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Carbon Footprint - A Luxury Good:

Implications for a Norwegian Tax Proposal

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Abstract

Consumption-based emissions from international trade are substantial, but are not reported to the UNFCCC. In this master thesis, we have analysed the relationship between individual expenditure and the consumption-based carbon footprint in 2012, using a two-region model to account for trade. Total average per capita emissions is 10 tonnes CO_2, and indirect imported emissions accounts for 43% of the total carbon footprint. The carbon elasticity in Norway is likely above one, as our results indicate that it is 1.19. More specifically 1.37 for indirect imported emissions, 1.09 for indirect domestic emissions and 1.1 for direct emissions. In other words, the relationship between consumption-based emissions and expenditure are increasing at the margin. Therefore, carbon emission is a luxury good, and a tax would be progressive. The cause appears to be the cheap, clean electricity in Norway. Reviewing the literature to assess unilateral policy options, we find a broad consensus in favor of a carbon tax. However, as the estimates for the current social cost of carbon ranges from 12 USD/tonne CO_2 to 900, setting a tax level is difficult. Implementing a carbon tax unilaterally also demands a border carbon adjustment (BCA) to protect the exposed industry, and avoid carbon leakage. The empirical results indicate that this is not particularly effective. Levying the tax upstream would be preferred, but is impossible with most imported goods. Generalized emission intensities for product categories can be utilized, but will create adverse incentives and perhaps increase global emissions. More accurate estimates would help, but increase costs and complexity. Challenges aside, Norway are all but dependent on the efforts of other, larger nations, if we are to avoid potential damages to our economy caused by climate change. Setting an example for others to follow may be the only way to achieve this, and we should therefore start to pursue unilateral efforts in the product categories that yields the most reductions.

Acknowledgements

We were thrilled when the possibility to work with Gunnar Eskeland and Patrick Narbel arose. Through an internal note given to the attendants of the course "The Economics of Climate Change" in May, they announced that they were looking for master students who wanted to write a thesis on the subject of carbon tax. In addition, they wanted help with some work related to a request from the Green Party in Norway, on the more specific subject of a revenue neutral carbon tax for Norway. We applied straight away, and ended up with being assigned to the task sometime during the early days of the Norwegian summer. Through the initial phases of the project, we helped Patrick as best we could with gathering information about carbon tax schemes. At the same time, we tried to educate ourselves for the task ahead, namely conducting our analysis on the consumption-based emissions in Norway, and writing this thesis. Through Patrick's plentiful help, and the valuable insights of Gunnar, a seasoned veteran, we have always felt confident that we would come out on top. The workflow has been great, and the subject in itself immensely interesting, albeit sometimes frustrating and somewhat gloom. Being a part of the younger generations, we are both worried about the lacking prospects of the international collaboration in battling climate change, and the potential outcome of a changed world. Still, working with these issues is a meaningful and important task, that we take great pride in. We would like to direct a special thanks to our supervisor, Gunnar, Patrick, Elisabeth Isaksen and Glen Peters. Also, we would like to thank SNF at NHH, and Hordaland Fylkeskommune for granting us scholarships. We would also like to express our gratitude for the love and support provided by our close friends, (respective) girlfriends and our families. Enjoy!

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1 Introduction and Background

1.1 About Methods to Calculate National Emissions

There is a scientific consensus that the rising levels of carbon dioxide in the atmosphere caused by human activities are rising the average surface temperatures on Earth (UNFCCC, 2014). In response, international agreements like the Kyoto Protocol (1997) and the Paris Agreement (UNFCCC, 2015) have been ratified to combat climate change. The latter aims to limit the global rise in temperature this century to well below 2 degrees. Under these agreements participating countries have committed to binding national emission targets and are required to submit annual national emission inventories to document their CO_2 emission reduction. Countries are required to report all emissions and removals taking place within their borders and within areas over which the country has jurisdiction (EEA, 2013). This way of allocating emissions is called the territorial-based approach. Another well-established way to allocate emissions is the production-based emission accounting. Using this method, a country report all CO_2 emissions caused by their citizens and businesses, irrespectively of where in the world these emissions actually take place (EEA, 2013).

Although these approaches provides important information about the mitigation progress in a country, they are not without disadvantages. A downside is related to carbon leakage.[1] Aichele and Felbermayr (2015) showed that countries committed to the Kyoto Protocol increased their embodied carbon imports from non-regulated countries by about 8%, while the emission intensities of their imports rose by about 3%. Kuik (2009) showed a carbon leakage rate of about 11% due to fragmented cli-

[1] Carbon leakage refers to situations where cost related climate policies cause businesses to move their production to countries with laxer or no climate policies (European Commision, 2016). This may result in increased total emission of CO_2. As the global effect of CO_2 emissions is unaffected of where they actually take place, the earth is worse off, in spite of local/regional efforts.

mate actions and Böhringer, Fischer, and Rosendahl (2010) found a global leakage rate of up to 28% when Europe reduced their emission due to suboptimal climate policies.

Consumption-based emission accounting is an alternative to the territorial approach. The method includes emissions from global trade, in the way that it excludes the carbon footprint of exports, and includes that of imports (Davis & Caldeira, 2010). Emissions are allocated to the country where the final consumption takes place. This assures that if production is moved abroad due to climate policies, the emissions from production is still allocated to the country which citizens consume the goods and services.

Currently the official numbers on CO_2 emissions in Norway from Statistics Norway (SSB) is based on the territorial and production-based approach (SSB, 2015). As mentioned, these methods provide important information of how well Norway does in relation to their legally binding commitments in the international agreements, and how effective climate policies and new production technologies are on emissions. The method also has the advantage that the required data are relatively easy to collect and measure (Grantham Research Institute, 2011).

There are no official numbers for consumption-based emissions in Norway. While SSB (2015) acknowledges that consumer-based analysis are useful, official reporting is not conducted due to methodological challenges. They argue that the methodology would rely on strong assumptions on the production processes across countries as one would need to address emissions from the entire supply chain.

The emissions embodied in trade are complex matters and the method requires data from all trading partners of a country, and these data must be aggregated (Grantham Research Institute, 2011). However, if we manage to overcome these challenges, the results might be important and useful. In addition to the advantages of a more global perspective on the climate change, the consumption-based approach could also help raise the awareness among consumers (Grantham Research Institute, 2011). This is particularly important as household consumption is found to be accountable for 60% of all GHG emissions globally (Ivanova et al., 2015). A change in consumer habits could thus have a major effect on global emissions.

1.2 Trade, Imports and Consumption-Based Emissions

Global trade is on the rise. It came to a halt during the financial crisis, and is currently once more lagging behind the predicted trajectory, but the curve is still moving upwards (WTO, 2016). From 2006 to 2015, the amount of goods imported to Norway has increased from 410 billion NOK to 615 billion NOK (SSB, 2016a).

Taking this trade into account, Reinvang and Peters (2008) painted a rather grim picture of the Norwegian carbon footprint abroad. While domestic emissions had remained rather stable around 55-57 Mt CO_2 per year from 2001 to 2006, the consumer based emissions abroad grew by 33%. At 39 Mt CO_2, it accounted for 45% of our total emissions in 2006. In developing countries, which typically have more emission intensive production sectors, the Norwegian carbon footprint increased by 65%. In China, the Norwegian carbon footprint increased from 2.4 Mt in 2001 to 6.8 Mt in 2006, while our imports in monetary values only increased by 90%. Not only do we import more, we import a higher share of carbon intensive products. As 70% of China's electricity comes from coal power plants (Reinvang & Peters, 2008), one could say that Norway is not importing electricity from coal power plants via the electricity market in Europe (Vagle, 2015), but by buying goods from China.

A destinctive Norwegian issue when accounting emissions based on the production and territorial approach is related to Norway's economic situation. The carbon intensive petroleum industry accounts for 15% of GDP and 39% of export (Regjeringen, 2015). According til Boitier (2012), it is difficult to abate in Norway without actually reducing economic activity as the production-based approach includes emissions from the production of exports like oil. Therefore other abatement efforts in Norway has little impact on total emissions. The official emission accounting from SSB underlines this. The total emissions of CO_2 show a steady growth from 1990 to 2015, and the growth in CO_2 emissions has been especially high for the oil and gas sector.

Peters, Andrew and Karstensen (2016) states that the term "carbon footprint" is also often misused, and not properly clarified in different policy contexts. They advocate that the carbon footprint should be defined by a consumption based approach, where the emissions are assigned to the country in which the good that is associated with the emissions is consumed. Whether direct carbon emissions or equivalents are used, should be clarified by the context. Using equivalents shifts the focus towards food and agriculture, where emissions are mostly related to methane, nitrous oxide and land use. As to why is this not a common approach to this date, Peters et al. (2009) suggest that this could be a result of policy makers introducing climate measures affecting emissions of which they have direct jurisdiction, leading to territorial accounting.

Developed countries generally get higher emission estimates using a consumption based approach, as the decrease in territorial emissions are offset by the imported emissions (Peters, Minx, Weber & Edenhofer, 2011; Le Quéré et al., 2015). Both the Nordic Countries (Norway, Sweden, Denmark and Finland) and the EU28 are net importers of CO_2. Notable fluctuations in the import share, includes a decrease in the early 90's, presumably because of the collapse of the Soviet Union, and an increase between 2000 and 2005, due to imports from China (Peters et al., 2016). There has since been a slight decrease of both territorial and consumption emissions. In the case of Norway, the export of oil and our energy intensive industry even out the difference between the two measuring methods, but Norway is still a net importer of carbon.

Research looking at emissions of carbon dioxide using a consumer approach, illuminates the behavioral patterns within the populace that leads to emissions, rather than looking at the means of production (Karstensen, Peters & Andrew, 2015). This may in turn contribute to shifting the focus of policy makers, aiming to curb consumption rather than production (Karstensen et al., 2015; Hertwich & Peters, 2009).

The research on consumer based emissions is piling up. Weber and Matthews (2007), found that the CO_2 footprint from imported products accounted for about 30% of the total American household emissions. The accountant and consultancy firm Deloitte recently released a report on carbon imports and exports (2015), focusing on consumption-based emissions in Australia. It concluded that the inland reduction in emissions in the examined countries were offset by the net emission exporters, mainly China. To make things worse, the carbon intensity resulting from Chinese production methods was, in some cases, five times higher than that in the US. As an example, in 2011, 31% of Australian emissions were emitted overseas. Even though Australia is one of the biggest net importers from China, they are not the worst of the bunch. Germany, the UK and France are even worse off, importing 50-60% of their emissions.

Using a consumption-based approach, Barrett et al. (2013) showed that the UK´s emissions of greenhouse gas (GHG) rose with 1% per year between 1990 and 2008. During the same time span, the emissions reported to the UNFCCC by the use of territorial-based method shows a decrease in GHG emissions of 27%, a 1.4% yearly decrease. Steen-Olsen, Weinzettel, Cranston, Ercin and Hertwich (2012) also concluded that the UK are the biggest net CO_2 importer from other EU countries. In the UK, these results have spiked a debate (John Barrett et al., 2013). Researchers have called for a new standard of reporting that includes imported emissions, and a new set of policies to go with it. However, the resistance from certain parts of the parliament have slowed the process of creating a political consensus.

Isaksen and Narbel (2017) utilizes the consumption based approach, investigating the relationship between spending in the Norwegian consumer market and embodied emissions, using input-output tables from SSB and the Norwegian consumer survey of 2007. They find, rather unexpectedly, that the relationship seems to be linear, and close to unity. A sizeable share, 39%, of these consumption based emissions are also embodied in imports. Other similar studies, like Girod and de Haan (2010) and Golley and Meng (2012) also conclude that there is a strong relationship between consumption or income, and carbon emissions. Given that a large share of our consumption is imported, this would imply that we need to curb spending on carbon intensive, foreign commodities, or somehow decrease the carbon footprint of these goods if we are to decrease consumption-based emissions.

In Norway, SSB (2015) reported a decrease in the per capita CO_2 emissions of just above 6%, from 9.4 tonnes to 8.8 tonnes CO_2 in the period 1999 to 2012, based on the territorial approach. However, Steen-Olsen, Wood and Hertwich (2016) examined the development in Norwegian consumption based CO_2-equivalents emissions in the same period, and concluded that they have risen by 26%. The paper concluded with a mean carbon footprint of 22.3 tonnes CO_2-equivalents per household in 2012. They also suggested that to abate in a sufficient manner, clear strategies to reflect consumer based carbon footprints must be put in place. To do so, a functional analytical framework to determine the carbon intensities of consumer products, both produced locally, and imported, is needed.

2 Consumption and Emissions in Norway

In the following analysis, we have examined the emissions from imported and domestically produced goods and services. Using a similar methodology as that of Isaksen and Narbel (2017) and the consumer survey of 2012, we find that the share of the total emissions from imported goods has increased since 2007, and now account for more indirect emissions than that of indirect domestic production.

