Iceland's Consumption and Decarbonisation

An examination of carbon-neutrality goals given consumption-based emissions in Iceland

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Abstract

As an effort in combating climate change, the Icelandic government has set the ambitious goal of a carbon-neutral economy before the year 2040. Meanwhile, projections show continuing growth in private household consumption. The aim of this thesis is to examine these goals of carbon-neutrality using an alternative way of accounting for carbon emissions, a consumption-based approach in contrast to production-based, keeping in mind the expected increase in consumption. The aim is twofold. Firstly, the relationship between consumption and emissions is examined. Granger causality was seen running from consumption to production-based emissions, while the opposite was the case for consumption-based emissions, which were shown to lead consumption. This suggests that lowering consumption-based emissions is impossible without lowering household consumption, while decoupling production-based emissions from consumption is shown to be possible. Secondly, these results are used to present rough scenarios showing different paths of consumption-based emissions depending on household consumption behaviour. If the goal is to decrease global emissions, not simply emissions within the borders of Iceland, it is unlikely that complete carbon-neutrality (i.e. consumption-based) is reached without changes in consumption.

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Introduction

It is commonly acknowledged that climate change is the gravest challenge facing humanity today. The burning of fossil fuels since the start of the industrial revolution has propelled economic growth but at the same time started a chain of events that have resulted in global warming, ocean acidification, loss of biodiversity and extreme weather (United Nations Environment Programme, 2018). Our generation's challenge is to prevent the worst catastrophes.

In 2015, the Paris Agreement was signed. It was proof of the willingness of nations to come together to a common goal and presented ambitious goals of lowering global greenhouse gas emissions. Nations committed themselves to undertake radical efforts to combat climate change (UN Climate Change, 2018). The main aim is to hold the "increase in the global average temperature to well below 2°C above pre-industrial levels and pursu[e] efforts to limit the temperature increase to 1.5°C above pre-industrial levels, recognizing that this would significantly reduce the risk and impacts of climate change" (The United Nations Framework Convention on Climate Change, 2015). Since then, climate change has taken centre stage in international politics. Although there is overall agreement that something has to be done[1], there is not much agreement on what courses of actions are best.

In discussing climate change actions, many have pushed for a radical change in our consumption habits and argued that changing our daily habits is one of the fundamental solutions to climate change (see e.g. Wynes and Nicholas, 2017; Schanes et al, 2016, Girod et al, 2013 and Princen 2001). Whether this means that the weight should be put on the shoulders of individuals rather than bigger actors such as governments or corporations is debatable, but it is clear that the effect of private consumption and behaviour on the environment is substantial and without the contribution of private households the fight might be lost.

This relationship between private consumption and carbon emissions (and their planned decrease) will be the focal point of the thesis. The focus will be on Iceland, although some of the broader conclusions might well be applicable to other countries. Iceland is an interesting example, because all stationary energy in Iceland comes from renewable sources, geothermal and hydro power. This makes Iceland, in many ways, more suited to make the changes needed for mitigating climate change. Furthermore, Iceland can be seen as an example of what other economies will look like after the shift to renewable energy has taken place. Nevertheless, we have to be careful not to jump to conclusions, since Iceland is unique in being situated far away from other economies, in a rather inhospitable climate, and heavily relies on imports of food and goods for con-

[1] Of course, there are exceptions. If we look at the views dominating politics in the United States or Australia, for example, they do not agree that anything needs to be done.

sumption. This means that some of the difficulties Iceland faces will not be the same as other countries might face with similar energy production.

The questions I seek to answer are the following two: What is the relationship between private consumption and emissions? How do the existing commitments and plans of the Icelandic government stand if we take the emissions caused by consumption into account? To answer these questions both private consumption and emissions have to be understood.

My aim is therefore twofold. First, I will examine the relationship between consumption and emissions. I present an alternative way of emissions accounting that is gaining popularity, namely linking emissions to the consumer rather than the producer. This results in higher emissions accounted to Iceland than conventional numbers show. Private consumption will be examined in relation to the emission numbers from these two different accounting approaches. Second, I will examine the implications of this alternative way of accounting emissions for Iceland's commitments to the Paris Agreement: Can carbon emissions be lowered to the same extent if we take into account consumption-based emissions, rather than simply the traditional production-based emissions?

The thesis is structured in the following way: The first chapter recounts the background literature on carbon emissions and growth. In the second chapter, two different ways of accounting for emissions will be presented and Iceland's emissions history will be put into context with the emissions of other countries. The third chapter is on Iceland, its environmental commitments and consumption. The fourth chapter introduces the method used to examine the relationship between emissions and consumption, Granger causality, and the result of that analysis. Finally, the last chapter presents four scenarios based on the analysis of the previous chapter and is aimed to show possible emission pathways over the next two decades, depending on the extent the link between consumption and emissions can be cut and how much consumption will increase.

1 Background: Growth and Emissions

The link between growth and greenhouse gas emissions has been discussed and debated for decades and anything close to a conclusion has been controversial and contested. Nevertheless, it cannot be denied that economic growth, as we know it, and global carbon emissions have historically gone together. But is this an inevitable link or can economic growth continue without risking the environment?

We can trace the discussion about growth and environmental deterioration at least as far back as Thomas Malthus's *Essay on Principle of Population*, published in 1798. There, he presented what is now called the Malthusian trap, which predicts that at some threshold populations will be too numerous for the environment to sustain it. The accepted view is that this prediction failed, since technological innovation and institutional changes have always saved us from a complete collapse of the environment (see e.g. Reuveny and Decker, 2000). Nevertheless, Malthus's theory may be more relevant than one might think, since writers such as Costanza and Alier have argued that just as the financial markets before 2008 were built on unsustainable loans, causing a bubble that burst, we are now situated in an environmental bubble: We have borrowed too much from nature and future generations, and if we continue this way the bubble will burst (Alier, 2009; Costanza, 1991). The question is, how can we avert an environmental crash while not sacrificing our welfare?

The answers to this question are many and differ a great deal. Some have argued that growth will push for the technological innovation we need while others argue that the only way out is de-growth, or sustainable recession. These answers depend on the link between growth and emissions. Is it possible for economic growth to continue while cutting down emissions, as the Paris Agreement requires, or do the emissions keep rising while simply moving to different locations? These are all questions that have been put forth, but have not been answered conclusively. A brief account is presented below, since they are relevant when looking at carbon emissions and consumption.

1.1 Decoupling or Carbon Leakage

The hope is that the connection between greenhouse gas emissions and economic growth can be cut; this is termed decoupling. The possibility of decoupling has to be established before its validity can be checked. This has been done in studies, with an examination of whether GDP leads emissions, or the other way around. The theory is that if GDP leads emissions, GDP could continue growing while disconnecting from emissions. This would suggest that decreasing emissions would be possible without sacrificing economic growth. Obviously, this is economically preferable. Studies have found this to be the case in many countries (Zhang and Cheng, 2009; Soytas and Sari, 2009; Soytas et al., 2007), while other studies have found evidence to the contrary (Halicioglu, 2009; Esso and Keho, 2016), i.e. growth being impossible without carbon emissions.

Despite these differing results, many have sought to find evidence of decoupling. There is good evidence for overall decoupling in developed countries (Liaskas et al., 2000; Wu et al., 2018). Meanwhile, there is evidence of an increase in emissions linked to production of goods and services, consumed by developed countries, in developing countries, where decoupling is not visible (Wu et al., 2018). This is what has been called carbon leakage or offshoring of emissions. This seems to suggest that what is perceived as decoupling is simply a shift of the location of emissions, not really a decrease of the emission caused by the consuming countries (Knight and Schor, 2014). Studies have shown that embodied carbon originating in developing countries is increasingly flowing to developed countries. According to Davis and Cadeira (2010), 23% of carbon emissions in 2004 could be traced to the production of goods that ended up being consumed in another country.

This idea of decoupling can be traced back to Grossman and Krueger's paper on an inverse-u-shaped relationship between economic development and environmental degradation (1995). This relationship has been called the Environmental Kuznets Curve (EKC) as it proposes the same kind of relationship as Kuznets postulated being between income and inequality. The idea is that when economic development has reached a certain point, technology and innovation will solve environmental problems. In Grossman and Krueger's paper, there is no talk about carbon emissions, but others have added to the literature and sought to find a similar relationship between emissions and economic development (Apergis, 2016; Huang et al., 2008; Martinez-Zarzoso and Bengochea-Morancho, 2004; Riti et al., 2017).

Arguably, talking about this possible u-shaped relationship is misleading, regardless of whether it is based on facts or not. If there is any such relationship, the peak of the curve is likely to be so high that even if carbon decreases after that, the carbon already emitted greatly exceeds the environment's capacity (Moomaw and Unruh, 1997). In other words, even if this relationship holds, it may be argued that we need more drastic action than to wait for emissions to decrease on their own.

