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A Study of the Environmental and Economic Effects of Subsidizing Alternatives to Red Meat

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Abstract

The rapidly increasing trend in meat consumption causes a great challenge for policy makers. With 20% of the individual's total emissions originating in food consumption, this gives an area of opportunity in decreasing emissions through promoting dietary changes. This study investigates the effects on greenhouse gas emissions and net costs of subsidizing less emitting alternatives to red meat. A regression model is applied, attaining own-price and cross-price elasticities on which the rest of the calculations are based. It is found that cheese and chicken are counterproductive to the aim of decreasing emissions. The best result on emissions is found when subsidizing only seafood and eggs, while cutting the net costs in half. However, the small effect on emissions does not justify the costs of implementing the subsidy. We therefore suggest a combination with a tax on more emission intense goods.

Acknowledgements

First and foremost, we would like to thank our supervisor Sarah Säll for being patient with our confusion and answering all our questions. We would also like to thank each other for being the only reason we finished before the deadline and actually wrote primarily during daytime. Furthermore, we would like to thank Janina's parents and Sarah's husband for proof reading the whole thing and not being too critical and our discussant Christoffer, for giving us helpful input. Last but certainly not least, we would like to thank the secret room of requirement for providing us free coffee, a room with a view, endless amounts of sparkling water and occasional free doughnuts.

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1. Introduction

It is well known that agriculture in general and livestock production in particular is one of the main sources of greenhouse gas (GHG) emissions worldwide, with Sweden being no exception. During the period 1970 to 2016, the Swedish consumption of meat has been increased by 50%, reaching a level of 87.7 kg per capita (National Food Agency, Sweden, 2013). This poses a great challenge for policy makers, working to fulfill the target of reaching no net emissions by 2050 (Direktiv 2014:53). Several studies on how to turn this trend around has been made during the past decade, primarily focused on environmental taxes on meat. The results from these, however, do not have an effect potent enough to make a significant difference in the consumption. A new angle must thus be adapted to explore further the possibilities of optional policy instruments to reach the climate target. Therefore, this study aims to investigate the option of turning the trend towards less emitting dietary choices, by applying subsidies to alternatives to the emission intense red meat. This is done by analyzing the correlation between prices and quantities, attaining elasticities on which the simulation of the effects of such a subsidy are based. The question we aim to answer is: What is the net cost for the government, comparing change in GHG emissions and the cost of the subsidy, to introduce simultaneous subsidies on red meat alternatives as an optional policy instrument for meat taxes?

From an environmental perspective, policy instruments are used with the purpose to limit, avoid or compensate environmental damage that occur due to market failure. A market failure is when perfect competition is inadequate to reach an optimal situation, leading to a welfare loss for society. The reason for this is the deficiency to include external effects in the price of the product, leading to a gap between the private cost and society's cost. Policy instruments are used to mend this gap. When such an instrument is efficient it achieves this at the lowest possible cost for economic actors while avoiding negative impacts, or create positive ones in other areas of society.

The most commonly used approach to manage negative externalities is taxation. An environmental tax is implemented to reduce pollution (Common and Stagl, 2005). By implementing a tax equal to the marginal external cost, production will, in theory, be reduced to an efficient level by making it more expensive to pollute. The price of the good should reflect the social cost of production rather than the economic costs alone.

A less used approach is subsidies, which is a form of governmental help where the government provides economic support to promote production or consumption (Brännlund & Kriström, 2012). An environmental subsidy should in theory promote goods and services that have positive external effects. However, it is rare to use subsidies as an instrument for decreasing consumption of goods with large negative effects, by promoting alternatives with less negative effects. There are a few examples where it is used to promote these "less bad" goods: Subsidies on railways is used to promote consumption of train travel as an alternative to aviation and car travel. Traveling by train does not have intrinsic positive environmental effects but is good in comparison to the alternatives (Swedish Transport Administration, 2017). Furthermore, a similar subsidy is used in Sweden on electric and hybrid cars, because of their less negative effect on climate compared to other cars (Swedish Government, 2015). We argue that this kind of subsidy could be a policy instrument of interest in dietary changes towards a less emitting food consumption pattern, viewing alternatives for red meat as this kind of a "less bad".

As mentioned previously the government of Sweden developed a national climate target in 2009 that stated "no net emissions of greenhouse gases by the year 2050" (Direktiv 2014:53). An investigation by the Swedish Environmental Protection Agency (Naturvårdsverket) established that the goal is reachable by heavily decreasing the amount of domestic GHG emissions, while increasing the amount of carbon dioxide absorbed into forests and fields, and decreasing emissions in other countries to balance out the remaining emission outlet (Swedish Environmental Protection Agency, 2013).

On an individual level, the average Swedes emits 11 tons of CO_2 equivalents per year –where 7 tons are from household consumption (Swedish Environmental Protection Agency, 2017a). To reach the target of no net emissions of GHGs, Sweden needs to come to a situation where the average Swede emits less than 2 tons of CO_2 equivalents (CO_2 e) per year (Swedish Board of Agriculture, 2018a).

On a national level the total emissions caused by consumption reached 105.03 million tons CO_2 e per year 2015 (Swedish Environmental Protection Agency, 2017b). The level has been rather constant since 1993, fluctuating around 100 million tons CO_2 e per year. The agricultural sector in Sweden emitted 6.879 million tons of CO_2 equivalents in 2016 out of the Swedish total domestic outlet from production of 52.893 million tons (Swedish Environmental Protection Agency, 2018a). This amounts to 13 percent of Sweden's total greenhouse gas emissions. The consumption-based emissions from food consumption are even higher, reaching 6.2 million tons from domestic produced goods 2015 and additional 15.15 million tons came from consumption of imported food products (Swedish Environmental Protection Agency, 2017c). This equals an average emission of 2.18 tons CO_2 equivalents per capita from food consumption, which equals approximately 20 percent of the aggregated individual emissions. Therefore, policy instruments to promote dietary changes, provide an area of opportunity to reduce the emissions and thereby increase the possibility of reaching the no net emissions goal by 2050.

According to Röös (2012) the levels of GHG emissions from red meat exceeds that of other protein sources (with the exception of some dairy products). The emission level from beef is 8.66 times higher than that of chicken, and 17.33 times higher than that of eggs. This combined with red meat (defined as beef and pork) being the most consumed in relation to other meatsmotivates implementing a policy instrument to decrease consumption-driven emissions from these (Swedish board of Agriculture, 2018 c).