The results provides useful insights as to where Norway stands when basing the emission accounting on the consumer-based approach. By comparing with a similar study using numbers from 2007, we are also able to cross-check our results, and thus the robustness of the model.

2.1 Research Question

Is carbon footprint a luxury good in Norway?

2.2 Methodology

The consumption-based approach takes into account that imported goods and services come from places with different production technologies. Importing goods can therefore have an adverse effect on emissions compared to actually producing them domestically, if the foreign emission intensities are higher.

This consideration is reflected by distinguishing between emission intensities in Norway (labeled NOR) and emission intensities from the rest of the world (labeled ROW). These emission intensities are given in kilograms of CO_2[2] per US dollar spent on goods and services, and was provided by Glen Peters from the Center for International Climate and Environmental Research in Oslo (CICERO).[3]

Our method also distinguishes between indirect and direct emissions. Direct emission refers to the emission occurring from the actual consumption of a good or service. The CO_2 emission from fuel combustion as you drive a car belongs to this category. As does the CO_2 emission from preparing your meal on a gas stove or a gas grill.

Indirect emissions are not related to the actual consumption of goods and services, but rather the emissions embodied in all processes throughout the supply chain. There is for instance no emissions related to drinking water from a plastic bottle, but the actual process of producing and distribution the plastic bottle is not emission-free. This category is a complex matter, as it involves the emissions from extraction of material and production of intermediate products, to the emissions from distribution and the final production process.

Isaksen and Narbel (2017) operates by using emission intensities that takes either a monetary or a physical approach. The monetary approach refers to CO_2 emissions per USD spent on goods and services. The indirect emissions are calculated through this approach. The physical approach refers to the CO_2 emissions per physical unit consumed.

Further, we need to take into account that the needs of a household grow in a less than a proportional way per additional household member. To exemplify, a couple getting twins will not double their need of electricity, food, gasoline etc. Simply dividing a household's carbon footprint on the numbers of household members will

[2]Actual CO_2, not CO_2-equivalents

[3]The emissions intensities can be found in Table A1 in the Appendix

thus not take into account economics of scale, and provide inaccurate results. As we want our results to be per capita, this issue is solved by using the OECD-modified scale. According to this scale, a household head is given the value 1, each additional adult is given the value 0.5 and kids are given the value 0.3 (OECD, 2013). This means that a household consisting of two parents and three kids, is adjusted by a factor of 2.4.

Basing our methodology on a similar study by Isaksen and Narbel (2017), we find a household's carbon footprint by following formula:

$$\text{carbon footprint}_h^{total} = \text{direct emissions}_h + \text{indirect emissions}_h^{Nor} + \text{indirect emissions}_h^{RoW} \tag{1}$$

The direct emissions are found directly by multiplying the emission intensities with the consumption, either in monetary or physical terms. For the indirect emissions, we distinguish between Norway and rest of the world. The domestic carbon footprint is found using the following equation:

$$\text{carbon footprint}_h^{indirect,Nor} = i_{Nor} \times [(1 - s) \times (y_h \times C^{Nor})^T] \tag{2}$$

i is a vector of domestic emission intensities for the 57 GTAP commodities. s is the import share, y is the matrix of the consumer survey and C is a concordance table linking different product classifications together. The formula for rest of the world is:

$$\text{carbon footprint}_h^{indirect,RoW} = i_{RoW} \times [s \times (y_h \times C^{RoW})^T] \tag{3}$$

This is equivalent to the following mathematical notation[4]:

Carbon footprint=

$$\begin{pmatrix} i_{1,1} & \cdots & i_{57,1} \end{pmatrix} \times \left(\begin{pmatrix} s_1 \\ \vdots \\ s_{57} \end{pmatrix} \times \left[\begin{pmatrix} y^{bp}_{1,1} & \cdots & y^{bp}_{1,183} \\ \vdots & \ddots & \vdots \\ y^{bp}_{3363,1} & \cdots & y^{bp}_{3363,183} \end{pmatrix} \times \begin{pmatrix} c_{1,1} & \cdots & c_{1,57} \\ \vdots & \ddots & \vdots \\ c_{183,1} & \cdots & c_{183,57} \end{pmatrix} \right]^T \right)$$
$$= \begin{pmatrix} cf_{1,1} & \cdots & cf_{1,3363} \end{pmatrix} \tag{4}$$

2.3 Data

This section provides a thorough explanation on the data needed for the analysis. Our data are collected from various sources, whereas goods and services are classified in accordance with different product classifications. Below is an overview of the three classification systems used.

Classification of Individual Consumption by Purpose (COICOP)
A product classification system developed by United Nation Statistics Division for the purpose of analysing and observing consumption and expenditure pattern by individuals in a household (Eurostat, 2016).

Global Trade Analysis Project (GTAP) Data Base
The GTAP Data Base breaks down commodities into 57 categories[5] (GTAP, 2013).

[4]The column vector of import shares are not calculated through matrix multiplication, but multiplied into each cells of the corresponding 57 GTAP goods and services.

[5]A list of all 57 GTAP goods and services is found in Table A1 in the Appendix

Classification of Products by Activity (CPA)
A product classification system categorizing goods and services in accordance with activity and common characteristics (Eurostat, 2013).

Consumer Expenditure Survey

Data on household expenditure were obtained from SSB´s Consumer Expenditure Survey (CES) from 2012. The CES maps the consumption pattern among Norwegian households, and the main findings are made publicly available on SSB.no. The entire dataset on a household level was made available for us through Norwegian Centre for Research Data (NSD).[6] The dataset consists of 3363 households and covers expenditure on 183 goods and services classified by the Classification of Individual Consumption According to Purpose (COICOP).

Input-Output Table

An input-output table shows the interdependence between sectors in an economy, as sectors in the economy are dependent on input from each other. Industries demand inputs from other sectors to produce their output, and businesses also supply other sectors with input for their production of output. An input-output table thus provides the flow of final and intermediate goods and services across industries in monetary units (OECD, 2015).

SSB provides input-output tables with information about the total use of imported goods and services between sectors as well as total use of domestically produced goods and services between sectors. This information was used to calculate the amount of import in a sector relatively to total use of goods and services. This will further in the thesis be referred to as import shares.[7]

[6]Please note that NSD is not responsible – through providing access to this dataset – for the theories and methods used, or results and conclusions drawn in this work.

[7]The import shares can be found in Table A1 in the Appendix

$$\textbf{Import share}_j = \frac{\text{Total import}_j \text{ (Total use of imp. goods and services from all sectors)}}{\text{Total domestic}_j \text{ (Total use of dom. produced goods and services from all sectors)} + \text{total import}_j}$$
$$, \textit{where } j = \textit{sector} \tag{5}$$

Emission Intensities

The emission intensities, measured in kg CO_2/USD, are based on GTAP´s latest release on bilateral trade and transport data between 140 countries for 57 goods and services (GTAP, 2016). The intensities are found through the relationship between Norwegian household consumption on goods and services and the global emissions from Norwegian consumption. The emission intensities includes the whole global supply chain related to products consumed. This ensures that products are produced with different production technologies.

Further, as the Consumer Expenditure Survey is available in NOK, conversion from kg CO_2/USD to kg CO_2/NOK was necessary. The average 2012 exchange rate of 1 USD equaling 5,8 NOK was used for this conversion.

The emission intensities discussed above are only utilized for the calculation of the indirect emission. In addition to those, the emission intensities for the direct emission categories are also needed. The category of direct emissions includes electricity, gasoline and diesel, gas, heating oil and kerosene.

Electricity

The monetary emission intensity for electricity is based on an average of 8,5 grams of CO_2 per kilowatt hour. This number was chosen based on the assumption that the mean emission intensity of the Norwegian renewables is 7 g CO_2/kWh (Isaksen &

Narbel, 2017), and that these renewables accounted for 99% of the Norwegian power production in 2012 (Adapt Consulting, 2013b). 2012 was in fact a record year of hydropower production, and the total Norwegian consumption was lower than the total production. The last 1% of the production was assumed to be produced by the two operational Norwegian gas power plants at that time, Kårstø and Melkøya, with an estimated emission intensity of 277 g CO_2/kWh (Adapt Consulting, 2013a). 8.5 g CO_2/kwh was further divided by the average price per kWh in 2012 to get the intensities in CO_2 per NOK, so it could be directly linked to the expenditure reported in the consumer survey. As the consumer survey had a variable for what county the respondent lives in, we were able to take into account the different prices of electricity across the 19 Norwegian counties.

Gasoline and Diesel

The emission intensities for fuels were derived by looking at the average price per litre of fuel and CO_2 emission per litre combusted. These numbers differ depending on whether we look at diesel or gasoline, but as there is an almost equal share of gasoline and diesel cars on Norwegian roads (SSB, 2016c), we use the average of emissions from gasoline and diesel.

Average fuel price in 2012: $13.99\dfrac{kr}{liter}$ (SSB, 2013a)

Average CO_2 per liter: $2.50\dfrac{kgCO_2}{liter}$ (Helland, 2009)

$\frac{2.50\frac{kgCO_2}{liter}}{13.99\frac{kr}{liter}} = 0.18\frac{kgCO_2}{NOK}$

Heating Oil and Kerosene

Emission intensities for heating oil and kerosene are based on the physical approach, CO_2 per litre. As the consumer survey has variables for the amount of heating oil and kerosene consumed in litres, the emission intensities could easily be multiplied with the amount of heating oil and kerosene consumed. The emission intensities are repectively 2.28 kg CO_2/litre and 2.52 kg CO_2/litre (Isaksen & Narbel, 2017).

Gas

For gas the intensity used was 0.117 kg CO_2/NOK, equivalent to Isaksen and Narbel´s (2017) study.

Technicalities of Indirect Emissions from Fuel

When calculating the indirect emissions, it is important to subtract the direct emission variables from the CES to avoid double counting. However, there are emissions associated with both driving the car and the production of fuel itself. Simply subtracting all expenditure on fuel when calculating indirect emission would neglect emission from production of fuel. This was solved by differentiating between so-called well-to-tank and tank-to-wheel intensities. The tank-to-wheel intensity is the carbon emission per litre fuel combusted, 2.49 kg/litre as discussed above. The well-to-tank is all emissions occurring from the well to a car's tank is filled up. This number is 0.45 kg CO_2/liter (Helland 2009), or 0.032 kg CO_2/NOK with the use of average 2012 prices on fuel.

Concordance Tables

Methodological challenges arise as the data is organized according to different classification systems. In order to work with the data, they need to be stated in a similar product classification.

The CES classifies products according to COICOP, the emission intensities are classified according to GTAP, and the input-output-table groups goods and services according to CPA. In the end, we want the expenditure data and the import shares stated in GTAP. In that way, we can directly multiply the emission intensities to the expenditure and find the carbon footprint.

The conversion is done by utilizing concordance tables linking different product categories together. As there are no official concordance tables, a concordance matrix need to be made. In order to most accurately identify the difference in carbon footprint from 2007 to 2012, the same concordance matrix as Isaksen and Narbel (2017) is utilized in this thesis. By doing so, we make sure that changes in result stems from changes in consumption and not assumptions.

A COICOP-GTAP concordance matrix is made by deciding at the allocation of COICOP to the 57 GTAP categories. As an example, product c04.4.1 in the CES is water supply. This can be allocated to G45, water. Other products can however not be allocated that simply. For instance, product c09.2.1, major durables for outdoor recreation, cannot be allocated to one single GTAP category. The product consists of a wide range of products, from camper vans, caravans and boats to horses, hot-air balloons and golf carts. This product category can be allocated to no less than eight GTAP categories. In addition to this, we must take into account the weighing of the product within each of the categories. How much should be allocated to category G09 (Cattle, sheep, goats, horses) and G27 (textiles) compared to G30 (wood products) and G29 (leather products). Should you assume equal distribution? There is a many-to-one relationship, and the allocation is based on rather strict assumptions.

Valuation Schemes

The IO and CES are stated in accordance with different valuation schemes. The households in the CES were asked to expense their consumption of goods and services by what they paid at the point of sale. Hence, the survey was reported in purchase prices.

The IO table was reported in basic prices, referring to the amount received by the producers. This is the purchasers´ price minus net taxes on products and trade and transport margins.

To bring the two datasets into a common valuation scheme by converting the expenses in the CES to basic prices, information about taxes and subsidies, and transport and trade margin are required. This information is available in the IO table. The conversion follows the same method as Isaksen and Narbel (2017) and Steen-Olsen et. al (2016).

Rates on taxes less subsidies (net tax) are calculated as:

$$\alpha_j = \frac{a_j}{t_j^{bp}} = \frac{\text{tax less subsidies on products}_j}{\text{total supply at basic prices}_j} \tag{6}$$

When working on trade and transport margins, it is important to distinguish between the margins and non-margins sector, symbolized respectively by N and M. The distinction is important as the margins deducted must be redistributed to the margin sectors.