1.2 Growth and Regulations

The conventional idea is that drastic environmental actions, such as stringent regulations, hinder economic growth by adding costs to firms and even push polluting businesses to move from countries with high regulations to countries with low regulations, often called pollution havens. The pollution haven hypothesis is difficult to confirm, since it relies on knowing why firms outsource their production. International outsourcing[2] happen when

[2]Outsourcing is not the same as offshoring, which captures all of a firm's activity abroad; direct investments, joint ventures and arm's length trade.

part of a firm's production is undertaken by unrelated firms abroad. As Cole et al. argue in their paper on the link between outsourcing and the environment, knowing the net effect of environmental outsourcing is detrimental for understanding the dynamics of the challenge of lowering emissions (2014).

Strict environmental regulations might cause high abatement expenditures on firms. If the cost of outsourcing to another country with more lenient environmental regulations is lower than the abatement cost, then a firm is likely to trade with firms abroad. This has been confirmed to be the case for example in Japan (Cole et al., 2014). But one should be careful to conclude that outsourcing necessarily results in more emissions; different production processes abroad might even lower total emissions. We have to remember that the aim of the firm is to avoid costs, not to emit as much as possible. Regardless of whether total emissions increase or decrease, it is still likely to be costly to firms, since many cases of outsourcing would not have occurred if it weren't for strict environmental regulations forcing the market to change. This supports the common idea that environmental regulations work against the economy.

The idea that environmental regulations necessarily hinder economic growth was challenged by Michael E. Porter (1991). In opposition to the pollution haven proposition, he argued that well-designed environmental regulations could boost a country's competitiveness. In another paper written with Claas van der Linde, they "argue that properly designed environmental standards can trigger innovation that may partially or more than fully offset the costs of complying with them" (Porter and van der Linde, 9, p. 98). The crucial part would be that the regulations be well designed and do not allow for carbon leakage to pollution havens (Ambec et al., 2013). A definite proof of the hypothesis holding has yet to be found. In an OECD study, Albrizio et al. argue that there is no empirical evidence that environmental policies have led to any permanent positive effects of this kind (2014).

The Porter-hypothesis opposes a purer form of a belief in free-markets, since it presupposes some kind of market failure that results in inefficient markets. Environmental regulations are then seen as forces that correct these failures and make the market more efficient. It therefore opposes the business-as-usual approach, based on the idea that completely free markets will solve the problems we face. This is the view that technological progress on the supply side and change in consumption behaviour on the demand side will push for the changes needed to react to climate change (e.g. Knight and Schor, 2014), i.e. the markets will react to the demands of the consumers. This view has been criticised for not incorporating the "real" costs of production, namely, that the environmental costs are not included in the price (Smith, 2011, p.9-13).

There has been found evidence of carbon leakage following environmental regulations with carbon-intensive production moves to pollution havens. Aichele and Felbermayr state that “Kyoto has indeed led to leakage,” showing that countries bound by the Kyoto protocol increased their carbon embodied imports from non-committed countries by 8% (Aichele and Felbermayr, 2015, p. 104). A study by Cole et al. from 2006 further underscores the fact that the regulations themselves and the infrastructure matter; the study shows that the corruptibility of a country decides its suitability as a pollution haven. This goes to show that the possibility of carbon leakage has to be kept in mind when implementing commitments to climate change mitigation and putting environmental policies in place.

In talking about emissions, growth and climate regulations it is therefore crucial that a country’s reduction on a national level is not offset by carbon leakage. The question therefore is not solely whether we can sustain economic growth while lowering territorial emissions, but whether we can sustain growth while lowering *total* emissions (Jiborn et al., 2018). Understanding the complex relationships of international trade and the emissions involved can further help us reach our goals.

2 Carbon Emissions from Production and Consumption

Before starting my discussion of the amount of carbon emissions and different ways of accounting for them, a clarification is in order. When discussing and writing on greenhouse gas emissions, we often simply talk about carbon emissions. In many cases, but not all, people are not only referring to carbon dioxide but all greenhouse gas emissions. The reason for this is that the greenhouse effects of other gases are often presented in reference to carbon dioxide; they are incorporated in overall emissions as carbon-equivalent emissions (Myhre et al., 2013). For example, methane traps 28 times more heat than carbon, and therefore translates into 28 units of carbon-equivalents in overall emissions. Below, I will specify when I'm talking about carbon dioxide-equivalent emission. In most cases, I will be referring to carbon emissions in the stricter sense, that is to say, without the additional emissions of other greenhouse gases.

In what follows I will discuss two common ways of carbon accounting; production-based and consumption-based accounting. I will discuss the difference of the two approaches and present the historical evolution of emissions in selected countries. I end this chapter by discussing the ratio between the two calculations. There are good reasons for using either approach, but, as I will argue, there is better reason to use both, since they complement each other and can be used in helping us reach different goals. It should be underscored that these are simply different ways of assigning emission to countries; the total sum of emissions in the world is the same regardless of the accounting approach. The growth of global emissions from 1970-2015 can be seen in figure 1, where it is depicted as an index, where emissions in 1990 are 1.

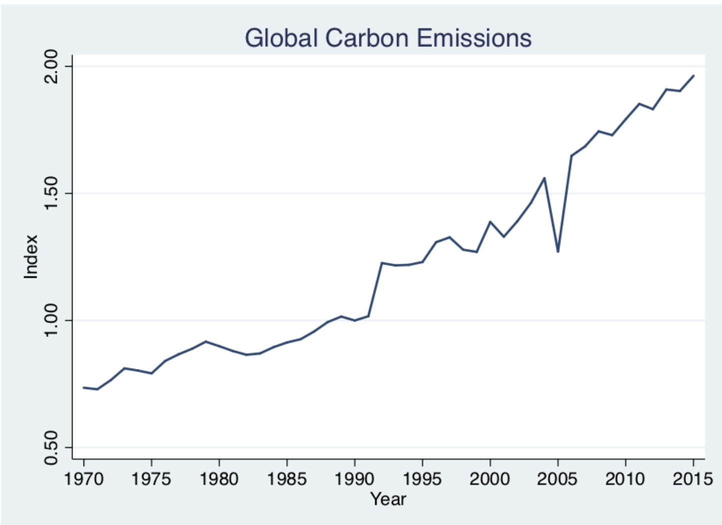

Figure 1: Global Emissions 1970-2015

2.1 Production-Based Emissions

A straight-forward way of calculating a country's emission is to account for all emission emitted within the country's borders. These emissions are often called territorial emissions or production-based emissions. These are emissions from all production within the territory or country, as well as transportation, industrial processes, animal husbandry and other sources within the region. This is relatively easy to calculate, since the sources are all located within the country. This is a plausible explanation for the popularity of using this way of accounting.

This is the approach used by the Intergovernmental Panel of Climate Change (IPCC), the body of the United Nations dedicated to research on climate change and related issues. The United Nations Framework Convention on Climate Change and other international environmental treaties, such as the Paris Agreement, base their objectives for lowering emissions on these production-based emissions. The goals and commitments of the Icelandic government, as well as other signatories to the Paris Agreement, concern these kinds of emissions.

Since governments have more control of production and industries within the country than over carbon-embodied goods imported for private consumption, this might further make this way of accounting popular. In other words, governments might be more likely, or at least think they are more likely, to see changes in production-based emissions and succeed in lowering production-based emissions rather than emissions related to overall consumption and imports.

2.1.1 EDGAR

The data on production-based emissions used in this thesis are from the Emissions Database for Global Atmospheric Research (EDGAR). It provides global data on emissions linked to human actions, both past and present, which is categorised by countries or regions. It includes emissions from all anthropogenic activity, excluding land-use, land-use change and forestry (LULUCF), as is conventional in emissions accounting. The emissions are valued according to values set by the IPCC and are calculated according to international statistics on fuel consumption and crop use, using a bottom-up approach (Janssens-Maenhout et al., 2017). EDGAR differs a little bit from the national inventory from Iceland (The Environment Agency of Iceland, 2018), but the difference is only slight and should not change the results of this analysis.

2.1.2 The Evolution of Production-Based Emissions

Global carbon and greenhouse gas emissions have been continually rising since records began and the contribution of countries is unequal, with the countries that were industri-

Figure 2: Production-based Emissions

alised first have emitted and continue to emit proportionally more than most developing countries, although countries like China and India are continually gaining momentum.

According to the report of the Joint Research Centre (JRC), published with the newest data in 2017, the world's six largest emitters, China, the United States, the 28 countries in the European Union (EU28), India, Russia and Japan, account for around 65% of total global greenhouse gas emissions, while only having 51% of the world's population (Janssens-Maenhout et al., 2017, p.3). This can be insightful when looking at the commitments and implementation of the Paris Agreement.

Since the signing of the Paris Agreement, some countries and regions have seen a decrease in their emissions. Among these is the European Union, which has seen a significant decrease in emissions compared to 2005. Although this can in part be attributed to the commitments of the Paris Agreement, there is also reason to think that this success is partially because of the effects of recessions, which have been shown to have a positive effect on green investment.[3]

In figure 2, we can see the historical carbon dioxide emissions of a few selected countries. On the left side, we have three Nordic countries; Iceland, Sweden and Denmark, and on the right side we can see the three countries that are the biggest emitters; China, the United States and India.[4] The trend that has been seen in the whole of the European Union can be seen in Denmark and Sweden. Iceland, on the other hand, has not seen this decrease. There was a slight fall in emissions after the financial crash in 2008, but since 2012 production-based emissions have been increasing.

