</td>
<td>Sodium, Saturated fat, Added Sugar</td>
<td>100 kcal</td>
<td>Yes</td>
<td>Sum</td>
<td>Score</td>
<td>Yes</td>
</tr>
<tr>
<td>ONQI</td>
<td>Fibre, folate, Vit A, C, D, E, B12, B6, K, Ca, Zinc, Omega-3 fatty acids, bioflavonoids, carotenoids, Mg, Iron</td>
<td>Saturated fat, trans fat, Sodium, sugar, Cholesterol + fat quality, protein quality, energy density, GL</td>
<td>*</td>
<td>*</td>
<td>*</td>
<td>Results are shown as scores from 1-100</td>
<td>Yes</td>
</tr>
<tr>
<td>British FSA-Ofcom</td>
<td>Protein, fibre, “fruit, vegetables and nuts”</td>
<td>Energy, saturated fat, sugars, sodium</td>
<td>100 g</td>
<td>No</td>
<td>Food gets A- and C points from 0-10 which decides how healthy or unhealthy a food item is</td>
<td>A food is classified less healthy if it gets 4 points or less as a final score</td>
<td>No</td>
</tr>
</tbody>
</table>

* Could not be found in available articles.
Nyckelhålet (translated to “the key hole” in English), is a food label for food items, founded in Sweden in 1989 by the Swedish National Food Agency. The certification now exists also in Denmark, Norway and Iceland. The criteria for the label are based on the most recent research on the connections between food and health and have been critically examined. If a food item has the symbol of a key hole, it shows that the food item has less sugar or salt in it and more fibre, whole grains, healthier or less fat compared to other foods in that specific food group. The criteria of whether a food item can be labelled or not differs within different food groups, e.g. cereals are compared with cereals and sausages with sausages. An extract from LIVSFS 2005:9 of which foods that can be labelled with Nyckelhålet is shown in Table 2. By eating key hole labelled food, the Swedish National Food Agency claims that the consumer will be more alert, and the risk of obtaining chronic diseases will decrease as well (National Food Agency, 2017a). As Nyckelhålet is a sound, science based labelling scheme aimed to facilitate a healthier food consumption, however lacking the explicit inclusion of micronutrients and protein in its certification, it could be an option to use Nyckelhålet instead of the nutrient indices described above or nutrient- or product specific taxes or subsidies.

Table 2. Extract from LIVSFS 2005:9. Criterions for some foods to be labelled with Nyckelhålet.

<table>
<thead>
<tr>
<th>Food items</th>
<th>Terms</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Skimmed milk (0,5%, 0,1% fat) and corresponding fermented products</td>
<td>Fat content maximum 0,5 g/100 g</td>
</tr>
<tr>
<td>2. Flavoured fermented milk products without sweeteners</td>
<td>Fat content maximum 0,5 g/100 g</td>
</tr>
<tr>
<td></td>
<td>Mono- and disaccharides totally maximum 9 g / 100 g</td>
</tr>
<tr>
<td>3. Plant based products without sweeteners, aimed at being an alternative to the products in point 1</td>
<td>Fat content maximum 1,5g/100 g</td>
</tr>
<tr>
<td></td>
<td>Saturated fat and trans fat maximum 0,3 g / 100 g</td>
</tr>
<tr>
<td></td>
<td>Pure mono- and disaccharides not added</td>
</tr>
<tr>
<td>4. Products containing a mix of only milk or cream, aimed at being an alternative for cream</td>
<td>Fat content maximum 5 g / 100 g</td>
</tr>
</tbody>
</table>

3.5. Life cycle assessments of food considering nutritional quality

The climate impact of food products is commonly calculated using life cycle assessment (LCA) methodology. LCA is a quantitative method for assessing a product’s or service’ environmental impact. It’s an established method where inflows of natural resources (e.g. raw materials, energy, land and water) and outputs in the shape of products, by-products, emissions and waste are quantified for a specific system and all the steps taken in its lifecycle. It has the goal of being a comprehensive methodology for assessing the environmental impact of a product or service, thereby avoiding sub-optimisations and problem shifting (Guinée et al., 2011).

A food’s carbon footprint (CF) is the amount of GHG emitted by a food product during its lifecycle and is therefore a subset of a complete LCA including emissions from agriculture, horticulture or fishing, emissions from fertilizers, processing, transportation and storage of food. The transport to the home and possible waste in the households are usually not included as the LCA generally ends when the food product reaches i.e. a supermarket (Trolle et al., 2014). Even if these activities have a role in the climate impact they do not affect comparison between products in the supermarket (Saarinen et al., 2017).

The nutritional quality is not often considered in food related LCAs (Stylianou et al., 2015; Saarinen et al., 2017) although some studies have explored the use of nutritional profiling algorithms as the basis of functional unit (Smedman et al. 2010; Saarinen, 2012; Heller & Keoleian 2012; Masset et al., 2014;
Drewnowski et al., 2015; Saarinen et al., 2017), and other researchers have included nutritional quality in other ways (Kagi et al., 2012; Kernebeek et al. 2012; Vieux et al., 2012; Stylianou et al., 2016).

Drewnowski et al. (2015) examined the relation between nutrient content, energy density and GHG emissions of food by using two alternative nutrient density profiles, derived from Drewnowski & Fulgoni (2008) and Drewnowski et al. (2009). They looked 483 foods and beverages for the French food-composition table. They found that nutrient dense foods such as grains and sweets had the lowest GHG emissions but also a low nutrient quality. For some foods, they found that their high emissions of GHG were compensated by the foods’ high nutritional content e.g. meat and dairy products.

Masset et al. (2014) has tried to identify sustainable foods in order to investigate whether FAOs definition of sustainable food is compatible with foods actual nutritional value, affordability and environmental impacts. They looked at the relationship between environmental impact, nutritional quality by using the SAIN/LIM method and price. For all foods, a sustainability score based on median GHG emissions, price and SAIN/LIM was calculated. The highest score was given to the food with the best value for all three variables. They found that for some foods’, their GHG emissions were inversely correlated with their nutritional quality, e.g. meat products had a medium high nutrient quality but a high environmental impact.

Van Dooren et al. (2017) recently proposed a novel nutrient profile model which reflects both the climate impact and the nutritional impact of food. Their new index is a reformulation of the NRF index (Drewnowski, 2005) where the food’s GHG emissions are taken into consideration by including data from LCAs on the food’s emissions of CO2e, and will be put into a single score called Sustainable Nutrient Rich Food index (SNRF). Which nutrients to include in this index has been researched based on the nutrients’ environmental impact as well as their contribution to human health. With this taken into consideration plant protein, fiber and non-saturated fatty acids was decided as the nutrients providing good health as well as little GHG emissions, whereas sodium, saturated fat and sugar was decided as nutrients with limited health benefits and higher GHG emissions (van Dooren et al., 2017)

The Nutrient Density to Climate Impact (NDCI) model by Smedman et al. (2010) is divided into two parts. The first part is based on the NRF score by Drewnowski (2005), although Smedman et al. (2010) has done some modifications in the NRF index. They consider 21 nutrients to encourage, including carbohydrates and fat, and no nutrients to limit. Moreover, Smedman et al. (2010) only takes nutrients which contributes to >5% of the recommended daily intake into the calculation. When the nutrient density is calculated, this number is put in relation to the foods climate impact, calculated as CO2e. The result is a number showing the foods nutrient density in relation to climate impact. Smedman et al. (2010) found that milk got the best NDCI score out of other beverages such as soy drink, oat drink, red wine, beer, soft drink, orange juice in their study.
4. Method and Data

4.1. Evaluation of alternative ways of considering foods’ nutritional aspects in a climate tax

The following alternatives to consider foods’ nutritional aspect in a climate tax were evaluated:

- Using a nutrient index to be estimated for individual food items. For this alternative, the idea is that all food items would be taxed according to i.e. the new Swedish nutrient index in relation to climate impact (SNICI).
- Using a nutrient index estimated for different food groups (i.e. bread, fruit, vegetables etc.). For this alternative, food items would also be taxed based on i.e. SNICI, but all bread types for example would get an average SNICI score which the tax would be based on.
- Using the labelling scheme Nyckelhålet, i.e. food items labelled with Nyckelhålet would be exempt from the tax, and other foods would be taxed according to their climate impact.
- Combining a climate tax with a tax on either single nutrients (i.e. saturated fat, sugar, sodium) or a tax on single food items (i.e. sweetened/sugary beverages). For these two alternatives, a tax on sugar for example would be implemented parallel with a climate tax on food, a tax would be levied based on e.g. how much sugar a food item contains.
- Subsidies on specific healthy food items. For this alternative, some food items proven healthy to consume (i.e. fruits and vegetables) would be subsidized. The idea is that these food items would be subsidized with a fixed amount, this would most likely be implemented parallel with a tax on unhealthy food items or nutrients and/or a climate tax on food.

To evaluate different alternatives a set of evaluation criteria were formulated based on the literature on health and climate taxes (section 3.2 and 3.3).

The chosen criteria involved in the evaluation are:

1. **Capturing of healthiness.** How the method capture healthiness i.e. the nutritional quality of the food product(s) that are being taxed.
2. **Practical implementation.** The method would either be easy to implement or it would demand many structural and organisational changes for food producers and retailers.
3. **Cost.** The cost of implementing the method. A more complicated method might lead to high administrative costs.
4. **Transparency.** The method would be possible to create and implement in a transparent way.
5. **Credibility and scientific base.** The method need to have credibility and be scientifically based.
6. **Undesirable consumption.** Unwanted consumption of some food items or nutrients could occur as a side effect of the implemented method.
7. **Risk for fraud.** There is a risk for fraud to occur.
8. **Acceptance.** There are public and political support for implementing a tax.

