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Economics School of Namur - ESN

CO₂ emissions accounting: two sides of the same coin

Author : François Orban

Thesis Director : Bertrand Hamaide

Thesis Reader : Jean-Marie Baland

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Foreword

This thesis is the result of the most important work of my academic cursus for obtaining my Master's degree in Economics at the Economics School of Louvain, after completing my Bachelor at Université Saint-Louis in Brussels.

I have always been particularly interested in the field of environmental economics since I followed the course of that same name in my 3rd year of Bachelor at the Université Saint-Louis with, as professor, Prof. Bertrand Hamaide.

When searching for my thesis subject, it was only natural that I decided to turn to this field of economics. Who could better assist me in my redaction than the person that gave me a taste of that branch of economics?

When I started the project, I had a basic knowledge of all ins and outs of the battle against global warming. I have learned a lot about the subject and ultimately desire to work in that precise field later on in my life.

It was obvious for me to ask Prof. Hamaide to support me throughout the redaction of this thesis. I am very grateful to him for helping me on a day-to-day basis, with his high level of expertise, his availability and his dedication in the thesis that you are about to read. We spent hours discussing about choosing the right subject, the modifications that had to be made, what I wanted to dig further, ... He was also there when I needed a motivation boost, or advices concerning other fields than the one of this thesis. I would like to profusely and sincerely thank him for that. He will always be an example to me.

I would also like to thank Dennis Fenton, who has helped me a lot with written quality in English. Moreover, his knowledge in the field have also helped me a lot, to have a different opinion from someone who is expert in a similar field of economics.

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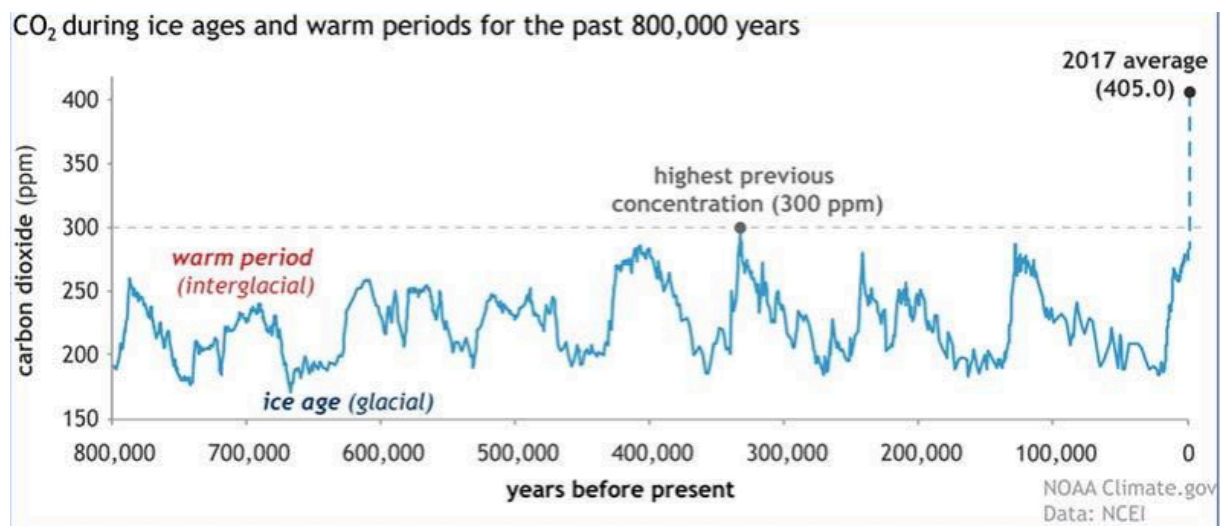
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1. Introduction

Since the existence of human beings on earth, CO₂ levels have varied between 150 ppm (parts per million – the number of CO₂ molecules per million molecules of dry air) and 300ppm. They remained unchanged for hundreds of millennia. It allowed man to evolve and become a successful species.

Recently, as we see on the time scale in Figure 1.1, there has been a boom in CO₂ levels that is almost instantaneous. In 2017, the average was 405ppm. This change occurred within a century. The planet's atmosphere has changed rapidly, and our GHG emissions are the cause.