If we look at China and India, we can see a clear trend upward. There is a slight downturn in China's emissions in 2015, but it is hard to say if that is evidence for a real reduction in emissions or just a temporary decrease in an otherwise upward trend. The United States seem to have reached a peak around 2005, and they, as many other developed countries, see a significant decrease in production-based emissions.

2.2 Consumption-based Emissions

In the previous section I gave a brief account of the worries academics have about the consequences of stringent environmental policies and increasing import and export of goods, about carbon leakage and outsourcing. Rising from these worries, an alternative way of accounting for emissions has been presented. It seems obvious that only looking at production-based emissions does not tell the whole story: Without the consumer, there would be no production.

The idea behind consumption-based emissions is simple. Instead of linking emissions to the producers, the overall carbon emissions of the production of goods are linked to the final consumer. If my shoes are made in China, the carbon emitted in their production is ascribed to Iceland, not China, since they are consumed by me. But, although the

[3]An interesting relationship between the business cycle and fluctuations in emissions has been studied. What has been called Green Keynesianism is the idea that in recessions the government should invest in green industries and infrastructure (Alier, 2009). This has actually been the case in many countries following recessions, and has resulted in an asymmetry between the increase in emissions during a period of expansion and the decrease of emissions during recessions, with the increase being smaller than the decrease (Acaravci and Ozturk, 2010; Shahiduzzaman and Layton, 2015; Huang and Jorgenson, 2018; Sheldon, 2017; York et al., 2003). These studies have even been used to argue that sustainable de-growth might be the best way out of the dangers of climate change (Alier, 2009).

[4]This excludes the European Union, which, when taken as one emitter, is a bigger emitter than India.

idea is simple, the execution is not. With the complex flow of resources and products between countries, it required more complicated ways of accounting, followed by more uncertainty.

On the face of it, this seems a fairer way of accounting for emissions, but it is not without its faults. Overlooking any practical problems with calculations, it might be problematic to blame the consuming country for all emissions, even if they occur because of the production of the goods they consume. The consumers have no power over policies of other countries. It is more straight-forward for a consumer in Iceland to demand that the Icelandic government enforce stricter climate regulations than for her to demand the same in China, Ecuador or South-Sudan[5]. Furthermore, it is rarely apparent to a consumer how much emissions can be linked to the production of goods she consumes.[6]

Nevertheless, linking emissions to the consumer can shed light on the sources of emissions, and can help policy makers and the international community understand how to combat climate change and where it's possible to cut back on emissions, since we know that we have to cut down emissions wherever possible if we want to reach our goals and avoid the worst effects of global warming.

2.2.1 Eora

The data used are from the Eora Global database, which is available online (Eora). It is a state of the art multi-region input-output (MRIO) database that links production sectors and their emissions to countries (Kanemoto et al., 2014; Lenzen et al., 2013). For years, input-output tables have been used to link pollution to the final consumer, especially in order to calculate the carbon footprint. The developers argue that this database is more accurate and detailed than other databases. What the Eora adds to the literature, is that its accuracy means that it can be used as a basis for policy recommendations (Lenzen et al., 2013).

The database covers 15.909 sectors across 187 countries, and it provides time series on consumption-based carbon dioxide and other greenhouse gas emissions from 1970 to 2015 for each country, excluding LULUCF emissions. In constructing the consumption-based inventories, it uses the Leontief demand-pull model (Kanemoto et al., 2014; Lenzen et al., 2013). To prevent inaccuracy, the data on emissions are from different sources, including the EDGAR database discussed above (Kanemoto et al., 2014).[7]

[5] Big portions of the Icelandic carbon-footprint can be linked to production in these countries specifically (Clarke et al., 2017).

[6] Some of these drawbacks could be fixed relatively easily, while others do not have a clear solution. For example, a label with the embodied carbon on a product, similar to the calories on food packaging could solve part of the problem of the consumer not knowing. But there seems to be no simple solution to the problem of pushing for stricter emissions policies in other countries, other than the international treaties which are already in place.

[7] Other sources include OECD, Eurostat, Energy Information Administration (EIA) and the United

2.2.2 The Evolution of Consumption-Based Emissions

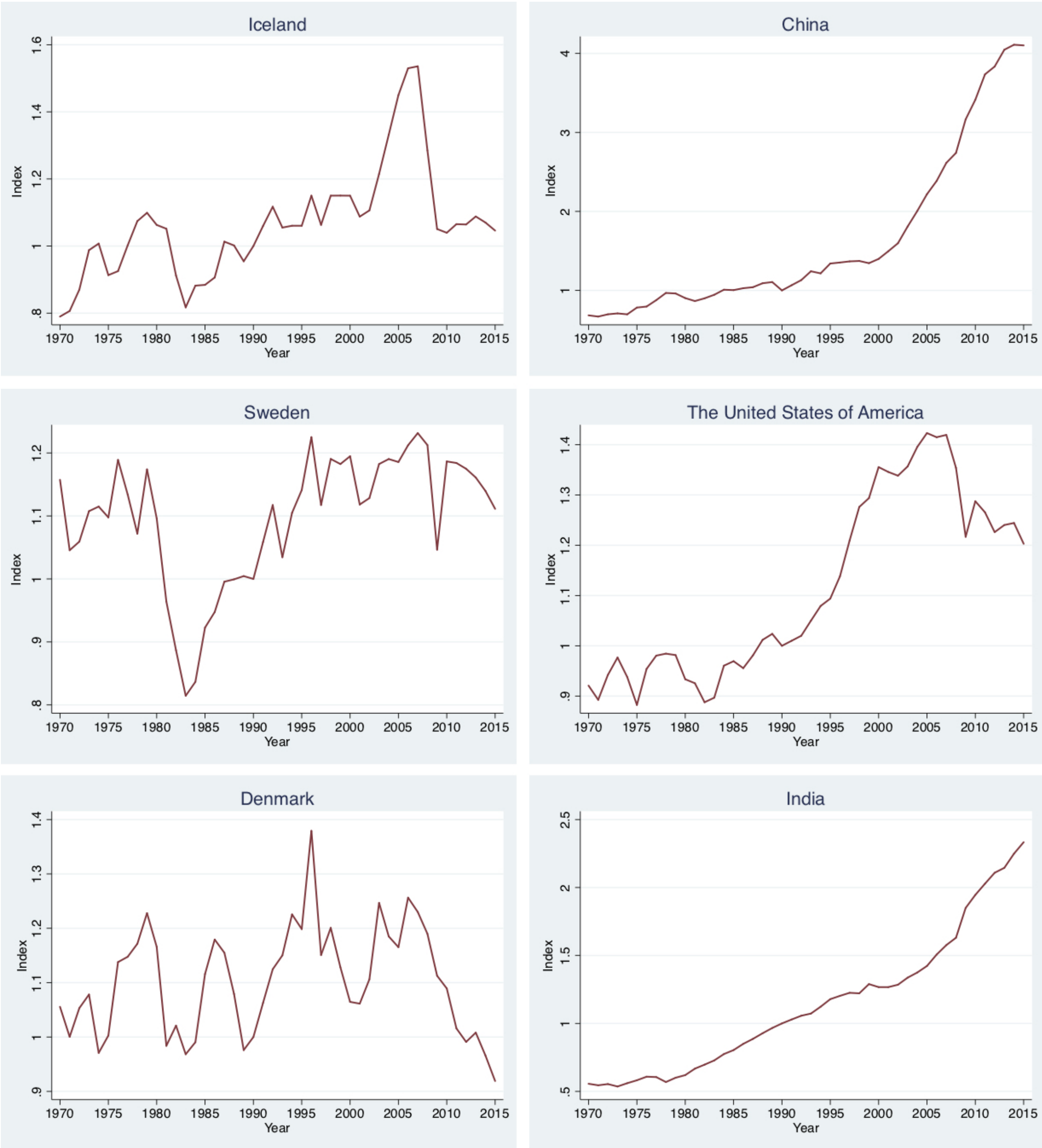

Figure 3: Consumption-based Emissions

The overall conclusions that can be drawn from looking at consumption-based (CB) emissions and comparing them to production-based (PB) emissions are the same as previous studies have shown, i.e. that developed countries are overall increasing their CB emissions while decreasing PB emissions. This means that while PB emissions are decreasing in some countries, they are increasing somewhere else, in step with the increase

Nations Statistic Division (UNSD) (Kanemoto et al., 2014).

in CB emissions, since an increase in one country's CB emissions means an increase in PB somewhere else.

In figure 3, the consumption-based emissions for the same selection of countries as above can be seen; Iceland, Sweden and Denmark on the left, and China, the United States and India on the right. The first thing to note is that India and China are the only countries of the six where CB emissions are lower than their PB. This is because many of the goods consumed in other countries are produced in China and India (Peters et al., 2012). It is somewhat surprising that the CB emissions of Iceland are not higher; Iceland is a rich country that relies on international trade and transportation for goods.