Depending on how well the different criteria are fulfilled by the different methods, the methods were assigned one or two pluses [+] or minuses [-]. This is shown in Table 7, in the result section 5.1 and the scoring justified in subsequent sub-sections. These criteria and the final scoring of the different alternatives was done based on previous literature about different methods for taxing food products (section 3.2 and 3.3), by consulting people knowledgeable in the subjects (Andersson, J; Carlsson, C; Öhrvik, V, 2017) and by discussion in the supervisor group.
4.2. Development of a new nutrient index designed for Sweden

The concept of using nutrient indices in relation to foods’ climate impact was assessed and discussed by designing a nutrient index for Sweden, based on food consumption, requirements and recommendations for the Swedish population. We named this index Swedish Nutrient Index (hereafter SNI). When designing the nutrient index, the following decisions concerning the design needed to be made: which reference person and accompanied nutritional requirements to use, choice of nutrients to include in the index, to cap the nutrient at 100% intake of the daily recommendation or not, the basis of calculations (100g, 100 kcal, serving size or a mix). Further decisions in the design of the index was whether to calculate the sub scores as sums of the different nutrients or as mean values, if the final score will be achieved by a ratio, by subtracting the negative score from the positive score or by dividing foods into classes based on their separate positive and negative scores. A summary of how the index was created is presented in Table 3. The final design of the index is a result from an evaluation of different nutrient indices. The three methods NRF9.3, SAIN/LIM and WNDS (Drewnowski, 2009; Darmon et al., 2009; Arsenault et al., 2012) were tested to see how the results turned out and how they were affected by different design choices. Each method was calculated for the foods in the Swedish food Composition database, the results from each method were compared with each other and thereafter discussed to find what method that would be most suitable to use. It was found that different indices had varying positive and negative aspects in their design and that a mix of some of the evaluated indices provided an index that was judged here as suitable for Sweden. The choices will be further explained in the coming sections.

Table 3. Design choices for the newly created nutrient index.

<table>
<thead>
<tr>
<th>Reference person</th>
<th>Number of included nutrients</th>
<th>Cap at 100%</th>
<th>100 g, 100 kcal or serving size as basis of calculations</th>
<th>Sub scores or mean value</th>
<th>Ratio or subtract the neg. sub score from the positive</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man/woman, 18-30 years, 70.2 kg, 1.6 PAL, 2525 kcal energy demand</td>
<td>21 (18 to encourage, 3 to limit)</td>
<td>No</td>
<td>100 g for the negative sub score, 100 kcal for the positive sub score</td>
<td>Sub scores</td>
<td>Subtract the negative from the positive</td>
</tr>
</tbody>
</table>

4.3. Swedish Nutrient Index in Relation to Climate Impact - SNICI

For putting the foods nutrient density index in relation to its climate impact, a similar method was applied as the one used by Smedman et al. (2010), called Swedish Nutrient Index in Relation to Climate Impact (hereon SNICI), here applying the nutrient density score from the new index. The nutrient density score of a food item was divided by the number of grams CO₂e in 100 grams of the food item. The calculated number will then be a score for the food items nutrient density in relation to its climate impact. The higher the score, the healthier and climate friendly/sustainable the food item is.

Data on the food items’ climate impact, described as kg CO₂e per kg product was derived from Mat-klimat-listan 1.1 by Röös (2017) (appendix 1). Numbers were however updated with the latest characterization factors from IPCC.
4.4. Database for food items’ nutrient content

For collecting data on the food items’ nutrient content, the Swedish Food Composition database, from the Swedish National Food Agency was used. This database provides information on the nutritional composition of 2090 foods and dishes, more than 50 nutrients are presented for each food data. This database is updated continuously and the nutrients which are specified in NNR 2012 are prioritised in the data (National Food Agency, 2015).

4.5. Reference person

In order to calculate a nutrient index, a reference person is needed to base the calculations on. That is, a made-up person with made-up age, weight, activity level and energy level. When these levels are decided, the reference person’s requirements for macro- and micronutrients can be estimated and the index can then be calculated on these requirements which in this thesis are supposed to reflect an ‘average person’ in Sweden. The reference person for the calculations was obtained by calculating mean values for men and women, 18-30 years old, this age group was chosen since they have the highest nutrient requirements. This approach was chosen since the method also will include data from a nationwide survey on the Swedish population’s food consumption called Riksmaten (2012). From Riksmaten, the mean intake values for all participants were used.

More precisely, the reference person’s nutritional requirements were obtained by taking the weight, PAL*, and energy demand for a ‘mean’ woman in Sweden, and the same was done for a ‘mean’ man in Sweden. Thereafter, mean values for weight, PAL and energy demand were calculated to get the average values of a man/woman in Sweden. Data was obtained from NNR 2012 (Nordic council of ministers, 2014). The recommended values of saturated fat and protein were calculated based on the reference person’s weight, PAL and energy demand (Table 4).

<table>
<thead>
<tr>
<th>Reference person</th>
<th>Weight</th>
<th>Physical Activity Level (PAL)</th>
<th>Energy demand (kcal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Man/Woman, 18-30 years</td>
<td>70.2 kg</td>
<td>1.6</td>
<td>2525</td>
</tr>
</tbody>
</table>

4.6. Choice of nutrients

In the SNI, we chose to include as many nutrients as possible as we wanted the index to reflect ‘healthiness’ accurately. The choice of which nutrients to include in the index was made based on the nutrients of which specified information existed in both Riksmaten, NNR 2012 and the food data base. 18 nutrients to encourage met these criteria and the highest requirements for each nutrient was chosen. The index includes both nutrients to encourage and nutrients to limit due to the results that these types of indices performs better than indices based on nutrients to limit only (Drewnowski & Fulgoni, 2014). The nutrients to limit are chosen based on NNR 2012 which claims that sodium, sugar and saturated fat should be consumed in limited amounts due to the risk of their contribution to NCDs (Nordic Council of Ministers, 2014). The included nutrients to encourage and the included nutrients to limit are presented in Table 5 and 6 along with the mean intake of these nutrients in Sweden from Riksmaten, the Nordic nutritional recommendations for these nutrients and the weighting factors. The weighting factors are further explained in section 4.7.

* Physical Activity Level.
Table 5. Mean intakes of nutrients to encourage in Sweden from Riksmaten, NNRs “highest” recommendations of the nutrients to encourage, the weighted factor 1 for nutrients to encourage. Calculated as NNR/Riksmaten.

<table>
<thead>
<tr>
<th>Riksmaten “all”</th>
<th>NNR 2012 “highest recommendation”</th>
<th>Weighting Factor 1 [NNR/Riksmaten]</th>
<th>Nutrient</th>
</tr>
</thead>
<tbody>
<tr>
<td>81</td>
<td>70.2</td>
<td>0.87</td>
<td>Protein (g)</td>
</tr>
<tr>
<td>19.1</td>
<td>25</td>
<td>1.31</td>
<td>Fibre (g)</td>
</tr>
<tr>
<td>821</td>
<td>900</td>
<td>1.10</td>
<td>Vitamin A (RE)</td>
</tr>
<tr>
<td>7</td>
<td>10</td>
<td>1.43</td>
<td>Vitamin D (µg)</td>
</tr>
<tr>
<td>12.4</td>
<td>10</td>
<td>0.81</td>
<td>Vitamin E (mg)</td>
</tr>
<tr>
<td>1.2</td>
<td>1.4</td>
<td>1.17</td>
<td>Thiamine (mg)</td>
</tr>
<tr>
<td>1.5</td>
<td>1.7</td>
<td>1.13</td>
<td>Riboflavin (mg)</td>
</tr>
<tr>
<td>95</td>
<td>75</td>
<td>0.79</td>
<td>Vitamin C (mg)</td>
</tr>
<tr>
<td>2</td>
<td>1.5</td>
<td>0.75</td>
<td>Vitamin B6 (mg)</td>
</tr>
<tr>
<td>5.5</td>
<td>2</td>
<td>0.36</td>
<td>Vitamin B12 (µg)</td>
</tr>
<tr>
<td>259</td>
<td>400</td>
<td>1.54</td>
<td>Folate (µg)</td>
</tr>
<tr>
<td>10.4</td>
<td>15</td>
<td>1.44</td>
<td>Iron (mg)</td>
</tr>
<tr>
<td>875</td>
<td>800</td>
<td>0.91</td>
<td>Calcium (mg)</td>
</tr>
<tr>
<td>3.119</td>
<td>3,500</td>
<td>1.12</td>
<td>Potassium (mg)</td>
</tr>
<tr>
<td>331</td>
<td>350</td>
<td>1.06</td>
<td>Magnesium (mg)</td>
</tr>
<tr>
<td>46</td>
<td>60</td>
<td>1.30</td>
<td>Selenium (µg)</td>
</tr>
<tr>
<td>10.8</td>
<td>9</td>
<td>0.83</td>
<td>Zinc (mg)</td>
</tr>
<tr>
<td>35</td>
<td>18</td>
<td>0.51</td>
<td>Niacin equivalents</td>
</tr>
</tbody>
</table>

Table 6. Mean intakes of nutrients to limit in Sweden from Riksmaten, NNRs maximum recommended value, the weighted factor 2 for nutrients to limit. Calculated as Riksmaten/NNR

<table>
<thead>
<tr>
<th>Riksmaten “all”</th>
<th>NNR 2012 “maximum recommendation”</th>
<th>Weighting factor 2 [Riksmaten/NNR]</th>
<th>Nutrient</th>
</tr>
</thead>
<tbody>
<tr>
<td>88</td>
<td>90*</td>
<td>0.98</td>
<td>Sugar (g)</td>
</tr>
<tr>
<td>3,118</td>
<td>2,400</td>
<td>1.3</td>
<td>Sodium (mg)</td>
</tr>
<tr>
<td>30</td>
<td>28.06</td>
<td>1.07</td>
<td>Saturated Fat (g)</td>
</tr>
</tbody>
</table>

Due to lack of information about added sugar in the food data base, the index includes total amount of sugar. The reference value of 90 g sugar is taken from Livsmedelsförägten (2014). The Swedish consumption of sugar from Riksmaten is in the calculations counted as the sum of the consumed sugars mono- and disaccharides. The recommended value of saturated fat in grams was calculated from the recommendation of <10E% of saturated fat per day. Protein was calculated from the recommendations of a daily intake of 0.8-1.5 g of protein per kilo body weight. The value of 1 g per kg body weight was chosen since this value will ensure a sufficient intake of protein for our reference person of 70.2 g per day. Moreover, as protein sources often have a large climate impact (Ranganathan et al., 2016) an amount of protein in the lower range was chosen.
4.7. Weighting factor

Two weighting factors, one for nutrients to encourage and one for nutrients to limit, were used to reflect current limitations in Swedish food consumption patterns in the index so that the included nutrients are weighed in proportion to how important an increased or decreased consumption of the nutrient is. The weighting factor for nutrients to encourage was created by taking the recommended daily value of each nutrient, from NNR 2012, and dividing it by the value on current intake from Riksmaten, hence reflecting how well the intake of the Swedish population is in line with the Nordic nutritional recommendations. For the nutrients to limit, the weighting factor is calculated by taking the value on intake from Riksmaten which reflects how much the Swedish population consume of each nutrient to limit daily, and divide it by the maximum recommended value of each nutrient, based on NNR 2012. This then reflect how much over or under the maximum recommended daily values the Swedish population consume of these nutrients. The different values from Riksmaten, NNR 2012 and the weighting factors are presented in Table 5 and 6.

