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Meat the Future

A Cost-Benefit Analysis of a Pigouvian Tax on Meat in Sweden

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Abstract

This thesis considers a hypothetical Pigouvian tax on meat in Sweden. The theoretical framework regards controlling for externalities and previous empirical research of excise duties on food, which end up in a Cost-Benefit Analysis (CBA) with a policy recommendation. Food production contributes up to as much as 26% of all GHG emissions and increasing meat consumption are positively correlated with the risk of colorectal cancer. This leads to a distorted market due to existing negative externalities. Imposing a tax on meat consumption in Sweden will have direct effects on both consumer and producer levels, which leads to consequences in terms of lost utility of not eating meat respectively lost revenues due to less sold meat. Nonetheless, there are also gains from an environmental perspective and reduced health care costs. Hence, the purpose is to analyse whether the accompanied costs outweigh the benefits or if a vice versa connexion prevails. The conducted CBA with succeeding empirical results suggests that a Pigouvian tax on meat cannot, under the assumptions of this thesis, come with improved net social benefits (NSB), despite lower costs from an environmental as well as from a health care cost perspective.

Keywords: Pigouvian tax, meat consumption and production, negative externalities, cost-benefit analysis, Sweden

Abbreviations

COP21 - Conference of Parties, 21st meeting

CS - Consumer Surplus

DWL – Deadweight Loss

EPA - Swedish Environmental Protection Agency

EPHA - European Public Health Alliance

FSTWG - Finnish Sugar Tax Working Group

GHG - Greenhouse Gas

NFA - National Food Agency, Sweden

NPV - Net Present Value

PCB - Polychlorinated biphenyl

PMC - Private Marginal Cost

PS - Producer Surplus

SBA - Swedish Board of Agriculture

SCC - Social Cost of Carbon

SEK - Swedish Krona

SMC - Social Marginal Cost

SNB - Social Net Benefit

SS - Social Surplus

SSB - Sugar Sweetened Beverage

WCRF - World Cancer Research Fund

WTP - Willingness to Pay

WWF - World Wildlife Fund

Table of Contents

1. Introduction

Greenhouse gas emissions are externalities and represent the biggest market failure the world has ever seen - Nicholas Stern, 2008

Where the Kyoto protocol and the Copenhagen agreements have been falling short, the Paris climate conference (COP21) in December 2015 broke new ground by managing to gather 195 countries to sign a first ever binding global climate treaty (European Commission, 2016). Finding Sweden to perform well with fairly low sources of greenhouse gas (GHG) emissions relative several other European countries (Eurostat, 2016), new ways have to be found in order to reach the high set COP21 goals. While manufacturing, heating houses and transportation are large polluting industries, meat production is reported to, surprisingly for many, contribute up to as much as 26% of all global GHG emissions (see e.g. Steinfeld et al. 2006). Meat production does not only cause external environmental effects due to GHG emissions, high intake of two types of meat (red and processed meat) are also concluded to be positively correlated with colorectal cancer (see WCRF, 2014: Battaglia Richi et al., 2014: Boada et al., 2016) - which adds negative external effects of meat consumption through increasing healthcare costs.

A common way to control for externalities is to introduce a Pigouvian tax (Pigou, 1920) on meat. Similar applications could be observed in nearby countries like France, Denmark and Finland, where a reduction in consumption for certain goods has been aimed (Paloheimo, 2012: Jensen and Smed, 2013: Berardi et al., 2012). From a Swedish perspective, Säll and Gren (2012), Mårtensson (2014) and Törneke (2014) have tried to highlight the external effects of meat on the climate and analyse how big a potential tax could be to mitigate these. However, little research has been done on the subject of taxing meat from a health perspective. Swedish meat consumption has increased with approximately 30% between 1970 and 2013 (See Figure 2), while the number of patients diagnosed with colorectal cancer has almost doubled (See Figure 1). Although empirical research point towards negative consequences, it is not clear whether a tax would be harmful or useful for the society as a whole. Clearly, a fundamental research of health care costs and benefits, as a result of a meat tax, are missing in order for a nuanced political debate to take place.
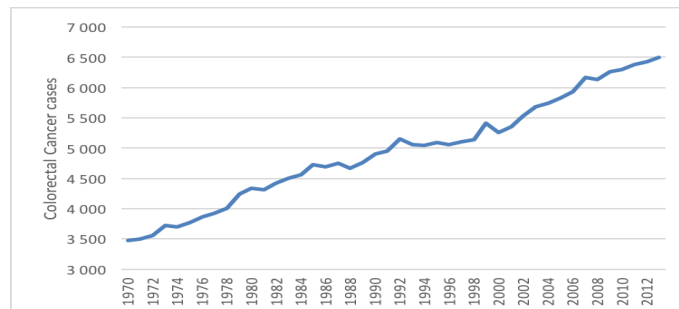
Figure 1 - Cancer Cases in Sweden (The National Board of Health and Welfare, 2016)
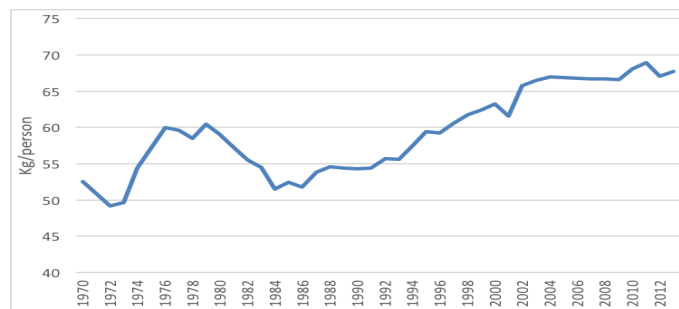

Figure 2 - Meat Consumption in Sweden (The National Board of Agriculture, 2016)

Despite the prevailing consensus among the scientists regarding the health effects of enhanced intake of red and processed meat there is relatively little research done on the direct effects on the society. In combination with social cost of meat consumption from an environmental perspective, this essay aims to broaden the research area further. At the same time, it will try to contribute towards being a tool for making policy recommendations as efficient as possible. This essay will therefore, take the form of a Cost-Benefit analysis (CBA) evaluating what economic impacts different sizes of a hypothetical excise meat tax will have on the Swedish society. What effects, in monetary terms, will a change in meat consumption have on the environment, the consumers and producers of meat as well on the health care cost of colorectal cancer?

Can a tax correct for the presence of externalities of meat consumption and meat production, from a social cost and benefit perspective?

The main result of this essay is that a Pigouvian tax on meat is negative from a net social benefit perspective. In spite of the reduced cancer costs and lower GHG emissions, the losses in the production sector are not outweighed. Provided results should be considered carefully due to some framework limitations, like for example that the market demand has been based on linear elasticity values and thereby ignoring convex preferences. However, for practical

reasons and with support from the empirical research an excise tax on meat is chosen for this essay's purpose.

The essay begins with a definition of externalities in addition to what extent these are linked to meat consumption. Additionally, a review over past research of how meat consumption or meat production affect healthcare costs respectively environmental costs is presented. Thereafter, a theoretical part regarding controlling for externalities is introduced, with a subsequent literature review over recently implemented and analysed Pigouvian taxes. Consequently, there is a presentation of the methodology of the essay, simply the CBA contextualized with regards to meat consumption. The results of the CBA debouching into our own analysis with a subsequent policy recommendation that reconnects to earlier presented theory. Some concluding remarks in addition to suggestion for further research will finish.

2. Externalities

In order to clarify potential external effects of production or consumption of meat, it is of relevance to introduce the term externality. The pure definition of the term refers to the impact consumption or a production of a good or service has on a third party. The third party will not be compensated since it lie outside the price mechanism, and the consumer or producer that causes the externality will not bear all costs of their actions, which creates inefficiency on the market. Clearly, the welfare of each consumer, or producer, does not depend solely on his or her own actions. (Hindriks and Myles 2004, p.196f). These external effects are associated with a social cost or benefit. The third party have not voluntary making the choice of being involved in production or consumption of the good or service, why they have not either chosen to incur the cost or benefit of the same.

It is of importance to contextualize the concept of externalities as well. In other words, examine whether the consumption and production of meat can generate externalities, and if these are either assumed to impose a social cost or a social benefit to the society.

Lastly, it is important to make a clarification of what the term "meat" actually refers to in this context. Meat refers to red meat, which in turn includes beef, pork, goat and lamb from domesticated animals as well as game meat and processed meat. Processed meat refers to that it has been preserved by smoking, salting, and curling or treated by chemicals in some way. (WCRF 2011).

2.1 Externalities of the consumption and production of meat

When one decides to consume meat, one evidently is exposed to an increased risk of colorectal cancer (WCRF, 2014: Battaglia Richi et al., 2014: Boada et al., 2016). The health effects upon the ones who fall ill by colorectal cancer are associated with an increased cost of cancer, due to the fact that more patients are in need of treatment, a cost affecting the society. Another perspective is the climate impact of the meat production. Consensus exists among scientists regarding the overall effect of the production of meat, it causes emissions of GHG.

2.1.1 Health Perspective

Meat is considered to be an essential dietary source of protein and important nutrients such as iron and vitamins. Also, the protein in meat is considered to be of high quality, which depend on how many essential amino acids the food contains. Meat is considered to entail all the essential amino acids (8 of 20), which is high in comparison to other plant food. (Svenskt Kött 2016b). As long as you combine it with a balanced diet, there is substantial evidence that shows that an intake of lean meat is affecting the long-term health positively. (McAfee et al., 2010).

However, the World Cancer Research Fund (WCRF) has in collaboration with the American Institute for Cancer Research, released, in 2011, released a report where causes of colorectal cancer were discussed. The report addresses what food intake that can either prevent or increase the risk of cancer of the colon and the rectum. A recurring potential factor to increased cancer risk is the meat consumption, essentially the intake of red and processed meat. The report compiles 10 studies where 9 of them showed increased risk of colon cancer connected to higher intake of red and processed meat. High consumption of red and processed meat was also found to be a significant risk and convincing cause of colorectal cancer. (WCRF, 2011). Additionally, in WCRF:s (2016) latest version, their conclusions stand.