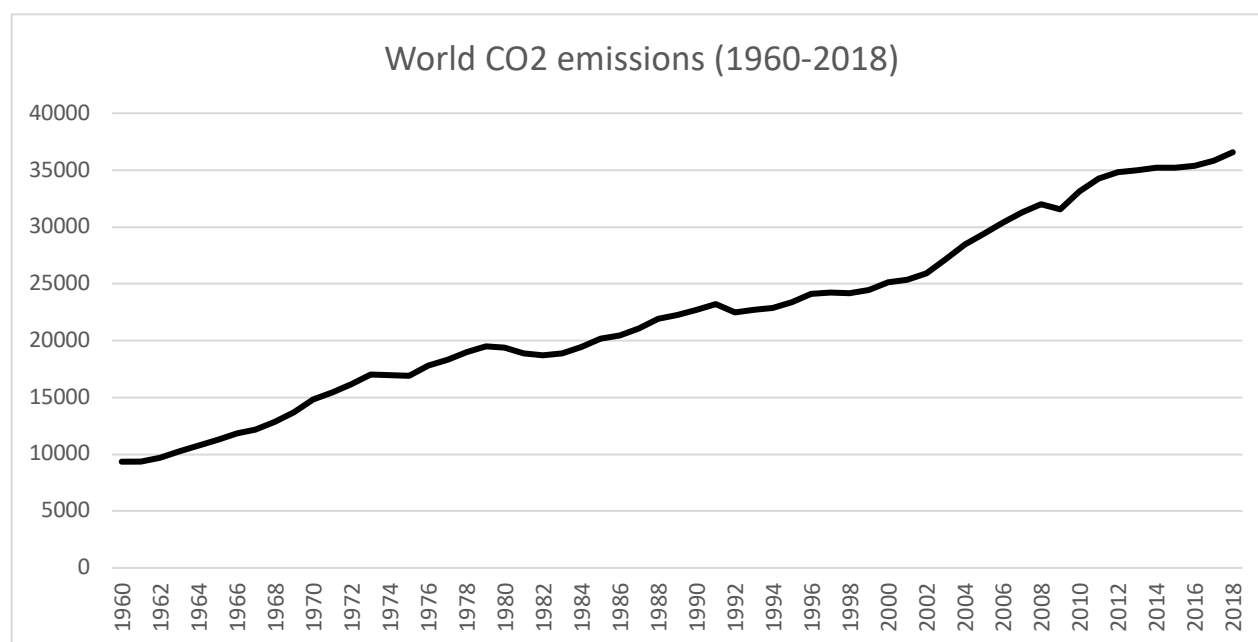
Figure 1.1



These new levels of concentration are way above the historical averages. These carbon concentrations have risen mostly due to the burning of fossil fuels that emits carbon dioxide into our atmosphere in order to produce energy. This questions our relation to atmospheric pollution and carbon dioxide in particular, compared to our ancestors.

Over a smaller time period, we see on Figure 1.2 that for the last 60 years, CO₂ releases in the atmosphere have not stopped growing. Over this period, world emissions have grown by 391%! If that trend was to continue for the next 60 years, it would be an ecological disaster that would endanger not only animal species but also, and most importantly, human beings.

Figure 1.2



Source : GlobalAtlasProject Data: UNFCCC

This evolution, as shown graphically, does not look favorable. Despite the different measures put in to place at the global level, the amount of CO₂ emissions does not seem to slow down.

Pollution and economic activity are closely related in the literature and many theories arise from that relation. The main ones will be looked at in the second chapter of the thesis. All theories require data, and all policies should be based on measurement. Measuring GHG emissions at the national level – national accounting – is a major challenge. The third chapter is dedicated to the explanation and study of the two most widespread way of accounting of CO₂ emissions : production-based and consumption-based methods. The fourth chapter will be devoted to an analysis of Belgium following the two above-mentioned accounting methods. It will see what implications the different methods may have for Belgium, for Belgians, and for the implementation of the global treaties. Chapter 4 then provides a comparison between Belgium and a similar sized non-OECD member country, (Albania).

Throughout this thesis, I hope that the reader will be able to understand the importance of the fight towards the reduction of carbon emissions, with an insight of some of the main economic theories, analyses of the recent policies and their results, a detailed analysis of each

of the accounting methods and well as a more precise analysis of the situation in Belgium over the last 30 years, with comparison to Albania.

One of the reasons why Belgium is particularly concerned with global warming is that it is a small country with access to sea. One of the results of climate change is the global sea level rise, due to the melting of the ice caps, glaciers and the warming of the water in the oceans which makes its volume expand. In 2012, NOAA experts (National Oceanic and Atmospheric Administration) suggested a worst-case scenario for global sea level rise (in the US) of 2 meters by 2100. In 2017, it was even revised to 2.5 meters (still in an extreme case scenario). This is not good news for Belgium's coastal area or economy (NOAA, 2017).

The key aim of this thesis is to show that the conclusions we draw from environmental policies strongly depend on the way we get to these figures, mainly the accounting method and the units used for calculation. I will try to draw conclusions over which is, in my opinion, the best accounting method for environmental matters, and what could be done in the future for a fairer climate policy worldwide, that allows poorer countries to continue their development and that commits the developed countries to reduce their impact on global warming.

Before going any further, let us emphasize the two following important points:

Greenhouse gas (GHG) is defined as “one of several gases, especially carbon dioxide, that prevent heat from the earth escaping into space, causing the greenhouse effect” (Cambridge, 2020). This effect is the main driver of climate change and global warming. The best-known gas of the GHGs is carbon dioxide (CO₂). This gas is defined as “the gas formed when carbon is burned, or when people or animals breathe out” (Cambridge, 2020).

But CO₂ is not the only GHG. Other GHG include nitrous and or sulfur oxides. Hence, in order to have a common scale of computing all gases, an equivalence has been created in order to make comparisons and generalisations easier. We then speak of CO₂ equivalent. “A carbon dioxide equivalent or CO₂ equivalent, abbreviated as CO₂-eq is a metric measure used to compare the emissions from various greenhouse gases on the basis of their global-warming potential, by converting amounts of other gases to the equivalent amount of carbon dioxide with the same global warming potential” (Europa, 2020).

2. Theoretical part

When talking about economic activity, growth has always been the leitmotiv of all economic actors. Recently, however, more and more concerns are being raised about the damage this constant seek of growth imposes to our natural environment.

The rise of the global warming alert really began in the 1980s. Scientists understand step by step that human activity is at the basis of this global concern, and that if no action is taken rapidly, the human being may be on the verge of its ruining. These past decades saw a growing concern about environmental depletion. More and more conventions are held throughout the world to raise awareness about this problem.

Environmental pollution and growth are thought of as following the same path. But, after a certain threshold, more wealth seems to lead to diminishing pollution. This hypothesis is known as an environmental Kuznets curve (EKC). It explains the pollution of a country in relation with its economic development. First, to create wealth the country needs to produce and pollute, using mainly the secondary sector of the economy. Then, once it is getting more developed, the pollution level decouples from the increasing wealth, and ultimately, once the threshold is reached, the pollution diminishes as the country is developed, and oriented to the tertiary sector of services. The final EKC looks like an inverted U-shaped graph. But does it hold in reality?

Grossman and Krueger (1995) are the first ones to have studied the phenomenon of growth linked to environment. They estimated the relationship between income and 14 local pollutant indicators, and find in most cases that environmental degradation first increases with income, then decreases. They find that air and water quality benefit from growth in poor countries once a critical threshold is reached. This threshold is set to be \$10 000 per capita (in 1985 dollars). As a country experiences more prosperity, its citizens ask for better care of the environment, putting pressure on policy-makers. Enforcement of these measures is needed in order to apply the rules of production. It is however important to note that they do not claim that pollution always decline with growth after a certain point but rather, they say that growth cannot be generalized as always worsening pollution.