For the weighting factor for nutrients to encourage, a number above 1 means that the Swedish population do not eat enough if this nutrient, consumption ought to increase. A number below one means that the Swedish population eat according to recommendations or more. For the weighted factor for nutrients to limit, a number above 1 means that the Swedish population eat too much of this nutrient and consumption should decrease. A number below 1 means that they eat according to recommendations or less.

4.8. No cap and no demand for certain percentage of recommended daily value

For this study, it has been decided that the values will not be capped at 100% of recommended daily allowance. This because this study looks at single food items, and the recommended daily values for nutrients are expressed as amount per day but refers to the average intake from the diet for a longer period, for example a week (National Food Agency, 2016a). Moreover, the RDA is not an upper recommendation limit (Saarinen et al., 2017), decreasing the importance of capping nutrients.

In a study of Smedman et al. (2010), the nutrients in a food item had to provide >5% of the recommended daily value to be included in the index. Here it was decided not to include this criterion since nutrients are valuable even if they come in a small amount in certain food items.

4.9. The basis of the calculations

For nutrients to encourage the basis will be 100 kcal and for nutrients to limit the basis will be 100 g. This was decided due to the recommendation from Drewnowski et al. (2009) that it might be preferable to use 100 g as a basis for the nutrients to limit and 100 kcal for nutrients to encourage since it is more consistent with EU food labeling systems. Moreover, in Sweden, overweight and obesity is one of our most serious public health issues (National Food Agency, 2016b), to include the food items energy density in the index seems therefore reasonable. In our evaluation, it was found that if 100 g is the basis for both nutrients to encourage and nutrients to limit, then the sub-score for nutrients to encourage can get very large, especially for nutrients which are energy dense. These food items, which often are eaten in smaller amounts gets unjustly high scores when they are based on 100 g rather than 100 kcal. If both scores on the other hand are calculated with 100 kcal as a basis, the sub score for nutrients to limit tend to get very low in comparison to the sub score for nutrients to encourage. This because the sub score for nutrients to limit is lower to begin with as it only includes three nutrients, to additionally divide this already small number with the food items energy density results in a low sub score for nutrients to limit.
4.10. Algorithm

The sub scores for both nutrients to encourage and to limit are expressed as sums, i.e. the sub scores are not divided by the number of nutrients considered in the calculations. This decision was made since we found the values to be distributed more reasonable and more spread out and it was easier to see a difference between healthy and unhealthy food items. For example, taking the mean of the sub-scores for nutrients to encourage and to limit means that both scores will be valued alike. Also, many nutrient profiling models are designed accordingly (Fulgoni et al., 2009; Drewnowski, 2009; Drewnowski, 2010; Drewnowski & Fulgoni 2014; Röös et al., 2015). Nutrient profiling scores are usually calculated by subtracting sums or means of both sub scores, or by calculating a ratio between the means (Drewnowski et al., 2009), in this index the sub score for nutrients to limit is subtracted from the sub score of nutrients to encourage to obtain the final nutrient score since this is the most commonly used, and preferred design option (Drewnowski, 2009; Sluik et al., 2015).

The algorithm is calculated as shown in Figure 1 and 2. The amount of each nutrient to encourage [nutrient_e] in a food item is multiplied by the weighting factor for that nutrient. Thereafter this value is divided by the RDA from NNR for this nutrient. This is thereafter multiplied by 100 and divided by the number of kcal in the specific food item. Then, this is done for all 18 included nutrients to encourage, and the value for all the nutrients to encourage [nutrient_e] are summed and then multiplied by 100 to obtain the sub score for nutrients to encourage.

\[
1. \left( \frac{\text{nutrient}_e \times \text{weighted factor 1}}{\text{RDA}} \right) \times \frac{100}{E_i}
\]

\[
2. \sum \text{nutrients} \times 100
\]

Fig. 1. Algorithm for nutrients to encourage, to calculate the sub score for nutrients to encourage

For the nutrients to limit, the amount of each nutrient [nutrient_l] is multiplied by the weighting factor 2 for that nutrient. Thereafter, this value is divided by the maximum recommended value (MRV) for this nutrient and then multiplied by 100. This is done for all nutrients to limit, and then the values for all the nutrients to limit [nutrients_l] are summed together to obtain the sub score for nutrients to limit. To obtain the final SNI score, the sub score for nutrients to limit is subtracted from the sub score of nutrients to encourage.

\[
3. \left( \frac{\text{nutrient}_l \times \text{weighted factor 2}}{\text{MRV}} \right) \times 100
\]

\[
4. \sum \text{nutrients}_l
\]

Fig. 2. Algorithm for nutrients to encourage, to calculate the sub score for nutrients to encourage
4.11. Normalization and removal of food items with extreme values

When calculations were done, the values were normalized between 1-100. This was done to avoid negative numbers when calculating the nutrient index in relation to its climate impact. Certain food items obtained quite extreme values from the calculations where the highest values were found for offal such as liver due its high contents of mainly Vitamin A. These food items were all given the normalized value of 100. Some food items obtained extremely low values from the calculations due to high amount of a nutrient to limit, most often sodium, and that they contained none- or very few nutrients to encourage. The lowest values were found in food items such as stock cubes, salt, spice mixes, baking soda and yeast. These food items were all given the normalized value of 1.
5. Results

5.1. Evaluation of different alternatives

Table 7 presents a summary of the results from the evaluation of different alternatives to consider food’s nutrient content in a climate tax on food. The justification behind the scoring against the different criteria is presented in section 5.1.1-5.1.5.

Table 7. Evaluation of different alternatives to consider food’s nutrient content in a climate tax on food

<table>
<thead>
<tr>
<th></th>
<th>Nutrient index for single foods</th>
<th>Nutrient index for food groups</th>
<th>Nyckelhålet</th>
<th>Single foods</th>
<th>Single nutrients</th>
<th>Subventions on healthy food items</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capturing of “healthiness”</td>
<td>++</td>
<td>+</td>
<td>++</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Practical implementation</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Cost</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Transparency</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Credibility, scientific base</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
</tr>
<tr>
<td>Undesirable consumption</td>
<td>--</td>
<td>-</td>
<td>-</td>
<td>++</td>
<td>++</td>
<td>-</td>
</tr>
<tr>
<td>Risk for fraud</td>
<td>++</td>
<td>++</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Acceptance</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>++</td>
<td>+</td>
<td>++</td>
</tr>
</tbody>
</table>

5.1.1. Nutrient index for single foods

This alternative capture healthiness very well since it can include everything from 3 to over 20 nutrients in its calculation and as it can include both nutrients to encourage and to limit. Currently, this is one of the most detailed methods available to assess the composite nutrient quality of individual food items (WHO, 2011). To practically implement a method like this would however be difficult and demand considerable resources since all foods would be needed to be nutritionally analysed and then calculated according to a nutrient index method which someone needs to keep track on so that fraud and/or cheating doesn’t occur. Moreover, everything needs to be revised and updated when changes in recipes are done. This whole process will be very costly as only to analyse one food item costs about 25 000 SEK (Öhrvik, V. pers. Comm. 2017).

To create a nutrient index involves many different design choices which will affect the results; some foods will be favoured/disfavoured which could be perceived as unfair by some food producers as well as consumers as the belief of what consists a healthy diet varies. To create a transparent model would be relatively easy to achieve. The risk for undesirable consumption is perceived as low since all food items would be included in the scheme and therefore, both unhealthy and healthy food items would be taxed based on how nutritious they are. Also, food items with high climate impact will be taxed, and this combination of climate impact and nutrition ought to lead to a decreased consumption of
unhealthy foods with high climate impact and increased consumption of healthy food items with lower climate impact. Even if the design choices for the index are made transparently with scientific support this does not ensure that the index would be accepted by other parties as normative choices in the design of the index are inevitable.

5.1.2. Nutrient index for food groups

This method would not capture healthiness as well as an index for single food items as foods would be put in different food categories and be evaluated according to the average values in that category. An example can be seen in Table 8 on how the nutrient index can vary within a food group. This method would be considerably easier to implement than nutrient index for single foods, since a nutritional analysis on individual food items would not be necessary. Criteria as for what characteristics a food should contain in order to belong in a certain food group would need to be developed however, and this food group would need to be nutritionally analysed, however the Swedish Food database could be used here to obtain food’s nutritional content which would decrease costs. Costs would also arise as it is a new method which would need to be administratively implemented. The issue of transparency is the same as for an index for single foods and the acceptance and credibility might be lower for this method since food items can vary a lot within a food group as can be seen in Figure 3 where some dairy products’ nutrient index (SNI) is shown. Nonetheless, climate data from LCAs is usually presented for food groups (see appendix 1). To use food groups when including nutrition in a climate tax might then be consistent with how LCA data on food is handled as it would be analysed on the same level as the climate impact. It could be more difficult to find scientific support for this method as food items with e.g. a high sugar content could be valued the same as a food item without sugar e.g. for different types of breakfast cereals. The risk for fraud could be high for this method as food producers could try and manipulate their recipes in an unjustifiable way in order to fit in to a certain food group. But the nutritional data for the food groups and how this division would be done could possibly be achieved by the Swedish national food agency and thereby decrease the risk for fraud.