Chao et al. (2005) examine the relationship between recent and long-term meat consumption and the risk of incident colon and rectal cancer. The most consistent associations were found between distal colon cancer and high consumption of processed meat during a longer period. It is concluded that a prolonged high consumption of red meat is associated with distal colon cancer but not colorectal cancer. (Chao et al., 2005). Larsson et al. (2005) observe similar findings in their study, but some weak evidence for rectal cancer. They examine data from approximately 60000 individuals aged 40-75 years from "the Swedish Mammography Cohort", and found a significant positive connection between red meat consumption and risk of developing distal colon cancer. The authors made a comparative analysis of women who consumed 94 gram red meat per day or more, compared to those who consume less, namely less than 50 gram per day. Findings suggests that the group which consumed 94 gram per day or more suffer far more a risk of developing distal colon cancer. Even if the evidence for rectal cancer is relatively weaker according to Larsson et al. (2005) and Chao et al. (2005), there are numerous of studies (Battaglia Richi et al., 2014: Boada et al., 2016: Bouvard et al.,

2015; Norat et al., 2002; 2005: Sandhu et al., 2006: Cross et al, 2007) that support the fact that an long-term consumption of red meat and processed meat is associated with a heightened risk of colorectal cancer, thus the both types of cancer combined.

WCRF (2011) are assembling the two types of cancer, colon and rectum cancer, and groups them as colorectal cancer. McAfee et al. (2010) mean that these two types of cancer can have different etiology, meaning that there are different initial causes to the cancer, and questions the evidential power of the studies WCRF compiled. McAfee et al. (2010) claims that there are methodological limitations and inconsistencies associated with these studies, and therefore the overall validity of their findings may be affected. Also, the cause of colorectal cancer is often a combination of different factors and it is often hard to isolate one single cause the disease (Williamson et al. 2005).

However, it is the consumption of meat that exceeds the daily recommendations that is of interest and thereby may cause colorectal cancer. Even if there are some dissonance among the scientific results regarding the general effects of meat consumption, the majority of the scientists agree that we are consuming too much of the good (Nordic Council of Ministers 2012, p. 22: Battaglia Richi et al. 2014). Even, McAfee et al. (2010) recognize that we should eat less red meat and processed meat.

Social Cost of Cancer

There are social costs associated with the health effects of meat consumption. If you are diagnosed with colorectal cancer it does obviously come with a cost. Due to the extensive health care system in Sweden, the health care cost of cancer treatment is paid by the society. This in turn gives reason to lift the discussion regarding the concept of moral hazard, a type of information asymmetry. It can be interpreted to generate an externality of consuming meat, by the fact that the one person that consumes a good associated with risks (in this case meat) not necessarily bears the whole cost of the action (Hindriks and Myles 2004, p. 259). The cost of treating colorectal cancer can thereby be interpreted as an externality of meat consumption due to treatment is paid by the society.

The cost of colorectal cancer accounts for 11 % of the health care cost among the European Union countries and it is the second highest cost of health care among cancer types, shortly after the cost of breast cancer. The cost of colorectal cancer, verdict on the whole population

in Sweden corresponds to 700 million Swedish kronor (SEK) (Luengo-Fernandez, Ramón et al., 2013). The cases of colorectal cancer in Sweden are 10 per cent of the total cancer cases each year and the third most common with a bit more than 6000 diagnosed cancer patients each year, (Cancerfonden 2015: National Board of Health and Welfare 2011), why the cost of colorectal cancer are relatively high per diagnosed patient. If the consumption of meat continues to the same extent and the cases of colorectal cancer increases each year, the social cost will increase in the future. This provides an additional reason to examine this externality further.

Risk of Developing Cancer due to Meat Consumption

Although colorectal cancer costs seem to rise with higher intake of meat, it is not definitive that cancer will evolve. Therefore, assessing consumption of red and processed meat and colon cancer comes with a great deal of uncertainty. A large array of studies, regarding increased risk of cancer have found a significant increase of number of colorectal cancer patients related to a higher degree of meat intake (Norat et al, 2002; 2005: Sandhu et al., 2006: Cross et al., 2007). On the other hand, few have been able to conclude an inverse or insignificant relationship suggesting that it is of great importance to account for such relative risk when monetizing the increasing cancer cases connected to a higher intake of meat. Sandhu et al. (2006) provide a pooled meta-analysis of studies over risk of colorectal cancer. Findings showed that an increased risk of colorectal cancer lie between 12 and 17% when the daily intake increases by 100 grams. Further, the relative risk is concluded to be different based on whether a consumer belongs to a group of low- or high-intake of red and processed meat (Norat et al., 2005; 2002: Willett et al., 1990: Cross, 2010).

2.1.2 Environmental Perspective

The debate of global warming is nowadays a matter of how to turn the trend over rather than recognizing the trend - a trend that is affected by meat production and consumption. The Swedish Board of Agriculture (SBA) (2013) highlights the importance of a sustainable meat industry and points directly towards the necessity of less meat consumption in the Western World (SBA, 2013). In the same report, it is argued that as much as 18% of all GHG emissions are related to meat production. Furthermore, Steinfeld et al. (2006) show that it could even be as high as 26%.

All sorts of production of animal products leave a carbon footprint. The beef livestock may be the worst of them all since it ruminates, which in turn leads to high emission of methane. The whole production cycle of beef emits relatively more GHG than any other production of meat (World Wildlife Fund (WWF) 2015). The management of natural manure and production of chemical fertilizers as well as the feed production are all causing high emission of GHG, like carbon dioxide and nitrous dioxide (SBA, 2013).

Besides the obvious carbon footprint in terms of GHG emission, the meat industry also affects the climate through the relatively high use of water in the production. One kg produced beef requires as much as 15000 litre water, where the majority is needed to grow feed crops. For instance, corresponding figures for pork is 6000 litres of water (Hoekstra 2012). There are nevertheless differences depending on where the production is located and the numbers above may be more applicable on the meat industry seen from a global perspective. In Sweden the same footprint of water in the production may be much less, mainly because the feed crops are watered by rain and that Swedish farmers have access to water to a greater extent than, for example, farmers that is located at warmer climes (WWF 2016). Nonetheless, relative to other potential protein sources, the meat industry is causing a larger impact on the climate and is therefore associated with a cost to the society.

Social Cost of GHG emissions

Climate economist Nicholas Stern points towards GHG flotation not only being a global cause of heating our planet, but also a highly global matter of concern regarding the consequences (Stern, 2007, p.1; 2008). Changing patterns in earth temperature are setting of many different irregularities in how the world evolves. Anomalies in rainfalls are creating flooding catastrophes, increasing drought areas that are forcing populations on the run from specifically exposed, local countries closer to the equator (Stern, 2007, p.17ff). All such effects, and numerous others, will have severe outcomes on suffering countries economic structures and employment of budgets, creating skewness and divergence from GDP levels and trends. Also, a lot of governmental budgets have to be re-allocated towards managing increasing risks from global warming (Stern, 2008).

Richard Tol has been investigated the issue regarding monetizing impacts of GHG emissions on society by continuously updating and reviewing the economic changes due to global warming. It is crucial to find a correct measure of social cost of carbon (SCC) in order to

make climate policy recommendations from cost-benefit analysis without deviating too much from social optimum (Tol, 2005; 2008; 2011). Tol (2008) are highlighting the arbitrariness in the assumptions of future marginal climate changes in his, and the research his meta-analysis is built upon. Whether SCC is marginally exponential increasing or decreasing creates a lot of uncertainty in the measurement. Tol (2008) is estimating SCC from GHG emissions impact on GDP. In his most recent study (Tol, 2008) he suggests that the SCC is increasing to which Stern (2008) raise the possibility of an irreversible marginal cost of climate and further emphasises the urgency of quick reductions in GHG emissions.

Biological Diversity

Meat that comes from natural pasture (In Sweden, it is usually beef and lamb) can be good for the environment since it enriches the biodiversity. Worth mentioning is that this may only be applicable to Sweden and countries alike. In other areas of the world the meat production is often devastating natural areas to make room for grazing animals or feed production (WWF 2015). This problem occurs in South America, where the meat industry causes negative impacts on the climate (Carvalho et al. 2013). For example, the grazing beef livestock in this region are characterized to be low-efficient. The reason is that the productivity per area unit is significantly lower while the same area generates more GHG emissions than corresponding area per unit in Europe and especially Sweden (Cederberg et al., 2009). Even if the production of beef and lamb are positively contributing to the Swedish landscape, it is considered to be low-efficient due to time the livestock are going on the natural pastures before they become food. This in turn leads to more emission of so called *CO2-equivalents* (includes carbon dioxide, methane and nitrous oxide), per kg meat. (Lööv et al., 2013: Röös, 2013).

In order to reconcile both the advantage of biological diversity and the negative impact on the environment, the meat production can implement a procedure where the climate load can be eased. It is called *Silvopastoral agroforestry* and refers to a model where you basically compensated for your carbon footprints through plantation of leaf trees, which are later, used in the production of bioenergy. An optimal compilation of these two could offset the negative impact on the environment. (Dahlin and Lundström, 2011: Ibrahim et al., 2010: Karltun et al., 2010: Kumm, 2011). It is however, a comprehensive procure and tender to be costly because the production often requires wide and big natural pastures (Kumm, 2011).

2.2 Substitutes to meat

In order to live a healthy life, it is crucial to meet the need for protein in the daily diet. To circumvent the health and climate issues of meat consumption and production, a change in diet might be a solution. Aiking et al. (2006) argue that if people are convinced to substitute towards more vegetable proteins instead of animal proteins, there would be multiple benefits, such as reducing energy demands, water usage, biodiversity, human health and animal welfare. A change in lifestyle and mentality may be necessary since a change in production is not sufficient enough to reach climate-smart goals. (Aiking et al. 2006: SBA 2016).

As mentioned, meat contains biological and high-value protein and is a contributor of healthy minerals and vitamins (NFA 2016c, Nordic Council of Ministers 2012, p. 22). However, according to the NFA (2016c) there are numerous of adequate examples of other food types that contain sufficient amount of protein, like fish, egg and dairy products. In order to be stringent it is of relevance to examine whether these substitutes (fish, dairy products and egg) are associated with similar externalities as meat.