The trade and transport margins are found by the use of the following formula.

$$\beta_j = \frac{b_j}{t_j^{bp}} = \frac{\text{trade and transport margins }_j}{\text{total supply at basic prices}_j} \tag{7}$$

To get the CES in purchase prices, the first step is to deduct the net tax from all sectors. Next, the margins must be deducted from all sectors, thereafter redistributed to the margin sectors.

The net tax and margin removals for the non-margin sectors:

$$y_j^{pp} = \frac{y_j^{pp}}{1 + (\alpha_j + \beta_j)} \in N \tag{8}$$

For the net tax and margin removals, and redistribution of margins to the margin sectors, the equation $\sum_{i \in M} \beta_i = -\sum_{i \in N} \beta_i$ must hold.

2.4 Findings

The results from 2012 show an average total of just over 10 tonnes CO_2 emission per capita, based on a sample of 3306 Norwegian households.[8] The dominating share of the total emissions is the imported indirect emissions. On average, imported indirect emissions accounts for 43% of the total emission, while domestic indirect emission accounts for 39%. The remaining share of 18% is direct emission. The summary statistics presented in Table 1 below also reveal that the average per capita expenditure on goods and services is about 43.6 thousand USD, adjusted according to the OECD-modified scale.

Table 2 shows the carbon multipliers for the emission categories. It reveals that the average carbon multiplier is 229 grams CO_2 per USD spent, and that direct emissions has the highest carbon multiplier of 543 grams CO_2 per USD.

[8] Outliers was removed using the dfit measure for identifying influential observations, measuring the sensibility of the predicted values. Values exceeding 2*(k/n) is considered as influential values (Baum, 2006). The test removed 61 of the total sample of 3363 households that was considered influential.

Variable	Mean	Std. dev.	Minimun	Maximum
Expenditure	43.6	22.02	2.70	286.96
Total emissions	10.02	6.18	0.63	69.34
Direct emissions	1.78	1.88	0	16.31
Indirect dom. emissions	3.91	2.29	0.32	28.20
Indirect imp. emissions	4.34	3.44	0.25	43.09

Table 1: Summary statistics of the findings.

Variable	Carbon footprint multiplier (g CO_2/USD)
Total emissions	229
Direct emissions	543
Indirect dom. emissions	133
Indirect imp. emissions	403

Table 2: Carbon footprint mulitpliers

The relationships between carbon footprints and expenditures are presented in Table 3. The slope coefficients in the log-log regression models[9] represents the carbon elasticity.[10] Hence, the carbon elasticity for Norwegian consumers according to our findings is 1.19. The elasticity implies that the relationship between carbon and expenditure is slightly increasing at the margin. In other words, this elasticity implies that an 1% increase in expenditure results in a 1.19% increase in carbon emissions. The relationship between total carbon footprint and expenditure is graphically illustrated in Figure 1 below.

Our results show a higher carbon elasticity for imported indirect emissions, 1.37, compared to the carbon elasticity for domestic indirect emission of 1.09. This is also

[9]A Ramsey´s regression specification error test (RESET) conducted on our regression model taking a level-level form indicate that we cannot reject the null hypothesis of no functional form misspecification at a 5% level of significance. The RESET on the log-log model rejects the null hypothesis. An log-log model thus seem more appropriate for our analysis.

[10]Carbon elasticity is the percentage change in carbon emission to the percentage change in expenditure on goods and services.

Table 3: Regression output

Variables	log(Total emissions)	log(Indirect, ROW)	log(Indirect. NOR)
log(Expenditure)	1.19***	1.37***	1.09***
	(0.00)	(0.00)	(0.00)
Constant	-2.23***	-3.84***	-2.77***
	(0.00)	(0.00)	(0.00)
Observations	3302	3302	3302
R^2	0.78	0.73	0.86

Robust standard errors in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

seen in Figure 2, where the the graph showing the relationship between imported indirect emissions and expenditure has a steeper curve. The carbon elasticity for direct emissions is 1.1.

As elasticity is greater than one, carbon emission is per definition classified as a luxury good. Carbon emissions increase more than proportionally with an increased income. The implication is that the people emit more and more as they increase spending.

Table 4 shows the expenditure elasticity[11] for the emission categories. The domestic expenditure elasticity of 0.93 uncovers that an 1% increase in total expenditure on average, increases expenditure on domestic goods and services with 0.93%. The expenditure elasticity for imported goods and services of 1.37 implies that the more money you spend, the relatively more you spend on imported commodities compared

[11]Expenditure elasticity is the percentage change in expenditure on domestically and imported comsumed commodities relatively to the percentage change in total expenditure.

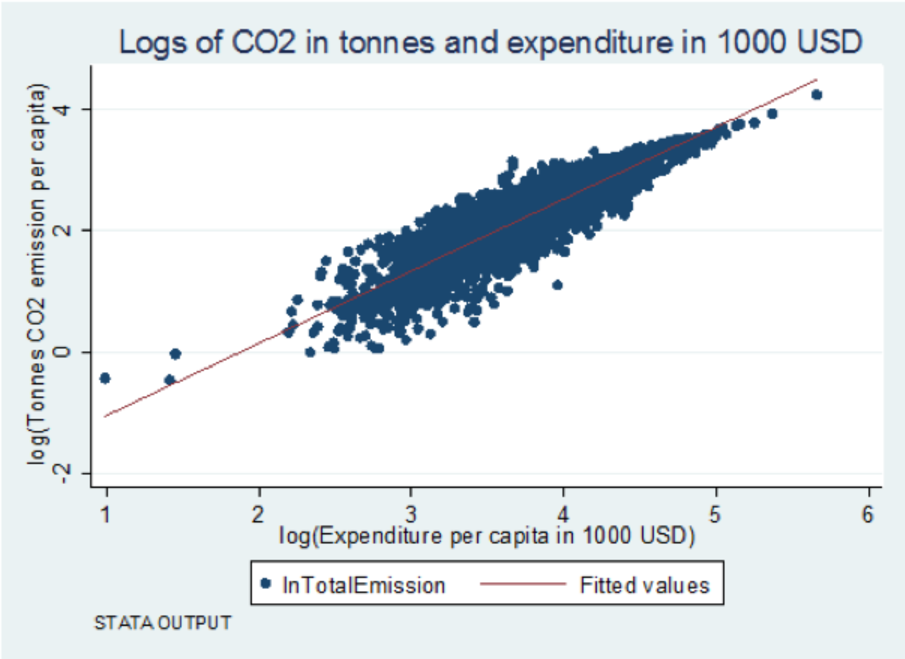


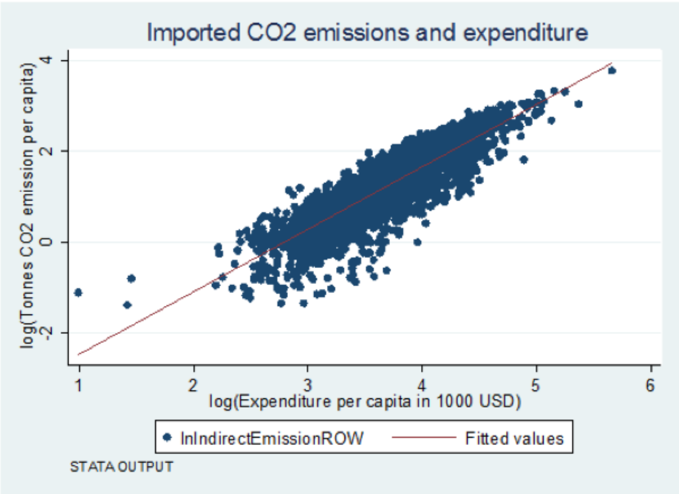
Figure 1: Relationship between the logs of total carbon footprint per capita and the logs of total expenditure per capita.

to domestic commodities.

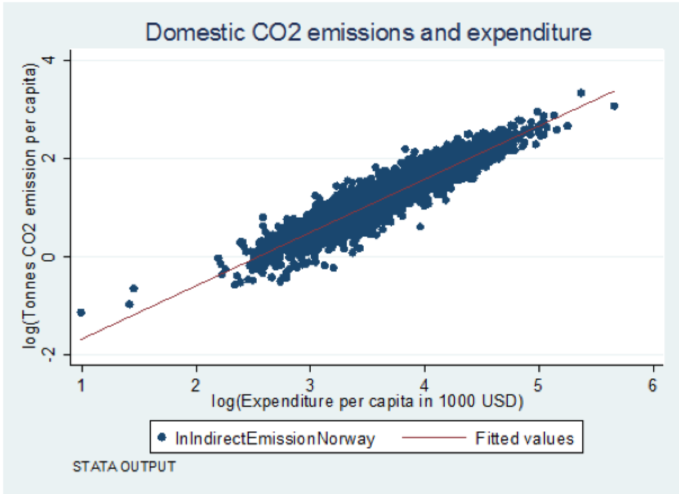
Table 4: Expenditure elasticities and carbon elasticities.

Category	Expenditure elasticity	Carbon elasticity
Indirect domestic emisssions	0.93	1.09
Indirect import emissions	1.37	1.37
Direct emissions	0.53	1.1

How the carbon emission categories vary with expenditure can further be illustrated by looking at expenditure quintiles. Looking at the lowest expenditure quintile, 42% are indirect domestic emissions and 37% are indirect imported emissions. In the highest expenditure quintile, the corresponding shares are 38% and 48%, respectively. This coincides with elasticities found above. As you increase expenditure, more and



(a) Imported indirect emissions and expenditure



(b) Domestic indirect emissions and expenditure

Figure 2: Relationship between the logs of indirect imported carbon footprint and total expenditure per capita, and between the logs of indirect domestic carbon footpring and total expenditure per capita.

more money is spent on imports.

Expenditure quintile	Q1	Q5
Indirect imported emissions	37%	48%
Indirect domestic emissions	42%	38%

Table 5: The lowest and highest expenditure quintiles´ indirect emission shares.

Consumption categories

Figure 3 shows the share of emissions and expenditure for all goods and services, broken down into five broader categories.[12] It reveals that it is the transport category that contributes the most to total emissions, while the expenditure on transport only account for for 17% of the total budget. This underlines the high carbon footprint multiplier of 0.53 kg CO_2/ USD. The category called “Other” is also a big contributor

[12] A table listing the groups is found in Table A2 in the Appendix

to total emissions, but the main driver to this is the large share of total expenditure. The carbon multiplier for this category is 0.13 kg CO_2/ USD. The table also show that emissions from energy is low in Norway, due to the clean electricity sector. Furthermore, the purchase of clothing contribute to a big amount of emissions per USD spent, with a carbon footprint multiplier of 0.36 kg CO_2/ USD.

Figure 3: The average carbon footprint per capita and expenditure for five consumption categories

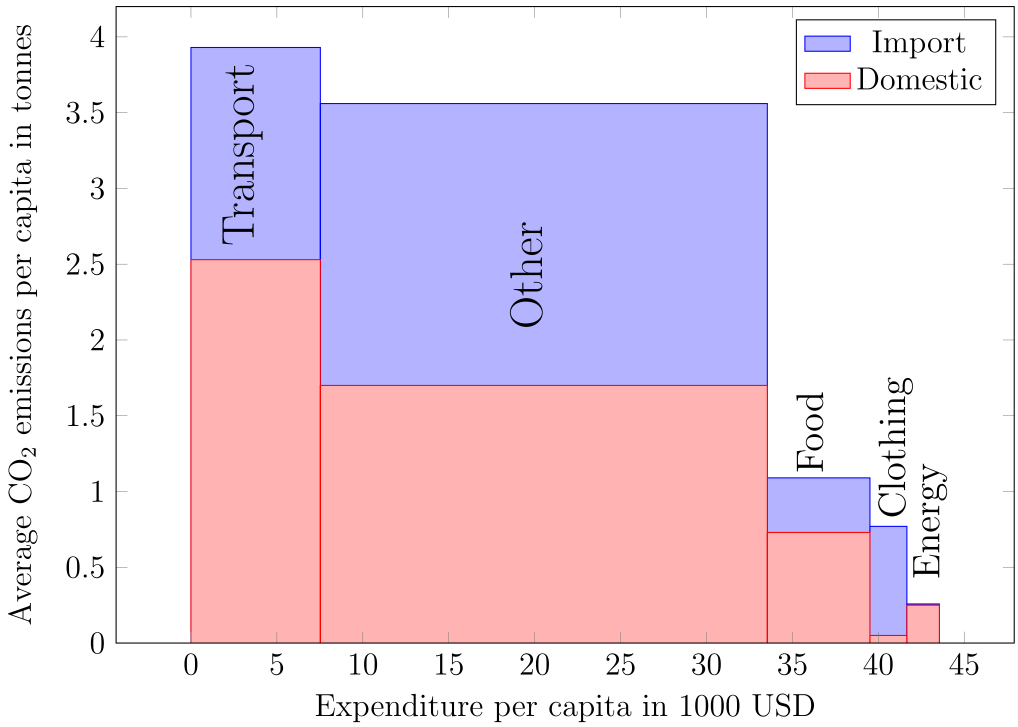


Table 6 illustrates that carbon emissions from food and energy have an carbon elasticity below unity and is thus decreasing at the margin. This is no surprise, as both standard economic theory and empirical results imply that relatively rich people spend a lower share of their budget on food and electricity than relatively poor people.