Fig. 3. Variations in nutrient index for the food group “dairy products”, based on a calculation of SNI.
5.1.3. Nyckelhålet

This method captures healthiness well, although it does not include micronutrients. Some food items which do not fulfill the criteria for the food group they belong to, to be labelled with Nyckelhålet could still get a high nutrient index, for example semi-skimmed milk with 1.5% fat gets a high index since it is fortified with Vitamin D and contains other healthy nutrients. It does however not meet the Nyckelhålet criteria due to its ‘high’ fat content. Another example is the bread-spread liver pâté which gets a high nutrient index but can only be labelled with Nyckelhålet if it has less than 10 g of fat per 100 g product (LIVSFS 2005:9).

For some other foods, like potato chips, it could be favourable to use Nyckelhålet, and not include micronutrients because potato chips get a relatively high index due to its high content of potassium, Vitamin C and calcium but could not get labelled with Nyckelhålet due to its high content of fat and salt. In Figure 4 an example is shown on which products that could be labelled with Nyckelhålet and not. Potatoes can be labelled as it’s a non-processed root vegetable, skimmed milk can be labelled as it only has 0.5% fat, and liver pâté light can be labelled as it has a lower fat content than the normal liver pâté.

It should also be mentioned that food products for children up to 36 months are not allowed to be labelled with Nyckelhålet (LIVSFS 2005:9), these foods would then need to be considered separately, and perhaps be exempt from the climate tax. The practical implementation would be easier than for nutrient indices since Nyckelhålet already exists for labelling healthier food options and supermarkets already keep track of which products that are labelled with Nyckelhålet in their computer systems (Karlsson, C. pers. Comm. 2017). It is scientifically based and follows dietary guidelines which gives it good credibility and, hopefully, acceptance. Since foods with a high amount of saturated fat, sodium or sugar cannot be labelled with Nyckelhålet a tax system which excludes products labelled with Nyckelhålet might lead to healthier consumption and not to undesirable consumption. As the foods’ climate impact will be taxed as well, the risk for unwanted consumption decreases even more as food items which can not be labelled with Nyckelhålet would get a tax based on their climate impact, penalising food items with high GHG emissions. An issue could however arise for unhealthy food items with low GHG emissions. The risk for fraud is perceived to be smaller than for the first two alternatives as existing rules as to which food items that can be labelled with Nyckelhålet already exists (LIVSFS 2005:9), this is however dependant on how unlabelled food items will be taxed.
Fig. 4. Example of some products which can and cannot be labelled with Nyckelhålet. The green columns show that the food item can be labelled.

5.1.4. Single foods and single nutrients

This alternative would not capture healthiness as well as the other methods. For this alternative, the focus is on one nutrient or on one product (e.g. sugary beverages). Other unhealthy nutrients or products would still be untaxed, e.g. if soda were to be taxed, unhealthy products like candy would cost the same as before. Practical implementation would be easier than for a tax based on nutrient indices since only a limited number of products would be affected leading to a less complicated and costly system. Moreover, it would be cheaper to implement a tax on i.e. sugared beverages than on sugar as a tax on sugar would affect all food items containing a certain level of sugar and a tax on sugary beverages would only affect the specific food group ‘sugary beverages’. Depending on which food items that would be included, the credibility could be high and supported by scientific evidence. Transparency ought to be easily achieved. A tax on for example sugared beverages could however, lead to unwanted consumption of other products with high levels of e.g. sodium and/or saturated fat. Some of the undesirable consumption could be avoided as the climate impact would be included in the tax and thereby giving food items such as dairy and meat products, high in saturated fat a higher tax rate due to their high emissions of GHG (Wirsenius et al., 2011; Säll & Gren, 2015).

There is an important distinction between saturated fat and sugar in this context; products rich in saturated fat, i.e. meat and dairy also cause high emissions of GHG and sugar has a low climate impact. Hence, it might be more important to tax sugar in parallel with a climate tax on food to avoid unwanted consumption. The risk for fraud is perceived as quite small for this alternative as it would be easier to monitor the calculations and practical steps that needs to be done for the food products before a tax rate can be levied on it. Nonetheless, it would most likely be easier to cheat if a tax on one nutrient would be implemented, as producers and manufacturers could perhaps go around the system when registering the amount of e.g. sugar in their products.
5.1.5. Subsidies on healthy food items

This method would capture only healthiness in the affected products affected by the subsidy. Fruits and vegetables have support from the Swedish National Food Agency (National Food Agency, 2017c) and from NNR 2012 (Nordic Council of Ministers, 2014) as both these sources claim that we should eat more fruit and vegetables. Products within this food group could therefore be suggested to have a comprehensive scientific base, and therefore a good reason to be subsidised. The idea is that a food group (i.e. fruits and vegetables) would be classified as healthy and obtain a subsidy in parallel with an implementation of a climate tax. This can be done transparently and the acceptability is likely to be good. Fewer products would probably be affected by a subsidy leading to a less complicated and less costly practical implementation than for the more complex alternatives. The risk for fraud decreases in a less complicated system as well. Subsidies on healthy foods could be a good compliment to a climate tax and a tax on unhealthy products decreasing potentially the risk of unwanted consumption (WHO, 2015). How the climate tax would be levied on the subsidised products would need further investigation.

5.2. The new Swedish nutrient index

The results from the calculations of the new index in relation to climate impact is shown in Table 8 for a few food items selected to give a good illustration of how the SNICI plays out for different foods. In the first column, different food categories can be seen, for example ‘Animal products’, under each category some food items are shown, i.e. bacon, sausage, etc. and in the second row their nutrient density score (SNI) is presented. In the third column, the amount of emissions calculated as kg CO\textsubscript{2}e per kg food product is shown. In the last column, the calculation of the foods nutrient profile in relation to its climate impact (SNICI) is presented, calculated as [Nutrient density/ g of CO\textsubscript{2}e per 100 g].

**Table 8.** Results of certain food items’ SNI, emissions of GHG, and the SNICI

<table>
<thead>
<tr>
<th>Food Category</th>
<th>Nutrient density (SNI)</th>
<th>CO\textsubscript{2}e (kg/kg product)</th>
<th>SNICI (SNI/ g of CO\textsubscript{2}e per 100 g product)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ANIMAL PRODUCTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bacon</td>
<td>14.60</td>
<td>10</td>
<td>0.01</td>
</tr>
<tr>
<td>Sausage (falukorv)</td>
<td>15.76</td>
<td>10</td>
<td>0.02</td>
</tr>
<tr>
<td>Minced meat 50/50</td>
<td>21.59</td>
<td>21</td>
<td>0.01</td>
</tr>
<tr>
<td>Chicken breast filé</td>
<td>28.21</td>
<td>3</td>
<td>0.09</td>
</tr>
<tr>
<td>Liver pâté</td>
<td>35.42</td>
<td>10</td>
<td>0.04</td>
</tr>
<tr>
<td>Liver (pig)</td>
<td>100.00</td>
<td>7</td>
<td>0.14</td>
</tr>
<tr>
<td>Liver (cow)</td>
<td>100.00</td>
<td>35</td>
<td>0.03</td>
</tr>
<tr>
<td>RICE, PASTA, POTATO, LEGUMES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pasta</td>
<td>18.86</td>
<td>0.8</td>
<td>0.24</td>
</tr>
<tr>
<td>Basmati rice</td>
<td>18.96</td>
<td>2</td>
<td>0.09</td>
</tr>
<tr>
<td>Pasta (whole grain)</td>
<td>20.97</td>
<td>0.8</td>
<td>0.26</td>
</tr>
<tr>
<td>Potato</td>
<td>23.47</td>
<td>0.1</td>
<td>2.35</td>
</tr>
<tr>
<td>Chickpeas (dried)</td>
<td>24.93</td>
<td>0.7</td>
<td>0.36</td>
</tr>
<tr>
<td>DAIRY PRODUCTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Double cream (40% fat)</td>
<td>13.34</td>
<td>5</td>
<td>0.03</td>
</tr>
<tr>
<td>Food</td>
<td>% fat</td>
<td>% protein</td>
<td>% carbohydrates</td>
</tr>
<tr>
<td>-----------------------------</td>
<td>-------</td>
<td>-----------</td>
<td>-----------------</td>
</tr>
<tr>
<td>Hard cheese (38% fat)</td>
<td>14.36</td>
<td>10</td>
<td>0.01</td>
</tr>
<tr>
<td>Sour cream</td>
<td>18.28</td>
<td>2.5</td>
<td>0.07</td>
</tr>
<tr>
<td>Fruit yoghurt</td>
<td>19.73</td>
<td>1.2</td>
<td>0.16</td>
</tr>
<tr>
<td>Yoghurt (0.5% fat)</td>
<td>25.83</td>
<td>1.2</td>
<td>0.22</td>
</tr>
<tr>
<td>Milk (0.5% fat)</td>
<td>28.19</td>
<td>1.2</td>
<td>0.23</td>
</tr>
<tr>
<td>FRESH FRUIT</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apple</td>
<td>20.80</td>
<td>0.2</td>
<td>1.04</td>
</tr>
<tr>
<td>Banana</td>
<td>21.44</td>
<td>0.6</td>
<td>0.36</td>
</tr>
<tr>
<td>Orange</td>
<td>28.44</td>
<td>0.6</td>
<td>0.47</td>
</tr>
<tr>
<td>Lemon</td>
<td>30.20</td>
<td>0.6</td>
<td>0.50</td>
</tr>
<tr>
<td>Strawberries</td>
<td>34.23</td>
<td>0.6</td>
<td>0.57</td>
</tr>
<tr>
<td>FRESH VEGETABLES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Avocado</td>
<td>20.44</td>
<td>1.4</td>
<td>0.15</td>
</tr>
<tr>
<td>Cabbage</td>
<td>34.71</td>
<td>0.2</td>
<td>1.74</td>
</tr>
<tr>
<td>Tomato</td>
<td>36.07</td>
<td>1.4</td>
<td>0.26</td>
</tr>
<tr>
<td>Carrot</td>
<td>39.73</td>
<td>0.2</td>
<td>1.99</td>
</tr>
<tr>
<td>Broccoli</td>
<td>53.09</td>
<td>1.4</td>
<td>0.38</td>
</tr>
<tr>
<td>CEREALS AND FLOUR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wheat flour</td>
<td>19.03</td>
<td>0.6</td>
<td>0.32</td>
</tr>
<tr>
<td>Sifted rye flour</td>
<td>20.42</td>
<td>0.6</td>
<td>0.34</td>
</tr>
<tr>
<td>Bulgur</td>
<td>20.70</td>
<td>0.6</td>
<td>0.35</td>
</tr>
<tr>
<td>Rye flour whole grain</td>
<td>21.25</td>
<td>0.6</td>
<td>0.35</td>
</tr>
<tr>
<td>Oat meal</td>
<td>21.36</td>
<td>0.6</td>
<td>0.36</td>
</tr>
<tr>
<td>FISH AND SHELLFISH</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Smoked caviar (Kalles)</td>
<td>10.58</td>
<td>3</td>
<td>0.04</td>
</tr>
<tr>
<td>Pickled herring (matjesill)</td>
<td>15.96</td>
<td>3</td>
<td>0.05</td>
</tr>
<tr>
<td>Cod</td>
<td>30.85</td>
<td>3</td>
<td>0.10</td>
</tr>
<tr>
<td>Plaice</td>
<td>31.30</td>
<td>3</td>
<td>0.10</td>
</tr>
<tr>
<td>Salmon (farmed)</td>
<td>25.63</td>
<td>3</td>
<td>0.09</td>
</tr>
<tr>
<td>OILS AND FATS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coconutfat</td>
<td>1.00</td>
<td>1.5</td>
<td>0.01</td>
</tr>
<tr>
<td>Butter</td>
<td>7.50</td>
<td>10</td>
<td>0.01</td>
</tr>
<tr>
<td>Butter (unsalted)</td>
<td>15.04</td>
<td>10</td>
<td>0.02</td>
</tr>
<tr>
<td>Rape seed oil</td>
<td>16.20</td>
<td>1.5</td>
<td>0.11</td>
</tr>
<tr>
<td>Butter and rapeseed oil</td>
<td>17.17</td>
<td>5.75</td>
<td>0.03</td>
</tr>
<tr>
<td>liqu (liquid)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PAISTRIES, CANDY, SNACKS ETC.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chocolate bar (Marabou</td>
<td>13.25</td>
<td>2</td>
<td>0.07</td>
</tr>
<tr>
<td>schweizernut)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chocolate ball</td>
<td>14.03</td>
<td>2</td>
<td>0.07</td>
</tr>
<tr>
<td>Chips (flavoured)</td>
<td>14.77</td>
<td>2</td>
<td>0.07</td>
</tr>
<tr>
<td>Ice cream</td>
<td>16.86</td>
<td>2.4</td>
<td>0.07</td>
</tr>
</tbody>
</table>
When including the new nutrient index with climate impact, many results were affected; food items with the highest nutrient density score did not necessarily end up with the highest SNICI score.