To limit the scope of the thesis, a limitation of red meat alternatives is required. Ideally, the subsidy would include soy products and other plant based “meat-replacers”. However, the shortage of data on such goods made the inclusion impossible. Therefore, this paper will focus on other less emitting alternatives to red meat: chicken, seafood, eggs and cheese. Red meat is in this paper limited to beef and pork, and geographically restricted to Sweden. The emissions studied in this paper are limited to greenhouse gas.

2. Previous literature

As mentioned above, from a theoretical point of view, subsidies are normally used to encourage consumption of goods with positive external effects rather than discouraging consumption of goods with negative external effects. This might explain the lack of previous studies in the area using subsidies rather than taxes. Viewing subsidies on alternatives to red meat as an option to climate taxes to obtain the same effect also makes these studies of interest. Some research has previously been done on environmental taxes on meat, to decrease the demand for these goods.

A study by Säll and Gren (2016) apply a Pigovian tax on meat and dairy, with a range from 8.9-33.3 percent. The tax is placed on the consumption side which is motivated by targeting imported goods as well as domestic. The effect of the tax is then applied on four different pollutants, which is found to be reduced by 12.1 percent of the total emissions from only livestock production, if the taxes are simultaneously applied. The authors use the AIDS model to estimate the price elasticities and income elasticities of meat and dairy products and find that the own price elasticities are low and inelastic (in absolute terms) and higher for the income elasticities.

Similar to our study, Wirsenius et al. (2011) is primarily interested in GHG reduction and studies the effect of an environmental tax on animal products. Elasticities are calculated with the AIDS model to analyze the effects. The context here is the whole of EU and looks at the direct effect of the tax on decrease in production of animal food products and the reduction of GHG emissions that follows. It also examines the potential further GHG reductions if the arable land, pre-tax used for feed, were to be used for biofuels. The tax levels are average for the external costs of the emissions from each production sector. They find that applying the tax would result in a 7 percent decrease of GHG emissions from agriculture in the EU, of which 80 percent of these originated from cattle and sheep. The increased usage of the renewable bioenergy would result in a reduction of 5 percent of EU total emissions.

Edjabou & Smed (2013) look at the case of Denmark, examining the effect on GHG emissions from introducing consumption taxes on food. In contrast to the other two papers, the tax is also applied to other foods than animal products, with their GHG-emission per kg as a distributional measurement. Two scenarios are tested based on two different measurements of social costs from CO_2-equivalents. Interesting enough, for our study, the compensated tax is shown to be negative in the case of vegetables, chicken and fish (though not for cheese). This can be compared to the kind of emission reducing subsidy this study will examine. Since the less emitting food is faced with a negative one and the foods with higher emissions with a higher positive one, this can be viewed as a form of subsidy in combination with taxation on high emission foods. The AIDS model is used here as well to estimate the elasticities, and the study places great emphasis on health consequences from changing the diet. The result show that the cost-effective solution only will reduce the emissions from food by 2.3-8.8 percent and will have low effect on health.

Among the three articles, the own-price elasticity for beef varies quite significantly. Both Wirsenius et al. (2011) and Edjabou and Smed (2013), finds rather high own-price elasticities for beef, with -1.18 respective -1.3, compared to Säll and Gren (2016) who finds an elasticity of -0.66. Consequently, this will have large implications for their results, on the effect a taxation of beef will have on emissions. This might be explained by the difference in location, the variations in food culture and year of the studies. However, this explanation requires a rather big divergence of attitudes and demand for beef between the countries, with the Swedish consumer being far less sensitive to price changes than the Danish and average European consumer. This leads us to question whether the elasticities in the articles are to be accredited with the same level of reliability.

3. Method and data

3.1 Data

Our data on consumption quantities is found in the Swedish board of agriculture's (Jordbruksverket) statistical database (Swedish Board of Agriculture, 2018 c) and the data on consumption price index is from Statistics Sweden (SCB).

The data on red meat and red meat alternative quantities used in this paper are from the Swedish board of agriculture's statistical database (Swedish Board of Agriculture, 2018c). The data on seafood include different kinds of fresh fish, shellfish and frozen fish. The collection of fresh fish data ended in 1999. A regression done by Sarah Säll (2018) resulted in an estimation of fresh fish quantities from 1999 onwards, which were used in this paper to calculate the total amount of seafood consumed.

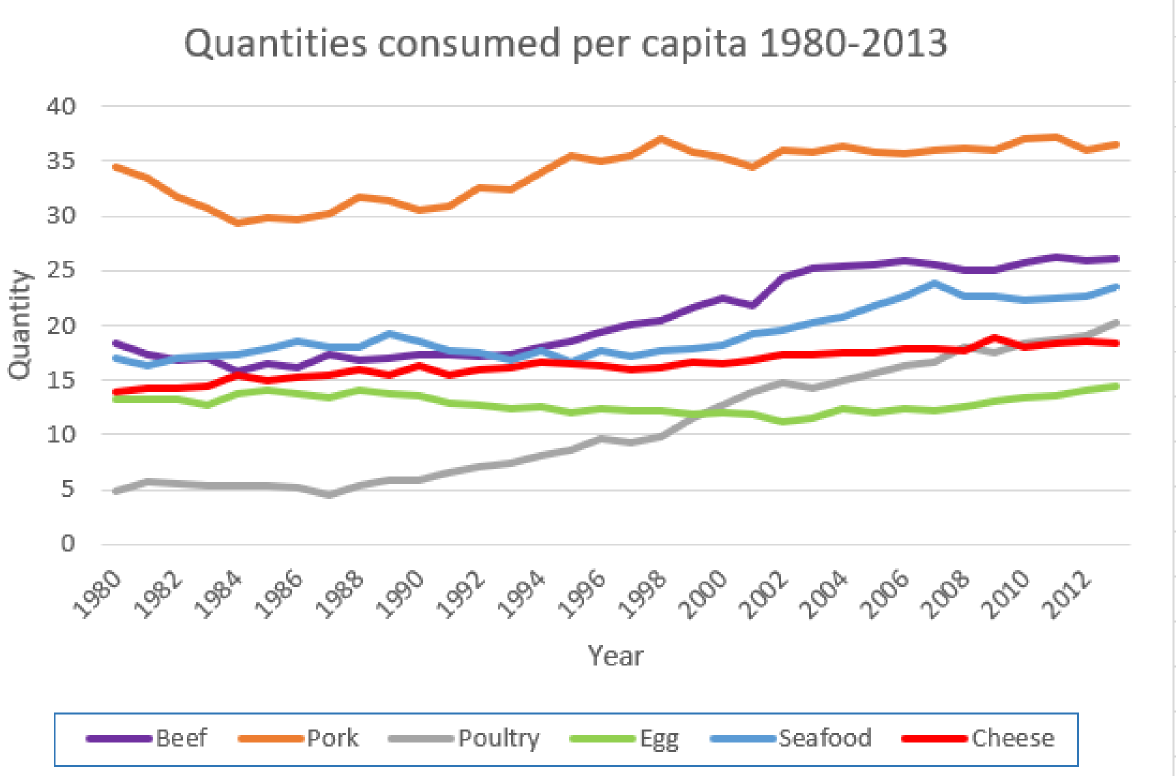

Figure 1. Quantities of different food types consumed per capita 1980-2013.