2.2.1 Fish

Fish is considered to be a good natural source of protein, minerals, healthy fatty acids and vitamins and is recognized to be a substitute to meat (Sidhu, 2003). The negative impacts of consuming fish, from a Swedish perspective, are concentrated to the risk of getting poisoned by consuming fish containing polychlorinated biphenyl (PCB) and dioxins. Consuming these types of fish may cause lifelong effects on the nervous system. At the same time, fish that may contain these toxics are limited to live in certain streams and in Sweden are these types of fish consumed much less in total (Becker et al., 2007). The discussion regarding intake of fish often ends up in the positive health effects of fish consumption. Fish contains healthy fatty acids, like omega-3, which can prevent certain types of heart diseases (Djoussé et al., 2012: Becker et al., 2007). Additionally, in contrast to the effects of meat consumption, long-term consumption of fish was inversely associated with risk of both proximal and distal colon cancer (Chao et al., 2005: Larsson et al., 2005) as well as colorectal cancer (Norat et al., 2005). Given the health and nutritional benefits, the consumption of fish should therefore be encouraged (Sidhu, 2003). The population of Sweden is recommended to eat fish 2-3 times a week (NFA, 2012) but less than a third of Sweden's population eat fish at least two times a

week as a main course (NFA, 2012) why a recommendation of increased fish intake is also of relevance from a Swedish perspective.

Like any other food industry, the production of fish has an impact on the climate. Compared to the consumption of meat, the carbon footprint from fish is however relative low (Röös, 2012). The actual effects on the environment differ from the meat production in that sense that the fish industry take relatively more advantage of a resource that exists in wild stocks, which may reduce the emission linked to domestic production. Still, it may lead to overfishing which impose a great threat against the biological diversity. (Ziegler, 2008). Naturally, the fish industry is also associated with GHG emissions linked to the inputs of the primary production in terms of fuel to boats, electricity and packaging. Röös (2012) monetizes the emissions from the chain of production and finds that one kg consumed fish causing at an average, 3 kg CO_2. To put it in perspective, Röös (2012) presents the corresponding value for one kilo meat that is 13 kg CO_2 on average, but as high as 26 kg CO_2 per kg consumed beef product.

2.2.2 Dairy Products and Eggs

The NFA (2016c) emphasizes dairy products and eggs as suitable substitutes for meat, but at the same time, in contrast of fish, not exaggerating humans general need of such source of intake. Dairy products are recognized as necessities in reaching recommended daily intake of protein, minerals and vitamins. Further, dairy products are an essential source of calcium, which is vital for the human bone. (Brugård Konde et al., 2015). Although, NFA (2016b) is in some sense reserved in their recommendations of daily intake of dairy products. From a healthy perspective it is important not to exceed the intake of products with high fat and instead choose products that contain lower amounts. However, an intake of low-fat dairy products that cover the daily needs, may in turn lowers the risk of high blood pressure, stroke and type-2 diabetes (NFA 2016b). Egg is also considered to be a source of high-level protein as well as of healthy monounsaturated fatty acids. Further, egg has a high content of vital vitamins as B, D and E. (Gard et al., 2010). From a health perspective, there are allergens associated with this group of substitutes. For example, if you allergic to egg one reacts to the protein in the egg white. Children are the most affected group and the allergy often takes its expression in skin rashes (NFA 2016d). Whether the health effects of these types of substitutes are linked to a social cost of the same proportions as meat, is hard to conclude. The research area is not as comprehensive and conclusive.

Dairy cows are producing manure, which can cause a major negative environmental impact. Local water resources can be contaminated and degraded by the fact that manure and fertilizers are managed poorly (WWF 2016). Further, the dairy industry is sharing most of the climate impacts with the meat industry, but according to Röös (2012) the amount of CO_2 per kg/litre milk is 4.6 kg CO_2 on average - significantly lower than for same amount meat. The measured amount CO_2 for egg is 1.5 kg CO_2 per kg consumed eggs. The main source of emissions from the egg production is the one linked to the production of hen feed. The feed is derived from production of soybeans, a production that emits relatively large amount of GHG, especially if it is located on deforested land. Resembling negative effects come from all types of animal food production, but in comparison to the meat and dairy industry, egg production is not contributing positively to the biological diversity. The reason is that the majority of the laying hens are living indoor and eating feed from grain and soybean. (Wallman et al., 2013).

2.3 Summary

A recurring theme that permeates the empirical research on the area, is that an enhanced intake of red and processed meat leads to an increased risk of developing colorectal cancer. There are studies that deliver limited results in some cases but the general implications indicate that a higher intake of red and processed meat are associated with an increased risk of some type of cancers, especially distal colon cancer where the evidence is the most conclusive. This issue can be discussed from a societal angle, as an extended consumption of meat leads to potentially more people being diagnosed with colorectal cancer, which in turn raises the total cost of treating colorectal cancer patients. Furthermore, the production of meat is associated with large GHG emissions that harm the climate, which also is considered to be a cost to the society.

To create a sustainable diet in the future, the recommendations of daily intake need to be followed - consume less meat, especially red and processed meat, and substitute with other adequate protein sources. Noteworthy is that Röös (2012) states that a substitution should be undertaken with caution due to the often unknown indirect effects. These substitutes are also associated with a social cost, but only from an environmental perspective due to the fact that the research regarding the health effects are not as conclusive and harder to connect to a pure cost for the society.

3. Controlling for Externalities

An inefficient market will give rise to a divergence between private and social costs (or benefits). There are various ways to control for the occurrence of externalities. Examples are *Internalization*, *Licenses*, *the Coase Theorem* and *Pigouvian taxes,* which all are discussed first in this chapter. Secondly, the theory and empirical research on the area are presented. The theory and previous research regarding controlling negative externalities are discussed in order to create a foundation of what policy instrument that may be best suited for the purpose of changing the meat consumption in Sweden. Subsequently, according to these, a Pigouvian tax in form of an excise tax seems to be the most suitable to mitigate the effects of the externalities.

3.1 Internalization

Internalization refers basically to the fact that the consumer, or producer, causing the externality and the one that is affected merge into the same unit. The externality issue could be solved through maximizing the profit by uniting the two economic agents, which will lead that the externality is taken into account within the merged unit and they stands for their own cost. Hence, efficiency is reached since the private cost and social cost become the same. Internalization is not a process without difficulties. A merger raises the possibility/risk of a firm becoming a monopolist, which in turn is associated with welfare losses that may exceed the initial losses of the externalities. Moreover, single firms do not wish to enter into a merger. Economic agents contribute to the externality to different extent why some agent might be treated unfair. (Hindriks and Myles 2004, p. 213f). In reality will internalization, as a concept, be hard to implement in Sweden. This because the Swedish health care system does not allow for patients to bear the full cost of any disease as internalization suggest. Additionally, due to the many actors in the market of meat production, will it be complicated to apply for this thesis purpose since internalization is optimized in markets with few agents involved, which is not the case of the agriculture sector.

3.2 Licenses

A direct control of externalities can be achieved by introducing the usage of licenses. Simply, by putting limits of how much of an externality that can be generated at a social optimum.

The license refers to a quota where a specific quantity of the externality is permitted. Legislating these licences and let them later be tradable, ensures that those who obtain the greatest benefit of the externality uses them (Hindriks and Myles 2004, p. 210). Further, tradable licenses can both streamline the market but also guarantee that the desired amount of externalities is generated (Lööv et al. 2013). However, an information problem may occur since it is hard to know all the costs and benefits before making a policy decision, why it is difficult to know what the social optimal level is (Hindriks and Myles 2004, p. 210f). Lööv et al. (2013) discuss the possibility of contextualizing trading with licenses in the meat industry. Measuring the GHG emissions from a single farm is problematic and costly. Furthermore, it is difficult to control whether the firm emits more GHG than is permitted. Hence, it may be difficult apply trade with licenses in the meat industry.

3.3 Coase Theorem

The Coase theorem takes its origin in a paper by Ronald H. Coase (1960). The theorem refers to the fact that efficiency can be attained in a market even with the presence of externalities, but without actual intervention from the government (Hindriks and Myles 2004, p. 196). Efficiency on the market may be achieved by the fact that economic agents resolve the issue of externalities themselves. Every social cost caused by an externality that it is inherently mutual in nature. It is in the agent's interest to reach some kind of private settlement with the one generating the externality in order to eliminate them (Baumol, 1972). Hence, well-defined property rights, complete information and no transaction costs need to be assumed in order to reach well efficient markets without governmental intervention (Hindriks and Myles, 2004, p.214f). Unfortunately, the Coase theorem suffers from some shortcomings when it comes to practical relevance. Well-defined property rights may be hard to implement when it comes to externalities. There is no clear distinction between who the purchaser is and who the producer is of the externalities (air pollution e.g.). Also, the assumption of zero transaction costs is not really plausible. Trading commodities between two agents as a part the settlement is associated with a cost. It requires time and money to find a partner to conclude an agreement with, travel costs to the point where you can exchange the commodities, and moreover, there is often legal costs linked to an agreement. Similar to internalization will it work best with few agents involved. (Hindriks and Myles, 2004, p.216: Baumol, 1972).