The meat group contains the highest SNI scores as well as some lower scores. Liver had the highest nutrient density score of all food items and liver pâté also had a high score, mainly due to their extremely high values of Vitamin A. Their final score was however about the same as the other animal products because of the high climate impact of food items from lamb and cow. Among the meat products, chicken breast file has the second highest SNICI score due to its high nutrient index and quite low climate impact of 3 kg CO₂e per kg of food. In the meat group, effects of the weighting factor can be seen in liver and liver pâté mostly. This is due to their high content of Vitamin A, which has a weighting factor of 1.1, folate with a weighting factor of 1.54, and iron with a weighting factor of 1.44. The contents in the nutrients to limit are quite low as well in liver and liver pâté, although liver pâté contains more saturated fat than liver, resulting in a high final nutrient density score.

In the dairy group, certain food items with lower fat content and quite high water content got higher SNICI scores. This due to the relatively high nutrient index caused by the low contents in the nutrients to limit and the high amount of protein and calcium. Moreover, low-fat milk is fortified with Vitamin D. These products have the lowest climate impact of the different dairy products with 1.2 kg CO₂e per kg of food. Due to the weighting factor, the scores in the dairy group differ mainly by differences in Vitamin D, weighting factor 1.43. Saturated fat is weighted quite high with the factor of 1.07 resulting in high sub scores for nutrients to limit for food items with high contents of saturated fat such as cheese, double cream and sour cream.

In the group Rice, pasta and potato, potato gets one of the overall highest SNICI scores due to its broad nutrient content, low contents in the nutrients to limit and very low climate impact with only 0.1 kg CO₂e per kg of food. Dried chick peas were added in this group, and gets the highest final score of 0.36 of all the included, protein rich foods in Table 8.

The results of the fish group were affected by the weighting factor for nutrients to limit for the processed food items kaviar and pickled herring which had high values of sodium or saturated fat, both weighted high. Differences in the sub scores for nutrients to encourage was due to high contents of Vitamin A and D in salmon and cod and Vitamin D in plaice.

For oils and fats, the largest differences affected by the weighting factor was found in the sub scores for nutrients to limit. For example, coconut fat, a hardened fat, with almost only saturated fat in it got a very high negative score. Rapeseed oil was not as affected by the weighting factor due to its content of unsaturated fatty acids. Different kinds of butter had the same amount of saturated fat, the final SNI
was affected by varying salt content in the different butters, an effect amplified by the weighting factor for sodium which was 1.3. Adjustments in the SNI methods for food items with a very high content of fat might be considered. For example, in the original version of the SAIN/LIM method, for all food items with > 97% fat, i.e. oils, three additional nutrients were added to calculate the SAIN score (sub score for nutrients to encourage), Vitamin E, alfa-linolenic acid and monounsaturated fatty acids (Darmon et al., 2009).

In the group for fresh fruit, much of the differences in the SNI score depends on the amount of sugar in the fruit as well as the amount of Vitamin C which is the most prevalent vitamin in these fruits. The climate impact of fruit varies a little bit with strawberries, banana, lemon and orange having the highest climate impact with 0.6 kg CO$_2$e per kg of food. The weighting factor affect the results mainly due to different amounts of folate and potassium which are weighted high. The only nutrient to limit occurring in fruit is sugar. If sugar was weighted higher (here 0.98) the different amount of sugars in fruit would have an even larger impact on the results.

In the group for fresh vegetables, broccoli gets a high nutrient density score due to high amount of Vitamin A, Vitamin C, Iron, Folate and Calcium. The final SNICI score depends mainly on whether the vegetables are imported or not as this results in higher GHG emissions from transport and production. Vegetables such as carrot and cabbage gets a climate impact on 0.2 kg CO$_2$e per kg of food, resulting in a higher SNICI score. The food items with higher amount of Vitamin C did not result in extra high positive sub score as it has the weighted factor of 0.79. Avocado was the only vegetable affected negatively by the weighting factor due to its content of saturated fat.

The group of pastries, candy snacks etc. contain cookies, chocolates, buns, cakes, sugar, honey, syrup and ice-cream. Popcorn got the climate value for corn – or imported salad greens (1.4 kg CO$_2$e per kg of food) and obtained the highest final score mainly due its content of protein, fiber and Vitamin A and its low content of sodium, sugar and saturated fat.

In the group of different breads (hard and soft), differing fibre and sugar content was the main cause to differences in the final SNICI score. The hard bread ‘Wasa Husman’ stood out a bit however with almost three times as much fibre as ‘Lingongrova’ and the sifted rye-flour bread and almost nine times as high as the tortilla. Furthermore, the Lingongrova and the sifted rye-flour bread had much more sugar than the tortilla and the Wasa husman, and the tortilla had approximately doubled the amount of sodium than the other breads. All the bread types had the same climate impact of 0.8 kg CO$_2$e per kg of food leading to similar SNICI score for all breads with tortilla getting the lowest score of 0.21, and Wasa husman getting the highest score of 0.25.
6. Discussion

A tax on food based solely on foods’ climate impact would naturally penalise foods which cause high emissions of GHG during their life cycle. This would include food items such as meat (mainly red meat) and other animal based foods such as egg and dairy products like cream, cheese and yoghurt (Röös, 2107). Food items with lower emissions such as root vegetables, legumes, bread, grains, cereals, flours, sugar (Röös, 2017) would be subject to a lower tax rate. Among food items with a larger climate impact there are some that could be argued to be healthy for us to eat, such as milk and smaller amounts of meat as these food items contain protein as well as important vitamins and minerals. However, there is only a small risk of obtaining negative health effects due to a decrease in consumed meat and dairy products as Europeans eat much more protein than needed (Westhoek et al., 2014), and minerals and vitamins can be derived from other food products. Amongst the food items with lower GHG emissions there are some unhealthy alternatives such as sugar, soda, juice, candy and chips. A climate tax alone might lead to an increased consumption of these foods, which might lead to unhealthier dietary patterns after an implementation of such a tax than before.