The quantity data is based on consumed rather than produced quantity. By using consumption data all emissions, including the emissions from imported goods, are included. This gives us a more accurate estimation of changes in emissions from a consumption subsidy. The consumption data is expressed in slaughter weight rather than retail weight, since the emission calculations from Röös (2012) are based on slaughter weight.

The quantities are illustrated in figure 1. We chose to handle dessert cheese and hard cheese as one homogenous product named cheese by combing their quantities. Here, it is clear that eggs have been subject to a rather stable consumption level during the time period. Chicken, on the other hand, has increased five times since 1980, and beef consumption have grown with 7 kg/capita.

There are many variables that has a clear link to the consumption of red meat that are omitted for reasons of lack of relevant data. For example, the model does not differentiate between organic and conventional farming, even though the price of the two will differ.

Figure 2 show the price index for each good between 1980-2013. The index for each good start at 100 for 1980 and illustrate the price changes for each good. The price index for cheese is based on the index of hard cheese. It is clearly visible in the figure that while goods like cheese and seafood have been subjects to a big increase in price, the price of chicken have only increased with 50 percent in the 33-year period.

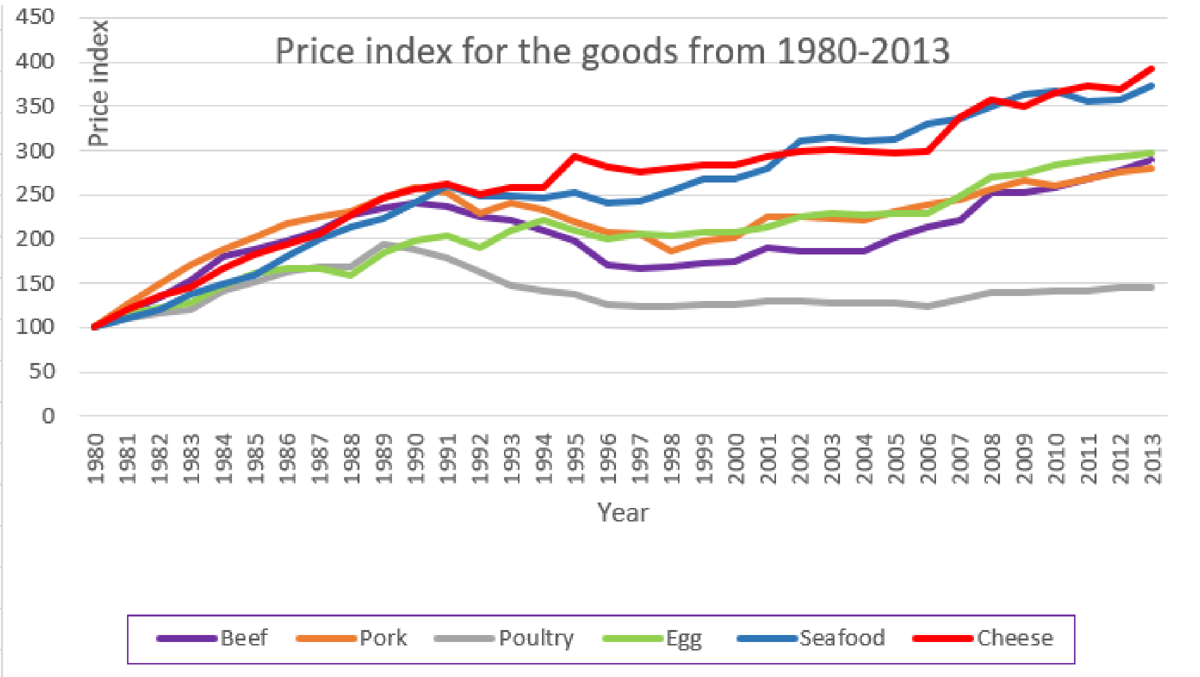

Figure 2. Price index for goods between 1980-2013.

The 2013 prices of all goods are found in the yearbook of agricultural statistics 2014 (SCB, 2014). The prices found in the report are based on consumption price of specific goods. The price of cheese is based on the price of Herrgårdsost, chicken price on frozen chicken and the seafood price on frozen cod fillets. All these prices can be found in table 1.

Table 1. *The good's price per kg*

Good	Price/kg
Beef	98.4
Chicken	31.2
Seafood	90
Eggs	28
Cheese	76.3
Pork	67.5

Data from Röös (2012) is used, illustrating how much greenhouse gas each good emits per kg produced, shown in figure 3. Beef has the highest emissions per kilo product, emitting 3.25 times more than that from cheese and 17 times more than that of seafood and eggs. The emissions from cheese is 0.33 times higher than that from pork. Chicken emit half of what pork does and seafood and eggs half of the emissions from chicken.