3.4 Pigouvian Tax

In taxation theory, Arthur Pigou (1920) did set new standards for how to control externalities in public welfare by what is today called a *Pigouvian tax*. The tax is supposed to correct for some mispricing that the externalities are causing in the market. A main concept of the tax is that the consumer or firm that is generating the negative externalities should compensate by paying a tax that is equal to the marginal damage the externality causes. Shifting marginal private costs so they coincide with costs for the society at the optimal level of produced quantity solves the dilemma (see Figure 3). (Hindriks and Myles, 2004, p. 208). Pigou's (1920) theory is based on the assumptions that there, implicitly, is only one single agent causing one single externality. Carlton and Loury (1980) argue that a Pigouvian tax alone cannot control for negative externalities, why it is only working from a short-term perspective. Carlton and Loury (1980) question the effects of a Pigouvian tax when there are additional firms, consumers and externalities. Consequently, if the Pigouvian tax is set correctly, it can raise welfare by altering the cost of the externality, which will ensure that the optimal amount of it will be produced (Hindriks and Myles 2004, p. 206).
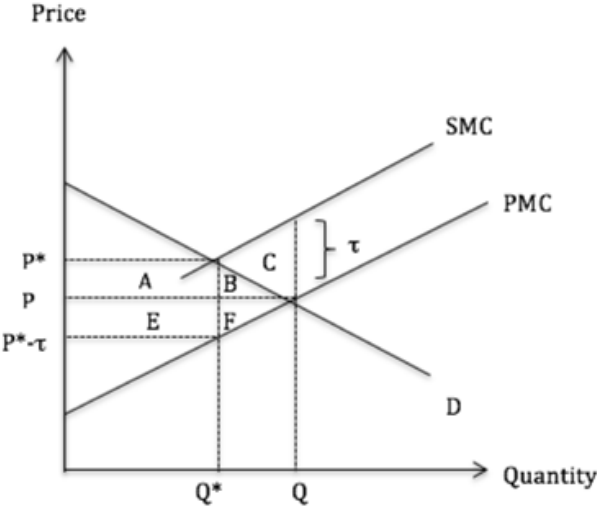
Figure 3 – Pigouvian tax on externalities

Uncontrolled externalities suggest that the pre-tax situation generates an output of the good, $Q > Q^*$, at the price, $P > P^*$. The price mechanism fails and a deadweight loss (DWL), represented by area C, is created, where the social marginal cost (SMC) exceeds the private marginal cost (PMC). Since the market is incapable of controlling for externalities, a tax of size $\tau = SMC(Q^*) - PMC(Q)$ is imposed on each sold unit in order to minimize the externalities, i.e. DWL (Hindriks and Myles 2004, p. 207).

Here, policy makers could proceed with implementing either an *excise duty* or a *progressive tax.* An excise will simply be a tax on all domestic sales of a good, while the progressive has the same characteristic but with the main difference that it increases when consumption increases (Hindriks and Myles, 2004, p. 378). In context of meat consumption, the latter is an intuitive implementation choice due to the situation where the recommendations of consuming meat are exceeded. However, it will require high administrative costs since consumption levels of meat have to be registered for all meat-consuming individuals. This makes it hard to monitor what kind of good that is actually consumed and to what amount. Hence, an excise tax is practically better suited for this essay's purpose.

Naturally it is relevant to include the concept of tax incidence, after a tax is implemented. The subsequent effect is often a change in consumed quantity, why distributive effects of the tax between producers and consumer occur. One group will take the excess burden of taxation (Mieszkowski 1969). Here, both consumers and producers will bear some costs. Due to a higher price to a less quantity for the consumers of meat, their surplus, and hence utility, will decrease. It corresponds to the area of A and B in Figure 3.

Similarly, producers will face indirect losses offset by the higher market price of meat and their lowered received net price, $P^* - \tau$, combined with less output. It is represented by the area E and F. Furthermore, will third parties obtain benefits from reduced GHG emissions and reduced healthcare costs due to less production and consumption corresponding to the area B, C and F. Out of these costs and benefits will A and E be redistributed from consumers and producers to the government in form of taxes. Since A, B, E and F only are reallocations between parties in the economy; one could interpret C (net benefits) as the only real theoretical change due to the taxation (Boardman et al., 2014, p.95ff). Therefore, it is of interest to further investigate whether this theoretical change in net benefits is positive or negative for the society in practice, i.e. monetizing the area of C.

In order to decide which, type of policy instrument that fits the purpose of controlling externalities caused by consuming meat, it is crucial to investigate the empirical research on the area.

3.5 Previous research

The research area is scant regarding the potential effects of a excise Pigouvian tax on meat consumption, particularly in Sweden. There is some empirical research discussing an implementation of a Pigouvian tax on meat consumption from an environmental perspective. Mårtensson (2014), Säll and Gren (2012) and Törneke (2014) which have independently intended to estimate the size of a hypothetical tax rate due to the marginal environmental effect of meat production. Mårtensson (2014) investigate if there is a possibility to mitigate the climate impacts from meat production by introducing a tax with the purpose of reducing the consumption of meat. Säll and Gren (2012) provided results where a tax on beef and pork were 28 % respectively 26 %. They found that a Pigouvian tax on consumer level might reduce as much as 4.4% of all GHG emissions in Sweden, where taxing pork seem to be the most efficient one. Maria Mårtensson (2014) reinforces Säll and Gren's work, but is also adding that a Pigouvian tax on meat might be a cost-effective approach to dampen GHG emission trends. On the other hand, Törneke's (2014) study is lacking estimates of emission reductions, but produces robust results of that an imposed tax would decrease consumption of meat. While Säll and Gren (2012) are taxing three kinds of meat separately (beef, chicken and pork), Mårtensson (2014) and Törneke (2014) choose to only include beef consumption in their studies. At the same time, there are cost-effective advantages to tax meat as a whole and not as subgroups. Pork and beef all have different positive and negative effects on the climate. Seen from a global perspective, the total consumption should be decreased and not just the intake of beef, for instance (Dahlin and Lundström 2011).

No meat tax has been implemented anywhere so far, hence evidence of effects are uncertain. However, similar taxation initiatives on food can be observed, where European Public Health Alliance (EPHA) (2015) mentions that fat and sugar taxes are nowadays realities or under investigation in e.g. France, Finland and Denmark. In absence of investigated tax, one could turn to such similar applications for lessons, guidelines and conclusions in order to design a tax.

For almost twenty years, an excise consumption tax in Finland on some sweet goods has been a reality in order to control for the increasing obesity and its effects. The Finnish Sugar Tax Working Group reviewed the tax system in 2011 and stipulated an increase to €0.95 per kg on sweets and ice cream respectively €0.11 per litre soft drink (Paloheimo, 2012). Evidence

pointing towards that existing sweet tax not only decreases body mass, but also lowers the risk of type 2 diabetes by up to as much as 13% (Sarlio-Lähteenkorva and Winkler, 2015). Although positive health effects, the ongoing tax system is debated. Critics argue that it fails to cover sweets that are not listed in the tax schedule but still harmful for the human health, hence some production companies suffer more than others, despite providing similar products. The Finnish Competition Authority (FCA) further downgrade the tax design by claiming that mentioned skewness in taxing goods might in extent lead to less foreign investments due to hurting domestic companies (Paloheimo, 2012). As a response to the remarks, FSTWG are investigating possibilities of developing the sweet tax into a pure sugar tax in the food market. Although the critique still stands, FSTWG sees difficulties through increasing administrative costs, enforcing sugar content on products, which is not yet legislated. Hence, FSTWG still finds prevailing excise tax design to be the most practical one under current circumstances (Sarlio-Lähteenkorva - Winkler, 2015).

In Denmark, sugar taxes have been used before. But as a part of Denmark's latest greater tax reforms, a newly founded excise fat tax was introduced and implemented on goods with a higher value than 2.3% of saturated fat in itself. Imported goods were prescribed with a tariff fee in order to treat domestically and foreign produced equally. Estimations show that implemented tax has reduced saturated fat consumption by 10-15% (Jensen and Smed, 2013). Implementing the tax without fundamental support made the Danish parliament to abolish it already within a year. It is shown that different retailers chose to increase prices on given taxated good both more and less than the actual value of the tax (Smed, 2012). Further, opponents, such as farmers and consumers, argued that it was too much of a bureaucratic decision hurting the labour market with increasing administrative costs (Stafford, 2012) and that people used the opportunity to shop in nearby, lower-tax countries, instead (Jensen and Smed, 2013). The politicians contrary argued for its efficiency and that long term effects should have been evaluated after a few years. Due to economic crises and therefore already high pressure on firms, parliamentarians abandoned the tax. Even though it was abandoned due to financial matters, evidence show that large and powerful industry actors were highly involved in the governmental work of modelling the excise fat tax (Stafford, 2012).

In similar cases, organisations with private interests are often affecting the outcome which points toward that the tax design being undermined from lobbyism and hence an easy target of critique from scratch. Also, trying to regulate the agricultural sector is not easy due to its

size and structure but also to the matter of powerful lobby organisations. It makes interventions hard and filled with challenges. (Bødker et al., 2015: Perrotta, 2011).

Another early adopting country of health taxes is France, where an excise tax on sugar sweetened beverages (SSB) of approximately €0.73 per litre soda entered into force 2012 (Villanueva, 2011). Subsequently, micro data suggest that prices of soft drinks rose significantly as a result of the implemented tax. Although the tax was designed due to sugar content, evidence point towards that the tax increase has gradually moved to soda products, leaving less-sugared substitutes like flavoured water unchanged in price. Onwards does larger retailing groups show behaviour of shifting own produced soda drinks even more than competing brands in store - over-shifting prices - while others tend to under-shift (Berardi et al., 2012).

Critique towards taxing consumption in order to fight negative health aspects as obesity has been provided in different forms. Cornelsen et al. (2015) see evidence that consumption can be lowered to a certain degree if the consumer bears all the burden of the tax. Despite benefits, the study does not support that a reduction in consumption fully can cover for the uncertainty in what people will substitute for and its consequences on health. Highlighting the importance that the area of research requires further estimations of the sizes of these indirect effects (Cornelsen et al., 2015). Furthermore, is it uncertain how cost-effective a tax on various categories of food really is. Taxing tobacco and alcohol has been proven to have an effective outcome, while food being a necessity for humans to survive (inelastic demand), hence tougher to turn consumption over. Some argue that the aggressive tax reforms around Europe only are poor excuses for financing deficits in governmental budgets (Villanueva, 2011).

In recent years, countries like Hungary and the U.K. have followed in the tracks of taxing unhealthy products by implementing similar designs. However, these implementations are newly introduced why no immediate conclusions of the effects have been made.