6.1. Considering nutrition in a climate tax on food

To reduce the risk of an increased consumption of unhealthy foods with low climate impact, which could occur if a climate tax alone was implemented, the inclusion of ‘healthiness’ is important. Even though it could be preferable to include nutrition in the form of a nutrient index, a taxation of a single nutrient such as sugar might be most important as it has been found that GHG emissions and ‘healthiness’ are inversely related when it comes to sugar (Briggs et al., 2016) and these kinds of taxes have been supported among health advocates (Mytton et al., 2014). It is argued that taxes on single nutrients such as saturated fat will decrease the consumption of the taxed nutrient but may also increase consumption of other unhealthy nutrients such as salt or sugar (Jensen & Smed, 2012). Similar effects have been acknowledged in several studies (Mytton et al., 2012; Mytton et al., 2014; Cornelsen et al., 2014; Thow et al., 2014; Niebyslki et al., 2015; WHO, 2015; Waterlander et al., 2016), which all stresses the importance of assessments and evaluation of health-related taxes before, during, and after implementation, something that would be required for a climate tax as well. If a tax on sugar would be implemented alongside a climate tax, products with high prevalence of saturated fat (e.g. red meat and dairy products) would be penalised by the climate tax due to their high GHG emissions (Wirsenius et al., 2011; Säll & Gren, 2015). This would hopefully avoid an increased consumption of saturated fat. It is suggested that alongside a tax on e.g. sugar and climate impact, subsidies on healthy foods such as fruits and vegetables should be implemented to decrease the outcome of unwanted consumption (Cornelsen et al., 2014). With overweight and obesity being a big problem in Sweden (National Food agency, 2016b), subsidies alone may not be the best solution since Epstein et al. (2012) found that subsidies on healthy food can result in an overall increase in energy intake. Moreover, the tax base and tax design needs to be thoroughly planned (Cornelsen et al., 2014), and here it would be important to analyse how the climate tax would affect certain health outcomes.

An important aspect which should be highlighted is that a tax which solely, or among other nutrients penalises sugar and/or fat could potentially negatively affect undernourished elderly which commonly needs energy dense foods to get enough energy – although other nutrients are of course also important for them (National Food agency, 2011). A tax might make some products too expensive for elderly to afford and some exception might be needed for this group.

If taxing single foods items, the definition of what constitutes a soda for example would be needed. Mexico implemented a tax on non-alcoholic beverages with added sugar (powder, concentrates or ready-to-drink) (WHO, 2015). This criterion is clear and the producers know that if they add sugar to their beverage it will be affected by the tax. Food producers could be tempted to change their recipes to get a lower tax rate. For example, natural fruit juice could be used as sweetener instead of added sugar. What the positive health effects of this would be as opposed to if pure sugar (if any) was added is unclear as there are no evidence suggesting that fructose is ‘healthier’ than sucrose (National food
Agency, 2016c). A positive example of changes in recipes can however be given from Hungary, where an assessment on the introduced ‘public health product tax’ (PHPT) based on sugar, salt and methylxantine content in food products, showed that 40% of food producers had reformulated their products, that 30% had removed undesired components completely in their products and 70% had decreased the quantity of undesirable components in their products (WHO, 2015).

For the nutrients sugar, sodium and saturated fat, there are scientific support, claiming that these nutrients are unhealthy to consume and that a too large consumption of these nutrients can lead to obesity, cardio-vascular diseases and other NCDs (Nordic Council of Ministers, 2014). These scientific findings are also something that the population widely acknowledges (Enghardt Barbieri, 2013). Nonetheless, establishing how the rates of obesity and other illnesses that are caused by these nutrients and how many that are caused by other factors is difficult (Andersson & Fransson, 2011).

As for nutrient indices, uncertainties include how well these reflect healthiness of a food item, and how a nutrient index should be designed so that it reflects ‘healthiness’ well for most foods. In nutrient indices, as the concept is designed today, the quality of nutrients and their bioavailability is not accounted for (van Kernebeck et al., 2013). For example, the protein quality and bioavailability of iron is higher in animal based foods than in plant based foods (Drewnowski & Fulgoni, 2008). By adding factors to account for nutrient quality and the varying importance of different nutrients, a nutrient index could account for these aspects.

The method used to include nutrition in a climate tax should not encourage overconsumption of protein as that has large environmental impacts; a capping of protein could be considered. Capping of other nutrients might also be preferred but literature on how overconsumption of specific nutrients affect people and the environment is limited (van Kernebeck et al., 2013). As discussed, nutrient indices are complex to design and several choices needs to be made when designing them (Drewnowski, 2009; Drewnoski & Fulgoni, 2014). WHO states the need for a good nutrient profile model and are in the process of creating one (WHO, 2015). If a transparent and scientifically based model could be created to use on a global scale it might be easier to get acceptance for nutrient indices, and thereby to use for food taxation. Since nutritional status differs between countries it might be difficult to create a global nutrient index, suited for all countries. Inclusion and/or weighting of different nutrients depending on countries’ specific nutritional needs would be preferable. To understand the context of where the tax will be implemented is of big importance (Mytton et al., 2014).

All methods to include the nutritional value of food in a climate tax considers the nutrient content of food, however it is uncertain how well the method captures the ‘healthiness’ of food. Consumers will buy a range of food items which constitutes a certain diet. It is the ‘healthiness’ of this diet, rather than individual food, that is important in the long run. However, a healthy diet consists of food items with a sufficient number of nutrients which are essential for the body’s well-being (Nordic Council of Ministers, 2014), and then we’re back at the importance of single nutrients again. To conclude, it’s important to look at the issue of healthy diets on the nutrient, food item and diet level.

It is crucial to thoroughly assess the effects and well prepare the implementation of a climate tax on food which includes nutrition. Denmark’s introduction of a tax on saturated fat is a good example of an unsuccessful tax implementation, where its unpopularity, lack of political support and suspected negative effects on the industry forced the tax to be retracted less than a year from its introduction (Vallgårda et al., 2014). This shows that even if the methods have scientific evidence backing up the usage of them in a climate tax, it is uncertain whether the population would accept them (Mytton et al., 2014). Hence, public support, and support from key actors is an important factor to consider. It is also necessary to clearly communicate that the tax is implemented to improve health for the population and

*Methylxantine is a substance that affect not only the airways but stimulate heart rate, force of contraction, and cardiac arrhythmias at high concentrations.
to decrease emissions of GHG from the food system (Cornelsen & Carreido, 2015). To implement another excise duty in Sweden might be more accepted compared to such an introduction in other countries since there are already several other similar duties although people are generally negative towards taxes (Swedish Tax Agency, 2013). Politically, excise duties on food is a sensitive subject. Research suggests that knowledge about the climate impact of food is small among consumers (Shi et al., 2016) and that it is a touchy subject do ‘decide’ what people should put on their plates (Hederos, 2017). However, only information about healthy and climate friendly food is not effective enough to lead to improved health for people and environment (Garnett et al., 2015). A tax might be accepted if it can create an awareness of health dangers (Taxclimate.com, 2017) and facilitate a healthier food consumption, something at least a half of the Swedish population seems to be interested in according to a study by Nordström (2015), but this means that there’s also a large part who does not want to know the health- and environmental outcomes of the food they eat. Perhaps people would be more accepting of a climate tax that also includes nutrition as it otherwise could be argued that one of the main purposes of food - to provide us nutrition - is lost.

6.2. Practical implementation and cost of a climate tax on food which includes nutrition

Unfortunately, the capturing of healthiness does not correspond with how easily the alternatives could be practically implemented. Methods which capture healthiness best per food item is the ones which would be most complicated to implement, thereby methods including nutrient indices would be most complicated to implement. As this would be done in relation to climate impact there will be even more steps in this process. Nyckelhålet would then be the method which best captures healthiness and its implementation would be easier than using nutrient indexes as it’s already an established certification. At all Swedish retail stores, all products which are to be entered in the store’s system needs to be filled in certificate form with includes a marking for whether the food can be labelled with Nyckelhålet or not. The form needs to be filled in for food which is not labelled with Nyckelhålet as well (GS1 Sweden, 2017). However, this is not a very safe system as companies can fill this out wrongly and it is not sufficiently supervised (Karlsson, C. pers. Comm. 2017). Nonetheless, as a system already exists for retail stores as of how to certify specific food products with e.g. Nyckelhålet when they reach the supermarket, an inclusion of a tax within this system may not be too complicated to implement. Then an addition in the system for different foods’ climate impact would be needed to set the tax rate for climate impact. If single nutrients would be taxed it would be necessary to have a sound method to determine how much saturated fat, sugar or sodium different products contains. When Denmark introduced a saturated fat tax they needed to provide food producers and manufacturers with comprehensive information as how to establish how much saturated fat different products contained (Smed, 2012). For example, if an implementation will take place it needs to be ensured that sufficient capacity for monitoring and enforcement is available and that other policies concerning the food system does not go against or compete with the new one (WHO, 2015).

The cost can be assumed to go hand in hand with practical implementation, the more complicated a method would be to implement, the costlier it would most likely be. To analyse vitamins is most expensive as it is most labour intensive (approximately 2,000 SEK per vitamin, compared to 1,000-1,500 SEK for all minerals). Macronutrients costs around 1,000 SEK and to obtain data on more fatty acids and types of carbohydrates would cost a bit more. So, the total amount for one food product would be around 25,000 SEK (approximately 2500€), depending mainly on how many vitamins that are analysed. Additionally, there is a cost for test preparations, pooling, homogenization, quality control of data and all calculations and more things (Öhrvik, J. pers. Comm. 2017). Additionally, the cost to implement and analyse foods’ climate impact will arise. It is important that a cost-benefit assessment is performed before implementation to see if the expected health gains would way up the costs (Cornelsen et al., 2014). However, public health improvements have been proven to lead to large economic gains (Sælensminde et al., 2016; WHO, 2015). For example, NDCs, which are caused mainly by unhealthy lifestyles cost billions of dollars yearly globally (Niebylski et al., 2015). Excise
duties is one way of correcting for market failure (Mytton et al., 2012) which is currently used for influencing alcohol and tobacco consumption in many countries. Therefore, in theory it should be possible to implement an excise duty also on food.