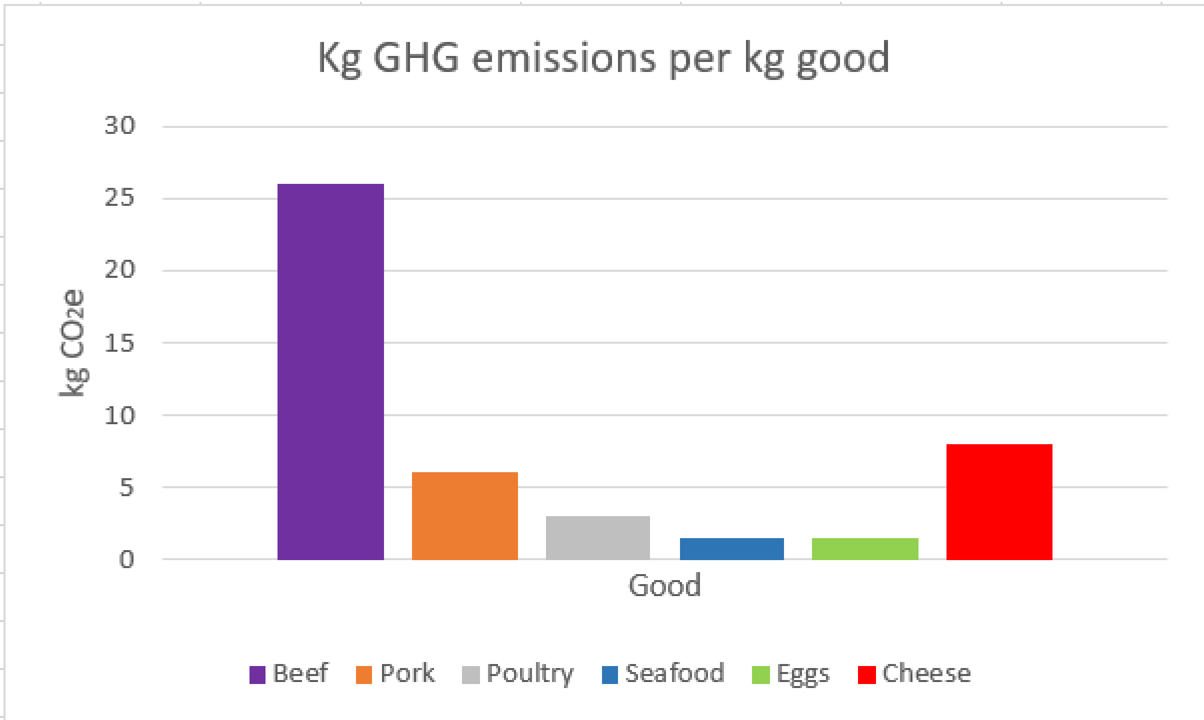

Figure 3. Kg GHG emissions per kg good.

The data on the population of Sweden 2013 comes from Statistics Sweden (2018a) and describes the number of people living in Sweden the 31:st of December 2013. GDP per capita 1980 to 2013 is collected from the World Bank's statistical database (2018a) and is expressed in SEK/capita.

There are two comprehensive studies dominating the conversation of the environmental cost of GHG emissions; Tol (2005) and Stern (2007). Since the assessed costs of these two differ, both will be used and compared to the costs of implementing the subsidies. Stern concludes a cost of USD 114.99 (expressed in 2013 year's USD) per ton CO_2 equivalents which equals 752.72 SEK/ton and 0.753 SEK/kg CO_2 equivalents. Tol's conclusion of USD 39.23 (expressed in 2013 year's USD) per ton CO_2 equivalents equals 256.8 SEK/ton and 0.257 SEK/kg CO_2 equivalents.

The exchange rate used consequently in this study is from the World Bank exchange rate from 2013 (World Bank, 2018b) of 6.514 USD to SEK.

3.2 Method

To answer the research question a simple OLS analysis on the data will be used to find elasticities. This will be done in the software Gretl by making the quantity of all goods respectively a function of their own price index and the prices index of all other goods.

$$LogQ_i = \varepsilon_i LogP_i + \theta_i LogGDP + \sum_{j=1}^{n} \varepsilon_{i,j} LogP_j \qquad (1)$$

Q_i is the quantity of the dependent good, and P_i the corresponding price index[1], and ε_i is the own-price elasticity of that good. P_j is the price indexes of all the other goods (*j=1…n*). $\varepsilon_{i,j}$ are the cross-price elasticities of these goods and hence how much the quantity of the different goods will change with a price change on itself and other goods. θ_i is the income elasticity which show how the good reacts to a change in income.

This will result in a linear correlation between the price index and the quantity of the different goods with the coefficients as elasticities. Due to the linearity of the model, it will not show any optimal level of subsidy. Because of this, four different subsidy levels will be chosen to represent the effect of introducing the subsidy. The analyzed levels are at 3, 10, 15 and 20 percent of the prices.

To calculate the change in quantity demanded from introducing the subsidy, a second model will be applied.

$$\frac{\Delta Q_i}{Q_i} = \sum_j^n \frac{\Delta P_j}{P_j} \varepsilon_{i,j} + \frac{\Delta P_i}{P_i} \varepsilon_i \qquad (2)$$

ΔQ_i is the unit change of the quantity and ΔP_j and ΔP_i is the unit changes of the prices of the independent and dependent goods from introducing the subsidy. This gives the percentage change in quantity. By comparing this to the 2013 year consumed quantity we obtain the unit change in quantity.

The governmental cost for the subsidy is calculated by multiplying the change in price with the new consumed level:

$$C_{sub} = \sum_k^m (-\Delta P_k) * Q_k^0 \left(1 + \frac{\Delta Q_k}{Q_k}\right) \qquad (3)$$

Where C_{sub} is the total cost of the subsidy at a set subsidy level. $-\Delta P_k$ is the negative numeric change in price for all goods at the same subsidy level, where *k* (*k=1…m)* are all the subsidized goods. Q_k^0 is the quantity in 2013, with no subsidy applied. This gives the total cost of introducing the subsidy.

To calculate the environmental benefits (expressed in avoided costs) from the subsidy, the kg unit change in quantities from the subsidy, ΔQ_k, is multiplied by the corresponding GHG emission levels

[1] For specific numbers, see appendix 2.

found in Röös (2012) (see table 1). This gives the kg unit change in GHG emissions caused by the simultaneous subsidy. The sum of the changes is then multiplied by the estimated costs per kg CO_2 equivalents from Tol (2005) and Stern (2007), described in the data. The changes are also compared to the goal of 2050, described above, to reduce emissions by 9 tons per capita in Sweden.

A comparing calculation will also be made, subsidizing the goods with 1 SEK one at the time, to find the goods on which 1 SEK of subsidy has the largest effect on GHG emissions. The extensive model will then be applied on the goods with a decreasing effect on emissions, repeating the whole process. The two end results will then be compared.

4. Results

In this chapter the results will be presented and interpreted.

From applying equation 1, own-price elasticities (marked with green) and cross-price elasticities where found. As shown in table 2 all own-price elasticities with the exception of eggs came out negative. A negative own-price elasticity indicates normal or inferior goods. The positive own-price elasticity on eggs indicate that eggs are a giffen good. There is no empiric evidence for the existence of giffen goods. Therefore, we conclude that these results can be questioned due to their incompatibility with theory, and a new result was thus calculated.