In a report from 2011, on behalf of Swedish Environmental Protection Agency (EPA), are Dahlin and Lundström examining the potential outcomes of different political tools. If a good is taxed with the aim to affect the consumption of it, it is desired to put the tax on consumer level. The risk of outsourcing may therefore be reduced, due to the fact that imported goods

and domestic produced goods are meeting the same political tool. A tax on producer level, a tax on CO2-emissions for instance, may instead harm the domestic production. (Dahlin and Lundström, 2011). Using GHG emissions as a base for taxation has the obvious purpose of minimizing environmental damages. However, when such emissions are diminishing, the base for taxation is also shrinking, meaning that other taxes have to be increased in the long run to maintain the same level of social welfare. (Brännlund, 2006, p. 15).

Dahlin and Lundström (2011) continues to discuss the possibility of introducing policies based on more protectionist assumptions, like higher tariffs on meat that is considered to relatively worse for the climate. These kinds of actions may be helpful and contribute to Swedish agricultural sector, which characterizes of low profitability, in comparison to international farmers. According to the Swedish producers, it can be explained by the relatively higher demands on the production that feature Sweden. Higher demand on animal welfare and restrictions in use of antibiotics, are some examples. It is therefore of interest to protect the domestic production, especially since it is losing share of market to competitors abroad. (Dahlin och Lundström, 2011). However, Lööv et al, (2013) highlight the problematic associated with this kind of protectionist policy. With the current WTO-rules it is complicated to implement high tariff rates on other goods that is considered to have relatively worse impact on the environment. Also, in absence of a worldwide agreement will it be a matter of a redistribution of the meat. It is hard to control for systems of production that cause relatively more GHG emission in relation to others, why the utility of such a policy is restricted. (Dahlin and Lundström, 2011: Lööv et al., 2013). Moreover, from a global environmental point of view, the majority of the Swedish trading partners regarding meat and dairy products are derived from countries where the productions are similar to those in Sweden. The level of GHG emissions that these goods are causing, are equivalent to the one in Sweden. (Wallman et al., 2013).

3.6 Summary

Lowering the total meat consumption might be desirable since the people in Sweden are consuming more meat than recommended why it might be the time to implement an incentive for the population to change their diet decisions. However, voluntary actions on an individual level are not enough to reach a sufficient level of reduced GHG emissions (Lööv et al. 2013: Wirsenius et al. 2011), why the discussion regarding a governmental intervention is relevant.

SBA (2013) claims that when designing a policy tool, like a tax on meat consumption, it is crucial to have a holistic approach, in other words weigh in all relevant effects and costs. Whilst some research on taxing meat consumption, and its effect on GHG emissions and consumption behaviour, exist (Säll and Gren, 2012: Mårtensson, 2014: Törneke, 2014), neither one includes the negative externalities from health care costs. An exceed intake of red and processed meat is known to be associated with increased colorectal cancer risk, why implementing a Pigouvian tax based on this angle, in addition the environmental, might make a contribution to research area on the subject.

4. Methodology - Cost-Benefit Analysis

Any tax arises questions of costs versus benefits for policymakers in the political process. In this case, there are two different paths of consideration. First, one could proceed as before without any tax on meat, resulting in consumption patterns continuing as in previous years. Secondly, the government has the power to implement a tax of a certain size on meat consumption, which will result in a different outcome due to a change in consumption behaviour. A cost-benefit analysis (CBA) has the purpose of quantifying the value of such policy consequences in monetary terms in order to provide guidelines when a social decision-making is in progress.

4.1 CBA in theory and practice

As no specific country so far has adopted a Pigouvian tax on meat consumption will an ex ante analysis be applied, meaning an analysis being done before the project has been implemented (Boardman et al, 2014, p.3). The CBA process presented by Boardman et al. (2014, p.5 ff) will be used as guidelines in our way to making a policy assessment.

A main quest for a CBA is to strive for a pareto improvement by analysing net benefits of the project (Mishan and Quah, 2007, p.6). However, pareto efficiency is a rather strict condition, why often times the less restricted Kaldor-Hicks criterion is applied in practical cases. This means that the efficiency of a project is reached if agents' utility gain fully can compensate for agents' utility losses in monetary terms (Layard and Glaister, 1994, p.182). Projects that come with positive net benefits open up for possibilities of allocations fulfilling criterions of the Kaldor-Hicks criterion (Boardman et al., 2013, p.30f).

Monetizing these utilities are often done through estimations of the willingness to pay (WTP) for any economic agent, which oftentimes are estimated by using consumer (CS) and producer surpluses (PS). CS is simply the difference between what consumers are willing to pay minus what they actually pay for a good. Observing a market under perfect competition will all agents face the same market price and obtain utilities corresponding to their own WTP. Consequently, CS could be used as an approximation of WTP (Mishan and Quah, 2007, p.30: Hultkrantz and Nilsson, 2004, p.55). Similarly, the PS can be estimated as the price a producer obtains for its product minus production costs. The sum of CS and PS

constitutes the full social surplus (SS) (Mishan and Quah, 2007, p.55). In order to CS and PS to be correct measurements, markets with perfect competition have to be assumed, which is, however, not often the case. Suspecting a market failure could lead to a government intervention, e.g. by taxing the given distortion. It leads to affected prices, which in turn reduce CS and PS. However, a tax in itself is not viewed upon as a cost for the society. It is considered to be a transfer between the consumer and the government, who is later reallocated back to the society (Hanley and Spash, 1993, p.10: Boardman et al., 2014, p.58f). Furthermore, a tax will always create skewness and some deadweight loss (DWL) will occur. However, it is possible to exclude any such measurement from the CBA since the purpose of the excise tax is to correct or already existing externalities.

The concept of price elasticities of demand comes well in use when investigating how much meat consumption changes due to a change in price. A price elasticity measures how much of the demand that is changed due to a price change. In other words, the responsiveness of the demanded quantity or the consumer's WTP for the same. The cross-price elasticities can be used when examining how much of the changed consumption that shifts to the other goods (Hultkrantz and Nilsson, 2004, p.45f), e.g. substitutes to meat.

In certain cases, particularly when a market is distorted, there might be posts that are not traded with, and therefore does not come with any direct market value. However, since the posts come with some utility for every agent, they have to be valued in any best possible way. Such type of valuing goes under the definition of shadow pricing and is supposed to reflect the value it adds to the society (Boardman et al., 2014, p.132).

Another important distinction to make is between primary and secondary markets, in order to not count any post twice. Primary markets are the ones directly affected by the implemented project, while secondary ones are obviously indirectly affected (Boardman et al., 2014, p.82). One rule of thumb is that only the utility changes in primary markets should be accounted for since they are able to capture the full impact of the project. However, if the secondary market is not a case of perfect competition, skewness in prices exists. Therefore, such indirect effects could be included as well. (Boardman et al., 2014, p.131).

4.2 Monte-Carlo: Sensitivity Analysis

Executing the ex-ante CBA, it is of great necessity to make credible predictions of how future parameter values, for example consumption, production and pollution, will develop as a reaction of the implemented tax. Dealing with such forecasting is always difficult and the CBA therefore comes with a lot of uncertainty issues (Hanley and Spash, 1993, p.20). The uncertainty is reflected in the predicted impacts of the governmental intervention and in the monetizing of the same. In order to reduce the risk of making wrongful assumptions due to uncertainty, it is suitable to obtain a sensitivity analysis. Some parameter values are costly and difficult to elicit the exact number of, why one can assume that they vary between a maximum and minimum value of a certain distribution. (Hultkrantz and Nilsson 2004, p. 306). Thus, it is essential to obtain the maximum and minimum value of the parameter, as well its statistical distribution, in order to induce an adequate measurement (Hultkrantz and Nilsson, 2004, p. 323).

A well established, and common, way of accounting for uncertainty is through a *Monte Carlo Analysis*. The essence of Monte-Carlo analysis is to reduce a distribution of outcomes by multiple stochastic sampling of parameters (Boardman et al., 2014, p. 182; p. 188). This can be performed by letting a computer program (e.g. Microsoft Excel) draw numbers from a random distribution of variances and means, from the sample used (Dunn and Shultis, 2012, p.2). Using a drawing of a size large enough (approaching infinity), one could use the *Law of Large Numbers* and the *Central Limit Theorem* to argue that the estimated values will converge to the true values within the span of uncertainty (Dunn and Shultis, 2012, p.44). This way of handling uncertainty is done with the purpose of deliver a robust policy recommendation. To further check that the distribution of the randomization is well behaved and somewhat close to the status quo, histograms over social net benefit distributions is provided as well (Boardman et al., 2014, p. 190).

4.3 Social Discount Rate

All investments, and the resources that come with them, have opportunity costs since they could be used in other projects. Also, people tend to prefer consumption today over the future, why it is of importance to obtain the net present value (NPV) of a project (Baumol, 1968). By using the NPV-criterion, one is able to make intertemporal comparisons of the project (Boardman et al., 2014, p.137). NPV-criterion demands a correctly set social discount rate

(SDR). Since cost-benefit analysis often applies to if private assets should be reallocated to the government, is it of importance that the SNB of the public project in the future are able cover the losses in the private sector, which depend on what SDR that is used. In the equation below, *n* stands for the number of observations and *t* for the discounted time horizon in years.

$$NPV(SNB) = \sum_{t=0}^{n} \frac{SNB}{(1 + SDR)^t}$$

However, SDR differs between countries and type of projects. Evans and Sezer (2004) estimate the SDR to lie between 3 and 5% for six larger different, but similar trade-wise, economies. Another analysis by Evans and Sezer (2005) investigate SDRs of EU countries, suggesting that no clear trend in changes of SDR can be observed. In Sweden's case, a rate of 2.8% is presented.

4.4 Policy Recommendation

The CBA is to a large extent a tool for allocation of resources and making recommendations rather than decisions, where the latter are matters of the political arena (Boardman et al,. 2014, p.15), why it only should be interpreted humbly from a normative standpoint. In the end, the recommendation should always take off from the Kaldor-Hicks criterion by proposing the project returning the highest NPV of SNB. If negative values are returned, one should interpret it as the counterfactual case being the right alternative to suggest to the decision makers (Boardman et al., 2014, p.15). In the case of a tax implementation, it is not always relevant to find an allocation that maximizes the NPV. This essay's purpose is to control for the negative net benefits the externalities had on the economy. When they are controlled for, there are no more incentives to further maintain the tax, why the government should strive towards setting a tax that returns a net benefit of zero between the counterfactual and the case of a tax.