Table 7 shows the consumption categories relative to expenditure quintiles. Comparing the highest and lowest quintile show that a person in the highest quintile on

Category	Expenditure elasticity	Carbon elasticity
Food	0.41	0.40
Clothing	1.07	1.06
Energy	0.28	0.42
Transport	1.67	1.22
Other	0.99	1.33

Table 6: Expenditure elasticities and carbon elasticities for the consumption categories.

average spend 3.7 times more money and emit 4.6 times more than the lowest quintile.

The ratio for expenditure used on domestic goods and indirect domestic emissions between the highest and lowest quintile is respectively 3.2 and 4.2. The most substantial results retrieved from investigating the quintiles, are that of the expenditure on imported goods, and the following emissions. As the expenditure elasticities explain, a one percentage increase of expenditure means that the expenditure on imported goods increases with more than one percent. We observe that the ratio between highest and lowest expenditure quintile on imported goods is 6.1, with the corresponding ratio between carbon emission for the two quintiles also being 6.1.

As the clothing and transport categories have an elasticity that exceeds 1, it is interesting to break these categories into smaller groups and see what groups push it above unity.

Table 8 breaks down the transport category into some if its GTAP categories. It explains that it is G48, "Other Transportation" and especially G38 "Motor Vechicles and Parts" that push the number up, both looking at the domestic and imported categories. G38 consists of motor vehicle and parts, such as car purchases. For this category, the highest expenditure quintile contributes to over 30 times more carbon

Table 7: Difference in the carbon footprints of the expenditure quintiles

Category	Expenditure			Carbon footprint		
	Q1	Q3/Q1	Q5/Q1	Q1	Q3/Q1	Q5/Q1
Total emissions	20.8	1.9	3.7	4.05	2.18	4.64
Indirect emissions (RoW)	3.7	2.4	6.1	1.48	2.41	6.14
Indirect emissions (Nor)	17.1	1.8	3.2	1.72	1.99	4.19
Food (RoW)	0.8	1.5	1.9	0.24	1.50	1.91
Food (Nor)	3.1	1.5	1.9	0.49	1.51	1.96
Clothing (RoW)	0.7	2.4	4.8	0.27	2.40	4.74
Clothing (Nor)	0.2	2.4	4.7	0.02	2.46	4.83
Energy (RoW)	0.0	1.8	2.7	0.00	1.71	2.55
Energy (Nor)	1.5	1.2	1.5	0.16	1.68	2.14
Transport (RoW)	0.5	4.1	16.8	0.33	3.00	10.42
Transport (Nor)	1.4	2.5	6.2	1.03	2.29	4.19
Other (RoW)	1.7	2.3	5.2	0.64	2.47	6.09
Other (Nor)	10.9	1.8	3.4	0.66	2.23	5.22

emission than the lowest expenditure quintile. “Other Transport” is road, rail and auxiliary transport activities such as travel agencies. The ratio between the quintiles here is just above 7. For air travels, this number is just under 4. We also checked to numbers for electronics, suspecting that it would have a high carbon elasticity. However, the highest expenditure quintile emits only 2.5 times more CO2 due to purchases on electronics, compared to the lowest quintile.

The elasticities in Table 9 uncovers that the elasticity ”Motor Vehicles and Parts” is 1.9 and ”Air Transportation” is 0.45. ”Other transportation” has an elasticity of 1.67.

For the clothing category, also associated with a total carbon elasticity above 1, textiles push the differences between expenditure quintiles up, while wearing apparel is about unity.

Category	Carbon footprint Q5/Q1
Air transportation (import)	3.81
Air transportation (domestic)	3.79
Other transportation (import)	7.05
Other transportation (domestic)	7.15
Motor vehicles and parts (import)	33
Motor vehicles and parts (domestic)	31.4
Texstiles (domestic)	5.2
Textiles (import)	5.2
Wearing apperal (domestic)	3.99
Wearing apperal (import)	3.99
Electronics (import)	2.5
Electronics (domestic)	2.5

Table 8: Difference in the carbon footprints of the expenditure quintiles for consumption categories

GTAP category	Carbon elasticity
Textiles	1.24
Wearing apparel	0.98
Air transportation	0.45
Other transportation	1.67
Motor vehicles and parts	1.9

Table 9: Carbon elasticities for consumption categories

2.5 Weaknesses with the Approach

There are some known weaknesses with our methodological approach, our dataset and our results. In this setion we will go through the ones that are known to us.

The result shows an explanatory power of 78%. One should carefully assess such high explanatory powers; a higher number is not necessarily better. A high explanatory power indicates that people with the same spending have an equal consumption pattern. This might be somewhat unrealistic.

Another potential issue arises from the fact that we adjusted the households down to the individual level using the OECD-modified scale. By doing this, we are adjusting for the efficiency of people living together, and therefore overestimating their emissions. Take a household of two adults as an example. Lets say that they emit 20 tonnes of CO_2. If we had split their emissions equally, they would account for 10 tonnes each, and the aggregated result would be the same as our starting point. However, using the OECD-modified scale, dividing the household with 1.5, we get individual emissions of 13.33 tonnes of CO_2. On the aggregated level this will in turn appear as 26.66 tonnes of CO_2, even though the actual number was 20 tonnes. Thus, one should be careful assessing the total aggregated emissions of the Norwegian consumers based on our results.

There are also some issues regarding the GTAP emission intensities. These are calculated as means of the emissions related to certain products, divided by the money spent on these products. Hence, our estimates of the indirect emissions for the upper quintiles are likely to be biased upwards, and the lower quintiles downwards. We have no way of correcting for the fact that some luxury goods, like expensive jackets, have a price tag sometimes ten times higher than a regular jacket, without necessarily leading to more emissions. It is reasonable to assume that a person in the highest quintile not necessarily buys four point eight jackets of the same kind as a person in the lowest quintile, but rather a more expensive one. Thus, we cannot exclude the possibility of a relationship that differs somewhat from our conclusion. Also, the emission intensities are reported as CO_2 to air, and not CO_2-equivalents. The actual emissions, including for example methane and nitrous oxide, can therefore be expected to be larger than what we report. This especially applies to product groups that can be related to agriculture.

Our analysis is based on consumption. We assume that there is a direct relationship between people´s wealth and their spending. This isn't necessarily true. A lot of the consumption of goods like for example electronics, is based on payment schemes and deferrals, in other words, money that the consumer does not have at the time of the purchase. Also, wealth can be kept in shares. As there is a tax on collecting dividends, shareholders are likely to keep their wealth within companies, rather than cashing it out. Thus, our assumption that consumption equals wealth is not necessarily true.

Regarding the import shares, the simplified percentages applied to for example food-stuff are obviously wrong in some cases. Paddy rice is not produced in Norway, still our approach assumes only 18% of the rice is imported. These percentages stem from the input-output tables provided by SSB, and the concordance matrix. The latter was also used by Isaksen and Narbel (2017), and again we wanted to assure that a comparison could be done. As there are different emission intensities for domestic and RoW production of these goods, the results might be affected. Whether this brings our results upwards or downwards is uncertain, as some of the GTAP categories may have lower import shares, as well as higher.

One of the product categories that stands out is car purchases, with an carbon elasticity of 1.9. A problem with this category is that a car purchase represents such a large investment for an individual. The average expenditure is about 43 000 USD, and this number could easily equal that of a new car in Norway. An individual that has purchased a car in 2012 is therefore likely to have reported an excessive expenditure that year, as such a purchase is often done by acquiring a loan. It is likely that this affects the outcome of our analysis. Depending on the magnitude of the embodied emissions relative to the price paid for the car, a person that would usually be on the lower parts of the curve, will be shifted upwards along the expenditure axis, and may either end up above or below their normal carbon-expenditure curve. However, the embodied emissions in this product category should be reported, as they are rather substantial.

Although the electricity sector in Norway is based on renewable sources, the reported numbers suggests otherwise, as producers sell Guarantees of Origin (GO) to the European market. The majority of the Norwegian consumers are therefore considered to consume a “European Mix”, with a large share of electricity produced from coal and nuclear power plants. We have not included this in our analysis, but rather based the emission intensity on what was physically produced in Norway in 2012, and thus physically ended up in the consumers power sockets. This also makes the results more comparable to Isaksen and Narbel (2017), who used the same approach.

2.6 Sensitivity Analysis

When we remove the car purchases from the sample, we get a slightly changed outcome. A lower total emission average at 8.87 tonnes per person, and a decrease in the carbon elasticity for indirect imported emissions of 1.21. Consequently, our conclusions would still hold in this case.

Basing the emission intensity of the electricity sector on a "Europaen Mix"[13] changes the findings substantially. The total emissions almost doubles, to 18.43 tonnes per capita. The carbon elasicity drops to 0.6, which changes our conlcusion of carbon emission being a luxury good.

Change	EU mix	No cars
Total emissions	18.43	8.87
Carbon elasticity	0.6	1.27

Table 10: Sensitivity analysis with a "European Mix" and no cars in the sample

[13]The emission intensity for the "European Mix" is the same as used in Isaksen and Narbel´s (2017) study: 0.542 kg CO_2/kWh.

2.7 Comparison with Isaksen and Narbel. What Has Changed?

Comparing our findings with those from Isaksen and Narbel (2017) analysis of the consumption in 2007, there are some findings that differ substantially.

The indirect emissions from imports now account for the biggest share of indirect emissions. While the indirect domestic emissions have been diminished by 33%, from an average of 5.8 to 3.9 tonnes of CO_2 per capita, the corresponding numbers for imports are down by 9.6%. The total reduction in carbon emissions is 18%. At the same time, the total expenditure has increased by 35%, from 32 400 to 43 600 USD. While Norway apparently has managed to reduce domestic emissions a lot, we have not managed to reduce imported emissions by nearly as much. A likely explanation to the substantial decrease in indirect domestic emissions seems to be the fact that the their average emission intensities have been subject to an equally high percentage reduction, namely 30%. However, the average reduction in imported emission intensities were also 30%, and the indirect imported emissions has, as mentioned, not decreased in the same manner.

We were uncertain if the reductions in emission intensities were caused by actual abatement in the production processes or just an increased accuracy in the numbers provided. Glen Peters from CICERO provided us with updated, and more accurate, emission intensities for 2007. We assumed these would be more comparable with the intensities used for the analysis of 2012. By comparing the updated 2007 intensities with the 2012 and the original 2007 intensities, we see quite a difference, reported in the Table 11. As the table shows, it is likely that Isaksen and Narbel (2017), would have obtained lower emission estimates with these updated emission intensities. This must be taken into account, before one applauds Norway for their abatement efforts.

Regarding the relationship between consumption and emissions, Isaksen and Narbel

Table 11: Percentage changes in emissions intensitites.

Emission intensities		2007a *(old)*	2007b *(updated)*	2012
Domestic	(2007a)	-	-24%	-29%
Import		-	-11%	-30%
Domestic	(2007b)	31%	-	-7%
Import		12%	-	-21%
Domestic	(2012)	41%	7.4%	-
Import		42%	27%	-

(2017) found a one-to-one relationship between expenditure and emission and hence a carbon elasticity of unity. Their analysis showed that the highest expenditure quintile spends 4.5 times more than the lowest quintile, and at the same time emits equally more. Consequently, the relationship is proportional. The carbon elasticities, both for indirect domestic and indirect imported emissions have risen, from 0.90 and 1.17 to 1.09 to 1.37, respectively. The consequences of higher carbon elasticity can be seen in Table 7. The highest quintile in 2012 consumed 3.7 times more than the lowest quintile, and at the same time emits 4.6 times more.

Table 12: Elasticities for expenditure and carbon in 2007 and 2012

Category	Expenditure elasticity	Carbon elasticity
Domestic 2007 (2012)	0.93 (0.87)	0.90 (1.09)
Import 2007 (2012)	1.18 (1.37)	1.17 (1.37)

The expenditure elasticity for imported goods have also risen, while it has fallen for domestic goods. Consequently, we apparently spend less and less money on domestic goods as our total expenditure rises, while the expenditure that goes to imported goods are increasing at the margin

2.8 Other Studies

To examine the plausibility of our results, it is useful to compare our main findings with that of other studies, and with the official numbers for Norway. SSB reports an average of 8.8 tonnes CO_2 emission per capita in 2012 (SSB, 2013b), based on the territorial approach. Compared with our findings of 10 tonnes, the use of consumption-based method shows a 20% higher emissions per capita.