Table 2. *Cross-price and own-price (marked with green) elasticities of the food types. *** indicates a 99% significance, ** indicate a 95% significance, * indicates a 90% significance*

Elasticities	Beef	Pork	Cheese	Chicken	Seafood	Eggs
Beef	-0.157	-0.0898	-0.404 ***	0.109	0.247**	0.293**
Pork	0.168***	-0.553***	0.195**	-0.131**	0.141**	0.054
Cheese	0.088	0.026	-0.092	-0.140*	0.130*	0.111
Chicken	0.284	-0.253	-0.069	-1.172***	0.118	0.831***
Seafood	0.145*	0.083	-0.391***	0.031	-0.142	0.141**
Eggs	0.464***	-0.322***	0.141	0.143	-0.523***	0.164

Goods own price and cross-price elasticities are read from left to right so that the cross-price elasticity of chicken for the quantity of cheese is -0.14

While equation 1 was used in its current form for most quantity estimations, adjustments had to be made for some goods. While estimating the quantity of beef and pork, a time lag was introduced in the price index of chicken. This was done to achieve a more functional balance between own-price and cross-price elasticities for beef and pork. While estimating the quantity of seafood problems occurred with achieving a negative own-price elasticity. Therefore, a time lag on the price index of seafood was introduced and squared while keeping an unlagged variable. The time lags can be justified by the fact that a change in price might not have an instant effect on consumption as adjustment in consumer behavior might take time.

A sensitivity analysis was applied to exclude variables not relevant for eggs, giving it a negative own-price elasticity. The result was achieved through excluding seafood and cheese from the equation. The elasticities from this are presented in table 3 on which the following results are based. Income elasticities calculated from the same model can be found in appendix 3.

In table 3 there is variation between positive and negative cross-price elasticities, which indicate that the goods are substitutes or complements respectively. Only in the case of beef, pork and chicken does the own-price elasticity show a bigger effect on the quantity than the cross-price elasticities. With cross-price elasticities having larger effect on the quantity than the own-price elasticity, there is an indication that there is a stronger correlation between the own quantity and the prices of other goods rather than the own price. This might have offsetting effects on the quantity due to the own price change when introducing subsidies.

Table 3. *Cross-price and own-price (marked with green) elasticities of the food types after a sensitivity analysis on eggs. *** indicates a 99% significance, ** indicate a 95% significance, * indicates a 90% significance*

Elasticities	Beef	Pork	Cheese	Chicken	Seafood	Eggs
Beef	-0.157	-0.0898	-0.404***	-0.109	0.247**	0.293
Pork	0.168***	-0.553***	0.195**	-0.131**	0.141**	0.054
Cheese	0.088	0.026	-0.092	-0.140*	0.130*	0.111
Chicken	0.284	-0.253	-0.069	-1.172***	0.118	0.831***
Seafood	0.145*	0.083	-0.391***	0.031	-0.142	0.141**
Eggs	0.694***	-0.562***	-	0.319	-	-0.155**

Goods own price and cross-price elasticities are read from left to right so that the cross-price elasticity of chicken for the quantity of cheese is -0.14

The change in demanded quantity is shown in table 4. For each subsidy level, the quantity of cheese, eggs, beef and pork is decreasing while the quantity of chicken and seafood are increasing. Due to the assumed linear demand, the change on the marginal is constant – giving a proportional increase in absolute terms from the increase in subsidy level. It is evident that the biggest change in consumption comes from pork, followed by seafood and chicken.

Table 4. *Change in quantity on different goods from implementing a subsidy*

Subsidy (%)	Beef (kg)	Pork (kg)	Cheese (kg)	Chicken (kg)	Seafood (kg)	Eggs (kg)
3	-0.021	-0.284	-0.005	0.178	0.253	-0.071
10	-0.070	-0.947	-0.017	0.592	0.844	-0.236
15	-0.105	-1.421	-0.025	0.888	1.266	-0.354
20	-0.140	-1.895	-0.034	1.183	1.688	-0.472

Table 5. *Change in kg CO_2 equivalents per kg quantity change from implementing a subsidy*

Subsidy (%)	Beef	Pork	Cheese	Chicken	Seafood	Eggs	Total
3	-0.546	-1.705	-0.040	0.533	0.380	-0.106	**-1.485**
10	-1.819	-5.685	-0.135	1.775	1.266	-0.354	**-4.951**
15	-2.729	-8.527	-0.202	2.663	1.899	-0.531	**-7.427**
20	-3.638	-11.370	-0.270	3.550	2.532	-0.707	**-9.903**

While cheese, beef, pork and eggs are decreased from the subsidy, the consumption of chicken and seafood are increasing. This is a consequence of the elasticity and variation in prices. The cross-price elasticity of seafood on cheese is shown to have an offsetting effect on the already low own-price elasticity of cheese due to the relatively high price of seafood. This is the cause of the negative results on the cheese quantity.

It is evident from table 5 that a decrease in GHG emissions due to a decreasing consumption of cheese, beef, pork and eggs will occur. An increase is obtained in consumption of chicken and seafood. In total, each subsidy level will generate a total decrease in emissions. This is further evident in figure 4. Comparing the results in table 4 with the ones in table 5, the biggest change in emissions is from a reduced quantity of pork. The equally big change in consumption of seafood only cause a 2.53 kg CO_2 equivalents change on a 20 percent subsidy level, compared to the 11.37 CO_2 equivalents change from pork. This is explained by the four times higher level of emissions of pork.