2.3 The Ratio Between Consumption- and Production-Based Emissions

As was shown in the previous section, carbon emissions can differ greatly depending on the accounting method chosen. The benefits and drawbacks of each method have been discussed. Since countries have more control over PB emissions and they are easier to calculate, they might be seen as more transparent. Using CB emissions has also been seen as more just, since they link the final consumer to the carbon emitted in the production of the goods. This means that poorer countries are not held responsible for the emissions caused by the production of goods that satisfies the demand of richer countries. The main drawback of this type of accounting is the problem of implementation. Furthermore, the benefits poorer countries gain from producing goods that emit carbon are often detrimental for the economic growth and prosperity.

Keeping these drawbacks and benefits in mind, incorporating these two accounts into one measure can provide additional information about the carbon intensity of countries. A straightforward way of doing so is calculating the ratio between the two, i.e. divide CB by PB emissions (Franzen and Mader, 2018). A closed economy would by definition have the ratio of one. Countries with the ratio higher than one, are those that produce less than they consume, with regard to carbon emissions. This can be seen as a way of showing a "carbon trade balance".

Figure 4 shows the ratio of the same six countries we discussed above. What initially surprised me it that the ratio in Iceland is much "better"[8] than in Denmark and Sweden. Sweden has had a ratio higher than two since 2012. Denmark has 1.6 and Iceland lags behind with a ratio similar to the U.S., or around 1.1. It should be pointed out that if a country is a net importer of emissions, so to speak, that does not mean that there is no good justification for importing. Importing might even result in less overall emissions than if the good was produced domestically (Jiborn et al., 2018).

[8]Better if we accept that it is more just to have a ratio close to one.

Figure 4: Carbon-Based/Production-based Ratio

Looking at these two ways of accounting and the ratio between them, the task of lowering emissions seems even more daunting. To undertake that task, it is important to understand the mechanisms behind it. The next section will concentrate on Iceland, her economy and consumption. This section gives rise to the analysis in the following section about the relationship between consumption and emissions in Iceland. This will hopefully add to our understanding of emissions and how our actions and consumption contribute to global emissions. This is helpful in looking at the plans of a carbon-neutral Iceland by 2040.

3 Iceland

Since the thesis is meant to address the decarbonisation goals of the Icelandic government, I will start by briefly discussing the Icelandic economy to put these goals in perspective.

Iceland is a tiny nation, with a population of around 360.000 (Statistics Iceland, f), on an island in the North-Atlantic Ocean. Despite the fact that it is geographically isolated, it has close ties to Europe, and has a seat on the Nordic Council. It is not part of the European Union (EU), but it is part of the European Free Trade Association (EFTA), alongside Norway, Liechtenstein and Switzerland. Iceland has its own currency, the Icelandic krona, which has historically been very volatile (Snaevarr, 1993).

In 2017, Iceland's gross domestic product (GDP) was 24,488 million dollars. Compared to the United States with 19,485,394 million dollars and Sweden's 535,607, Iceland's economy is not big. Nevertheless, Iceland ranked fifth in 2017, looking at GDP per capita, according to the World Bank (World Bank).

Since Iceland's industrialisation, fishing and fish processing has been the main industry, accounting 13.3% in 1997 and for 5.5% of total GDP in 2017[9] . An often overlooked but nonetheless substantial industry in Iceland is aluminium smelting and silicon metal production (3% of GDP in 2017), energy intensive industries which utilise the renewable energy that is abundant in Iceland in these. After the financial crash in 2008, tourism has grown immensely in Iceland, and now up to 10% of GDP can be attributed to tourist related businesses, with nearly 2 million tourists flying to Iceland in 2017 (Statistics Iceland, b,e).

According to the Central Bank of Iceland, the economic growth of the past few years is likely to continue. Table 1 shows the GDP growth and private consumption forecast for the years 2019-2024, as well as the actual numbers for 2017 and 2018. The forecast was published on May 10th 2019. Both GDP and private consumption are expected to grow by about 2.5%, which is slower than for the last two years, except this year, when we can expect a decrease in consumption (Statistics Iceland, a; The Central Bank of Iceland, 2019). The Icelandic population is also expected to grow, with population being around 406 thousand in 2040 (Statistics Iceland, g)[10].

[9]This decrease is presumably because of the relative increase in the tourist industry compared to the fishing industry.

[10]This depends on the projection, which is divided into low, medium and high, ending with the year 2067. The low forecast projects that the Icelandic population will reach a peak of around 377,142 in 2048 and then start declining. The medium projects a continuing rise until ending with 435,966 in 2067. The high projects the population reaching half a million in 2062, with a population of 513,281 in 2067 (Statistics Iceland, g).

Table 1								
	2017	2018	2019	2020	2021	2022	2023	2024
GDP	4.0	4.6	-0.2	2.6	2.7	2.6	2.6	2.5
Pr. Cons.	7.9	4.8	2.4	2.8	3.0	2.8	2.6	2.5

3.1 Icelands's Environmental Achievements and Commitments

The main attraction of Iceland is the country's nature and environment, commonly perceived as unique. One of the most common words associated with Iceland as a tourist destination is 'pure'. It's interesting to see that the pure nature of Iceland is drawing in these numbers of travellers, since tourism is one of the most carbon-intensive industries. International travel, i.e. flying between countries or travelling by ship, accounts for 3% of global emission (United Nations Environment Programme, 2018, p.3) and a return-trip for one from Iceland to Copenhagen with a commercial airline, emits a third of a ton of carbon per person, which is equivalent to driving a new car more than three times around Iceland (Carbon Footprint).

In many ways, Iceland's energy infrastructure and environmental consciousness, especially visible in a strong nature-conservative movement, reflects what other countries strive for. Because of the fact that Iceland's stationary energy, i.e. energy excluding energy used for transportation, is nearly completely renewable, with 99.5% of household energy-use being from renewable energy sources, such as hydro and geothermal power (Clarke et al., 2017, p.1175), Iceland is seen as an environmentally-friendly country. Furthermore, Icelanders pride themselves of their clean water, air and energy (Inspired by Iceland). Because of Iceland's knowledge and technological innovation in the fields of hydro and geothermal power, Iceland has been a leader in spreading the use of geothermal power (International Development Cooperation).

Thus, even though Iceland is a small nation and its emissions are only a tiny drop in the ocean of global emissions, its role in international cooperation towards a sustainable future should not be underestimated. What is more, if the global emissions are to decrease to zero, Iceland's emissions have to do so, regardless of its size. Iceland's infrastructure is indeed a perfect steppingstone towards a more sustainable future. But it is just a steppingstone; Iceland needs to take further steps, some of which will be difficult, and in doing so, show the international community that real changes can be made.

Of course, it is good to highlight what actions are positive, but I believe underscoring Iceland's shortcomings can be more informative for Iceland, as well as the global climate change movement. The reason for this is that Iceland is lucky that its main source of energy is renewable, and therefore does not have to make the fundamental changes in energy infrastructure as many other countries may need for lowering emissions. Iceland started ahead in the race against global warming, but that does not mean that is should wait for others to catch up before proceeding.

In 2018, the Icelandic government presented the first edition of their action plan for climate change. This was meant to be the first publication of many, detailing the government's plan to decrease Iceland's carbon emissions so that their goals and commitments could be met. As a signatory to the Paris Agreement, Iceland has committed to lowering territorial, or production-based, emissions of certain sectors by 30-40% by 2030 compared to 2005. Further, the government has set the ambitious goal of complete carbon-neutrality by 2040. According to the action plan, the current emphasis is on two main goals: Stop all use of fossil fuels before 2050 and improve land-use (Ministry for the Environment and Natural Resources, 2018). They detail how these goals are to be met, but for the purposes of this thesis, there is no reason to go into those details. What matters are these two goals of lowering emissions.

As has been said, Iceland uses renewable energy for heating and electricity, but its car fleet mainly uses fossil fuels. This should be changed, and it is indeed the main focus of the Icelandic government's action plan, where the focus is on moving from fossil fuels to electricity. Iceland has impressive innovation, and there is a constant effort for more sustainability in fishing and fish processing, but, as well as with the cars, the ships are driven by fossil fuels. There have been talks about utilising unused land, which is abundant in Iceland, to grow rape seeds for ship fuel, but there has still been no action (Bernodusson, 2018). That is perhaps the main shortcoming of the Icelandic actions against climate change; there are many ideas but there is little action.

In the plan, private consumption is not mentioned except in a brief discussion about the reduction of food waste. Furthermore, it is stated in the plan that, according to the Paris Agreement, "specific nations are responsible for domestic emissions but not for the carbon footprint of imports" (Ministry for the Environment and Natural Resources, 2018, p.41, translation mine). It is not clear what is meant by this. It could be seen as a political statement, stating that the government does not see any reason to push for changes in consumption. It might even be argued that this statement shows their willingness to look away from carbon leakage. It's not clear that this is the case, since this could also simply show that they are unwilling to commit to anything more than what the Paris Agreement asks for, while still acknowledging carbon leakage. Regardless of what is actually meant by this, it is quite clear that the government does not see any reason to discuss carbon leakage. While it is hard to say whether this is due to unawareness or a willingness to look the other way, the bottom line the same.