Abid (2017) has recently done an analysis to see if this hypothesis is confirmed in the facts by comparing European and Middle East countries over a possible EKC. To do so, he also focuses on the relationship between income (representing wealth) and emissions. The results show that there is no EKC-alike relationship among these countries. The relation is monotonically increasing in both regions. The author finds that in order to have a sustainable economic performance, the quality and efficiency of the governing institutions is vital.

As Karsch (2019) has studied in her review work, it seems erroneous to think that economic growth leads to environmental quality amelioration. The fact that an EKC has been found by few researchers such as de Groot, Withagen et al. (2001) in China for example, does not mean it is universal. She supports that more growth without institutions following-up, and without collective thinking cannot improve environmental quality. The solution to the problem has to be found by raising awareness and regulation by authorities and scholars.

In summary, EKC results cannot be generalized and should always be interpreted with caution.

To try to control and regulate these damages in order to keep a relatively high stock of natural capital and keep our surroundings as healthy and livable as possible, the United Nations (UN) have reunited countries into conferences that have as a main goal to control and define norms to ensure that the global warming does not exceed certain pre-defined objectives. The best-known objective is probably the 2°Celsius increase cap about the global temperature of earth that should not be overpassed at the end of this 21st century.

These reunions of countries have existed since decades and have taken time to finally find a way to develop and discuss about environmental concerns. Below will be depicted the most famous ones that have recently occurred.

2.1 The UNEP

The United Nations Environment Program (UNEP) is the first global organization created around environmental issues. It is the leading authority over this subject, and it ensures a coherent implementation of the environmental dimension of sustainable development within the United Nations (UN). It promotes partnership, and information-sharing among the nations

with the goal of improving life quality while respecting sustainable development, defined as “development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (World Commission on and Development 1987).

2.2 The IPCC

The Intergovernmental Panel on Climate Change (IPCC) was created back in 1988 with the objective of providing governments with all the necessary scientific information to develop rigorous climate policies. It has been put up by the World Meteorological Organization and the United Nations Environment Program. Lots of reports are published every year to inform about what drives climate change, what the future risks are and how they can be reduced. It is composed of 3 working groups and 1 task force, whose work is to develop and adapt the methodology for the reporting of GHG emissions.

The first IPCC report was published in 1990 and confirms the prediction scientists had that by 2050, a warm-up of +3°C is expected compared to the temperature at the pre-industrial era. It is 2 years later during the Rio Earth Summit that this strong need of change was seriously integrated in the political decision-makers’ minds of more than 120 countries over the world. During this meeting, recommendations were made to countries in order to facilitate them to implement projects that are sustainable, and more environmentally friendly. It was the first step taken that has led to the Kyoto Protocol 5 years later. It most importantly led to the creation of the UNFCCC that is developed into details below.

2.3 The UNFCCC

The United Nations Framework Climate Change Convention (UNFCCC) also more simply called “the Convention” is a convention created in 1992 and effective since 1994. As it stands in its name, it is a part of the United Nations. It has been ratified by 197 countries which makes it nearly universal. Its ultimate aim is to prevent dangerous human interference with the climate system.

The more developed countries (or industrialized countries or Annex B countries, each term being used interchangeably in this thesis) agree in this convention to provide financial help and shared technology to their peers that are less developed because they generally are the ones that are most responsible of the damage already caused to the environment, in their process

of development. These countries are called Annex 1 countries and are part of the OECD countries. Financial help provided by Annex 1 countries makes sure that it delivers better standards of living, better institutions and economic stability, to ensure reliable future economic prospect.

2.3.1 The COP

The Conference Of the Parties (or COP hereafter) is the supreme decision-making body of the Convention. Its core objective is to check the good functioning and application of the rules and objectives of the UNFCCC. They hold meetings every year, starting in 1995 with the COP1 in Berlin, and most recently held the 25th edition of their annual meetings in Madrid. Each country that is part of this COP is called a “party”. It is during these meetings that the parties can sign agreements on the reduction of GHG, with common objectives or different objectives for different type of countries. They also discuss about future decisions and cooperation to better tackle the environmental problems. Also, a range of experts in their domain are consulted.

2.3.2 The Kyoto Protocol

The Kyoto Protocol (KP, or Protocol, or Kyoto, interchangeably in this thesis), that entered into force in 2005 after the COP3 operationalizes the UNFCCC by inducing the industrialized countries to reduce and limit their emissions of GHG with individualized targets that they had set beforehand. This convention has no enforcement power, it only asks for adapted policies and measures, and it provides periodic reports. It places the burden on the developed countries, considering their “common but differentiated responsibility and respective capabilities”, recognizing that they are responsible of the largest part of the current GHG emissions in our atmosphere (UNFCCC, 1992).

In 2008, the first commitment period for the Kyoto protocol members started and it lasted for 5 years. The main target was a 5.2% reduction in emissions relative to the 1990 level of CO₂ emissions. In early 2013, the second commitment period called the Doha amendment was launched. It should last up to 2020, and has the ultimate goal of reducing by 18% GHG emissions as compared to 1990 levels. The parties of the second commitment period are not the same ones as those of the first.

The parties are divided into 3 main categories. The Annex I parties are industrialized countries that are members of the OECD plus countries classified as economies in transition (EIT) such as Russia or several Eastern Europe countries. Annex II consists of the OECD members only. They are specifically required to provide financial assistance to developing countries in order for them to adapt and undertake new activities, always in the sense of reducing emissions and stepping toward sustainable development. Non-Annex I countries mainly consist of developing countries. They are seen as most vulnerable to climate change due to several of their characteristics (such as low-lying coastal areas or fossil fuel producers). Another, more recent category is Annex B countries. It regroups the countries that are not only part of the Convention, but that have recently formally stated their reduction targets in the Kyoto protocol.