6.3. Discussion of the new nutrient index - SNICI

6.3.1. Included nutrients

The index that was created in this study, the SNICI, includes 18 nutrients to encourage and three nutrients to limit. It could be argued that fewer number of nutrients could be used and the index could still capture the ‘healthiness’ of food (WHO, 2011). For example, included nutrients could be limited to nutrients which play an especially important role in the diet of the Swedish population, that is nutrients that we eat to little or too much of. An index with fewer nutrients would be less expensive and complicated to implement as it would require less analysis of nutrients in food. However, here we wanted to design an index as accurate as possible, and with the weighting factor included in this index as an adjustment to the various importance of different nutrients we found it justified to include as many nutrients as possible. However, we acknowledge that future research should replicate the method with varying amounts of nutrients in order to establish the minimum set necessary.

In the Nordic nutrition recommendations, a maximum daily value for how much added sugar we should eat exists. This recommendation is that <10% of the daily diet should come from added sugar (Nordic Council of ministers, 2014). In the food data base, information of which sugars that are added is not evaluated due to the complexity of those kind of calculations, and there’s no maximum daily value in NNR for how much we should eat of the sugars mono- and disaccharides – only for added sugar. Therefore, the daily reference value of 90 grams of sugar was chosen from Livsmedelsföretagen (2014). The amount of added sugar in the analysed food items could have been estimated according to the methodology proposed by Louie et al. (2015). However, the restricted time available for this study did not allow this somewhat complex calculation. Future studies could advantageously use this approach to avoid over or under estimation of sugar levels and intakes. To this study’s advantage, using total sugar instead of added sugar in the calculation has been shown to be a reasonable option in other studies (Sluik et al., 2015)

6.3.2. The weighting factor

A weighting gives additional weights to nutrients that the population eats too little or too much of. Nonetheless, it does complicate the index and if a nutrient index as the one proposed in this thesis would be implemented, it would mean that the weighting factor would need to be revised as new data arrives on how the Swedish population eats. More importantly, as food intake and requirements vary between people, the weighting factor may not be representative for everyone.

6.3.3. To cap the values or not

Some of the nutrient indices described in the theoretical framework capped the content in the included nutrients at 100% of recommended daily allowance so that no nutrients would get overly high scores and be favoured in a sense if they contained more than 100% of RDA (Arsenault et al., 2012; Drewnowski & Fulgoni, 2014). The choice of capping the values at 100% of RDA or not would of course only affect those food items which contains more than 100% of the RDA for one or more nutrients. This occurred for some food items and nutrients but did nonetheless affect the results. But since the recommended daily allowances are guidelines as to what should be consumed of certain micronutrients within approximately one week (National Food Agency, 2016c), it was reasonable to not cap the nutrients at 100% of RDA in this index. In this study, certain foods had extremely high or low indexes and these were removed from the normalisation and instead assigned the min and max
values of 1 and 100. This should not be needed if capping would have been applied. But then, food items with high prevalence of certain nutrients would not have profited from their nutrient content, even though it could be argued that a consumption of more than 100% of RDA would not be harmful. It would be interesting if future research investigated if it would be reasonable to cap the nutrients at a percent higher than 100 to include the flexibility of the RDAs. Then research would be needed on how (over)consumption of different nutrients affect our health, or if it does not affect our health. The findings would then most likely vary for different nutrients and to have varying cap percentages for the different included nutrients would maybe be needed. To my knowledge this has not been done in any studies of nutrient profiling models and nutrient indexes and could be interesting to explore.

6.3.4. Unjustified fortification

Some arguments for capping the nutrients at 100% mean that otherwise, food producers could be tempted to unjustifiable fortify food products to obtain higher scores from the nutrient index (Arsenault et al., 2012). This issue should be acknowledged, and if an index does not cap the food item’s nutrient contents at 100% of RDA, other regulations or controls might be needed to ensure that unsupported fortification does not occur. Perhaps other guidelines would be needed as to distinguish ‘pure’ and fortified food from one another so that it wouldn’t be profitable to fortify a food if not needed. If it would be only negative to fortify more foods with nutrients which we need to eat more of, is on the other hand difficult to say. In Sweden, skimmed milk is fortified with Vitamin D as well as several margarines and other products (National Food Agency, 2016d). It could perhaps be argued that it would be more climate friendly to get your daily requirement of Vitamin D from e.g. fortified bread with a climate impact of 0.8 kg CO$_2$e per kg, than from products which naturally contains Vitamin D, such as fish which have a larger climate impact on 3 kg CO$_2$e per kg.

6.3.5. Allocation in LCAs

For liver products, climate data was used for the respective animals that the liver came from (i.e. cow and pig) due to the fact that liver cannot be produced in isolation from the complete animal. Liver is however a coproduct of meat production and if economic allocation is used in LCA (i.e. division of the emissions from e.g. pig production on pig meat and pig offal is done based on economic relationships) it has a lower climate impact than other meat parts of the same animal. For these kinds of products i.e. when a production process results in more than one product, the question arises as to how much of the overall environmental impact that is attributable to the product studied. Alternative allocation methods would have been interesting to include in our evaluation if time and resources to do it would have been available.

6.3.6. Comparison with results from previous studies

The results from our study on nutrient index in relation to climate impact is in alignment with that of other similar studies. The main part of the plant based foods got higher final SNICI scores than meat products (Garnett, 2011; Westhoek et al., 2011; Macdiarmid et al., 2012; Masset et al., 2014; Van Dooren et al., 2017). A few plant based foods; basmati rice, peanuts, cashew nuts and popcorn got lower final scores than liver from pig, which got the highest score of the meat products. As van Dooren et al. (2017), chick peas got the highest final score of the more protein rich food items. Also, we include a wider range of products in our study than other similar studies have done (Smedman et al., 2010; Macdiarmid et al., 2012), although a study by Drewnowski et al. (2015) includes 483 foods and beverages. As opposed to Smedman et al. (2010) study, this study included both nutrients to encourage and to limit in the nutrient index and included all amounts of nutrients in the food items while Smedman only included nutrients which had a higher prevalence than 5% of daily
recommended allowance in each food item, so the findings here cannot be justly compared with the ones in Smedman’s study.

Masset et al. (2014) found in their study that food’s GHG emissions are inversely correlated to their nutritional quality. Drewnowski et al. (2015) also found that the effect of some foods’ high GHG emissions was decreased by their high nutritional value when putting nutrition and climate impact in relation to each other. This could be found for some food products in this study as well, for example liver from pig ended up with a quite high final score due to its very high nutritional value despite its high climate impact. This indicates a difficulty which can arise when combining a nutrient index such as the one proposed with a climate tax, as Drewnowski et al. (2015) proposes, the large effects that some foods’ high nutritional value or high climate impact can have on the final score ought to be of priority for future research on the subject. Van Dooren et al. (2017) created an index which included nutrients to encourage that are good for both humans and the environment and nutrients to limit that are bad for humans and has bad impacts on the environment. Perhaps an index similar to this one would be easier to implement as it considers climate impact and nutritional quality of a food item in one single, combined score (opposed to SNICI which combines two scores into one final score), facilitating an implementation and avoiding the fact of the inversed correlation of GHG emissions and nutritional quality.

6.3.7. To implement a method like SNICI

When implementing a combined climate and nutrition tax, the goal is that products with high climate impact would get a higher tax, and if they have a high nutrient content they would automatically get some sort of deduction in the tax rate for that. But when levying some products from a part of its climate tax due to its nutrient content, all emissions from food production will not be taxed. It would be easier if this could be overlooked. Then, how high the tax rate would be, would depend on the final SNICI score, a high SNICI score would give the food item a lower tax rate indicating a healthier and more climate friendly product, and a low SNICI score would indicate that the food item has a large climate impact and is not very nutritious, its tax rate would be higher. So, for a food item that has a very high nutrient index but also a quite high climate impact, the final SNICI score would be high – and the tax rate lower. The same would happen if a food item had the opposite qualities; low nutrient index but also low climate impact. This is the point of having a combined tax, the food items will be taxed on their collective nutrient- and climate scores. This will to some extent erase the separate importance of both nutritious and climate friendly food, and how this could affect health- and/or sustainability outcomes would need more attention in future research. For example, the earlier discussed issue of sugar which Briggs et al. (2016) and Drewnowski et al. (2015) also acknowledges; that sugar a quite low climate impact but also very low nutrient quality might get as big a tax rate as another food item with much higher nutrient quality but a little bit higher climate impact.

6.3.8. Something needs to be done!

In a recent study by Bälter et al. (2017), which quantified self-selected diets eaten by Swedish citizens, it was found that diets with lower GHG emissions met recommendations from NNR 2012 as good as diets emitting more GHG. This shows that there are potential to change Swedish diets without risking inadequate nutrient intake. However, as these findings are an average, on an individual level there might be risks for certain groups of people. It seems as it will be difficult to obtain these changes towards healthier and more climate friendly diets if there’s no policies implemented (Garnett et al., 2015), such as a tax, which could perhaps direct consumers in the “right” way. An international climate and health related food tax would maybe be the best way to go as all countries would be affected equally.

To finish this discussion, I believe, as Demaio & Rockström (2015) points out, that most important is interdisciplinary, collaborative work between nutritional sciences, health sciences, sustainability and environmental sciences as well as between scientist, politicians, businesses and society. Without this,
it is difficult for food to be more than a growing problem hindering us from reaching national environmental- and global sustainable development goals.

6.4. Limitations

To implement a tax is complicated, and to stay within the scope of this thesis and of my knowledge on the subject, certain tax-related issues has been discussed with limitations and a full example of how a tax could be implemented is not included in this thesis but will be further discussed in the project by Emma Moberg, Elin Röös and their co-workers.

I would also like to acknowledge the fact that it is mostly the sustainability problem of climate change which is discussed in this thesis. Other sustainable development goals are equally important and would also need to be addressed in the search for a healthy and sustainable food system and should be included in future, similar studies.

6.4.1. The nutrient index

Whichever method for calculating a nutrient index one choses, they are inevitable to be arbitrary to some extent. All methods for calculating nutrient indexes include subjective choices. In the development of the SNICI, choices made concerning the design has been made as objectively and transparent as possible with help from scientific references supporting the decisions. To calculate the methods in a different way, with a different reference person or to include different nutrients would result in a somewhat different result. So even though one can strive towards objectivity it’s more important to be transparent about, and reflect on, one’s own subjectivity.