3.2 Consumption

Icelanders' consumption has steadily been rising for the last century, as can be seen from figure 5, which shows total private consumption at constant prices from 1970-2018. A noticeable peak with a following trough can be seen in 2007 and 2008, the final years of the boom Icelanders colloquially call the "good years"[11]. We can see that in 2018, consumption is at its highest and according to the projections of the Central Bank of Iceland (Statistics Iceland, a), we can expect it to continue rising in the next few years, accompanying the continuing growth of the Icelandic economy.

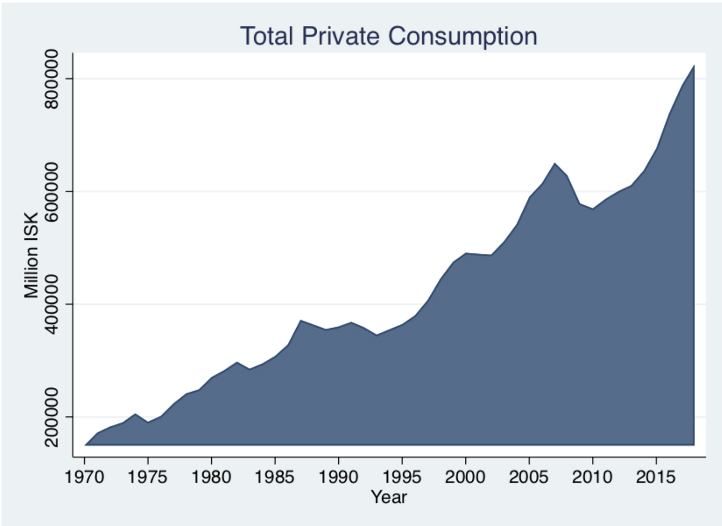

Figure 5: Total Private Consumption

Figure 6 shows the components of private household consumption in four different years (Statistics Iceland, d,c). Consumption is divided into ten components: (1) Food, beverages and tobacco; (2) clothing and footwear; (3) gross rent, fuel and power; (4) furniture, household equipment etc.; (5) medical care and health expenses; (6) transport and communication; (7) education; (8) recreation and culture; (9) restaurants and hotels; (10) miscellaneous goods and services.

A noticeable change from 1970 to 2015 is that the share of food, beverages and tobacco (1) and housing and power (3) has decreased significantly, from 24.5% in 1970 to 16.6% in 2015, and 26.7% to 19.4% respectively. Although the main explanation for this change are lower relative prices of these goods, part of it can also be explained by different consumption behaviour. The share of restaurants and hotels has more than doubled, which suggests that people dine out more frequently than they did before. In 1970 there were only a handful of restaurants in Iceland, but now there are over 500 registered in the online phonebook (Ja).

One of the most surprising changes is in the share clothing and footwear is of the total consumption. In 1970 clothing and footwear made up 6.0% of the total consumption, but

[11]It is common to refer to the "good years" as a period of excessive consumption. Further, people sometimes refer to buying things in the spirit of the "good years", referring to their consumption being perhaps beyond their means, since a good portion of goods, such as cars and TV's, was financed by loans during the boom.

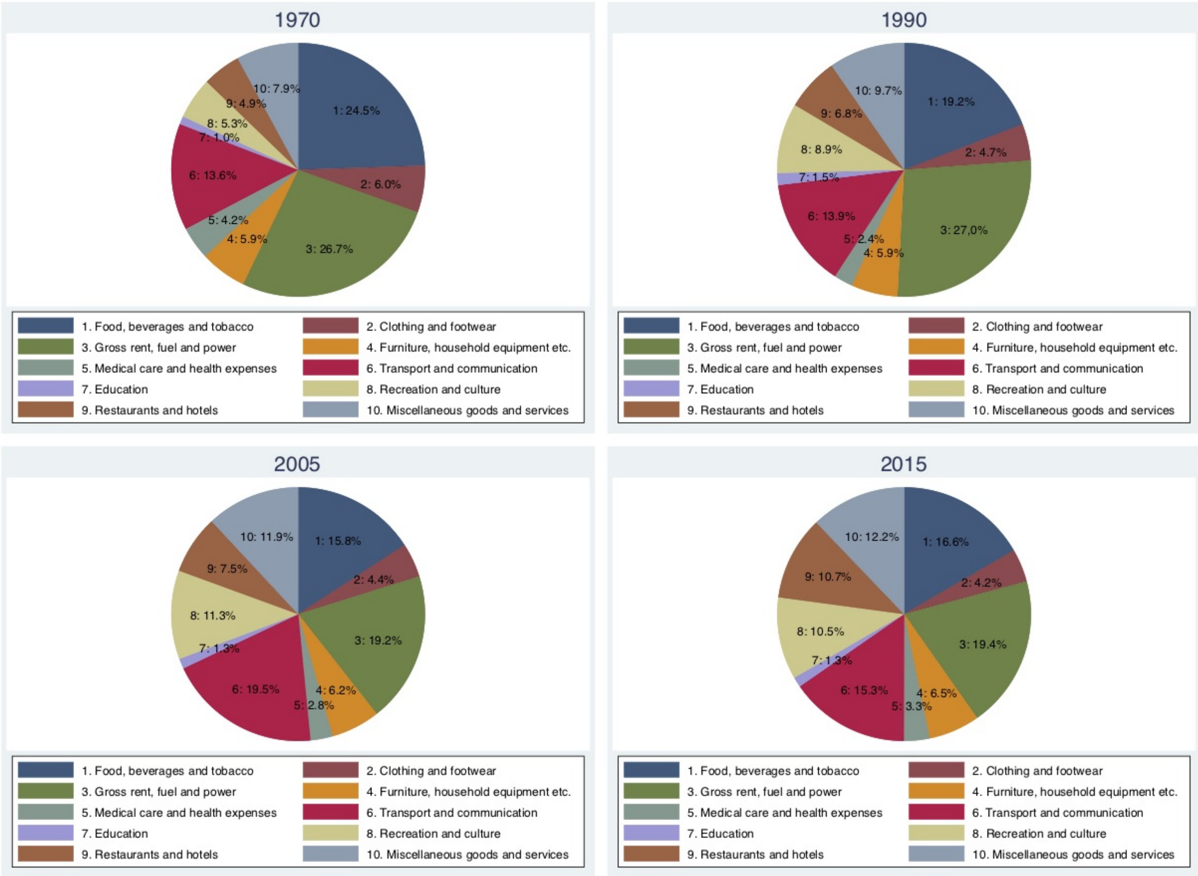

Figure 6: Components of Consumption

in 2015 it is only 4.2%. Since the pie charts only show the share of each component, it does not tell us anything about the amount being consumed. As can be seen in figure 6, total consumption was significantly more in 2015 than in 1970. As with food and beverages, it is not unreasonable to assume that the prices have lowered. Further supporting that claim is the amount of clothing Icelanders purchase each year. On average, each Icelander discards or recycles 15 kilograms of clothing and footwear a year (Ministry for the Environment and Natural Resources, 2019), suggesting that the purchases are substantial.

It is clear that majority of goods consumed by private households are not produced in Iceland but imported. The reasonable suspicion then arises, that carbon embodied in imports is substantial. In a study from 2017, Icelandic household consumption-based carbon footprint for 2010-2012 was calculated using the Eora database (Clarke et al., 2017). The authors find that household consumption causes 46% of the total CB emissions. Thereof, transportation comprises the biggest share, or 38%, with fuel and gas being 10%. Emissions caused by food and beverages are 20% and restaurants 3%. Emissions from clothing amount to 4%.

Compared to their share in the total consumption, transportation is by far the most carbon-intensive, since it amounted for around 15% of consumption, but 38% of emissions. Food and beverages also had a greater share in emissions than in consumption. Interestingly, spending money in restaurants causes less emissions than spending the same amount on food elsewhere. Clothes and other goods comprised a similar portion of emissions and total consumption. The least carbon-intensive sectors of consumption, according to the study, are shelter and services, including education, health care, culture and recreation. Knowing this could be important, if decarbonisation goals are to be met.

4 Consumption and Emissions

Now is the time to restate the research question of this thesis: Can carbon-neutrality be reached in Iceland if we take into account consumption-based emissions, rather than the conventional production-based emissions? In order to answer this question, the relationship between consumption and emissions has to be examined. As was pointed out above, some have attempted to find a causal relationship between carbon emissions and different economic factors, with mixed results. In doing an analysis of this kind, people want to confirm the hypothesis that carbon emissions do not lead economic growth, or, put another way, that lowered emissions do not necessarily result in lower economic growth. In this section I will attempt to answer the following question: Can a Granger-causal relationship be found between private consumption and consumption-based emissions?[12] An answer to this question helps us answer the broader question of whether consumption can keep growing while emissions decrease.