2.3.2.1 The Kyoto mechanisms

The main features the protocol has established is the flexible market mechanism, which is a market designed for the trading of emissions permits. Countries must first meet their target by introducing national measures, but if needed, they can ultimately trade permits and complement that with flexibility mechanisms which are :

- **International emission trading (IET)** : this mechanism consists of defining targets of emissions and allowing them to pollute up to a certain level of emission units. Once they exceed this level, they have to buy units from other parties, which therefore, would have “spare” units that they do not use. By this trade mechanism, countries that fail to respect their target have an additional cost, the cost of buying units for reaching their goal, whereas those with excess capacities have an income rewarding their good environmental practices. This market is known as the “carbon market” and works as any other market for commodity. Similar trading schemes can be implemented on a national and regional basis, and the government is the one who fixes the objectives.
- **Clean development mechanism (CDM)** : It allows a country with an emission reduction or limitation commitment to create an emission reduction project in a developing country. Each ton of GHG emissions reduced abroad will be rewarded by a credit equivalent to 1 ton of CO₂. It gives more flexibility to countries that need to reach their emission targets together while promoting green innovation and sustainable development in the least developed countries. Back in time, this project was expected

to produce more than 2.9 billion tons of CO₂ equivalent credits, during the first commitment period.

- **Joint implementation (JI)** : It is the same concept as the clean development mechanism, except that it allows an Annex B party to develop an emission reduction or removal project in another Annex B country. It provides investment and technology transfers between the 2 parties.

These 3 methods are based on the premise that it does not matter where the emissions are reduced in the world, as long as they are reduced, since the atmosphere is common for all. This may stimulate green investment in the developing countries and induce the private sector to diminish (or at least maintain) the actual level of emissions. It also provides an incentive to the use of more recent production systems that are cleaner with long term advantages rather than continuing the use of older equipment that is harmful to the environment.

Moreover, Kyoto introduced a new system of verification, monitoring and review, to keep track of countries' progress and to ensure transparency. The emissions have to be accounted for and recorded as well as the trades that they undertake so that the instance responsible for this monitoring can keep track of all the past transactions or emissions of each of the parties.

The protocol is designed not only to monitor and bind the committing parties together, but ultimately to reduce emissions. In that sense, it was designed to help countries to adapt to the consequences of climate change, with notably a fund to finance projects in developing countries that are in accordance with the long run view of reducing GHG emissions, and to develop greener technologies.

2.3.2.2 Kyoto drawbacks

Two conditions need to be met before the Protocol enters into force. The first one is that at least 55 of the 190+ countries of the convention need to ratify the protocol nationally. The other condition is that the industrialized countries (Annex B) within the ratifying parties must account for at least 55% of the emissions of the year 1990 from all the ratifying parties. This latter condition was harder to meet due to the US withdrawal, so most of the Annex B countries had to approve the project. This gave a serious power to countries such as Russia, Canada and Japan

to negotiate softer norms in the treaty, because Europe needed them to comply for the protocol implementation, otherwise all these efforts would have been lost (Böhringer and Vogt 2004, Sjöstedt and Penetrante 2013).

The main issue with this protocol is the fact that USA and China, 2 of the main emissions emitters of GHG have not ratified the protocol and that Canada has left it in 2011. Since the treaty has no legal power to enforce its objectives, countries as those cited above have decided not to take part and have therefore weakened the expected reduction of the global GHG and jeopardized the objectives of the whole protocol.

2.3.3 Paris agreements

Concluded in 2015 at the COP21 in Paris, the 195 parties have committed to reduce their GHG emissions. What is different with Kyoto is that this new agreement has a legally binding power whereas the former one only gave recommendations. It is the first universal arrangement over climate. It defines a common action plan to avoid more than 2°C increase of average global temperature of earth, and ideally, pursuing the goal of keeping the temperature at 1.5°C above the pre-industrial levels. The ultimate goal is to become climate neutral by the end of the 21st century. In short, it will be the continuation of Kyoto, with the addition of the constraining power.

The parties have agreed upon several major measures in order to limit global warming at 1.5°C. They hope to see the world emission peak being reached as soon as possible. When setting this objective, they keep into consideration that underdeveloped countries need to increase production to grow, so this will likely increase overall emissions, despite the efforts of developed countries. The Parties have committed to reunite every 5 years to set more and more ambitious goals based on scientific progress, to be transparent when it comes to disclosing their progress to ensure efficiency gains without boundaries. These periodical reunions have also been set to make sure that the objectives and the policy measures put into place are in line with the reality of the ground. Every state has engaged into publishing its objectives, so that they are available to anyone wishing to have access to that information. Cooperation is sought as a key procedure to ensure the global progress towards the objectives fixed by the agreement. It also puts a heavier burden on the industrialized countries to support the developing countries on their way to GHG reduction, on a voluntary basis, particularly on a financial basis.

The European Union has played a significant role in the definition of this agreement, by committing to reduce its internal emissions by at least 40% before 2030. Also, it has built a large coalition regrouping its constituent countries, developed or not, that were favorable to an ambitious arrangement.

2.3.3.1 USA's withdrawal from the agreement

Even if the agreement has not entered into action yet, the President of the United States, Donald Trump, has already decided to withdraw from defining national targets as well as financial contributions. This is bad news for the planet and for the effectiveness of the agreement itself. Zhang, Dai et al. (2017) explain the reasons and the impacts it had on the agreement, and how China should respond to the announcement.

The first impact of this decision is that it breaks the universality of the agreement, it diminishes overall confidence and undermines cooperation that is needed to tackle the global climate issue. Also, it cuts a part of the funds that should be given by the USA to developing countries. This decision being acted, it reports a huge charge on China's shoulders, being the biggest polluter left alone, that now has the leadership and the responsibility of discussing with the USA to maintain them engaged in climate decisions. Moreover, USA's withdrawal may lead other countries to do the same, decreasing even more the financial help and the expected success of the measure.

2.4 The results of these measures

The Kyoto protocol results have diverging views (Maamoun 2019), some acknowledge the fact that it has indeed reduced emissions, so it is successful, others think that it has only driven developed countries to migrate their production processes to less developed countries, an activity also called "pollution-haven hypothesis". These havens are generally countries where political conditions are such that it is cost-saving for a developed country to move its production in order to benefit from less stringent environmental policies. Generally, less developed countries tend to have laxer environmental regulations in order to attract foreign investors to come produce on their territory (Yang, Guo et al. 2018).