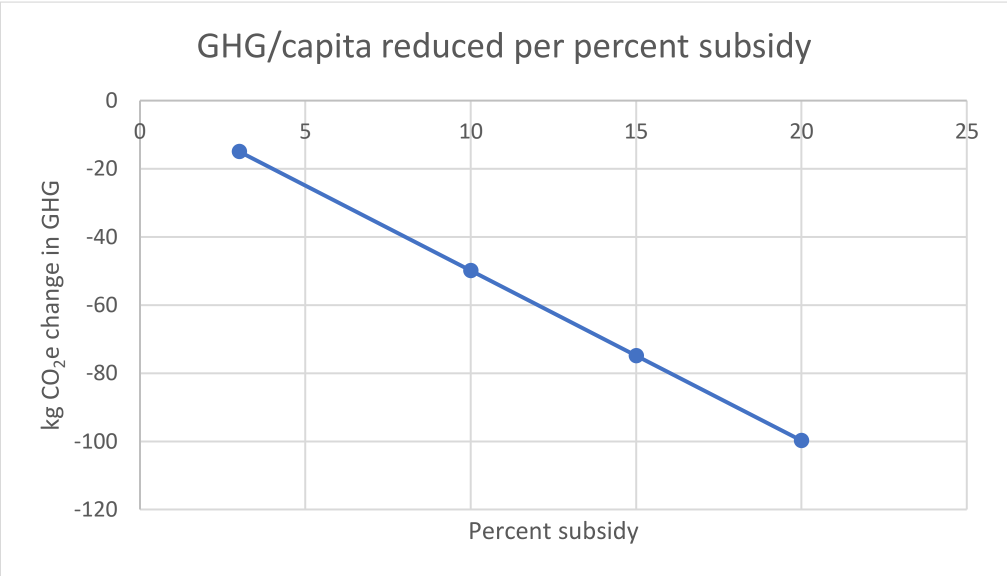

Figure 4. Kg GHG/cap change per percent subsidy.

Table 6. *Costs regarding implementing a subsidy*

Subsidy (%)	Change GHG (kg CO_2 e[2])	Cost Stern (kr)	Cost Tol (kr)	Cost Subsidy (kr)	Net cost Stern (kr)	Net cost Tol (kr)	Decrease of goal (%)	Decrease of agri. Sector (%)
3	-1.485	-1.118	-0.381	137.228	136.110	136.846	-0.017	-0.068
10	-4.951	-3.727	-1.272	463.484	459.757	462.213	-0.055	-0.277
15	-7.427	-5.591	-1.907	561.373	555.782	559.466	-0.083	-0.341
20	-9.903	-7.454	-2.543	944.275	936.821	941.732	-0.110	-0.454

[2] CO_2 equivalents = CO_2 e

The monetary levels from Stern (2007) and Tol (2005) were implemented, giving us the result in table 6. The negative numbers are to be interpreted as negative costs. The net costs are a comparison between these and the cost of the subsidy. The net costs are to be interpreted as the compensated cost of the subsidy, where not only the direct cost but also the indirect benefits from reduced GHG emissions are accounted for. However, the cost from Stern only decreases the cost from the subsidy by 0.7 percent – causing the net costs to be very small. Tol only reaches 0.3 percent. This is caused by the low change in GHG emissions from imposing a subsidy.

In relation to the goal to decrease GHG emissions with 9 tons CO_2 equivalents per capita by 2050, these results are minuscule. The contributing effect are at a 20 percent subsidy level 0.11 percent, whereas the cost from implementing the same is very high. As mentioned in the introduction, 2.18 of these tons originate from consumption of agricultural goods. Compared to these, the change in emissions is a decrease by 0.068 -0.454 percent. In an attempt to achieve a higher emission decrease, an analysis of the marginal effect of 1 SEK was enforced. This was applied separately on each good as a 1 SEK subsidy. The result can be found in table 7.

Table 7. *Kg GHG/cap effect of implementing a 1 SEK subsidy on each kg good*

	Cheese	**Chicken**	**Seafood**	**Eggs**
Beef (kg CO_2 e^2)	3.590491	2.376779	-1.85937	-7.10562
Pork (kg CO_2 e)	-0.56123	0.919176	-0.34348	-0.42117
Cheese (kg CO_2 e)	0.177094	0.660579	-0.21329	-0.58124
Chicken (kg CO_2 e)	0.054817	2.284507	-0.07985	-1.80437
Seafood (kg CO_2 e)	0.179932	-0.034842	0.055609	-0.17807
Eggs (kg CO_2 e)	0	-0.220092	0	0.118929
Total (kg CO_2 e)	**3.441108**	**5.986107**	**-2.44038**	**-9.97153**

Since the goal of the policy is to decrease GHG emissions, it is evident that cheese and chicken is counterproductive to this aim, much due to the complementarity found between chicken and beef. A decision is therefore made to exclude these goods from being subsidized to increase the total effect of the subsidy.

A narrowed subsidy is constructed where only seafood and eggs are included as red meat alternatives in the model. The former change in beef quantity, presented in table 4, has now increased from -0.140 to -2.81 in table 8. This is 20 times higher compared to the former results. Contributing with the highest GHG emission level per kg, this will have severe consequence for the net costs. An equally big change has occurred in the quantity of cheese. Another big change is that of chicken, shifting from an increasing change in quantity to a decreasing. Eggs, however, is subject the opposite transformation. The seafood quantity, on the other hand, decreases by 5620 percent– from 1.688 in table 4 to 0.003 in table 8.

Table 8. *Change in quantities from subsidizing seafood and eggs*

Subsidy (%)	Beef	Pork	Cheese	Chicken	Seafood	Eggs
3	-0.423	-0.214	-0.133	-0.577	0.000	0.067
10	-1.409	-0.712	-0.443	-1.924	0.001	0.222
15	-2.113	-1.068	-0.665	-2.885	0.002	0.333
20	-2.818	-1.424	-0.887	-3.847	0.003	0.444

Equally big changes will occur comparing the GHG changes in table 9 to table 5. The total change caused by the new subsidy faces an increase 10 times bigger than that of the old. The decrease of 9.9 kg CO_2 equivalents, on a 20 percent subsidy level, is now reaching 99.8 kg CO_2 equivalents on the corresponding level in table 9.

Table 9. *GHG/ cap change from subsidizing seafood and eggs*

Subsidy (%)	Beef (kg CO_2e)	Pork (kg CO_2e)	Cheese (kg CO_2e)	Chicken (kg CO_2e)	Seafood (kg CO_2e)	Eggs (kg CO_2e)	Total (kg CO_2e)
3	-10.989	-1.281	-1.064	-1.731	0.001	0.100	**-14.965**
10	-36.630	-4.271	-3.547	-5.771	0.002	0.333	**-49.884**
15	-54.945	-6.406	-5.321	-8.656	0.003	0.500	**-74.826**
20	-73.260	-8.541	-7.094	-11.542	0.004	0.666	**-99.768**

The estimated emission costs from Stern (2007) and Tol (2005) naturally follow the same pattern with a 10 times increase from table 6 compared to table 10. As a consequence of subsidizing fewer goods, the cost of the subsidy is lower – the new being 56 percent of the old. The relationship between the negative costs from Stern and Tol and the cost of the subsidy is greatly improved – now having a ratio of 14 percent for Stern and 4.8 percent for Tol. The higher change of GHG combined with subsidizing fewer goods results in a net cost decrease of 49 percent for Stern and 46 percent for Tol.