Even if there might exist arguments to design the algorithm differently than done here, there are no standardised procedures for development, testing and validation of nutrient profiling algorithms. When developing an evidence-based nutrient profile model, it is important that choices concerning the model’s design are based on scientific, objective and transparent criteria (Sluik et al., 2015). For this study, we have tried to design the algorithm accordingly, even if we’ve come to realize that this is very difficult. We have tried to show an awareness of other existing design choices and how they affect the result.

6.4.2. Data uncertainties

Both nutritional- and climate data are associated with uncertainties. For example, LCAs and nutritional data are based on raw products, but many of the analysed food items needs to be cooked before eaten, this can lead to extra energy use as well as changes in nutritional value, water content, bioavailability. Additionally, different types of fish are calculated for their nutritional content, but they all obtain the value of ‘fish and shellfish’ from Mat-klimat-listan (Röös, 2017). Within this study, these limitations can be accepted, since the aim is to evaluate different methods to be used in a climate tax on food which takes the nutritional aspect in consideration, and furthermore with a focus on nutrient indexes.
7. Conclusion

Several ways to include nutritional aspects in a climate tax on food are possible, all with their pros and cons. A method combining climate impact and a nutrient index such as the SNICI, would capture healthiness and foods’ emissions of GHG well but would also be complicated and costly to practically implement. To use an already established method such as Nyckelhålet, or to tax specific, unhealthy products or nutrients such as sugary beverages, sugar, sodium or saturated fat in parallel with a climate tax would be easier to implement, and perhaps stimulate consumption of healthy diets that cause lower emissions of GHG. Nonetheless it would still require considerable administrative work. Moreover, a tax on single nutrients or food products might need to be complemented with subsidies on certain healthy foods to avoid unwanted consumption of other unhealthy untaxed products.

A nutrient index suitable for Sweden can be created such as the example in this thesis which includes a weighted factor for of how the Swedish population eats and are recommended to eat. Moreover, the nutrients included in the index should have a clear importance for the population that will be affected by the tax and thereby by the index. That is, nutrients which have proven positive- or negative health effects ought to be included. The same goes for other design choices for the index which should be made transparently and objectively and have a sound scientific base. This is however almost impossible as the design is created by more or less subjective choices. Further research as WHO (2015) proposes, is needed in the science of nutrient profiling if it should be potential to obtain this. There are many things that needs to be done if we want to have a sustainable food system which provides sustainable and healthy diets for all, interdisciplinary collaboration between e.g. nutritional and environmental sciences is one of the things that are necessary. To combine a climate tax with the nutritional aspect seems very to point with todays need of fiscal policies which aims at generating a sustainable and healthy food system. To implement a tax in which both climate and nutrition is considered, we would get somewhat closer to give food a price which shows their real costs.

8. Acknowledgements

I want to give a big thanks to my supervisor Elin Röös who’s been truly devoted to this thesis and helped me when I’ve needed help. It would not have been easy to overcome all the obstacles if it weren’t for you. I would also like to thank my assistant supervisor, PhD student Emma Moberg, who’s been such a big support on this project. Thank you for all your time and help with this thesis. My evaluator Mattias Eriksson deserves a big thank you as well, for his insights and good comments, helping me to finalize the thesis. I also want to thank those we have gotten advice from at the Swedish National Food Agency, mainly Veronica Öhrvik. Lastly, I want to thank Malin, Christian, Kate and Amanda who has helped we with proof-reading, excel issues and daily doubts concerning thesis-writing.
9. References


Jensen, D. J., Smed, S. (2013). The Danish tax on saturated fat – Short run effects on consumption, substitution patterns and consumer prices of fat. Food Policy, 42 (2013), pp. 18-31


Appendix 1.

Mat-klimat-listan version 1.1 - med karakteriseringsfaktorn för metan 34

Klimatavtryck från olika livsmedelsgrupper. Klimatavtrycken innehåller utsläpp från primärproduktionen inklusive utsläpp från produktion av insatsvaror, förädlings, förpackning och transport till Sverige.

<table>
<thead>
<tr>
<th>Kategori</th>
<th>Klimatavtryck (kg CO$_2$e/kg produkt)</th>
<th>Kommentar</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Medelvärde: Variation:</td>
<td></td>
</tr>
<tr>
<td><strong>PROTEIN KÄLLOR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nötkött</td>
<td>35</td>
<td>17 - 40 Per kg benfritt kött</td>
</tr>
<tr>
<td>Lammkött</td>
<td>28</td>
<td>15 - 33 Per kg benfritt kött</td>
</tr>
<tr>
<td>Vilktött*</td>
<td>0,5</td>
<td>-- Per kg benfritt kött</td>
</tr>
<tr>
<td>Fläskkött</td>
<td>7</td>
<td>4 - 8 Per kg benfritt kött</td>
</tr>
<tr>
<td>Fågelkött</td>
<td>3</td>
<td>1,7 - 4 Per kg benfritt kött</td>
</tr>
<tr>
<td>Köttfärs</td>
<td>21</td>
<td>9 - 24 50% nöt och 50% fläsk</td>
</tr>
<tr>
<td>Chark</td>
<td>10</td>
<td>4 - 10 Falukorv 40% kötthalt</td>
</tr>
<tr>
<td>Fisk och skaldjur</td>
<td>3</td>
<td>0,7 - 28 Per kg filé/kg skaldjur</td>
</tr>
<tr>
<td>Ägg</td>
<td>2</td>
<td>1,4-4,6 Per kg ägg</td>
</tr>
<tr>
<td>Quorn</td>
<td>4</td>
<td>-- Per kg Quorn</td>
</tr>
<tr>
<td>Köttsubstitut**</td>
<td>3</td>
<td>1 - 6 Per kg</td>
</tr>
<tr>
<td>Nötter</td>
<td>1,5</td>
<td>1 - 4 Per kg nötter</td>
</tr>
<tr>
<td>Baljväxter</td>
<td>0,7</td>
<td>0,2-2 Per kg torkad vara</td>
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<tr>
<td><strong>MEJERIPRODUKTHER</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mjölk, fil, yoghurt</td>
<td>1,2</td>
<td>0,8-2,5 Per liter/kg vara</td>
</tr>
<tr>
<td>Grädde</td>
<td>5</td>
<td>2 - 6 Per liter/kg grädde</td>
</tr>
<tr>
<td>Ost</td>
<td>10</td>
<td>6 - 11 Per kg ost</td>
</tr>
<tr>
<td>Smör</td>
<td>10</td>
<td>6 - 10 Per kg smör</td>
</tr>
<tr>
<td>Mejeri övrigt</td>
<td>2,4</td>
<td>1 - 5 Per kg vara</td>
</tr>
<tr>
<td><strong>KOLHYDRATKÄLLOR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ris</td>
<td>2</td>
<td>1,5 - 3 Per kg torrt ris</td>
</tr>
<tr>
<td>Potatis</td>
<td>0,1</td>
<td>0,1 - 1 Per kg oskalad potatis</td>
</tr>
<tr>
<td>Pasta</td>
<td>0,8</td>
<td>-- Per kg torr pasta</td>
</tr>
<tr>
<td>Bröd</td>
<td>0,8</td>
<td>0,5 - 1,2 Per kg bröd</td>
</tr>
<tr>
<td>Mjöl, socker, gryn</td>
<td>0,6</td>
<td>0,4 - 0,9 Per kg mjöl/socker/torra gryn</td>
</tr>
<tr>
<td><strong>FRUKT OCH GRÖNT</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Frukt Norden</td>
<td>0,2</td>
<td>0,1 - 0,3</td>
</tr>
<tr>
<td>Frukt import</td>
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<td>0,2 - 1,8</td>
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<tr>
<td>Salladsgrönsaker Norden</td>
<td>1</td>
<td>0,2 - 6</td>
</tr>
<tr>
<td>Salladsgrönsaker import</td>
<td>1,4</td>
<td>0,6 - 6,5</td>
</tr>
<tr>
<td>Rotfrukter, lök och kål</td>
<td>0,2</td>
<td>0,1 - 0,9</td>
</tr>
<tr>
<td>Grönt/frukt flyg</td>
<td>11</td>
<td>--</td>
</tr>
<tr>
<td>Juice och sylt</td>
<td>3</td>
<td>2 - 7</td>
</tr>
</tbody>
</table>

**FETTER, SÄSER O KRYDDOR**

| Margarin | 1,5 | 1 - 1,6 | Per kg margarin |
| Olja | 1,5 | 0,5 - 2,5 | Per kg/liter olja |
| Sås, kryddor | 1 | -- | Per kg vara |

**UTRYMMES MAT**

| Kaffe, te | 3 | 2 - 10 | Per kg torrvara |
| Läsk | 0,3 | 0,2 - 1 | Per liter läsk |
| Godis | 2 | 1 - 4 | Per kg godis |
| Chips | 2 | -- | Per kg chips |
| Glass | 2,4 | -- | Per kg glass |

**FÄRDIGRÄTTER**

| Rätt med kött | 2,1 | 1 - 5 | Per färdigrätt (320 g) |
| Rätt med fisk | 1 | 0,5 - 1,5 | Per färdigrätt (320 g) |
| Rätt vegetarisk | 0,5 | 0,4 - 0,8 | Per färdigrätt (320 g) |

* Gäller endast kött från helt vida djur (älgar, rådjur, vildsvin) som inte stödutfodras, under förutsättning att dessa antas ingå i det naturliga ekosystemet och inte kontrolleras av människan. Annars får viltkött mycket grovt approximeras med lammkött.

** Köttsubstitutsprodukter är halv- eller helfabrikat som i textur och funktion efterliknar köttprodukter såsom olika korvar, grytbitar eller biffar gjorda på soja och andra baljväxter och vegetabilier men utan kött. Samt tofu och andra förädlade sojaprodukter.