4.5 Limitations of CBA as a Support for Decision Making

Naturally there are some shortcomings associated with the method that may not been taken into account. The technical restrictions regarding the CBA cause some measurement issues when it comes to monetizing all the relevant cost and benefits of a governmental intervention. (Boardman et al., 2014, p. 42: Hultkrantz and Nilsson, 2004, p. 324f). A sensitivity analysis is

assumed to be time consuming and costly. There are also difficulties associated with the general approach in such that finding the appropriate distribution of each parameter may be hard. This problem occurs when valuable information and data are lacking, which can affect the choice of measurement indicator and its accuracy (Boardman et al., 2014, p.15).

Further, when conducting a CBA there may be issues regarding the interpretation of an individual's utility. The individuals' utilities are here summarized, which may cause bias in the analysis due to the difference in individual preferences (Boardman et al., 2014, p.36). These individual preferences, measured with WTP, may also be different when it comes how one values the future and the present. Individual's appraisal of the future outcome for their children and future generations may not be accounted for. This comes to a head when an analysis examines climate impacts due to GHG emissions. Also, when applying a sensitivity analysis, like the Monte-Carlo analysis in this case, it is hard to know on beforehand what distribution the parameter's value is derived from.

By using pareto efficiency as a condition for decision making, one is hedged from implementing projects with negative net benefits. However, the condition fails to include concepts of equality between agents affected by a project. An allocation process from a richer agent to a poorer one - through a tax - could be valuated higher for the society than the recourses affected by the project in itself (Hindriks and Myles, 2004, p.122f). Microeconomic theory suggests that marginal utility from income are diminishing, pointing towards that rich agents get less utility on the margin than a poor one from a post given a uniform monetized value. Consequently, from a welfare maximizing point of view, a project that re-allocates from high to low income agents could be argued to always enhance social benefit (Boardman et al., 2014, p.479ff).

Typically a bureaucrat takes the following perspectives that are contrary to the spirit of CBA. It is illustrated through decisions that are coming from the budget office also are affected by the fact that politicians may think from a short-term perspective in order to get re-elected, which, depending for what purpose the CBA is conducted, may give a different policy recommendation. (Boardman et al., 2014, p. 15f). Finally, CBAs are assumed often are costly to execute, especially if it should create a solid foundation for further policy suggestions. (Boardman et al., 2014, p.22). That kind of cost can in the end be considered as a welfare loss.

5. Data

Monetizing the benefits and costs in CBA is the hardest part of the procedure. This chapter explains posts included in the CBA and how they are measured.

5.1 Description of CBA-posts

According to theory does meat consumption and production come with certain posts of additionalities (benefits) and displacements (costs). These are necessary to define in order to perform a CBA. Besides the externalities in terms of GHG emissions and cancer costs, there are also benefits attached to meat production and consumption. Producers (farmers) will receive some benefit from producing meat, while consumers will feel some utility from eating the same. However, these posts will most certainly change in some direction, due to an implementation of a meat consumption tax, leading to a higher price on meat. Pigouvian tax theory suggested changes in consumption patterns as a result of price changes, which in turn will have direct or indirect effects on consumers' utility of eating meat, producers' benefits, GHG emissions from production and cancer costs, presented in Table 1 below.

Table 1 – Description of CBA posts

Counterfactual		Tax	
Costs	Benefits	Costs	Benefits
Cancer treatment	Producer profits	Cancer treatment	Producer profits
GHG emissions	Consumer utility	GHG emissions	Consumer utility
		Change in producer profits	Change in cancer treatment
		Change in consumer utility	Change in GHG emission

Discussions could be made regarding the logic of including effects in some secondary markets. One might suspect a market failure due to negative externalities in status quo, why it, in accordance to mentioned theory; it is of importance to include some secondary effects as well.

5.1.1 A Swedish Perspective

Analysing a tax from a Swedish meat market perspective could be somehow problematic when one is accounting for global and local impacts, i.e. who that has standing. It is hard to tell if the impact should be perceived from a global or local perspective. Especially, since the people of Sweden are consuming both internationally and domestically produced meat.

However, Wallman et al. (2013) state the emission connected to the majority of the imported meat and dairy products are in level to the ones produced in Sweden, due to similar production. Noteworthy, is that a federal government will only include benefits and costs to local residents (Boardman et al., 2014, p.8). However, the Swedish consumers receive the constant utility regardless of the meat's origin. While a lower consumption level after a tax only will be affecting Swedish producers, from this essay's perspective, and therefore has to be corrected for. A theoretical reduction in GHG emissions is connected to domestic production, hence need correction. Furthermore, the risk of cancer due to consumption of red and processed meat will increase regardless if the meat is produced in Sweden or not, and could therefore be related to the total consumption of the good.

In conclusion, one has to restrict some posts and account for the share of total meat consumption that is derived from domestic production. Collecting such data release opportunities to distinguish global and local impacts of the Pigouvian tax on meat consumption.

5.1.2 Substitutes to Meat

In Table 2 the consumption of meat, fish and dairy products is presented. Applying a tax to meat consumption will increase its price and hence decrease the amount consumed. With linear estimates of own- and cross-price elasticities of meat respectively substitutes, Table 3, it is possible to calculate how much a certain tax will change consumption behaviours. Further on, it will become useful to account for how much of total meat consumption that is provided by domestic production (See Appendix: Equations 1-3). Uncertainty about this range of how much is actually produced in Sweden of total consumption exists, but has been estimated to lie between 32 and 51% of total consumption (Svenskt kött, 2016a). Hence, a measurement of total meat consumption that is provided by domestic production, $C_{\tau D}$ and C_{SD}, can be calculated in a similar way as before by multiplying, C_S and C_τ, with a randomly drawn number from the range.

Table 2 – Food consumption

	Kg/person
Meat	62.9
Dairy and egg	159.7
Fish	16.3

Sources: Statistics Sweden

Table 3 – Own and cross price elasticities of meat

	Meat	Dairy and egg	Fish
Meat	-1.121	0.083	-0.196

Sources: Lööv and Widell, 2009

When the consumption of meat dampens, because of the indirect effects of a tax, consumers tend to eat something else instead - if not for the benefit, so to meet the need for protein. According to the cross-price elasticities (Table 3) some consumption shift to dairy products. As can be observed in the table is that while dairy products is considered to be a substitute, is fish, perhaps surprisingly, more of a complement. Thus, when the price of meat rises, naturally the consumption of meat will go down but also the consumption of fish. NFA (2015c) recommends consumers to substitute meat for more fish and dairy products instead. Moreover, the NFA (2012: Sidhu, 2003) is recommending the people of Sweden to eat more fish due to the fact that an increased intake of fish is not associated with health risks. Preferred substitution will however not be considered in this essay due to given estimates of elasticities. Therefore, it can be argued that the potential healthcare costs caused by consumption of the substitutes are negligible, certainly since the consumption today not exceeding the recommendations, and that the evidence regarding the health risk associated with meat consumption are relatively more conclusive.

5.1.3 Social Cost of GHG Emissions

One direct effect of different consumption behaviour will be a change in GHG emissions since production decreases. Although meat consumption is expected to be lowered after a tax implementation are fish and dairy products, according to cross-price elasticities, decrease respectively increase when price on meat increases. All kinds of food production is contingent some emission, hence can one obtain estimated uncertainty ranges of GHG emissions per kilo produced of a certain food type, presented in Table 4. By using an estimated *shadow price* of between 0.14 and 0.63 SEK per kilo GHG emissions (Tol, 2008), can one measure the amount of GHG emitted in SEK, both at the counterfactual and after tax situation (See Appendix: Equations 4-10).

Table 4 – Emission from food and shadow price of emissions

	GHG emissions/kg	
	Low	High
Meat	4	40
Dairy and egg	0.8	11
Fish	1.5	7

Sources: Röös, 2012

By taking the difference between cost of emissions at status quo and after tax, one is receiving NB in terms of SEK from less GHG emissions.

5.1.4 Utility and Production Losses

For simplicity, it is assumed that the incidence of a Pigouvian tax is distributed equally on producers and consumers due to elasticities. First, one should consider the utility loss consumers feel from less consumption of meat. In Table 5, are expenditures an average Swede puts on food every year presented. Correcting for consumption in status quo and consumption with a certain tax, and obtaining the difference, will provide to us an approximated value of the NB in terms of reduced CS (See Appendix: Equations 11-13).

Table 5 – Food expenditures and consumption of domestic production

	Sales incl. VAT
	SEK/kg/person/year
Meat	58.6
Dairy and egg	21.9
Fish	72.9

Sources: Statistics Sweden

Following, effects on secondary markets should be included in the CBA. First, one has to consider losses and benefits in PS as a result of the lower (meat and fish) respectively higher (dairy products) consumption level. Similar to consumer utilities are producer's settlement prices here assumed to decrease in the same pace as the elasticities in order to fully correct for PS losses. Added to that producers will only loose profits from a decrease in domestically produced consumption, why the share between 32 and 51% (Svenskt kött, 2016b) also has been used here in order to correct for that. In Table 6 are producer costs and settlement prices provided. Calculating profits in status quo and with implemented tax leave us with the ability to obtain producer profits in both outcomes (See Appendix: Equations 14-22).

Table 6 – Settlement prices and production costs

	Settlement prices SEK/kg		Production costs SEK/kg	
	Low	High	Low	High
Meat	10.7	41.5	11	40
Dairy and egg	3.5	22.7	3.5	25.2
Fish		-		-

Sources: Swedish Board of agriculture: Statistics Sweden: Kumm, 2011. **Note**: *For fish, a value of 5 SEK/kg in real profits for producers has been used directly in Appendix: Equation 22 (Swedish institute for the marine environment, 2013).*

5.1.5 Risk and Social Cost of Colorectal Cancer

Last indirect impact would be the reduced cancer costs as an effect of reduced risk of colorectal cancer from less consumed meat. Studies have shown that an intake of meat increase risk and comes with an average cost per patient, presented in Table 7.