It is likely that the sum of direct emissions and indirect domestic emissions should be lower than the territorial-based emissions, as the latter includes emissions from Norwegian oil production and export activities. The sum of the direct and indirect domestic emissions is 5.69 tonnes CO_2 per capita, well below 8.8. Furthermore our findings regarding total emissions per capita are in line with the study from Steen-Olsen et al. (2016); an average of 10.5 tonnes CO_2 equivalents per capita in 2012 compared to our result of 10.2 tonnes.

Regarding the carbon elasticity of 1.19, it is rather high compared to other studies, especially studies focusing on other countries. Hertwich and Peters (2009) found a carbon elasticity of 0.81 from a broader study involving 72 countries. Weber and Matthews (2008) found that carbon elasticities vary from 0.6 to 0.8 for expenditure and Lenzen et. al (2006) found that the elasticity for energy requirement of household consumption for several countries is below 1. However, newer studies in Norway support our results. In addition to Isaksen and Narbel´s (2017) finding, Steen-Olsen et. al (2016) showed a carbon elasticity of 1.14.

Steen-Olsen et. al (2016) explained the particularly high carbon intensity in Norway with the fact that direct household energy in Norway, like electricity, is based on hydropower. As marginal consumption on direct energy typically decreases with income, it can be defined as a necessity. The total carbon elasticity in Norway is not reduced by the direct energy consumption, due to the low carbon footprint for direct energy in Norway. This is underlined with Isaksen and Narbel´s (2017) study showing that the carbon elasticity decreases to 0.64 with a European mix for electricity, and our similar sensitivity analysis giving a carbon elasticity of 0.6.

3 A Norwegian Tax on Carbon

In the following part of the thesis, we will review the available literature on carbon tax, to asses whether or not it is the best policy tool available for abating emissions unilaterally. We will also explore the idea of a revenue neutral tax, and what it would imply for the consumers and the efficiency of the scheme. Natural supplements to such a tax, such as a border carbon adjustment (BCA) and the Clean Development Mechanism (CDM), are also assessed.

3.1 Introduction

"A carbon tax is ... the most efficient means of reflecting the cost of carbon in all economic decisions", Rex W. Tillerson, Chairman and Chief Executive Officer of ExxonMobil, proclaimed in 2009. This company policy has continued, and now includes an outspoken support of a revenue neutral scheme (Cohen, 2015). Carbon taxes might have seemed to be unpopular, and thus hard to implement for officials usually elected for the short term. We have seen recent examples of this occur in both Australia (McGuirk, 2014) and France (Davies, 2010). However, such a statement from a company like ExxonMobil, could imply that a change in opinion might be taking place. And this time, in a broader circle than that of the economists, who have prescribed this measure for a long time (The Economist, 2011). According to the republican Harvard professor Greg Mankiw, who was recently interviewed in the film Before the Flood (Dicaprio & Stevens, 2016), the consensus among economists for a carbon tax is close to unanimous. Almost as unanimous as that of the environmental scientists, regarding whether anthropogenic climate change is real or not. The only thing that's missing is a public consensus, forcing politicians to act, he claims. As a republican, it is not surprising that he is also in favor of a revenue neutral tax scheme. The fact that the revenue neutral carbon tax experiment has been successfully conducted in British Columbia(BC), Canada (Elgie S., McClay J. 2013), and that industry actors here seem to be responding well (The Huffington Post, 2013), also adds to the perception that a shift in policies might be possible.

However, even though developed countries have implemented some textbook climate policies throughout the years, they are notoriously hesitant in strengthening them (Peters et al., 2016). The fear of losing a competitive edge are one of the biggest hurdles, including the effects of carbon leakage. Implementation of more strict policies is therefore more likely to happen in larger groups of countries, aided by BCAs. Such a uniform policy will most likely not be reached despite of the Paris Agreement, as it only addresses emission targets, and offers few concrete, agreed upon actions (Peters et al. 2016).

In the following we will review literature around carbon taxes, and conclude that there is a broad consensus that a universal, modestly increasing carbon fee is a cost efficient and effective abatement policy compared to both the current EU ETS cap and trade system, and other implemented policies. This would also apply if the tax is designed to be revenue neutral, as both green hardliners like James Hansson (2010) and The Environmental Green Party in Norway (Hansson, 2016), together with the liberal thinktank Civita (Saksvikrønning, 2015) and actors in the affected carbon intensive industry have all suggested (Bloomberg Bussiness Week's Editorial Board, 2015). There are also other compatible policies that show some promising prospects. Namely abating in the exporting countries, to lower the carbon intensity of the production of the goods that we consume here (Peters et al., 2016), and investing in green research and development (Meadowcroft, 2011; Fischer, Torvanger, Shrivastava, Sterner & Stigson, 2012).

There are, however, a lot of challenges that must be tackled before a carbon tax can be implemented on a large scale. Firstly, there is a somewhat overwhelming amount of uncertainty regarding the quantification of a proper discount rate for future generations. How much is it fair that we have to pay now, for our descendants not to suffer from climate change, considering that they may be much richer than us due to economic growth and efficiency gains? This uncertainty leads to the vast differences we observe in the estimates for the social cost of carbon (SCC). Also, how should the revenue be paid back in the case of a fee and dividend approach? And should the tax also be levied on imported goods like electronics and clothing through costums to avoid carbon leakage? If so, how?

There are a lot of different perspectives on these issues. To classify them, Dryzek (2013) created the theory of environmental discourse, which is based on two fundamental axes, related to whether a discourse is reformist or radical, prosaic or imaginative. Assuming that climate change is a serious issue which requires immediate action, but believing that current political-economic environment can be modified to put us on a sustainable path, the authors of this thesis adopt a problem solving (prosaic) environmental discourse and investigate solutions which can be implemented given the societal system we live in (reformist). Also, acknowledging that a global solution might not be imminent, and that Norway might have to act on it's own, we will focus on solutions that could be implemented at a domestic level. A domestic approach might not be effective in global reductions, as global problems do in fact require global solutions. However, unilateral policies can act as an incentive or example for other nations to follow. There are not necessarily any serious disadvantages of taking a leadership role, being a "first mover" in battling climate change (Eskeland, 2013). Abating in Norway alone will not affect the total global emissions in a significant way. We are dependent on other nations to follow suit.

3.2 The Social Cost of Carbon (SCC)

It has been ten years since Stern (2006) landed like a climate change bombshell in the middle of Downing Street, London. It projected cataclysmic economic collapse as a result of failing mitigation policies. The review has garnered both praise and criticism. In the review, it was concluded that the current SCC was 85 USD/t CO_2 (in 2000 dollars), and that the result of abstaining from immediate action could be an annual loss of 5% of world GDP, "now and forever". The critics of these conclusions have pointed out three perceived flaws of the review in particular (Ackerman, Frank, 2007). Namely that the discount rate is too low, the treatment of risk and uncertainty is inadequate, and the calculation and comparison of costs and benefits are done incorrectly. As a result of the different approaches to these questions, researchers have later come up with a wide range of different SCCs, and suggested tax rates. In one end we have the American economist William Nordhaus (2011), who suggests a current SCC of 12 USD/t CO_2, resulting in a suggested tax of 10-15 USD/t CO_2 increasing at a rate of 3.5% to 65 USD/t CO_2 in 2050. The SCC in use in U.S. Federal Rulemakings as of 2010 was 21 USD/t CO_2 (Greenstone, Kopits & Wolverton, 2011). In the other end, we find the likes of Ackerman and Stanton (2012), who by using the similar models, but with different assumptions, calculate a SCC of 900 USD/t CO_2 in 2010, rising to 1500USD/t CO_2 in 2050. They suggest that the necessary cost of emitting will have to be 150-500 USD/t CO_2 within 2050, if we are to zero out the emissions by 2100. These wide range of calculated SCCs makes it harder to decide the level of a carbon tax. However, Pindyck (2013) states that we should start taxing carbon regardless, as the most important thing is that consumers and businesses become aware that there *is* a social cost of carbon. He is also in favor of setting the tax rather high, aknowledging the unlikely, but possibily catastrophic scenarios.

3.3 Carbon Tax - A Superior Policy Tool?

The sentiment for a carbon tax started a long time ago. Back in the early 90's, when the threat of global warming was starting to be taken seriously, Shah and Larsen (1992) published a World Bank Working Paper stating that a carbon tax could be beneficial for developing economies. According to their results, the positive effects on local environment and health alone could outweigh the costs, without even taking the effect on global warming into the equation. Cooper (1998) criticised the Kyoto Protocol and the suggested cap and trade-scheme. He stated that a universal tax would make it much easier to ensure a global effort, and that the developing economies never would accept to participate under the agreed upon terms.

More recent empirical evidence also tend to tip the weight in favor of a carbon tax. A study published by the US Congressional Budget Office (Dinan, T., 2008), suggests that a carbon tax is the most effective tool for abating emissions compared to cap and trade. According to their calculations, it would create an economical gain that is five times higher than that of an inflexible cap and trade system. Sterner (2007) concluded that the implementation of carbon taxes has already played an important role in reducing emissions. According to his paper, the emissions from fuel use of certain OECD countries is up to 30-50% lower than what it would have been if its levels of carbon tax on fuel were similar to that of the US. His results suggest that the price elasticities on fuel is only inelastic in the short run, and that a carbon tax thus would be able to curb consumption of fuel in the longer run. Metcalf (2007), expands on how much of the political mistrust between The White House and Downing Street that jeopardized the US participation in the Kyoto Protocol is now bygones, and that a carbon tax is the best feasible option for abating on emissions. Nordhaus (2007) concludes that there are major advantages in implementing a carbon tax. Not only because of the effect on emissions, but also due to its ease of implementation, involatile prices, and the reduced potential for corruption issues. Another advantage of pricing emissions with a tax rather than cap and trade, is the reduced need for monitoring, reporting and verification (MRV), which again leads to much lower costs (Coria & Jaraité, 2015). A tax can be levied "upstream" at an oil production facility, at a coal mining site or the like, rather than "downstream" with the consumer, and the tax will propagate through the market by itself. An upstream carbon tax was also suggested by Metcalf and Weisbach (2009), who found that such an approach could cover 80-90% of US emissions, while having a relatively low cost of implementation.

Today, a multitude of policies are used for abating emissions, often in combination. Fankhauser, Hepburn, and Park (2010) find that these combinations can be harmful by undermining the price of carbon, and raise the cost of abating. A single stable carbon tax should therefore be preferred to today's arrangement with the EU ETS being enforced by the EU, and other regional and national measures coming on top. Pizer (2001) calculated that a global carbon tax would yield an eight times higher benefit than the cap and trade would in a short term, and five times higher in the long run. Hoel and Karp (2001) get even higher estimates. Under certain conditions, they find that a tax can yield a 16 times higher benefit than a cap and trade.

The Official Norwegian Report (NOU) "Environmental Pricing. Report from a Green Tax Commission" assesses the Norwegian abatement ambitions (NOU 2015), and advises that carbon taxes are implemented alongside the EU ETS. It is stated that only 10-15% of the world's GHG emissions are directly taxed, and that the forced price mechanisms that are in place are low compared to most estimates of the actual SCC. In Norway, 50% of the emissions are covered by the EU ETS, which is fixed until 2030 with a yearly linear reduction factor. As Norway aims to be carbon neutral by 2050, a committing target of this must be in place no later than 2030. Norway is committed to reduce emissions by 30% of 1990 levels by 2020 by the Kyoto Protocol, and has set an additional goal of reaching a 40% reduction by 2030. The government seems committed to these goals through public statements (Regjeringen, 2015), but still, during this year's budget negotiations, they have been heavily criticized for not implementing effective abatement policies. The target demands yearly reductions of

800 000 tonnes of CO_2, but the suggested budget would only lead to a reduction of about 100 000 tonnes, leading climate scientists at CICERO calculated (2016).

The NOU (2015) also discusses the potential of demanding carbon tax from sectors already included in the EU ETS. The reasoning behind this, as Saksviksrønningen also suggested in his Civita report (2015), is the current price of quotas, which is very low. However, there is a bi-effect of such a measure, namely that it would affect the prices on quotas in the entire EU, not only nationally. As the demand for quotas drop in Norway, so will the price. This will again increase demand elsewhere, and thus not necessarily lead to reduced emissions. It is stated that as the quota price is expected to rise, and that the carbon tax "on top" should only be a temporary measure for that matter.

Figure 4, translated from the NOU (2015), shows the marginal cost of emitting CO_2-equivalents in Norway. It is clearly visible that there is no resemblance of a flat tax on carbon, as there is a vast difference between the industries.