However, the Pollution Haven Hypothesis (PHH hereafter) is still, as it stands in its name, a hypothesis. This means that there is no consensus over its existence. Some studies show results in favor of the existence of such a hypothesis, others dismantle it. The subject is hotly debated and controversial due to its importance in policy making. The main concerns of each view will be examined, based on recent and less recent articles.

Pethig (1976) has started by extending the 2-goods Ricardo model by including pollution in it. He finds that if two countries differ only by their emission standards, the country with the highest emission standards will be the one exporting the polluting product to the other one.

2.4.1 Pollution Haven Hypothesis implications

Grossman and Krueger (1991) have conducted their researches on the impact of a North American Free Trade Agreement (NAFTA). This kind of agreements that “opens” the economies of several countries generally stimulates production and exchanges between the parties and so stimulates economic activity. In this case, it is expected that the production process will be divided like this : high capital intensity production for Canada and USA, and lower capital intensity production, with lower worker skills for Mexico. They mention that common sense and general knowledge would lead to a concentration of pollution where environmental regulations are less stringent, hence, Mexico will see more industrial production with unskilled labor and more pollution and the opposite would hold for the US; this is in line with the PHH. However, the authors found out that, in the absence of increased capital flows after NAFTA, the prediction is that Mexico might turn towards industries that generate less pollution than the ones before the agreement (indeed, labor-intensive sectors such as agriculture and labor-intensive manufactures are in fact cleaner than the average). That being said, in the case of a 10% increase in capital flow to Mexico, chemical releases will raise in Mexico (and so pollution too). As far as the USA are concerned, they are, according to the authors, expected to experience a slight environmental degradation, because less labor-intensive activities require additional energy to operate them and hence, additional pollution.

The authors find some potential benefits to this NAFTA, especially welfare gains for Mexico. Mexico was, at the time of this article, at the critical point where an increase in GDP/capita should lead to increased demand for better environmental quality (based on the

EKC hypothesis). The general conclusion from this paper is that trade liberalization implications on environmental quality depends on many factors: the scale of the economies concerned, the change in the sector compositions and the change in technologies that result from the trade agreement (Grossman and Krueger 1991).

Copeland and Taylor (1994) study the implications of North-South trade in general on the environment 3 years later than their peers in the paragraph above. They try to see what damage (or gain) the rise in trade liberalization has on the environment. There are two ways of looking at international trade and the environment, already implied by Grossman and Krueger (1991). First, those who say that more trade leads to more wealth, which in turns leads to more demand for tougher standards concerning environmental regulation. Second, those who think more trade induces more production and more pollution if production methods do not change. They create a two-country model where incentives to trade come from the differences of environmental policies, which is solely due to the different incomes of the countries.

They see that, in the case of a country in autarky, growth has a neutral effect on pollution. This is due to the policy switch to cleaner production processes that happens throughout the economic growth of the country. However, the model they use concerns two open countries. In that case, trade is also expected to increase wealth. If the only reason for trade is the difference in the price of pollution (pollution taxes), and that this trade does not allow to equalize for factor prices, trade worsens overall pollution compared to an autarky scenario. It is important to note that economic growth does not lead to the same outcomes on the environment in Northern countries than in Southern countries, because of the large economic disparities. Their two main conclusions are : 1. Trade generally reduces differences in factor prices in the case of heterogeneous countries. 2. The relative price of pollution in high-income countries is generally higher in autarky than in free trade.

On a smaller scale, Yang, Guo et al. (2018) tried to assess if the PHH is dependent or not on environmental regulation in China, particularly in the province of Jiangsu (which is more than 3x larger than Belgium, and approximately the same size as South Korea or Iceland, in terms of square kilometers). China faces a dilemma concerning the trade-off between environmental protection and economic growth. The country wants to keep growing, but this process leads inevitably to more pollution. They study statistics concerning more than 1000 new manufacturing firms in the province and select 3 representative indicators of regulation for

the environment. Their results are contradictory. One indicator supports the hypothesis (the objective indicator), another denies it (the cost indicator), and the last one is insignificant (the consequence indicator). That is why they support the point of taking the results from PHH studies carefully, and to think of every indicator separately to assess the results of a stronger regulation. Their results are somehow mitigated, not taking the party for or against PHH.

On the contrary, Shen, Wang et al. (2019) have found that a local PHH holds for the province of Guangdong, also in China. The size of the province is comparable to the one of Uruguay (nearly 6x Belgium), and is the first province of the country in terms of GDP since 28 years (at the time of the study). Their methodology is different from above, studying the flow of pollution intensive industries in relationship with environmental regulation within the province, that is characterized by a division into 2 parts: the core industrial region and the peripheral region. Their results show a pollution transfer from the core to the peripheral region since 2006, which supports the PHH hypothesis. This migration flow is due to the pressure that has been recently put on the industries in the core region.

The results also show that a negative relationship exists in the long run between environmental efficiency and the migration of these polluting industries in the peripheral region, degrading the environmental quality of the region. The peripheral regions have become the PHH of the whole province due to the lack of policies regarding environmental regulation instead of the commonly used pollution emissions control policy (Shen, Wang et al. 2019).

Levinson and Taylor (2008) examine the effects of environmental regulations on trade flows, to see if the PHH holds or not. They acknowledge the fact that study results differ over the existence of this so-called PHH. They decide to focus their study on pollution abatement costs. Previous studies find that sometimes these pollution abatement costs have no influence on trade flows and even in some cases that high abatement costs lead to more exports. This questions the ability of governments regulations to control trade flows.

They see that the sectors in which abatement costs have risen the most are the ones where net imports have also largely increased. The results of this study show evidence of the existence of the PHH (Levinson and Taylor 2008).