Table 7 – Risk and cost of colorectal cancer

	Low	High	Cost
Risk/g	0.0012	0.0017	
SEK/person/year			74.34

Sources: Sandhu et al., 2001: Luengo-Fernandez et al., 2013

Converting consumption at status quo and after tax to grams per day, in order to apply it to the risk of cancer, makes it possible to estimate decreased cost of cancer. Taking the differences of our counterfactual and after tax value will provide NB of cancer costs (See Appendix: Equations 23-27).

5.1.6 Net Social Benefits

As a last step before making the final recommendation, the Monte-Carlo framework is applied. By simulating 3000 observations of each NB post a value is returned, on average, which correspond to the true NB of the implemented tax. Also, Evans and Sezers's (2005) results of a 2.8% SDR will be applied. Leading one to obtain final present value of social net benefit after a certain Pigouvian tax on meat has been introduced.

$$SNB = NB_{GHG} + NB_U + NB_{Prod} + NB_{Cancer}$$

6. Empirical Results

The Monte-Carlo analysis is computed for different scenarios, in addition to the counterfactual situation, with a calculated social net benefit of each (see Table 8). Observing the distribution NSBs conclude that the randomization is well behaved (See Appendix: Histograms). The scenarios differ from each other depending on what tax rate that is implemented on meat consumption. The effects of the tax are in consideration when the changes of the cost and benefits are examined. At first, before implementing a tax, there is a counterfactual case, status quo. The counterfactual scenario shows that the SNB is -273 SEK (Swedish Kronor) per person and year. To put it in perspective, according to these results the meat consumption and production in Sweden corresponds to a cost for the society, on an equivalent population, of roughly 2.6 billion SEK.

Table 8 – Social Net Benefits

	Environmental cost	Utility loss	Cost of Cancer	Producer Profits	Social Net Benefit
1.	539.5	0.0	74.3	340.8	-273.0
2.	469.5	-27.5	68.9	111.9	-454.1
3.	467.7	-30.5	68.5	115.5	-451.1
4.	398.3	-90.4	63.5	86.0	-466.2
5.	295.3	-861032.7	55.7	338.9	-861044.8

Note: 1. Counterfactual, 0% tax: 2. Säll and Gren, 26% tax (Pork): 3. Säll and Gren 28% tax (Beef): 4. Recommended Daily Intake, 52.3% tax: 5. Meat Consumption Goes to Zero, 89.2% tax.

From Table 8, it can be observed that a higher price on meat due to tax on consumption leads to lower environmental costs and costs associated with cancer treatment. On the other hand, the profit the producers obtain decreases as the tax rate gets higher due to the fact that the overall consumption of meat will be lower than before the tax was introduced. Similar pattern can be viewed in the results for the utility losses. It gets bigger the higher the tax rate is. The tax rates that Säll and Gren (2012) found most effective on pork (26%) respectively beef (28%), are introduced in scenario 2 and 3. The pattern repeats itself for all posts and consequently, the SNB is not better off after these tax rates.

The overall conclusion from the empirical research states that it is necessary to consume smaller amount of red and processed meat (Nordic Council of Ministers, 2012, p. 22: Battaglia Richi et al., 2014: McAfee, 2010). Thereby, the fourth scenario will return a value

of SNB when the overall meat consumption in Sweden corresponds to the recommendations. As mentioned, the recommended intake of red and processed meat is 500 gram per week at maximum (NFA 2016a), which equals to 26 kg meat per person and year. The tax rate that reduces the consumption to this amount is found to be 52.3%. Despite the reduction in both cancer and environmental costs the losses in the production sector as well as the decrease in utility are not outweighed. A tax rate that lowers the consumption to the recommended level provide a SNB equal to -466.2 SEK per person and year. This is a lower SNB, both compared with the counterfactual and the SNB linked to the tax rates Säll and Gren (2012) found effective.

The last scenario includes a tax rate of 89.2%, which dampen the meat consumption close to zero. This in turn provides a result of a SNB equal to -861135.5 SEK per person and year. The reason why this tax rate done is to check for what result, the highest possible tax rate would provide. Since the estimations of consumer utility changes contained a fraction divided by meat consumption (See Appendix: Equation 11-12), the fraction will increase towards infinity as consumption goes to zero - making the result impossible to interpret. Still, the original CBA model holds for values of meat consumption equal to, or above 1 kilo. A tax rate of this size means that the meat consumption, due to linear approximations of price elasticities, turns negative, which is impossible in practice.

In Table 9, the percentage changes in overall meat consumption, GHG emissions and cost of cancer treatment are presented. According to the results, the higher the applied tax rate is, the less will the consumption of meat be. The same goes for GHG emissions and cancer costs. Apparently, the implementation of a tax has an effect on the costs associated with the externalities. For example, a 26% tax on meat consumption leads to a 29% fall in consumption, 14% less GHG is emitted and the cost linked to colorectal cancer treatment is now 16% lower. Thus, a Pigouvian tax on meat can correct for the externalities associated with meat consumption and production at some extent, but it is not efficient from a social cost and benefit perspective.

Table 9 – Percentage and real changes due to taxation

	% Consumption	% GHG	% Cost of Cancer	Cost of Cancer (SEK)	GHG emissions (SEK)
1.	0%	0%	0%	0.0	0.0
2.	-29%	-14%	-16%	12.1	79.2
3.	-31%	-15%	-17%	12.4	83.7
4.	-59%	-28%	-20%	14.8	151.3
5.	-100%	-45%	-25%	18.6	249.7

Note: 1. Counterfactual, 0% tax: 2. Säll and Gren, 26% tax (Pork): 3. Säll and Gren 28% tax (Beef): 4. Recommended Daily Intake, 52.3% tax: 5. Meat Consumption Goes to Zero, 89.2% tax.

Various variables come with different ranges of uncertainty. So far, we have considered an average effect of SNB. Even though it is likely that the average values is a good guess, prices and emissions can fluctuate due to unexpected exogenous effects. It could therefore be of interest to analyse a tax implementation under minimum and maximum uncertainty values, presented in Table 10. Out of 3000 estimated NSBs based on randomized parameter values, the largest respectively smallest values are presented in table min max.

Table 10 – Minimum and maximum

	Social Net Benefit	Average	Maximum	Minimum	St. deviation
1.	-272.8	-273.0	3474.3	-4038.6	1236.9
2.	-454.1	-454.1	2663.5	-3687.1	1196.0
3.	-451.1	-451.1	2833.2	-3895.5	1213.4
4.	-466.2	-466.2	2694.4	-3747.1	1187.9
5.	-861044.8	-861044.8	-857796.0	-864132.3	1254.6

Note: 1. Counterfactual, 0% tax: 2. Säll and Gren, 26% tax (Pork): 3. Säll and Gren 28% tax (Beef): 4. Recommended Daily Intake, 52.3% tax: 5. Meat Consumption Goes to Zero, 89.2% tax.

Clearly, the obtained minimum and maximum values deviate from the average. In the best of worlds, with only maximum values obtained, it is possible for an excise tax implementation to generate positive SNBs. On the contrary, due to that randomized parameter values been drawn from a uniform distribution, is an equally large risk present (See Appendix: Histograms). The minimum value is also an implementation outcome. Thereby, interpretations from minimum and maximum values are hard to do.

The main objective with a CBA, and what one later base the policy assessment on, is where the SNB obtains its highest positive value. However, such value cannot be found when observing the present value of SNB at year zero, presented in Table 11. Neither discounting forward to infinity yield positive values. Although PV(SNBs) is almost zero in the 35th year,

is the sum of all present values of SNBs still negative, meaning that a tax implementation does not satisfy the Kaldor-Hicks criterion.

Table 11 - Discounting

Years	1	2	3	4	5
0	-273.0	-454.1	-451	-466.2	-861044.8
1	-265.6	-441.7	-438.9	-453.5	-837592.3
2	-251.3	-418.0	-415.3	-429.1	-792586.1
3	-231.3	-384.8	-382.3	-395.0	-729570.2
…	…	…	…	…	…
35	≈0	≈0	≈0	≈0	≈0
…	…	…	…	…	…
∞	0	0	0	0	0
ΣSNB	<0	<0	<0	<0	<0

Note: 1. Counterfactual, 0% tax: 2. Säll and Gren, 26% tax (Pork): 3. Säll and Gren 28% tax (Beef): 4. Recommended Daily Intake, 52.3% tax: 5. Meat Consumption Goes to Zero, 89.2% tax.

7. Discussion

Performed CBA suggests that any tax rate cannot increase NSB. An introduced Pigouvian tax did affect the consumption, in accordance with previous research, and hence the external effect of cancer costs. Uncertainty measurements and unaccounted impacts undermine and complicate the interpretation of the results in a clear way. Thus, recommending an implementation of a Pigouvian tax, provided from a CBA, should be done with concern and complemented by a thorough discussion.

7.1 Validity of Results

Based on the results that tax implementation lowers the overall consumption of meat in Sweden at the same time, as the producer profits are smaller than before. In line with previous studies of an implementation, however now have the health care costs associated with meat consumption been accounted for and is shown to decrease as well. A tax on consumption mitigates the climate impacts, which is in line with previous research on the area, but also a new contribution to the area has been made. A Pigouvian tax on meat reduces the costs associated with treatment of colorectal cancer as well.

Changes in consumption behaviour that follows by indirect impacts, have been calculated through linear estimates of elasticities, which is an objective of critique. Since preferences often have the nature of convexity, could one suspect diminishing effects from price changes on consumption behaviour instead of used linear ones. Turning towards the post of e.g. cost of cancer, it is assumed that the risk of cancer changes with the same pace as consumption, no matter at what level the meat consumption is at. This, although, the relative risk is smaller or larger if you are a low respectively high intake consumer of meat, leading benefits from decreased cancer costs to perhaps being somewhat over- or underestimated. The same goes for benefit and cost changes in GHG emissions, producer profits and consumer utilities - highlighting the urgency of having the linear estimations top of mind when discussing impacts from the tax implementation. However, linear price elasticities are used since it provides an average in demand over the full population - providing somewhat robust estimations of the distribution in consumption changes due to the tax increase. Estimating demand could also be developed further than nonlinear elasticities by attempting to collect

data over household consumption of various income levels - this in order to fully capture the incidence of a Pigouvian tax.