Regarding setting a carbon tax policy for Norway, we already have some national experience on the issue. By the start of the millennium, a carbon tax had been in place for ten years, being particularly strict on some fuel types. However, the effects were modest, only leading to a decrease in the emissions to GDP by 2% (Bruvoll & Larsen, 2004). The reason is likely to have been the many exemptions for the energy-intensive industries, and the price-inelasticity in the markets of the taxed goods.

3.4 Carbon Tax and the Consumer

With a carbon tax, consumers will inevitably have to pay a large part of the mitigation costs. Product prices increase, and they have to either lower their consumption,

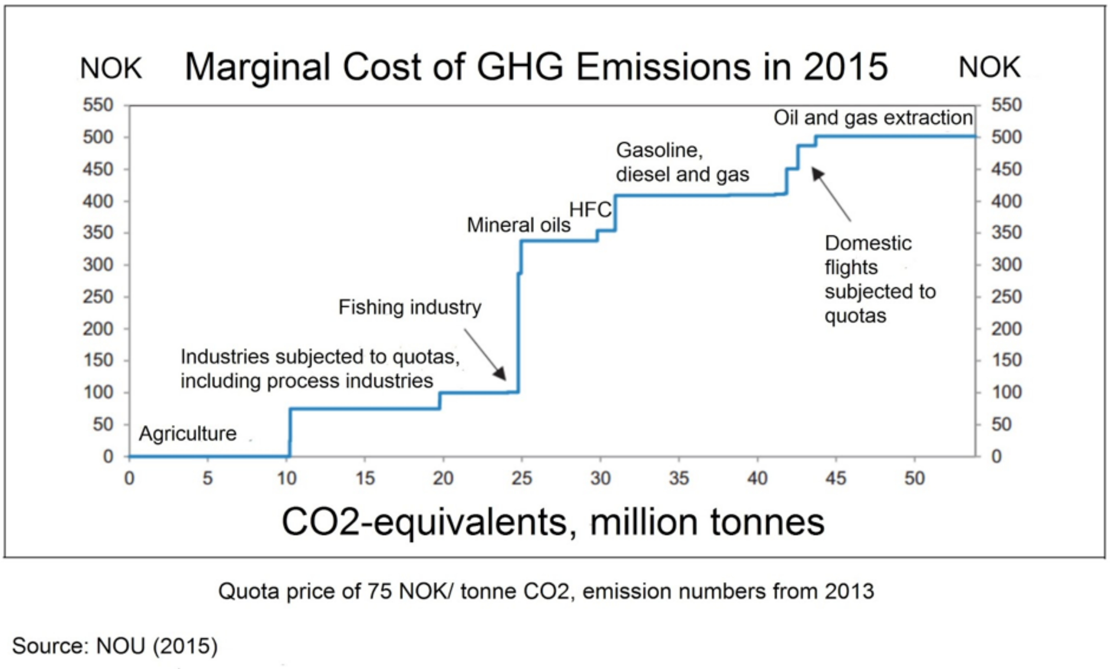


Figure 4: Marginal cost of GHG emissions in Norway in 2015

or change their habits. Edenhofer et al. (2010), calculated the costs (not taking the benefits into account) of heavy mitigation in a set of different models, given as percentages of world BNP. The levels of for example technological advancements vary, and consequently also the results. Saksviksrønning (2015), uses these models in his report to estimate the costs for the Norwegian consumers, in NOK (7.50 pr USD, Feb. 2015), which gives a fee of between 400-1 335 NOK/t CO_2 to attain the "400ppm-scenario". The payment per capita is thus 4 000 to 13 350 NOK (1,7% - 5,6% of the consumption in a household in 2013) given emissions of 54 million ton nationally. Saksvikrønning consider this cost to be acceptable, but points out that the same calculations for the US results in a higher estimated consumer cost of 809 - 2 693USD/pr. Capita, in other words a consumption reduction of 2,5% - 8,2%.

Regarding a revenue neutral tax, where the collected tax is paid back to the populace, the suggested way of paying back the revenue varies. Hansen and Semmler (2015) and Hanson (2016) both suggest a system where the mean of the collected funds are paid back to the adult populace, and children are attributed half of this sum. This would give a strong incentive to abate, as a relatively substantial sum could be earned each year for low income families, compared to their base income. This would be a progressive tax-scheme, given that the rich pollute more than the poor. It would also be a rather simple solution, that should be easy to implement. Saksvikrønning (2015) on the other hand, wants the revenue to be distributed as a mean of the respective income groups in a given geographical area. He argues that the already progressive tax scheme in Norway is a result of a long political process, and therefore should not be affected by the carbon tax. In his opinion, this would create more reasons to oppose the scheme, and thus make it more difficult to implement. The geographical aspect is a way of making sure that one doesn't punish people living in remote areas, who are more reliant on frequent car driving as public transport is scarce and impractical. He also suggests that the payment should be made not by a direct transfer, but rather as a cut in income taxes, as these are damaging to the economy, distorting people away from working.

Williams, Gordon, Burtraw, Carbone and Morgenstern (2014) investigated the cost of different approaches to return the collected taxes, not taking the benefit of abating into account. They concluded that a tax of 30 USD/t CO_2 would cost 866 USD per capita if a lump sum transfer was used, 407 USD per capita if the income tax was cut and 291 USD per capita if the capital tax was cut. The capital tax cut is the most efficient and regressive approach. The lump sum transfer is strongly progressive and also the least efficient approach. Cutting the income tax is more efficient than the lump sum transfer, but less regressive than a capital tax cut. As all the options have a cost, there is no double dividend, meaning that none of the payback methods results in a measurable value before measuring the benefit from mitigation.

3.5 Research and Development

An alternative to cutting taxes or paying back the collected funds, is to earmark them for specific projects. Qualitative research in Norway has concluded that taxpayers trust the government to spend the collected carbon taxes wisely, especially if the funds are earmarked for environmental efforts (Kallbekken & Aasen, 2010). The focus groups did not want the carbon tax to be spent on lowering other taxes, but rather to be invested in for example green R&D projects, of which they were informed.

Investing in research that might lead to greener energy production methods might be crucial. It would not help the environment that everyone bought Teslas and E-Golfs, if the power socket they plug the cord into at the end of the day is supplied by a coal power plant. This may somewhat have been the case, for example in Germany. Here, the “green shift” has backfired, as cheap coal from the US has outcompeted gas in the EU, and the new green facilities cannot meet the demand (The Economist, 2013). Somehow, this “dirty” electricity is also transporting itself to Norway, according to the EU’s calculations. Over 95% of the electricity consumed in Norway is generally produced by hydro power, yet the EU report that 70% of the consumed electricity originates from coal, gas and nuclear power plants through the GO market (Vagle, 2015).

Fossil fuels, which were projected to continue its price increase, recently reached historically low price levels due to the oversupply in the market, and the maintained OPEC production level (Craus, 2016). The price has somewhat increased after the OPEC agreed to decrease production from the first of january next year, but is til very low (Elliot, 2016). Robin M. Mills (2008) stated in the book *The Myth of the Oil Crisis: Overcoming the challenges of depletion, geopolitics, and global warming*, that the oil supply will last much longer than many have projected, and stay relatively cheap for a long time. This is bad news for green power production, which can only outcompete fossil fuels if their prices are pushed towards zero through subsidies and the like, as many of the biggest oil producers can produce oil at a very low cost. As this again would push the general energy price further down, and hence lead to increased consumption, this would most likely be both an expensive and ineffective approach to facilitate a shift in the energy production (Saksviksrønning, 2015).

The IEA numbers looked rather dim for the green shift back in 2014. 69% of the investments in new energy production went to fossil fuels (IEA, 2014). This changed rather drastically in the following year (IEA, 2015), were almost half of the new capacity was renewals. The newest numbers from IEA (2016) also state that renewables is experiencing the fastest growth, by far. Also, their estimates for 2040 show a somewhat positive outlook, with 60% of energy production coming from renewables, 150 million electric cars on the road and an efficiency gain in the energy sector that decreases demand by 5%. Still, 1.2 billion people lack access to electricity to this day, and 2.7 billion put their health at risk by using solid biomass for cooking. These numbers are predicted to be respectively half a billion and 1.8 billion in 2040. Helping all these people getting access to electricity without the use of fossil fuels can be difficult without technological advancements (IEA, 2016).

Torvanger and Meadowcroft (2011) and Fischer et al. (2012) expands on the market failure of underinvestment in green technology research. These investments are typically required to be large, and any potential gain is set far off into the future. Also, the likelihood of a firm capturing a substantial part of the benefit is small, as the technology will be replicated by the competitors. Another, rather big part, of the possible profit, could also be measured in the abated emissions. These "earnings" will not be gained by the company, but the populace of the world. Hence it makes sense to invest state funds in green R&D projects.

3.6 Border Carbon Adjustment (BCA)

If everybody could agree on a global, flat tax on carbon that was set close to the real SCC, it would be quite fine and dandy. However, this is hardly the case in the real world, which is haunted by the freeriding problem. As some abate, and pay to do so, others can choose not to. They will still be able to reap the benefits of the emission reductions, or they can pollute more without increasing emissions from the present state. Another known mechanism is the aforementioned carbon leakage.

Nordhaus (2015) explored a possible way of overcoming this issues. By forming "climate clubs", that impose restrictions on imports from countries outside of the club, an import tariff as low as 2% will be enough to make it beneficial to join the club in a situation where the tax is set to 25 USD/t CO_2. However, there has been raised concerns that such a practice might not be acceptable according to the WTO legal framework (Weber, 2015), as it may be considered as protectionism (Cosbey et al., 2012). Others are more optimistic. Acknowledging that placing barriers on import, like a BCA, is challenging from both a political and a legal viewpoint, Horn and Mavroids (2010) still conclude that a BCA might be designed in accordance with WTO rules. Other assessments of this potential issue, like that of Pauwelyn (2012) and Hillman (2013), also concludes along these lines. Even though the WTO prohibits border-tax that discriminates based on origin, there are certain violations that can get a pass justified by environmental exceptions. The latter concluded that "both the letter and spirit of WTO trade rules permit countries with carbon taxes to adopt "non-discriminatory harmonizing tariffs."". In other words, a country can protect its trade exposed industries under a carbon tax regime, by taxing imported goods produced without a similar tax scheme, provided that the tax is levelled and fair. This would also give an incentive for these countries to adopt carbon taxes, as it represents a revenue stream for the government. There are also cases where the WTO have ruled in favour of countries accused of discrimination on the basis of environmental protection issues. In 1998, the WTO dismissed the charge brought on to the US by India, Malaysia, Pakistan and Thailand, where the US had banned shrimp caught with certain kind of nets that also captures and killed endangered sea turtles (India etc v. US, 1998).

However, there are other issues than that of the WTO legal framework. Some papers conclude that a BCA might cause negative counter effects that undermine other policies, like those that addresses equity concerns. Both within countries, and on a global scale (Steininger et al., 2014, Fischer & Fox, 2012). Böhringer, Balistreri and Rutherford (2012) also suggest that BCA might increase inequality, as it will affect the poorer households budget more than the richer households. However, this can be countered by financial transfers (Springman, 2014). In addition, as the relationship between consumption and emissions in Norway are seemingly linear (Isaksen & Narbel, 2017) or increasing at the margin (Steen-Olsen et. al, 2016), this would presumably not be an issue.

Whether or not a BCA is actually effective in reducing emissions or not, is also debatable. Böhringer et al. (2012) conclude that BCA reduces carbon leakage and shifts the economic burden from abating countries to non-abating countries implicitly through market prices. However, the gains are small, and global cost reduction is also modest. Springman (2014) states that a BCA is not only ineffective in abating, but also economically detrimental, especially for developing countries. Bednar-Friedl, Schinko and Steininger (2012) found that correctly including emissions from industrial processes by using a multi-sectoral, multi-regional model, increased the magnitude of carbon leakage from the EU, and thus the potential effectiveness of a BCA. However, it is underlined that BCA should not be a definitive solution, as it may hinder developments in green technology in the exporting countries. It is not necessarily given that a BCA will reduce carbon leakage at all. A theoretical paper by Jakob, Marschinski and Hübler (2013) in fact suggest that carbon leakage could increase with an implementation of a BCA, as the production for the domestic market in China is more emission intensive than that of the exporting sector. As the export decline, production shifts to the domestic sector, and hence emissions increases. However, quantitative modelling like that of Weitzel, Hübler and Peterson (2012) and Böhringer et al. (2012), does not support these results. The former show that BCA can reduce carbon leakage, but with a declining marginal effect.

3.7 Financial and Technology Transfers

As a part of the Kyoto protocol, the Clean Development Mechanism (CDM) was meant to achieve two goals. Firstly, to ensure that emission reductions took place in developing countries by efforts of the developed countries, and secondly, to stimulate sustainable growth in these developing countries (UNFCCC, NA).