On the other hand, Cole (2004) has found little evidence of the existence of PHH in his paper concerning 4 pairs of countries (developed-developing). He acknowledges the fact that if pollution havens exist, they are likely to be limited to certain regions and do not last in time. His two other major findings are the following : 1. Pollution has a positive and significant relationship with the share of industrial production in GDP (for OECD-developed countries). Thus, the relative contraction of the industrial sector as a whole has been beneficial for the pollution emissions of developed countries. 2. Openness to trade shows a negative and statistically significant relationship with pollution.

In this paper, he also studied the EKC. He finds that the turning point in the curve that occurs at a relatively high level of income is due to the rise in demand for environmental regulation and the higher investments for greener technologies. The possibility for LDC's (Least Developed Countries) to follow a EKC alike curve when developing is unsure. There is only little evidence for this scenario to occur.

In order to have a global view of the subject, a recent review of the literature on PHH by Gill, Viswanathan et al. (2018) concludes that there is no conclusive result over the existence of pollution havens. PHH analyses generally neglect factors such as cost of mobility of industries, market or technology access. Also, in a location considered as a haven, increased production and trade can lead to growth, new employment opportunities and can bring improvement to the environment. Finally, the authors recommend further research over the link between the environment, foreign direct investment and trade.

2.4.2 Shortcomings of the protocol

Another problem that is often pointed out is that the protocol is adopted on a voluntary basis. The global results are then biased because of this opt-in solution. Some countries who think they cannot reach their objective would either leave before term, such as Canada, or simply not ratify the protocol at all, such as China and the USA. Thus, the parties that have signed in are parties that have the willingness to reduce their emissions and that comply from the beginning (Böhringer and Vogt 2004).

2.4.3 Early predictions over the effects of the protocol

Kyoto is the first step towards global collective action over the climatic warning. For some researchers such as Böhringer and Vogt (2004), its contribution very symbolic. The analysis is only based on the economic incentives of a country to stick to the protocol. They compare the willingness to pay (WTP) of the citizens of the country for better environmental actions with the costs for the country of complying to the program. The analysis has been done for the USA and tries to explain the rationale behind the withdrawal decision from the Protocol. From a political economy perspective, politicians take actions in order to satisfy more than half the population (to exceed the median voter), in order to be re-elected during the future elections.

Their analysis shows a low WTP for the USA, and high compliance costs. The basic economic rationale says that one should not accept a project in which costs exceeds potential benefits. The USA then made a rational decision from an economic standpoint. This decision puts pressure on other big polluters in the negotiations before the implementation of the Kyoto protocol. The withdrawal induces that the protocol became a treaty that finally just codifies production in Europe rather than radically change it in order to pollute less. The authors seriously doubt the fact that international agreements over environmental issues may be successful (Böhringer and Vogt 2004).

Holtmark and Mæstad (2002) have conducted an analysis to compare the results between 3 possible decisions. First, they propose a scenario with free unlimited emission trade. Second, they suggest a scenario without any possibility for trading emissions. Third, they suppose a scenario of emission trade with buying and selling restrictions, that was studied by the EU. Their results show that any of the 3 possibilities would have led countries to meet their Kyoto commitment to limit GHG emissions. In the totally free trade scenario, the international market would provide an identical price for every permit throughout the world. With no international trade, the market will be segmented with intra-country trade, each country having its own national price. In the case of the trade with restriction, the results of the paper are non-obvious.

It is finally found out that the EU restrictions will lead to better results than it would be in a free market, because the decisions will induce a rise in the price of the permits, therefore leading to an increased incentive to reduce emissions either because a country does not want to spend that much to be “authorized” to pollute, or because by limiting emissions, a country could

sell more permits that have higher price, increasing their revenues. The proposal seems to be effective in that sense (Holtmark and Mæstad 2002).

2.4.4 Ex-post analysis of the effects of the protocol

Maamoun (2019) has worked with a generalized synthetic control method (GSCM) in order to assess the results of the Kyoto protocol compared to a “no-Kyoto” hypothesis. The analysis brought a new dimension to the existing literature. It compares the signatories with a created counter-factual (control group) using several instruments in order to take into account the flexibility mechanisms of the Protocol as described by Almer and Winkler (2017). Indeed, it accounts for the signatories as a group, englobing the common effect of air pollution and the fact that collective action, through the above-mentioned synergy mechanisms (IET, JI, CDM), is brought forward in the protocol specification.

The results showed by the analysis are proving that the Kyoto protocol has reached its goal of reducing global emissions. The size of the reduction is between 6 and 7% compared to the no-Kyoto hypothesis. So, it shows that the KP has been a successful step, and even if some still think its implementation is not good enough, it states that at least, it has diminished emissions more than if no action was taken. Rather than complaining that it shifted emissions away, it must rather be seen as a successful first step, and a basis for the implementation of future regulations such as the Paris agreements. It is further recognized that, of course, further steps towards reducing CO₂ emissions nevertheless need to be taken (Maamoun 2019).

These positive results are confirmed by Aichele and Felbermayr (2012). The 7% decrease in domestic emissions is confirmed for the Annex B countries, but the results need to be heavily nuanced with the help of the carbon footprint. This footprint is calculating the GHG emissions that can be imputed to human activity for a particular country, in CO₂ equivalent. It does not matter if the good is produced or not on the domestic territory, what matters is the use of the good. So, a country’s carbon dioxide emission does not have to match with its footprint, due to international trade of goods. The authors evaluate the results from the committed parties of Kyoto.

The results of the above-mentioned study tell that the gains in emissions made on a domestic basis from the committing parties are counter-balanced by the increase of carbon

imports, which supports the PHH. The so-called “carbon leakage” neutralizes the positive effects of the treaty. They calculated that the share of imported over domestic emissions has risen by 14 percentage points for committing parties. From this result, they state that the protocol has, at best, had no influence on the global level of emissions, but has shifted the relocation of polluting production processes from committed to non-committed parties. This shows that the Kyoto protocol has been inefficient due to its lack of universal coverage. It is advised that a future project needs to incorporate most of the major economies to give better results or that the tax regimes of the committing countries must be adjusted in order to have a correct tariff on emissions, which turns out to be really demanding to achieve due to the heterogeneity of all the Kyoto parties (Böhringer and Vogt 2004).