Irreversible marginal cost of climate change is widely discussed, meaning that the measurement of costs related to GHG emissions perhaps being somewhat underestimated. By updating the area of costs the CBA might lead to different results and hence different interpretations of a potential tax.

One aim for the performed study was an attempt to capture the change in utility amongst citizens of Sweden, assuming that taste experiences, need of protein etc. are included in the price. If this fully captures how meat consumers feel is debateable. While the majority in Sweden more or less are consuming meat on a regular basis is there, however, part of the population that does not. A lower total consumption of meat in Sweden would therefore enhance the utility of this minority of ethical reasons. However, the total expenditure post has been divided by the full population of Sweden, meaning that the measurement also includes the utility of non-meat consumers.

Another source of wrongly estimating effects from meat consumption is due to the fact that we throw away a large fraction of food in Sweden every year. Whether food that has been thrown away should be monetized with the same utility loss as consumed meat is doubtable. Since we have data over total consumption (food that has been thrown away is included), is there a possibility that the NB losses in utility amongst consumers to be overestimated.

One theoretical assumption of the Pigouvian tax model is that it is one single agent causing the externality on another. Contrary, the Swedish meat market is not a monopoly, why difficulties of monetizing externalities correctly occur. Distinctions between who that is actually causing and being affected by externalities complicates the CBA. However, the essay uses a measurement technique based on per person values, why the performed CBA still may provide robust results under given assumptions.

The essay is merely regarding the Swedish meat market, why the external validity is questionable. Recommendations on an international level should be done with concern. However, it should provide a basis and inspiration for CBAs on other countries markets.

Even if a control is done regarding the imported amount of consumed meat, fish and dairy products, there is possibility of a bias occurring when collecting that kind of data. Lööv et al. (2015) lifting the possibility in overestimating meat consumption. Previous research has provided insights of domestic citizens travelling to nearby countries in order to shop the taxed good at a lower price. An excise tax on meat in Sweden might encourage similar behaviour, which performed CBA does not control for. Leading our estimates of reduced meat consumption being overestimated and therefore also the health effects connected to it.

7.2 Practical relevance

This study scrutinizes the impact of a Pigouvian tax on meat in order to create a foundation for a future policy recommendation for Sweden to stand on. The sector that is mainly affected is the agricultural one, which is relatively large and employs a lot of people, why it is a matter of topic in various political debates. Interesting results show that the producer side always come with positive social net benefits regardless of tax size. The producer profit is smaller than before but it still provides fruitful basis to the debate of whether farmers should be subsidised from EU level or not. When a tax is under consideration, subjective positions and emotional arguments often arises from strong voices related to discussed matter. Hence, consensus and a majority support for an implementation are of importance in order to achieve desired effect. Previous research of abandoned tax in Denmark highlights this issue. It is crucial to involve as many factors as possible into account, where this essay will provide fruitful support in order to avoid decisions being made only by the bureaucratic elite and offset possible backlashes for tax reforms.

Conducted CBA provide results of that producer profits are positive from a social cost and benefit perspective, which undermines the argument of farmers looses to much as a result of a tax. Therefore, it is more of a political argument since the CBA is providing an evaluation to base further policy decisions on. In order to convince the farmers, a government could argue that the revenues, that is collected from the tax, can be reinvested in the agricultural sector, e.g. subsidize feed, or monetary contribution to more climate friendly production. This in turn may lead to more climate friendly and efficient production, which may benefit the society in a long-term. For example, more climate friendly production can. However, when doing a CBA, the revenues are treated as a reallocation in the society since from societal concerns it does not matter where the revenues goes. As with every intervention from a government, some

people are gaining more than others from the outcome due to their preferences. This reconnects to the difficulties of conducting a pure WTP-measurement. Some people may be valuing a healthy life and less polluted air in front of lost profits for farmers and lost utility of not eating meat. Thereby, it will be a question of a trade-off. Also, with additional influence from lobby organizations, the tax revenues could be used for several purposes why it is difficult to pinpoint the exact outcome.

Previous research of tax implementation in Denmark argues that lobbyism undermined that tax design from start. However, whether the same structures goes for Sweden is not clear. Undoubtedly, if lobbyists possess the power to influence reports provided from agencies is it leading to a subversion of provided CBA. In this essay, some data from is conducted from agencies with subjective interest in the agriculture sector, leading one to be partly critical to such obtained values.

Furthermore, it is shown that a consumption tax on sugar and fat might just lead consumers to buy lower-quality products instead. However, since meat in Sweden is shown to have similar health and emitting impact as the imported meat, one could argue that Swedes substituting from domestically produced products to cheaper international ones, does not cause any extra health effects. Why it is also assumed, from this perspective, that we do not over or underestimate the health impacts in our study. However, international produced meat often times come with higher emissions and somewhat worse retention from an ethical perspective, which is not included in the study.

7.3 Concluding Remarks

This essay has contributed with results of how externalities related to meat production and consumption can be reduced by a Pigouvian excise tax. However, under the assumptions made is the tax calculated to be a burden for the society, the method in terms of a CBA suggests that no tax should be implemented. The area of research has to be broadened and measurements constantly updated in order to provide current recommendations.

A Pigouvian tax on meat can correct for the externalities associated with meat consumption and production at some extent, but it is not efficient from a social cost and benefit perspective.

8. Further Research

A realistic next step to further develop the research area is to include more accurate measurements of costs and benefits related to the negative externalities. One way in doing so is to estimate non-linear elasticities of demand and supply in order to capture agent's behaviour in a more precise matter. Also, a wider span of household income data should be included in order to give more precise estimates of the tax incidence.

A broader perspective of substitutes to meat consumption, such as leguminous vegetables and soy products, is desirable. Currently, the available data on these types of substitutes is insufficient and in need of an update.

Nicholas Stern (2008) is raising the question of a potential irreversible marginal cost of emissions. Highlighting the gravity of constantly updating emission costs in order to provide as relevant and up to date recommendations as possible.

Lastly, similar taxes have been implemented in countries with resembling governmental and institutional structures. To highlight this question further, it is of relevance to perform an ex-post analysis - meaning to evaluate the occurrence of a real meat tax implementation. Since political arguments often are based on empirical reasoning before theoretical, some mistakes may have to be made first in order to make a more efficient policy recommendation.

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Appendix

Following calculations have been done in order to follow through with the Monte-Carlo analysis and make a recommendation from a NSB value.

Definitions

τ	Tax rate
ε	Own price and cross price elasticity contingent food type
C_S	Consumption at status quo
C_τ	Consumption with tax
C_{SD}	Consumption of domestically produced at status quo
$C_{\tau D}$	Consumption of domestically produced with tax
GHG/kg	Amount GHG/kg contingent food type
GHG_S	Amount GHG/kg contingent food type and consumption at status quo
GHG_τ	Amount GHG/kg contingent food type and consumption with tax
Shadow price	Shadow price of GHG/kg
GHG_S Cost	Cost of GHG emissions contingent food type consumption at status quo
GHG_τ Cost	Cost of GHG emissions contingent food type consumption with tax
U_C	Consumer utility contingent consumption at status quo
U_τ	Consumer utility contingent consumption with tax
P	Total expenditures contingent food type per person and year
$Prod_{CS}$	Production costs contingent food type and consumption at status quo
$Prod_{C\tau}$	Production costs contingent food type and consumption with tax
SP	Settlement price - what producers receive from each sold unit food type
SP_τ	Settlement price after tax
S	Fraction of production that is not subsidies
R_S	Producer revenues contingent consumption at status quo
R_τ	Producer revenues contingent consumption with tax
Π_C	Producer profits contingent consumption at status quo
Π_τ	Producer profits contingent consumption with tax
Risk	Risk of cancer contingent grams meat per day intake
DMC	Decrease in meat consumption
Cancer costs$_S$	Cancer costs per person at status quo
Cancer cost$_\tau$	Cancer costs per person with tax
RAND	Randomizing between low and high values contingent post

Equations

1. $C_\tau = C_S * \left[1 + \left(\frac{\tau * \varepsilon}{100}\right)\right]$
2. $C_{SD} = C_S * [Low + (High - Low) * RAND]$
3. $C_{\tau D} = C_\tau * [Low + (High - Low) * RAND]$

4. $\frac{GHG}{kg} = Low + (High - Low) * RAND$

5. $GHG_S = \frac{GHG}{kg} * C_S$

6. $GHG_\tau = \frac{GHG}{kg} * C_\tau$

7. $Shadow\ price = Low + (High - Low) * RAND$

8. $GHG_S\ cost = Shadow\ price * GHG_S$

9. $GHG_\tau\ cost = Shadow\ price * GHG_\tau$

10. $NB_{GHG} = GHG_S\ cost - GHG_\tau\ cost$

11. $U_S = \frac{P}{C_S}$

12. $U_\tau = \frac{P}{C_\tau}$

13. $NB_U = U_S - U_\tau$

14. $Prod.C_S = [C_{SD} * (Low + (High - Low) * RAND)]/S$

15. $Prod.C_\tau = [C_{\tau D} * (Low + (High - Low) * RAND)]/S$

16. $SP = Low + (High - Low) * RAND$

17. $SP_\tau = SP * \left[1 + \left(\frac{\tau * \varepsilon}{100}\right)\right]$

18. $R_S = SP * C_{SD}$

19. $R_\tau = SP_\tau * C_{\tau D}$

20. $\pi_S = R_S - Prod.C_S$

21. $\pi_\tau = R_\tau - Prod.C_\tau$

22. $NB_{Prod} = \pi_S - \pi_\tau$

23. $Risk = Low + (High - Low) * RAND$

24. $DMC = \frac{1000 * (C_S - C_\tau)}{365}$

25. $Risk\ decrease = DMC * Risk$

26. $Cancer\ cost_\tau = Cancer\ cost_S * (1 - Risk\ decrease)$

27. $NB_{Cancer} = Cancer\ cost_S - Cancer\ cost_\tau$

Histograms