The main problem with consumption-based policies is that they address emissions in countries where the government implementing the policies does not have jurisdiction (Peters et al. 2016). The most cost effective way to abate may thus be to invest in abating in these low cost countries right away. More specifically, to make efforts to reduce the carbon footprint of production methods in China, thus decreasing the emission intensities attributed to the goods we consume in Norway.

Reinvang and Peters (2008) conclude that a good way to reduce imported emissions, is to transfer technological and financial means to the producing country, in line with the CDM. Abating efforts are most cost efficient when they are applied in developing economies, compared to physically abating at home. Steininger et al. (2014) also suggest that revenues from a possible BCA should be channeled to developing economies that are exporting goods. According to Springman (2014), allocating a larger share of the required emission reductions to the net importers, might slow down the economy in these regions. This will again create a backlash to the net exporters, like China, which will in turn hinder development of cleaner technologies. Thus, financial and technological transfers yield the best results among the evaluated policies also in this study.

Still, other assessments of the CDM typically show that it fails to deliver on especially the latter of it's two expressed goals. In an extensive literature review of nearly 200 studies conducted on the topic from 1997 to 2007, Olsen (2007) concluded that CDM does not significantly contribute to sustainable growth and poverty alleviation in the affected countries. In other words, result like that of Sutter and Parreño (2007) are common. They found that while 72% of their portfolio of firms contributing to the CDM most likely contributed to real emission reductions, only 1% where likely to have contributed to any sustainable growth. Other results even indicate that CDM-projects might in fact lead to increased global emissions, as the market equilibrium is disturbed as some receive funding and others do not (Rosendahl & Strand, 2009).

4 Analysis of the Results and the Literature

In the following part of this thesis, we will analyse the conclusions from the reviewed literature and our own results for the consumption-based Norwegian emissions of 2012. If a carbon tax is the best available policy tool, how should it be implemented in the Norwegian market, and what are the biggest challenges? Using the GTAP product groups, we will also discuss the carbon elasticities, and what they could imply as to what products might be a good place to start levying taxes.

4.1 Elasticities and Equity Concerns

As we elaborated in section 3.3 and 3.5, there are some equity concerns regarding a carbon tax and a BCA. It is a possible outcome that the burden will fall disproportionately on the lower income groups, as the relatively poorer groups tend to spend more of their total budget on goods and services like transport and electricity.

Table 7 shows that the highest quintile spend on average 3.7 times more money on goods and at the same time emit 4.6 times more CO_2 in total. Our results therefore indicate that total emissions increase more than proportionally with expenditure. In other words, the more money you spend on goods and services, the more energy intensive goods and services you consume. Thus, a carbon tax in Norway would most likely not be regressive overall.

The elasticities stemming from our results suggest that a tax on both direct and indirect emissions would in fact be progressive, as both elasticities from domestic and imported emissions are above one, making them luxury goods. Thus, a tax on indirect emissions would seemingly not undermine the policies aimed at achieving income equality in Norway. This is not to say that there are no exceptions. Certain groups of products would undoubtedly make for regressive tax schemes. This especially applies to food and energy, which have carbon elasticities of respectively 0.4 and 0.42. Taxing this groups in a less aggressive manner may be advised, as there might be some revolt if you end up curving the poorer quintiles consumption disproportionately. Especially when the overall message is that the richer pollute more. But going easy on these product groups would not be in line with economic theory and empirical results, which suggests that the tax should be flat.

As discussed in section 3.3, there are some that suggest that a progressive carbon tax would in fact be harder to implement than a neutral one, as resistance could arise from people affected. The way in which the collected tax is spent by the governing bodies would thus not only be likely to affect the efficiency, but also the reception of the scheme. However, as the Norwegian society is used to rather aggressive regressive tax schemes, we do not believe that this will be a big issue. Also, it would be very hard to argue, as Saksviksrønning (2015) suggests, that it is fair that the relatively rich are "allowed" to pollute more, without paying as much for it as the relatively poor. The "polluter pays principle" is rather easy to grasp and agree upon, and has for a long time been the accepted norm in environmental economics. This would go against Saksviksrønning's proposal.

4.2 Carbon Tax and BCA: Incentives and Feasibility

Using emission intensities like that provided from Glen Peters and CICERO might be one simplified solution to estimate how much carbon emissions a certain good is eligible for. However, there are problems related to taxing all goods of a certain product group based on a mean emission intensity. First of all, it would be unfair to the producers that are emitting as much as, or less than, the mean. The producers pulling the mean upwards would be facing a fee less than proportional to their emissions. This also implies that the worst polluters will face no incentive to abate towards the mean of the industry, as they are already facing a fixed customs barrier. At the same time, all the companies will in fact be incentivized to pollute more, if it can cut their costs. We end up with a classic "prisoner's dilemma", where the entire industry would benefit from abating and reducing their emission-intensity mean in the long term, but individually end up doing the exact opposite.

This problem could be tackled by letting producers document that they are in fact polluting less than the industry average, and thus should face a reduced fee. The worst polluters would still not be encouraged to abate, unless they could save more by doing so, than they already save by paying too little tax. Also, cheating on tests and false reporting on emission reductions might be a resulting problem, as the Volkswagen-scandal has shown. All these issues could again be faced with better monitoring of the industries, followed by more accurate estimates of emission intensities based on country, region, production methods and the like. Still, such efforts would inevitably lead to increased costs, and more complexity. Yet, unless there is perfect information, there is potential for rebound effects, adverse incentives and underreporting.

Another disadvantage with using intensities based on monetary values, is the large price fluctuations in goods and services due to sales, peak pricing and some goods being expensive due to brands and craftsmanship, without necessarily emitting more. Buying a TV at a discount, or planning your travels far ahead so you get cheaper flight tickets, does not make you pollute less. However, a monetary approach would assume that it did, and punish you less.

As mentioned in section 3.3, one of the the benefits with a carbon tax, is that it could be levied upstream, where the actual emissions occur, and then propagate through the market by itself. This advantage is lost if the tax is consumption based, based on the basic prices of the products and a generalizes emission intensities.

Despite all this, it still would be counterintuitive to tax the exposed industry at home to reduce emissions, without leveling the playing field for foreign competitors entering the market. Thus, a BCA might be strictly necessary to create a political consensus for a carbon tax at home. If the alternative is doing nothing, then a compromise that might even end up increasing emissions, might be recommendable just to signal a willingness to reduce emissions despite the costs.

4.3 CDM: Carbon Subsidies and Rainforests for Ransom?

An alternative or a potential supplement to a BCA, is the financial transfers that we elaborated in section 3.6. The empirical results of the literature on the CDM have been ambiguous. While they did lead to measurable abatement, they did not stimulate sustainable growth in the regions that received funding. This implies that the investments are not delivering on their promise. Why is that? A potential issue regarding investments in green projects in exporting countries, are the intentions of the recipients of these investments. Just as the exporting industry will face ambiguous incentives from a BCA, investments in line with the CDM might in fact create incentives to enter a polluting industry. A monetary transfer to invest in less emission intensive production methods, might in fact end up as a de facto subsidy for emission intensive industries. This could lower the threshold for investors to enter the market, and create more emissions as a result.

The same argument goes for buying pieces of land in the Amazon rainforest and the like, as the Norwegian Rainforest Fund have been doing. Knowing that a piece of forest is valuable, a profit seeking individual might simply threaten to level a piece of the rainforest to the ground, unless he or she is paid handsomely. Even if they wouldnt utilize the timber or the lands in the first place. Thus, effectively, they are holding the rainforest as a hostage for ransom.

All these issues do not exclude investments in green projects in developing countries, but it is important to map the potential rebound effects of these investments.

4.4 Norwegian Policies and the Paris Agreement

In effect as of the fourth of November, the Paris agreement does not specify national policies and how they should be implemented. Rather the agreement includes a goal of keeping the global temperature raise well below two degrees Celsius, with intentions to keep the temperature rise under 1.5 degrees Celsius. The agreement states that this should be achieved through heavy, economy-wide mitigation from developed countries and aid to help developing countries invest in mitigation and sustainable development. The agreement also includes reinforcements to the Warsaw International Mechanism on Loss and Damage, to help emergency response in the case of catastrophic events that are likely to have occurred due to anthropogenic climate change, and slow onset changes like sea level change and increasing drought (UNFCCC, 2015).

A carbon tax accompanied with a BCA that entails exceptions to certain developing economies, accompanied with efforts and investments in these economies, would seemingly be in line with these agreed upon guidelines. For Norway's part, our customs barriers already includes such exceptions, due to humanitarian issues (Norwegian Customs, 2015). In addition, we are already spending substantial state funds on aid, the aid budget for 2016 beeing 33.6 billion NOK (Speed, 2015). Using the same guidelines when assessing our contribution to sustainable growth and GHG-mitigation, might ease implementation. In regards of public acceptance, these facts may also make additional policies in line with the Paris agreement more of a "status quo" than a radical change, easing implementation.

4.5 Norway in the Global Game of Emission Reductions

As each country is still free to choose abatement policies, the stage is set for a global game. In this game, there are a multitude of small nations that are all but completely dependent on the efforts of the big polluters like the US, China and India. Norway, fitting the first description perfectly, are not able to abate in such a manner that a potential crisis could be averted. Possible negative effects to our local environment can thus only be prevented if we somehow manage to persuade the larger economies into abating.

The potential for forming "climate clubs" could be such a persuasive tool, as discussed in section 3.5. Norway are surrounded by relatively similar countries, that are more or less willing to make serious efforts to abate in an aggressive manner. Sweden recently proclaimed that they are going to be carbon neutral by 2045 (Darby, 2016). However inefficient, a BCA is needed to make a climate club an attractive company. Taking our results for the consumption based carbon footprint of Norway into account, it would also be easy to criticize efforts to persuade others into abating, if we did nothing ourselves to decrease our imports of CO_2.

The biggest net exporter of CO_2, is currently China (Deloitte, 2015). China would thus inevitably be affected by a large climate club appearing in one of it's biggest export markets, like the EU. Whether this would be fair or not, or even constructive, is debateable. It is true that some of China's extraordinary growth can be related to emission intensive exports, but it is by and large the western world who have demanded these cheap, emission intensive goods. These goods have also increased our wealth, by being relatively cheap. The complexity of this situation is a good example of what is yet to come. In India, there are currently a total of 60 million households living without access to electricity, an issue which the government has vowed to eliminate by 2018 (Singh, 2016). Should this electricity be provided by coal power plants, it would be catastrophic to the international climate efforts. However, countries like Norway is in no position to demand that such an undertaking is done solely by installing solar panels and windmills, taking our current levels of consumption and emissions into account.

Despite India's massive need for energy and a US president-elect that seemingly denies anthropogenic climate change, it's not all bad news in the climate change game. China's poverty rates are down below 2% (The World Bank, 2016), and they are starting to take their emission reductions rather seriously. In their new five-year plan, the Chinese government has pledged to reduce their emissions by 48% from 2005 levels by 2020, having reached a 37% reduction by 2015 (Henderson, Song & Joffe, 2016). China has also invested heavily in renewals, accounting for more than a third of the total global investments in 2014 (McCrone, Moslener, d'Estais, Usher & Grüning, 2016). Thus it may seem as China is already responding to both the internal and the international pressure to achieve emission reductions and improve the local environment for their citizens.

For Norway's part, albeit being small country, we are undoubtedly one of "the worst of the bunch" when it comes to carbon footprints. Our consumption is massive, we have a lot of energy intensive industry, and we export oil. Yet, we are blessed with a green energy sector and the world's largest per capita fleet of electric cars (Cobb, 2016). The fact that we are continuously ranked as one of the best countries in the world to live in, would also imply that if we cannot turn around our blatant emissions, then who can? As a rich nation, one could assume that we have a rather high willingness to pay for a stable climate. Thus, in the global game of emission reductions, Norway could do well by trying to set an example for others to follow, as it may be our only option to avoid damages to our own economy in the future.

4.6 Potential Redistribution of Norwegian Emissions

In our analysis, and that of Isaksen and Narbel (2017) and Steen-Olsen et al. (2016), we find the relationship between consumption and emissions of carbon to be close to linear. Having such a linear relationship might at first lead one to draw the conclusion that a carbon tax, or a fee and dividend, would be futile. A dime collected and a CO_2 particle to air avoided in one end of the market, would only be redirected and spent elsewhere, with the same outcome. Either directly by citizens, or indirectly by public expenditure. Thus no real emission reductions would occur. However, one must also consider the effect of relative prices changing in the market. Should one find an effective way to classify the emission intensity of goods, the price would rise a lot for certain goods, a bit less for others, and even perhaps fall for some types of goods. Given that at least some of these goods are substitutes to one another, one would shift the carbon expenditure curve downwards, lowering the coefficient in their relationship, and hence reduce consumption-based emissions.