This previous section shows that it is difficult to agree on a common result from the introduction of the KP. Some argue that its effects have exceeded expectations and that future agreements should be encouraged to reduce even more emissions and reach the future targets, whereas others counterbalance the result with the fact that it may have driven countries to delocalize their production processes, due to the non-universality of its application, increasing the emissions of developing countries. Indeed, to have a “perfect” agreement, every country should be signing it and put in into practice so that no side effects could be seen.

2.4.5 Effects on individual behavior of global agreements

A question that deserves to be asked is whether these macro-economic decisions really influence the micro-individuals, the population, to reduce their greenhouse gas emissions on a personal basis. Everyone has difficulties to see how a change on his tiny personal scale can influence the global concern of climate change. To reach the ambitious goals that have been set, efforts need to be made by individuals themselves in addition to policy-makers and firms. That is why the latest Paris agreements put a particular interest on policies that enhance the population’s awareness of the need to change their habits.

Bauer and Menrad (2019) have conducted a study on how the global targets over climate action are adapted to the behavior of individuals, especially for the Paris agreements. Since the goals of this latest agreement decided at the COP21 are widely supported by society, the authors examined if these targets are leading to new or adapted social norms concerning the behavior of individuals alone, and in society. Their study only concerns 226 students in Germany, but

still gives striking results concerning individual contributions towards the common goal of reducing human impact on environment.

The issue that was examined was whether or not individuals apply the goals stated in the agreement on an everyday basis to their way of life, for example by reducing their consumption of intensely polluting goods or activities, such as air travel or consumption of goods coming from far away or by changing their way of consumption like switching to green energy and consuming locally produced food, which will, in addition to reducing GHG emissions, improve their health.

The results of the study show that the individuals that were studied are likely to be involved on a personal point of view when it comes to carbon offsetting, green energy as well as consumption of local fruits and vegetables due to personal and social norms. The norms that were put in place during big events such as the COP21 lead to GHG reduction whenever the individuals concerned apply the rules to themselves. The policy makers need to consider personal behavior in order to improve global results of their country when they make environmental decisions. This incentivizes the population without any monetary valuation. But obviously such an analysis is very preliminary and rather biased since it only considers students, and it is well known that students do not generally reflect the various socio-economic groups of a country.

2.4.6 Transposition from international to national rules.

To be implemented, global rules are translated to each country from a legal perspective. In order to have a global tracking, and global results, member countries have to transpose those internationally agreed upon rules to national legislation. Morgan, Nalau et al. (2019) have evaluated how well the translated national rules match the Paris agreement commitment. They see coherence between the plans that have been undertaken in various countries. The analysis reveals significant differences between Annex B countries and the other countries. They see a relatively good improvement in rule translation from Paris agreement to national rules, which was a basic requirement of the UNFCCC when drafting the agreement.

2.4.7 Prediction over the effects of the Paris agreements

As exposed in some papers, Kyoto has had diverging results. It has indeed reduced emissions of the committed countries but it does not seem it has for others. Dong, Dong et al. (2018) have calculated the probability of the Paris agreements to reach its goals, using the top ten worldwide emitters. These 10 countries are responsible for 68% of the global emissions (in 2016). The size of the sample and the importance of their emissions are large enough to be considered as a good proxy for assessing the results of the Paris agreements.

The results obtained are not what is expected globally. The volume of the CO₂ emissions is predicted to increase by 26.5-36.5% compared to its value in 2005. Some parties, such as Russia, achieve their targets but in opposition, Saudi Arabia will have a severe carbon situation, because it does not commit to any national goal; it does not transpose the global directives into its own national legal system. Furthermore, results show that no trend can be used as benchmark for comparing the implementation of the targets. They acknowledge that the main way to reduce emissions is the use of renewable energies to limit emissions and stimulate growth at the same time. That is part of the explanation of the bad situation of countries that base a substantial part of their revenues on fossil-fuel extraction.

No European country is reported in the above-mentioned paper, because they are each considered as separated entities, Europe is not considered as a whole. Also, in recent times, Europe has been leading negotiations such as that of the Kyoto protocol. But will it achieve its goals set at the COP21?

Liobikienė and Butkus (2017) have analyzed the possibility to achieve the targets set by the protocol for European countries. They state that the growth of GHG emissions is largely due to the growth of the entire economy, and also to primary energy consumption. Concerning energy consumption, this goes in line with Dong, Dong et al. (2018) who stated that the main driver of pollution (for the top 10 world emitters) is the use of energy. Also, this former study concerning Europe, by Liobikienė and Butkus (2017), finds that if we consider Europe as a single entity and not each country separately, it is a huge polluter.

The results show that even if Europe has reached its target for 2020, according to past trends, it will not be able to decrease its emissions by 40% by 2030. The authors suggest the EU countries to conduct more policies over energy consumption reduction, because the actual

consumption of energy is too polluting, they are strongly in favor of the development of renewable energy sources, exactly as mentioned in the previous paper by Dong, Dong et al. (2018) over the top 10 emitters.

2.5 Conclusion of this theoretical part

This first part was designed to show the important steps that have been taken on a large scale in order to tackle this problem of global warming. Scientists have warned policy-makers first, then it took some time for all the parties to fit into a global climate organization, since the problem with GHG is that they do not only pollute the place where they are emitted, but are spread through the world, no matter the borders. That is why a single country's specific actions are not enough to tackle this problem, what we need is a global organization that is able to bring all polluting parties together to find a solution that is best for everyone, and for the earth as a global entity.

Later on, agreements such as Kyoto protocol or Paris agreements make sure that everyone has a specific goal to reach and is committed to it, so that everyone does his part of the job. But as explained above, we can see that even if some goals are achieved, the burden of pollution may be transmitted to other parties. As mentioned before, because of the global effect of emissions, it means that the problem is not tackled properly. However, these policies led to a growing concern of the population regarding future generations' ability to live a life that is as satisfying as earlier generations, and enjoying a reasonable stock of natural capital.