4.1 Methodology

The most common way to examine the relationship of this kind is using vector autoregression (VAR) models. VAR-models are helpful in trying to understand the dynamics of economic factors, since one does not have to presuppose the structure of the relationship of the variables. Furthermore, tests can be used to examine the directions, so to speak, of these relationships, i.e. whether x leads to y or vice versa (Verbeek, 2017, p.285-360; Enders, 2015, p.360-364). The following structure of VAR-models is used here:

$$\begin{bmatrix} E_t \\ C_t \end{bmatrix} = \begin{bmatrix} \alpha_{10} \\ \alpha_{20} \end{bmatrix} + \begin{bmatrix} \beta_{11} & \gamma_{11} \\ \beta_{21} & \gamma_{21} \end{bmatrix} \begin{bmatrix} E_{t-1} \\ C_{t-1} \end{bmatrix} + ... + \begin{bmatrix} \beta_{1p} & \gamma_{1p} \\ \beta_{2p} & \gamma_{2p} \end{bmatrix} \begin{bmatrix} E_{t-p} \\ C_{t-p} \end{bmatrix} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{bmatrix}$$

Written as two equations:

$$E_t = \alpha_{10} + \beta_{11}E_{t-1} + ... + \beta_{1p}E_{t-p} + \gamma_{11}C_{t-1} + ... + \gamma_{1p}C_{t-p} + \varepsilon_{1t}$$

$$C_t = \alpha_{20} + \beta_{21}E_{t-1} + ... + \beta_{2p}E_{t-p} + \gamma_{21}C_{t-1} + ... + \gamma_{2p}C_{t-p} + \varepsilon_{2t}$$

Where E_t and C_t stand for consumption and emissions at time t, α, β and γ are the coefficients and ε is the error term.

[12] It does sound tautological to ask whether there is a relationship between private consumption and consumption-based emissions, but it is not. Private consumption refers to consumption of private households, while consumption-based emissions refer to emissions connected to all consumption, public, private and of firms.

The most common way of examining this relationship is testing for Granger causality in VAR-models. Variable x is said to Granger cause y and not the other way around, if x and its lags enter into the equation of y, but y and its lags do not enter into the equation of x (Verbeek, 2017, p.305-306; Enders, 2015, p.363). In other words, using x when forecasting y adds information and makes the forecast more accurate. Granger causality is not the same as simple causality, since it does not say anything more than how well variables are in predicting the future, nor does it say anything about the possibility of a real causal relationship between the two. Nevertheless, Granger causality can suggest that some kind of causal relationship exists.

In a two-equation model, such as the ones used here, with p lags, emissions are said to not Granger cause consumption if and only if all of the coefficients β_{21}, β_{22} etc., are equal to zero. The interpretation would be that lowering emissions does not necessarily lead to lowering consumption. Conversely, if some of the coefficients are non-zero, then emissions are said to Granger cause consumption. This relationship can be univariate or bivariate (and if we include more variables, then multivariate), depending on whether this Granger causality goes both ways or not.

A common problem econometricians encounter when working with VAR-models is the possibility of integration or cointegration of different orders. For those that are not interested in the existence of unit-roots or cointegration, this is a nuisance that is best avoided, if possible. In 1995, Toda and Yamamoto presented a method for those looking to avoid this problem and are interested in testing economic hypotheses with restriction on coefficients, as I am. Therefore, I follow the method they propose.

Firstly, the maximal order of integration, d_{max}, is determined. Secondly, the lag length, k, is determined. After that the VAR-model is intentionally over-fit with additional lags, $p = k + d_{max}$. This allows us to focus on testing for general restrictions, which is the case with Granger causality, without having to worry about whether the true underlying model is integrated or cointegrated and to what degree (Toda and Yamamoto, 1995, p.227). But, since we know the model is over-fit, the coefficients higher than k can be disregarded, and should not be included when testing for linear restrictions, as is the case in testing for Granger causality (Toda and Yamamoto, 1995, p.227).

Granger causality was tested between the different components of private consumption and carbon emissions. 33 possible relationships were examined between eleven different components of consumption, total consumption and the ten components of consumption discussed above[13], and three types of emissions, production-based, consumption-based and the difference between the two, i.e. the carbon trade balance.

[13](1) Food, beverages and tobacco; (2) clothing and footwear; (3) gross rent, fuel and power; (4) furniture, household equipment etc.; (5) medical care and health expenses; (6) transport and communication; (7) education; (8) recreation and culture; (9) restaurants and hotels; (10) miscellaneous goods and services.

The reasoning for including the carbon emissions trade balance is the following: The hope is that Iceland will meet its goals of lowering emissions towards a carbon-neutral economy in 2040. This would mean that PB-emissions are zero in 2040. For the purposes of this thesis, I will assume that this will hold. Nevertheless, it does not follow that CB emissions will be zero. This means that the trade-balance is likely to be positive, even though PB emissions are none. This is why seeing the relationship between the trade-balance and consumption can give some insight into what remains if Iceland's commitments to the Paris Agreement are upheld.

4.2 Results

To clarify, the question asked is whether consumption Granger causes emissions or vice versa. If a unidirectional Granger causality is found running from consumption to emissions, but not the other way around, that suggests that we can decouple emissions from consumption. If, on the other hand, Granger causality is found to run from emissions to consumption, that suggests that in order to lower emissions, consumption needs to be decreased. Understanding how these relationships work is crucial for finding ways to lower emissions.

An overview of the results can be seen in Appendix A.

4.2.1 Production-based Emissions and Consumption

When looking at the Granger causal relationship between consumption and emissions, the results are overall similar to what many other studies have shown when looking at emissions and GDP or energy consumption (e.g. Zhang and Cheng, 2009). When looking at the total private consumption and PB emissions, an unidirectional Granger causality can be seen, running from consumption to emissions, where increased consumption results in increased emissions. This is also the case for six out of ten components of consumption, when the test is done on each component separately. The effect was positive except in the case for medical care and health expenses (5), were it was slightly negative[14], i.e. increase in most components of consumption results in higher emissions. What this tells us is that there is reason to believe that a big part of the consumption of Icelandic private households can be decoupled from PB emissions. Gross rent, fuel and energy (3) and education (7) seem to have no Granger causal connection to PB emissions. Furniture, household equipment and related goods (4) are shown to unidirectionally Granger cause emissions, while clothing and footwear (2) have a bidirectional Granger causal relationship with emissions.

[14] I do not have an explanation for why that is. It seems that a decrease in health expenses results in higher emissions.

4.2.2 Consumption-based Emissions and Consumption

The same kind of Granger causality was tested between consumption, and its components, and consumption-based emissions. Contrary to the results above, unidirectional Granger causality can be seen running from CB emissions to total consumption. This is also the case for three components of consumption; food, beverages and tobacco (1), clothing and footwear (2), and miscellaneous goods and services (10), while there is a bidirectional Granger causality between restaurants and hotels (9) and CB emissions. A unidirectional Granger causality can be seen running from recreation and culture (8) to CB emissions. All effects were shown to be positive, except for medical care and health expenses (5) and restaurants and hotels (9). No Granger causality can be seen between four components of consumption; gross rent, fuel and energy (3), furniture, household equipment and related goods (4), transport and communication (6) and education (7).

These results suggest that the decoupling that might be possible in the case of PB emissions is unlikely to happen in the case of CB emissions. This is because the emissions of previous years can better help explain an increase in consumption, but not the other way around. That is to say, lowering emissions would, according to this, lead to lower consumption.

4.2.3 The Carbon Trade Balance and Consumption

Lastly, Granger causality was tested between the carbon trade balance (CTB) and consumption, as well as its components. Unidirectional Granger causality was found to run from emissions to total consumption, similar to CB and total consumption. This same relation can be seen between CTB and food, beverages and tobacco (1), clothing and footwear (2), recreation and culture (8), restaurants and hotels (9) and miscellaneous goods and services (10). Where Granger causality was detected, the relation was never solely running from consumption to emissions, but a bidirectional relationship can be seen between CTB and furniture, household equipment and related goods (4). This last relationship was the only one that showed a negative effect, i.e an increase in consumption of these goods cause a decrease in TB.

These results suggest that overall, an increase in consumption causes an increase in the CTB. This points to there being carbon leakage, i.e. the increase in Icelandic consumption gives rise to an increase in emissions somewhere else. If this is the case, this further suggests that decreasing or changing consumption is important in lowering global emissions.

5 Implications for Iceland's Commitments

In the previous chapter, Granger causality was examined between different components of consumption and emissions. The interesting result is that the direction of the relationships was not the same for production-based emissions and for consumption-based emissions. If these results are confirmed by further examination, this could undermine the plausibility of current global climate change mitigation. The Paris Agreement calls for individual countries to lower their emissions, where "emissions" refer to PB emissions. But if the efforts do not result in the same global decrease in emissions, their effect is not as intended and global emissions, the emissions that need to be lowered, will not decrease at the rate needed. Of course, here the sole focus was on Iceland, and we cannot deduce anything substantial concerning other countries from an example of only one country.