4.7 Where to Start, and Further Research

Our analysis of carbon elasticities, yields some insights that might be helpful in forming a Norwegian tax on carbon, and deciding where it should it be implemented at trial. The results indicate that the most carbon intensive marginal increases in expenditure are nested in the category of indirect imported emissions. As for lowering our consumption based emissions, this is bad news. As we have elaborated rather extensively, reducing emissions through a BCA is not very effective and the practical challenges are rather huge. However, in the global game of abating, imposing customs on imported goods per CO_2 is a necessity. As Table 13 shows, the carbon elasticities might not be as one expects. The rather low elasticity for air transportation for one, is seemingly not fitting the common belief that the rich travel more than the poor.

The same goes for electronics. Possible reasons for this might be the availability of relatively cheap flights and consumer electronics. "Everyone" travels to their family up north or the Mediterranean coast every now and then, and "everyone" owns a smart phone, computer and flat-screen TV.

The categories within the indirect imported emissions that stand out with high carbon elasticities, is that of G27, G38 and G48. Respectively "Textiles" with a carbon elasticity of 1.24, "Motor Vehicles and Parts" with a carbon elasticity of 1.9 and "Other Transportation" with a carbon elasticity of 1.67. In other words, the relatively rich buys clothes, cars and vacations from travel agencies in an unproportional way related to their expenditure. These product groups may be a good place to start to measure the effect of an eventual BCA, as it hopefully will be more cost effective. Measuring the effect of the policy will also presumably be easier in a product category with a high carbon elasticity. However, before such a tax is set, the price elasticity of these goods must be known, and the SCC must be agreed upon. As mentioned, there is no current scientific consensus on the latter, this might have to be decided by a political process. Antoher hatch is the EU ETS, which inevitably would apply for parts of these product groups, making the effects of a tax less certain.

Table 13: Carbon elasticities and emissions intensities for selected GTAP categories

GTAP category	Carbon elasticity	Emission intensty (kg CO_2/USD)
G27, Textiles	1.24	0.47
G28, Wearing Apparel	0.98	0.42
G38, Motor Vehicles and Parts	1.9	0.28
G48, Other Transportation	1.67	0.69
G50, Air Transportation	0.45	1.00

The tax rate for a product group can be set by multiplying the SCC (USD/ t CO_2) with the emission intensity (kg CO_2/ USD) which gives a monetary value (USD tax / USD spent). This is the percentage change in price of a good due to a carbon tax.

This percentage change in price, together with a price elasticity for a certain group, can be used to establish the percentage consumption reduction in the said group.

Using air transportation and a rather low SCC of 21 (USDtax/ t CO_2) as an example, this gives the following carbon tax rate

$$0.021\frac{USD_{tax}}{kgCO_2} \times 1\frac{kgCO_2}{USD_{spent}} = 0.021\frac{USD_{tax}}{USD_{spent}} \Rightarrow \text{carbon tax rate} = 2.1\%$$

The estimates thus conclude that the tax on carbon increases price on air transportation with 2.1% when basing our anlysis on a SCC of 21 (USDtax/ t CO_2).

Using Norwegian numbers from Institute of Transport Economics (2009), international air travels for leisure purposes have an elasticity of -1.4. A formula for price elasticity of demand yields:

$$\frac{\%\text{ change in spending on a good}}{2.1\%} = -1.4 \Rightarrow \%\text{ change in spending on a good} = -2.94\%$$

The total reduction of CO_2 emissions is the total reduction in spending multiplied with the carbon intensity of the good.

The tax rate depends heavily on the SCC. A SCC of 900 (USD/t CO_2), as proposed by Ackerman and Stanton (2012), indicates a tax rate of 90% for air transportation. Another example, a SCC of 900 USD/t CO_2, would mean a tax rate for wearing apparel of

$$0.9\frac{USD_{tax}}{kgCO_2} \times 0.42\frac{kgCO_2}{USD_{spent}} = 0.38\frac{USD_{tax}}{USD_{spent}} = 38\%$$

According to the American economist William Nordhaus (2011), the SCC should start off with 12 USD/t CO_2 and increase to 65 USD/t CO_2 by 2050. Table 14 shows our proposed carbon tax rates in such scenario.

Table 14: Proposed carbon tax rate example when SCC = 12 and SCC = 65

GTAP category	Tax rate SCC = 12	Tax rate SCC = 65
G27, Textiles	0.56%	3.1%
G28, Wearing Apparel	0.50%	2.73%
G38, Motor Vehicles and Parts	1.2%	6.5%
G48, Other Transportation	0.83%	4.48%
G50, Air Transportation	0.22%	1.82%

In a scenario with SCC as those found by Ackerman and Stanton (2012), where SCC rise from 900 USD/t CO_2 in 2010 to 1500USD/t CO_2 in 2050, our proposed carbon tax rate would be as in Table 15. //

Summing up, the vast difference in the estimated SCC yields drastically different tax rates. A Norwegian consensus on the topic is therefore needed. Also, the price elasticities of the product groups must be known. Lastly, we have to recognize the adverse affects that overlapping with the EU ETS might cause.

Table 15: Proposed carbon tax rate example when SCC = 900 and SCC = 1500

GTAP category	Tax rate SCC=900	Tax rate SCC=1500
G27, Textiles	42.3%	70.5%
G28, Wearing Apparel	37.8%	63%
G38, Motor Vehicles and Parts	25.2%	42%
G48, Other Transportation	62.1%	103.5%
G50, Air Transportation	90%	150%

5 Conclusion

Our results indicate that a doubling in expenditure on the individual level means a 119% increase in CO_2 emissions. The carbon elasticities for respectively direct emissions, indirect domestic emissions and indirect imported emissions are 1.1, 1.09 and 1.37. This would imply that the relationship between expenditure and emissions in Norway is in fact increasing at the margin, and that the total outcome of a carbon tax on consumption would be progressive. Emissions of CO_2 in Norway is therefore a luxury good. This is a surprising outcome, as empirical evidence from other countries often indicate the opposite, namely a relationship that is decreasing at the margin. The reason for this outcome is likely the cheap, clean electricity in Norway.

These results give some indication as to how a carbon tax would affect consumption and emissions. GTAP groups that have a high carbon elasticity, combined with a high emission intensity would give the most reductions, but to know by how much exactly, the price elasticities of these goods need to be known. For example the product categories of "Textiles", "Motor Vehicles and Parts" and "Other Transportation", could be good places to start in regards to cost effectiveness and obtaining a measurable outcome. However, overlapping with the EU ETS has to be taken into account. The actual tax level would be differ in line with the chosen SCC, which estimates ranges from everything between 12 and 900 USD. As there is no current scientific consensus, this issue might be subject to a rigorous political debate. Further research is needed to narrow the SCC down to a more manageable interval.

There are a multitude of other issues preventing a unilateral carbon tax scheme from being optimal. Implementing a Border Carbon Adjustment (BCA) would not only be practically and politically challenging, but also questionable in terms of effectiveness, according to empirical evidence. The emission intensities used to calculate our results would also be deficient as a basis for tax and customs, as they are a mean of large product groups, and would not reflect the variety of the carbon footprints. This could seriously jeopardize the effort to avoid carbon leakage by creating adverse incentives, and possibly increase global emissions. To avoid these issues, better information about emission intensities is needed, but this would again be costly and add to the complexity of the system. Lowering the emission intensities of exporting countries through the Clean Development Mechanism can be effective, but does not seem to result in sustainable development. This mechanism can also lead to adverse incentives, as the transfers can end up as a subsidy for emission intensive industries. Summing up, the task of implementing a tax unilateral might seem overly challenging, but still necessary. Norway are all but dependent on the effort other, larger nations to turn the tide of climate change. Unilateral efforts in Norway will not help decrease global emissions as such, but it may help to inspire a global movement.

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A Supporting Information

Table A1: GTAP categories, emissions intensities and import shares

GTAP	Description	Norway Emission intensity (kg CO_2/USD)	RoW Emission intensity (kg CO_2/USD)	Import share
G01	Paddy rice	0.06	0.26	18.2%
G02	Wheat	0.14	0.42	18.2%
G03	Cereal grains nec	0.23	0.46	18.2%
G04	Vegetables, fruit, nuts	0.14	0.30	18.2%
G05	Oil seeds	1.55	0.29	18.2%
G06	Sugar cane, sugar beet	1.36	0.43	18.2%
G07	Plant-based fibers	0.08	0.66	18.2%
G08	Crops nec	0.35	0.39	18.2%
G09	Bovine cattle, sheep and goats, horses	0.10	0.32	18.2%
G10	Animal products nec	0.12	0.30	18.2%
G11	Raw milk	0.12	0.30	18.2%
G12	Wool, silk-worm cocoons	0.20	0.48	18.2%
G13	Forestry	0.07	0.27	12.8%
G14	Fishing	0.27	0.40	3.7%
G15	Coal	0.18	0.72	14.2%
G16	Oil	0.15	0.29	14.2%
G17	Gas	0.16	0.57	14.2%
G18	Minerals nec	0.42	0.81	14.2%
G19	Bovine meat products	0.12	0.25	24.5%
G20	Meat products nec	0.14	0.30	24.5%
G21	Vegetable oils and fats	0.20	0.35	24.5%
G22	Dairy products	0.15	0.27	24.5%
G23	Processed rice	0.17	0.42	24.5%
G24	Sugar	0.17	0.25	24.5%
G25	Food products nec	0.17	0.27	24.5%
G26	Beverages and tobacco products	0.18	0.22	24.5%
G27	Textiles	0.13	0.47	80.8%
G28	Wearing appare	0.11	0.42	80.8%
G29	Leather products	0.15	0.29	80.8%
G30	Wood products	0.14	0.30	35.4%
G31	Paper products, publishing	0.12	0.26	42.1%

G32	Petroleum, coal products	0.43	0.44	0%
G33	Chemical, rubber, plastic products	0.19	0.41	62.8%
G34	Mineral products nec	0.59	1.30	28.3%
G35	Ferrous metals	0.73	0.84	84.3%
G36	Metals nec	0.75	0.81	85.9%
G37	Metal products	0.18	0.44	49.9%
G38	Motor vehicles and parts	0.25	0.28	73.2%
G39	Transport equipment nec	0.15	0.43	44.2%
G40	Electronic equipment	0.09	0.31	73.4%
G41	Machinery and equipment nec	0.14	0.29	61.5%
G42	Manufactures nec	0.16	0.47	47.2%
G43	Electricity	0.21	1.17	4.9%
G44	Gas manufacture, distribution	1.31	1.04	0.7%
G45	Water	0.08	0.77	9.6%
G46	Construction	0.13	0.77	0.5%
G47	Trade	0.09	0.26	10.5%
G48	Transport nec	0.28	0.69	35.1%
G49	Water transport	0.74	0.97	1.5%
G50	Air transport	0.66	1.00	30.9%
G51	Communication	0.07	0.17	13.0%
G52	Financial services nec	0.02	0.09	7.6%
G53	Insurance	0.03	0.11	4.9%
G54	Business services nec	0.06	0.19	11.9%
G55	Recreational and other services	0.06	0.22	2.2%
G56	Public Administration, Defense, Education, Health	0.05	0.17	7.2%
G57	Dwellings	0.04	0	0%

Table A2: Consumption categories

Category	GTAP	Description	GTAP	Description
Food	G01	Paddy rice	G19	Bovine meat products
	G02	Wheat	G20	Meat products nec
	G03	Cereal grains nec	G21	Vegetable oils and fats
	G04	Vegetables, fruits, nuts	G22	Dairy products
	G05	Oil seeds	G23	Processed rice
	G06	Sugar cane, sugar beet	G24	Sugar
	G09	Bovine cattle, sheep and goats, horses	G25	Food products nec
	G10	Animal products nec	G26	Beverages and tobacco
	G11	Raw milk	G45	Water
	G14	Fishing		
Energy	G15	Coal	G43	Electricity
	G16	Oil	G44	Gas manuf., distr.
	G17	Gas	N/A	Direct emissions
Transport	G38	Motor vehicles and parts	G49	Water transport
	G39	Transp. equip. nec	G50	Air transport
	G48	Transport nec	N/A	Direct emissions
Clothing	G07	Plant based fibers	G28	Wearing apparel
	G12	Wool, silk-worm cocoons	G29	Leather products
	G27	Textiles		
Other	G08	Crops nec	G41	Manchinery and equi. nec
	G13	Forestry	G42	Manufactures nec
	G18	Minerals nec	G46	Contruction
	G30	Wood products	G47	Trade
	G31	Paper products, publishing	G51	Communication
	G32	Petroleum, coal products	G52	Financial services nec
	G 33	Chemical, rubber, plastic prods	G53	Insurance
	G 34	Mineral products nec	G54	Business services nec
	G 35	Ferrous metals	G55	Recreation and other serv.
	G36	Metals nec	G56	Public administration, defence, health, education
	G37	Metal products	G57	Dwellings
	G40	Electronic equipment		