Compared to the goal of decreasing emissions by 9 ton per capita, the result from the narrowed subsidy is 10 times higher. At a 20 percent subsidy level, 1.1 percent of the goal is achieved. Even on a 3 percent subsidy level the results in table 10 exceeds those on a 20 percent level in table 6. Compared to the emissions originating from agricultural consumption of 2.18 tons, the change in emissions is a decrease by 0.686 – 4.576 percent.

Table 10. *Costs regarding implementing a subsidy on seafood and eggs*

Subsidy (%)	**Change GHG** (kg CO_2e)	**Cost Stern** (kr)	**Cost Tol** (kr)	**Cost Subsidy** (kr)	**Net cost Stern** (kr)	**Net cost Tol** (kr)	**Decrease of goal** (%)	**Decrease of agri. Sector (%)**
3	-14.965	-11.265	-3.843	75.983	64.718	61.018	-0.166	-0.686
10	-49.884	-37.549	-12.810	258.132	220.584	208.248	-0.554	-2.288
15	-74.826	-56.323	-19.215	325.694	269.371	250.868	-0.831	-3.432
20	-99.768	-75.097	-25.620	530.137	455.040	430.369	-1.109	-4.576

5. Discussion and conclusion

In this study, we have estimated the net cost of implementing a subsidy. The calculations where based on price elasticities and new levels of consumptions where found. The change in emissions compared to the cost of a subsidy resulted in net costs. The efficiency of the subsidy was increased by only subsidizing seafood and eggs.

The choice of model to attain the net costs might be questioned, since it is limited on several points. The health aspect of lessening the amount of red meat consumed is not considered, even though this might be a further gain. It does not integrate the potential increased consumption of other goods from the money saved from the subsidy or counterproductive internal substitution between the alternative goods. This might have negative effects on emissions, if the consumer chooses to buy more cheese instead of eggs. A further weakness is probable omitted variables and only accounting for correlation, rather than causality.

An indication of the model not taking variating quality of data into full consideration is that it can not guarantee results in line with theory. This is shown in the result in table 2, where the price elasticity of eggs suggested it to be a giffen good.

Compared to previous literature, the own-price elasticity of beef (-0.16) found in this study is considerably lower in absolute terms. This results in a substantially smaller effect on quantity from changing the price. At –1.3, Wirsenius et al. (2011) have the highest elasticity, while Edjabou & Smed (2013) estimated a –1.18 elasticity and Säll & Gren (2015) landed on –0.66. While the own-price elasticity of beef is not as relevant in our study, due to being multiplied with the price change of 0, it indicates a probable lack in our model. Our own-price elasticity of chicken, of –1.17, is in line with the same in Wirsenius et al. (2011) and Edjabou & Smed (2013), with -1.0 and -1.4. Säll & Gren (2016) on the other hand have calculated an elasticity of -0.4, which differs radically from the former as well as ours.

A more complex model could have been used to increase the credibility of the results, such as the AIDS model combined with a demand system, similar to previous studies. However, the model does take into account how the different goods are affecting each other. Since it does include cross-price elasticities the model gives a better view on how the goods are related to each other than building the model on own-price elasticities exclusively. This model is customized to our research question and take into consideration the level and scope of the thesis.

With the quantity of fresh fish being estimated (from 2000 onwards) rather than observed, the plausibility of our result is lessened. This does not give an adequate reflection of reality and effects the results as a whole. Furthermore, the reliability of a result based on elasticities lessen as the price change increase. The implication of this for our study is that the results on a 3 percent level are more credible than that on a 20 percent level. To increase the plausibility of the result, the model might have been adjusted to compensate for the variation in quality of the data and the variation in the price-quantity relationships.

Comparing the levels of emissions from pork and cheese in figure 2 it is evident that cheese emits more than pork, making it only a beneficial alternative to beef. However, with the cross-price elasticity of cheese for beef consumption being negative, and thus a complement, makes subsidizing cheese counterproductive, as shown in table 7. This is further supported by Edjabou & Smed's (2013) article which concludes a negative tax rate for chicken and fish but not for cheese. This show a possible improvement of the model by excluding cheese entirely.

Regarding subsidizing seafood, even though the emissions from seafood are less than that of beef as well as pork, depletion is a major concern which is not taken into consideration in this study. This might be solved by not subsidizing species subject to overfishing and promoting fish that are sustainable.

The results show a potential decrease of GHG emissions from implementing the subsidy. It is higher when only subsidizing seafood and eggs, but in both cases relatively small in comparison to the ones in the literature. Wirsenius et al. (2011) argues that a decrease of 7 percent on the total emissions from consumption of animal foods in the EU might be achieved through a tax on animal foods, while Säll & Gren (2016) have a result of only 1.5 percent decrease compared to the total emissions in Sweden and 12.1 % compared to the national emissions from agriculture. Edjabou & Smed (2013) concludes the biggest change of a 10.4 - 19.4 percent decrease in emissions caused by food consumption.

Even though similar, a subsidy is not entirely comparable with the meat taxes found in the literature. The costs in the case of a subsidy will primarily be distributed to the government, while a tax will mainly affect the consumers and producers. Subsidies rarely causes deadweight losses, while taxes often do. However, the results might be compared, since the aim of the policy instruments is the same.

As seen in table 6 and 10, the net costs for implementing a subsidy are quite high. Using the population level of 2013, the 3 percent tax level for implementing a narrowed subsidy will amount to 0.732 billion SEK. However, the subsidy cost should not be viewed as a deadweight loss but rather a reallocation within the social welfare. The government can finance this cost several different ways:

The budget for the subsidy might be justifiable by comparing it to already implemented subsidies that are counterproductive to the climate target. An example is the reduced carbon tax for diesel fuels used in the agricultural, forestry and aquacultural sectors. This alone was budgeted to 0.82 billion SEK in 2017 (The Swedish Government, 2017) which could be used as an argument to introduce as costly subsidies that has positive environmental effects. Applying the theory that goods with negative external effects should be subject to taxation, reinforcing the carbon tax on these sectors might be another possibility to finance our subsidy.