What the results show is that unidirectional Granger causality can be seen running from consumption to PB emissions. This suggests that the two could be decoupled. In other words, consumption leads emissions, not the other way around. This means that less consumption leads to less emissions, but less emissions do not necessarily lead to less consumption. This is good news for Icelandic households, who do not inevitably need to decrease consumption so that the Icelandic goal of carbon-neutrality can be reached by 2040. Of course, changes have to be made, but sacrificing consumption would not be necessary.

Nevertheless, PB emissions are shown to Granger cause two components of consumption, namely clothing and footwear, and furniture and household equipment. This suggests that consumption of these goods has to decrease for Iceland to reach their emissions goals. This means that with changes in consumption behaviour, from more carbon-intensive to less carbon-intensive, the goals could theoretically be met and the cord between consumption and emissions cut, without needing to decrease consumption.

On the other hand, the results from the Granger causality analysis were not as positive concerning the possibility of lowering consumption-based emissions without decreasing consumption. The Granger causality was seen to run in the opposite direction, i.e. CB emissions lead consumption. This means that lowering emissions will likely lead to less consumption. The economic implications are much greater than of lowering PB emissions.

It's not clear why the Granger causality runs in opposite directions depending on whether it is production- or consumption-based. With regards to PB, theoretically it has been shown that GDP causes energy consumption, that in turn Granger causes emissions (Kolstad and Krautkraemer, 1993). Another route is obviously the case for CB emissions, although more analysis is needed to find out what it is.

5.1 Scenarios

In what follows I will roughly draw up four scenarios of Iceland's emissions until 2040. This is to examine what the consumption-based emissions might be expected to be in the next two decades. In light of the results of the Granger causality, this is interesting, since it seems impossible for Iceland to decrease CB emissions while increasing consumption. To reiterate a point made before: If we accept that globally we should aim at carbon-neutrality, then it is detrimental to understand all emissions caused by consumption, not only the territorial emissions. The commitments to the Paris Agreement only refer to PB emissions. This means that reaching the goals set to uphold these commitments does not automatically mean a decrease in global emissions, since emissions abroad, caused by Iceland, could possibly increase instead. Therefore, it is interesting and important to speculate about the evolution of CB emissions, given the planned decrease in PB emissions. The following scenarios are an attempt to shed light on the possible ways total emissions could increase or decrease, depending on how careful we are.

For the purpose of these scenarios I will assume that the goals of the Icelandic government will be met, disregarding any scepticism (however plausible) about the likelihood of the plans succeeding. I will assume that PB emissions will have decreased by 40% in 2030, compared to emissions in 2005, and that they will be zero in 2040[15]. The difference in the scenarios lies in how CB emissions will evolve.

The first scenario is where the evolution of CB emissions will be the same as PB emissions, that is to say, emissions in 2030 will be 60% of emissions in 2005 and carbon-neutrality will be reached in 2040. The second scenario assumes the same growth rate of the CB/PB ratio as can be seen in Denmark and Sweden. The third and fourth scenarios take into account the increase in consumption projected by the Central Bank of Iceland. The third assumes that any decrease in PB emissions will be offset by an increase in CB emissions as well as an increase because of increased consumption. This is the worst-case scenario. The fourth assumes that emissions abroad will increase, but not be completely offset the PB emissions, i.e. the difference between CB and PB emissions will increase in relation to the projected increase in consumption.

The scenarios are calculated from 2016 onward, since the data on emissions only cover the years up to 2015. Therefore, I pretend as if we stand in the year 2015, not 2019. This makes the projections inaccurate, as the PB emissions have in fact increased from 2015-2018, while I assume that they decrease according to the plan set by the government. This means that the real decrease of emissions that is necessary has to be faster than these

[15] It should be added that it's not completely clear what the carbon-neutrality goal refers to. Does it only refer to specific sectors in Iceland or does it concern the complete PB emissions? I will assume here it refers to the complete PB emissions, since that makes calculating the scenarios significantly easier. The overall conclusion should be the same if the goal only refers to part of the emissions, since that would simply mean that the target is not zero, but above zero.

scenarios show. This raises questions about the plausibility of the government's goals, but I will not address them here. The inaccuracy should not pose any real threats, since these scenarios are to illustrate a point, rather than to make an accurate forecast of what will happen in the next few years, depending on the path consumption and outsourcing takes.

5.1.1 Scenarios 1 and 2: Carbon-Neutrality

Figure 7 shows the first scenario. This would be the case if CB emissions would lower at the same rate as PB emissions. In 2030 emissions would be 60% of the emissions in 2005 and zero emissions would be reached in 2040. The decrease is calculated as being linear, i.e. emissions decrease by the same amount from 2015-2030, and similarly a set amount from 2030-2040, reaching the two goals set by the government. One can easily imagine this decrease being of a non-linear form, for example, gradually decreasing more and more, but since the period is so short, the change would only be slight.

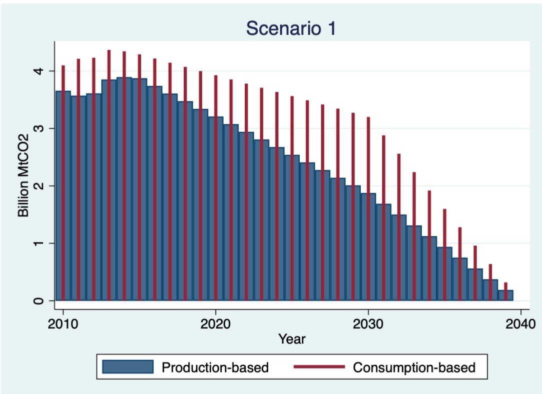

Figure 7: First Scenario

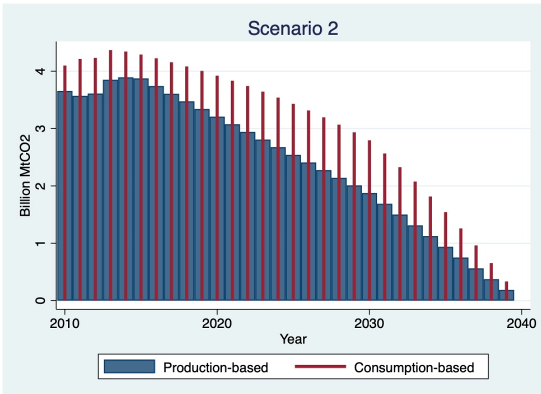

Figure 8: Second Scenario

Figure 8 shows the second scenario. This scenario shows a smoother decrease of CB emissions. This scenario is based on a plausible evolution of the ratio between CB and PB emissions, namely similar to the evolution of the ratio in Denmark and Sweden. In both Denmark and Sweden, PB emissions have significantly decreased over the last few decades while CB emissions have not decreased to the same degree (see chapter 2). The ratio between the two has steadily been increasing, as figure 4 in section 2.3 shows. The average growth rate of the ratio in both countries has been approximately 2% since 1990.

Using this growth rate, the future ratio between CB and PB is calculated for Iceland from 2015. Since the evolution of PB is taken as given, the CB are easily calculated based on these two values. If this were the case, a 40% decrease compared to 2005 would be reached in 2027, three years earlier than in the previous scenario and, by construction, carbon neutrality would be reached in 2040.

These two scenarios can be seen as environmentally ideal, since it would result in complete carbon-neutrality in 2040. But they would have less positive effect on Icelandic households, and their consumption, and in turn the overall economy. According to the analysis in the previous chapter, a decrease in PB emissions could theoretically be decoupled from household consumption. In other words, Iceland could reach its decarbonisation goals without decreasing consumption. This was not the case with CB emissions, since they were found to have the opposite relationship with consumption, i.e. a decrease in emissions would lead to a decrease in consumption. This shows the problem with these two scenarios. They would lead to, or rather call for, a decrease in consumption. This means that these scenarios that are environmentally feasible are not economically optimal and would call for actions now that might either slow Iceland's economic growth substantially or simply cause a contraction in the economy.

5.1.2 Scenario 3: Mindless Increase

The third scenario, which can be seen in figure 9, is the worst-case scenario. It shows what would happen if emissions would increase in step with consumption, and that all emissions would simply move abroad, so that any decrease in PB emissions would be offset by an increase in CB emissions. This might happen if by avoiding one source of emissions, we would move consumption and production to another source of emissions. This is not a likely scenario, but it is included so that it can be seen that decreases in PB emissions do not mean better overall emissions.

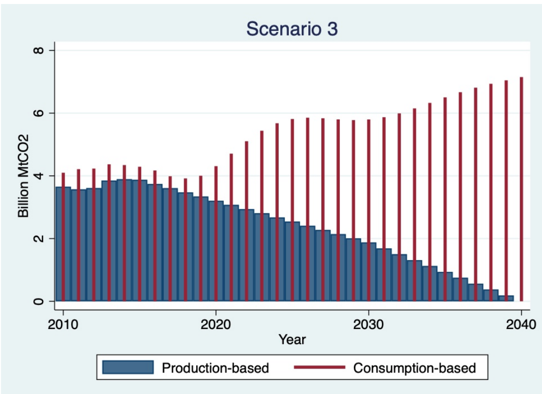

Figure 9: Third Scenario

As before, the PB emissions decrease linearly according to the government's goals. In computing the CB for this scenario, the results of the VAR-model used in the Granger-analysis above are used. The following equation was evaluated:

$$CB_t = \alpha_{10} + \beta_{11}CB_{t-1} + \beta_{12}CB_{t-2} + \beta_{13}CB_{t-3} + \gamma_{11}TotalConsumption_{t-1} + \gamma_{12}TotalConsumption_{t-2} + \gamma_{13}TotalConsumption_{t-3} + \varepsilon_{1t}$$

and estimates for α, β and γ are used to project the future CB emissions. Furthermore, the forecast of the Central Bank is used as a base for the future rise in consumption, after 2024, a flat 2,5% growth rate is presumed. As with the other scenarios, this is not a perfect forecast, but can still be helpful when thinking about future emissions.

This scenario would seem to spell disaster for the environment, while allowing for unhindered increase in consumption[16]. Since this scenario does not assume any constraint to consumption, CB emissions will increase, according to the Granger analysis above. This scenario is implausible, since it assumes that an increase in consumption will necessarily increase emissions proportionally, disregarding any decarbonisation that has or will likely happen.

Despite the implausibility of this scenario it serves the purpose of depicting what might happen if we mindlessly increase consumption and, instead of decarbonising industries, shift all carbon-intensive production abroad.

5.1.3 Scenario 4: Mindful Increase

In many ways this fourth scenario (figure 10) is the most plausible scenario of the four scenarios, given that the ambitious goals of carbon-neutrality in 2040 are reached. It shows the CB emissions that result both from an increase in consumption but also a decrease in PB emissions. Increasing consumption would call for some increase in carbon. The decrease in PB emissions would push CB emissions down (since PB emissions are included in CB emissions). This would cause the ratio between the two to rise significantly (see figure 11).

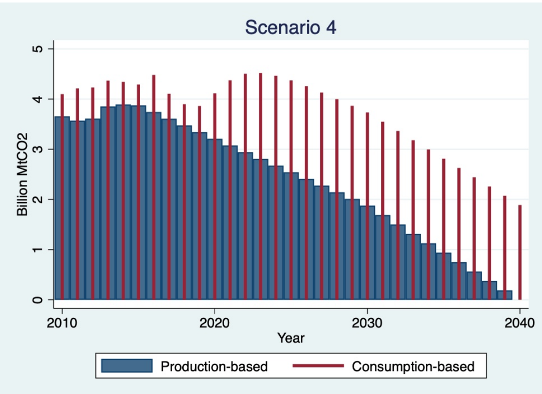

Figure 10: Fourth Scenario

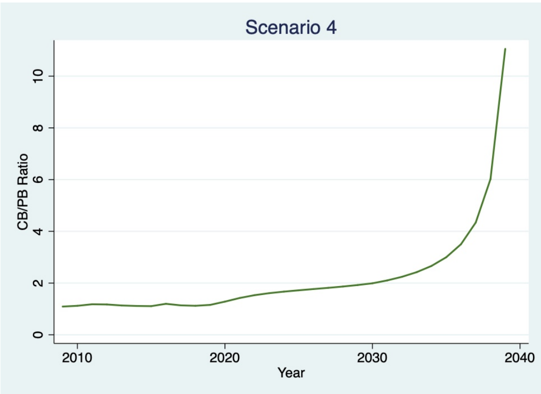

Figure 11: CB/PB Ratio

Here, I use the results of the VAR-model where the relationship between the difference between CB and PB emissions, the carbon trade balance, and total private consumption is examined. The model is the same as before, except CB is replaced by CTB. As before, the coefficients are used to make a projection of future emissions and a growth rate of 2,5% is used following the projections of the Central Bank.

[16]This would be good for the economy in the short run. What this would mean for the economy in the long run is not as clear.

5.2 Implications

What do these different scenarios tell us about Iceland's future emissions? While they do not tell us anything substantial, they do suggest that if we do not take consumption-based emissions into account, meeting the goals of the Paris Agreement will not necessarily have the positive effect it is supposed to. According to the analysis above, a decrease in PB emissions is possible, without any decrease in private consumption, but this is unlikely to lead to the same decrease in CB emissions.

If Iceland is committed to decarbonise on more than a local scale, an effort must be made to decrease consumption. This is not politically or economically feasible, since this would call for a public effort to decrease consumption of carbon-intensive goods, which is in contradiction to the conventional way of governing in the West. Regardless, the implications of accounting for the carbon embodied in imports is detrimental for any effort in lowering global carbon emissions to be effective. This is a step towards better understanding of how our behaviour and consumption affects global emissions.

If a very stringent consumption diet, so to speak, would be pushed for, the first or second scenario might well happen. The overall economic effects of such a diet are not clear, but they are unlikely to be positive in the short run. Lowered consumption could have devastating effects on the Icelandic economy in the short run and its long-run benefits would only materialise if the whole global community would take the same steps as Iceland. On a global scale, Iceland's share of total emissions is so tiny that pushing for this change would not be economically feasible unless there was some guarantee that other countries would follow. Iceland could pave the way for other nations and show what is possible but could also be left worse off if no other country acted. This is the fundamental dilemma of all climate change policies and mitigations.

What the analysis shows is that not all consumption has the same effect on emissions and other studies have shown that the carbon-intensity of different components of consumption can differ substantially (Clarke et al., 2017). This means that if the government wants to tread a more modest path, decreasing emissions while not pushing for a complete transformation of consumption habits, emphasising a shift in consumption from more to less carbon-intensive sectors of consumption, such as to services rather than goods, could make a great deal of difference.

Conclusion

The aim of this thesis was to examine the relationship between private consumption and carbon emissions in Iceland and, in light of that, examine Iceland's goal of a carbon-neutral economy by 2040. The aforementioned relationship was examined using two different ways of accounting for emissions; production-based and consumption-based. Granger causality was found to run from consumption to PB emissions. This confirms the hope that consumption does not necessarily need to decrease in order for Iceland to decarbonise completely, although some consumption may need to shift from more to less carbon-intensive sectors. A maybe less welcome relationship was found to be between CB emissions and consumption. Overall, CB emissions were found to lead consumption, which suggests that lowering CB emissions might prove difficult without a decrease in private consumption.

Using this information, four scenarios were presented to illustrate possible paths of CB emissions, given that PB emissions would decrease according to Iceland's goals. If complete carbon neutrality, i.e. with regard to both CB and PB emissions, is to be reached, a considerable decrease in consumption has to be pushed for, which is in contradiction with the projections of the Central Bank of Iceland and plans of the government. On the other hand, if an increase in consumption is to be allowed, we can expect the carbon trade balance to increase. It is hard to say what effects this would have globally, other than if this were the case everywhere, the decrease in emissions the Paris Agreement calls for will not be reached as fast as is hoped.

These results should not be taken as more than a suggestion of what might happen, and further analysis would be needed for any proper policy recommendations. What this analysis does show, is that understanding the effects of private consumption on emissions is detrimental if our goals to combat climate change are to succeed.

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Appendix A

Granger Causality: Consumption and Production-based Emissions

Consumption	Emiss. to cons.	Cons. to emiss.
Total	No	Yes (0.037)
Food	No	Yes (0.022)
Cloth	Yes (0.007)	Yes (0.032)
House	No	No
Furn	Yes (0.005)	No
Health	No	Yes (0.003)
Transp	No	Yes (0.041)
Edu	No	No
Cult	No	Yes (0.019)
Rest	No	Yes (0.001)
Misc	No	Yes (0.035)

Where, Food: food, beverages and tobacco; Cloth: clothing and footwear; House: gross rent, fuel and power; Furn: furniture, household equipment etc.; Health: medical care and health expenses; Transp: transport and communication; Edu: education; Cult: recreation and culture; Rest: restaurants and hotels and Misc: miscellaneous goods and services.

Granger Causality: Consumption and Consumption-Based Emissions

Consumption	Emiss. to cons.	Cons. to emiss.
Total	Yes (0.039)	No
Food	Yes (0.001)	No
Cloth	Yes (0.000)	No
House	No	No
Furn	No	No
Health	No	Yes (0.037)
Transp	No	No
Edu	No	No
Cult	No	Yes (0.012)
Rest	Yes (0.017)	Yes (0.029)
Misc	Yes (0.000)	No

Granger Causality: Consumption and the Difference between PB and CB emissions

Consumption	Emiss. to cons.	Cons. to emiss.
Total	Yes (0.004)	No
Food	Yes (0.000)	No
Cloth	Yes (0.003)	No
House	No	No
Furn	Yes (0.007)	Yes (0.014)
Health	No	No
Transp	No	No
Edu	No	No
Cult	Yes (0.020)	No
Rest	Yes (0.013)	No
Misc	Yes (0.006)	No