An option would be to implement a green tax-switching policy (grön skatteväxling). This might be done by introducing a tax on goods with high GHG emission levels, for example red meat, and using it to finance our subsidy. There is a possibility that this solution might act as a mutual boost on the effects - resulting in increasing potency on the respective policy instruments. This is further supported by Edjabou & Smed (2013), who applies both regular positive tax levels for food products with high emission levels and negative ones for less emitting goods. This is arguably a form of a green tax-switching policy, making a cooperative system of subsidies and taxes to promote dietary changes. With the highest results compared to their fellow researchers, the introduction of such a policy system might have a beneficial outcome.

In our study, there have been no inclusion of transaction costs, meaning that the costs of implementing and administering the subsidy will exceed the costs calculated in table 6 and 10. Due to the already high costs for insignificant effects, it might not be worth implementing the subsidy when not introducing it with some form of green tax-switching policy. This solution would be beneficial in two ways, both achieving a more substantial decrease of emissions, and financing the subsidy. The efficiency of implementing a tax on red meat combined with a subsidy on alternatives, would make for an interesting future research topic. Due to the limited reliability of our model and results, we do not recommend the current subsidy to be implemented. Therefore, we would like to see further studies on a more advanced level on subsidizing alternatives to red meat.

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Appendix 1

Year	Beef	Pork	Chicken	Eggs	Seafood	Cheese
1980	18.3	34.52	4.91	13.24	17	14
1981	17.39	33.5	5.63	13.2	16.3	14.2
1982	16.9	31.66	5.51	13.23	17	14.2
1983	17.03	30.69	5.37	12.73	17.1	14.5
1984	15.84	29.42	5.33	13.81	17.4	15.4
1985	16.54	29.84	5.33	14.04	17.9	14.9
1986	16.17	29.7	5.24	13.82	18.5	15.3
1987	17.3	30.28	4.54	13.41	18	15.4
1988	16.75	31.7	5.35	14.06	18.1	15.9
1989	16.92	31.43	5.82	13.75	19.2	15.4
1990	17.3	30.61	5.89	13.62	18.6	16.3
1991	17.32	30.93	6.52	12.81	17.7	15.5
1992	17.13	32.6	7.12	12.68	17.6	15.9
1993	17.41	32.5	7.48	12.43	16.8	16.2
1994	18.02	33.99	8.18	12.55	17.7	16.7
1995	18.51	35.55	8.69	11.96	16.7	16.5
1996	19.35	34.95	9.56	12.45	17.7	16.4
1997	20.1	35.46	9.31	12.13	17.2	16
1998	20.42	37.1	9.82	12.27	17.7	16.2
1999	21.58	35.9	11.46	11.89	17.9	16.6
2000	22.55	35.35	12.79	12.00	18.21	16.5
2001	21.74	34.55	13.91	11.85	19.22	16.9
2002	24.39	36.01	14.81	11.26	19.63	17.3
2003	25.17	35.83	14.3	11.49	20.34	17.4
2004	25.42	36.33	14.87	12.44	20.85	17.6
2005	25.63	35.87	15.72	12.05	21.76	17.6
2006	25.96	35.6	16.28	12.30	22.67	17.8
2007	25.54	36.11	16.69	12.23	23.88	17.8
2008	25.1	36.26	18.09	12.52	22.59	17.7
2009	25.04	36.11	17.51	13.01	22.6	18.9
2010	25.72	36.97	18.37	13.39	22.31	18.1
2011	26.25	37.29	18.74	13.60	22.42	18.3
2012	25.88	35.98	18.99	14.10	22.73	18.5
2013	26.08	36.59	20.27	14.37	23.44	18.4

Consumed quantities of goods per capita in Sweden between 1980 and 2013.

Appendix 2

År	Beef	Pork	Chicken	Eggs	Seafood	Cheese
1980	100	100	100	100	100	100
1981	117.70	125.60	109.50	116.60	111.02	120.40
1982	133.80	149.00	115.80	122.70	119.77	134.90
1983	152.50	170.30	120.60	128.70	137.26	144.50
1984	180.40	187.80	141.60	148.20	149.16	166.60
1985	189.00	202.50	151.30	160.17	159.15	182.70
1986	197.20	217.93	163.31	167.03	179.59	194.50
1987	209.12	225.50	169.00	166.32	199.85	205.70
1988	227.28	231.28	169.52	160.00	213.18	228.00
1989	235.72	245.64	194.53	184.86	222.58	246.00
1990	240.85	258.87	188.73	198.78	241.59	256.50
1991	236.06	253.36	177.69	203.47	259.28	261.63
1992	225.57	229.79	163.75	189.43	248.79	251.37
1993	221.88	241.16	146.82	209.33	248.16	258.55
1994	210.03	232.12	142.24	221.22	245.78	257.76
1995	198.88	220.02	136.94	209.63	252.22	292.46
1996	169.87	207.82	125.58	200.23	239.92	280.87
1997	166.41	206.13	123.49	204.85	243.52	275.56
1998	168.69	187.06	124.19	203.89	254.22	279.46
1999	172.70	197.11	126.56	206.82	267.56	282.87
2000	174.83	201.00	126.49	206.81	268.37	284.38
2001	190.83	226.02	130.09	213.77	278.85	293.03
2002	186.13	224.40	129.41	224.76	309.82	298.44
2003	187.21	223.64	128.21	229.58	313.68	300.49
2004	186.29	222.10	128.57	226.96	310.39	299.08
2005	201.74	230.99	128.42	228.85	313.48	297.47
2006	213.81	239.14	124.90	229.48	329.47	298.29
2007	220.77	244.28	132.16	248.99	336.42	337.09
2008	252.36	256.17	139.38	269.43	350.41	357.09
2009	251.46	266.08	139.98	273.84	362.92	350.54
2010	258.95	260.48	141.84	283.34	366.34	365.55
2011	267.93	268.48	142.30	289.65	355.45	372.13
2012	277.76	275.67	146.34	294.12	357.48	369.75
2013	288.80	279.12	145.31	297.29	373.30	392.43

Price index of beef, pork and red meat subsidies with 1980 as the base year.

Appendix 3

Income elasticities of each good

Good	Income elasticity
Cheese	0.089277*
Beef	0.969102***
Pork	-0.01858
Chicken	1.42102***
Seafood	0.853541***
Eggs	0.015749

This table show the income elasticities for the different goods. Most of the elasticities indicate normal goods, or necessary goods, with an income elasticity ranging between 0 and 1. Beef is tending towards a luxury good and chicken, according to the result, is a luxury good. Pork, on the other hand is an inferior good, according to this table. This means that an increase in income will tend to increase the consumption of all goods except pork, that will decrease.