Still, such policies remain necessary in order to increase people's concerns about climate change, so that they are aware of how their way of living and consuming influences the environment. Annex B countries have indeed increased their efforts towards the ultimate goal of maintaining a reasonable temperature change and reducing CO₂ emissions. They reached the goals that were set, but their consuming habits have not changed that much, possibly shifting polluting activities from their territory to another one or preventing them to reach more stringent emission reduction goals in the near future.

Underlying all these previously-mentioned theories, hypotheses and policies is the ability to measure pollution emissions. If you cannot measure emissions, you cannot set goals or measure the impact of policies. The following chapter looks at measuring and at two different

approaches. It will highlight interesting results that throw light on EKC, PHH, and the implementation of measures by the UNFCCC such as the KP. This will also raise some questions over geopolitics concerning a possible switch from one method to another, and who would be the winners and losers of such a switch.

3. Accounting methods (production – consumption)

3.1 Introductory remarks

When it comes to accounting emissions, the most widely used method is the production-based method, due to the ease of data collection and calculation. This method is the one used to calculate emissions since the beginning of environmental concerns. The other main way of calculation is the consumption-based method. This is slightly more difficult because it needs more data on the origins of the goods bought and consumed. The upcoming sections take a detailed look at each of the two methods.

The problem of choosing one method of calculation over the other is related to the challenge of deciding who is responsible for the pollution. Is it the consumer of the final product, or is it the producer of this product? The “best” accounting method depends on who one believes is responsible for pollution. If it is the producer, then the production-based method (PBM) may fit best, otherwise it is the consumption-based method (CBM). Authors such as Proops, Faber et al. (2012) are amongst the first to have made that connection between “emission” and “responsibility” relatively to CO₂. Their first consideration is that structural economic change is both the starting point and the solution for increasing emissions.

The problem has risen because of the international trade. If we consider a completely closed economy, the CO₂ equivalent emissions are the same whether the PBM or the CBM is used.

The traditional approach is the production-based approach. It is also the best-known approach and the most popular one. But why is it so? First of all, this method is the easiest one to calculate emissions, and the data collection of emissions is relatively simple, and available in most countries. It imputes the cost of pollution to the producer. But since the last century, international trade has grown exponentially. The concern is not anymore to penalize those who pollute, but to reduce global emissions and not just in specific countries. The one responsible for pollution is then not only the polluter but more than ever the consumer. That is why the consumption method has become more and more used and studied.

Peters, Davis et al. (2012) tried to examine the role of trade in accounting for CO₂ accounting. Because international trade is expected to continue its growth in the future, there is

a need to quantify more accurately the emissions embodied in the products that are not produced on the same territory than the territory where they are consumed. The “embodied” term means that we account for the emissions that come from the production of the good (or service) in another country.

The consumption-side approach seems to fit best in order to calculate the impact of our consumption on CO₂ emissions. But it does have a few weaknesses. The first one is that it is harder to calculate, because it needs trade data of international transportation to check where the product a country imports (and consumes) was produced and the impact on emissions. A second problem is that there is no consensus over the method of calculation of the CBM. This leads to difficulties when it comes to comparing different consumption-based levels of emissions from different countries that did not use the same methodological model. Also, the method relies on more assumptions than the PBM- and this reduces the accuracy of the method.

Franzen and Mader (2018) have calculated the ratio between CBM and PBM for different countries throughout the world (CBM over PBM). So, if a country imports much more embedded carbon than it exports, its ratio will be high. Their conclusions show that the intuitive thought that high importing countries would have higher ratios than high producing countries holds. They take the example of Switzerland, which is landlocked in the middle of Europe, and has a high CBM/PBM ratio. I think that this is due to the fact that Switzerland imports a lot of manufactured (and high carbon) goods and exports lots of services (or low carbon products). This may not especially hold for all landlocked countries.

The framework used in the Kyoto protocol is the production-based method. This method is considered to be to the advantage of developed countries, that can easily reduce their emissions by exporting their polluting activities to developing countries, in line with the PHH. Therefore, using the consumption-based method would help developing countries in the international negotiations and force developed countries to find solutions rather than getting rid of the problem for their territory by implementing polluting activities elsewhere. Indeed, as said before, the problem that needs to be tackled is global pollution, not pollution from any one country (Boitier 2012).

I personally think that the choice of the production method for the protocol was not a bad choice per se. Indeed, at the time of the decision, it would have been too risky to choose

the consumption method. There were not enough certainties over the method. It took time to create a general framework that enables comparisons over the countries. Also, originally, there may have been some pressure from the most powerful countries which are the developed ones, to choose the production method. Those countries may have seen some advantages in the production method that would enable them to reduce their domestic pollution on the short or medium term with less effort than if the consumption method was chosen. But now, things have moved on, and perhaps is a CBM is more appropriate...

3.2 How is the production-based method calculated (PBM)?

When implementing the Kyoto Protocol, the IPCC had to define a specific method of calculation of GHG emissions. For practical reasons, the production-based accounting method was chosen by IPCC to calculate the emissions of the countries. This method starts from the point of view that the emitter of the emissions is the one responsible for the pollution its production induces. This is in line with the Polluter Pays Principle (PPP). This PPP stipulates that those who damage the environment must bear the cost of such damage. A nations' emissions are calculated as follows : « It estimates the greenhouse gas emissions from all the oil, coal, and gas consumed in a country by private households, industrial production of goods and services and electricity production » (Franzen and Mader 2018). In this vision, the emissions are attributed to the location of the process that emits in the atmosphere. It is based on the fact that a significant proportion of emissions comes from the energy production process (Munksgaard and Pedersen 2001, Luppi, Parisi et al. 2012, Franzen and Mader 2018).

This method is rather simple to calculate, but obviously it has some disadvantages. The first one is that it omits emissions coming from international transportation. Because once the plane or the boat reaches international waters, who is responsible for the emissions? It is not related anymore to any specific national territory, so it is simply omitted. But these emissions still occur, so they need to be accounted for (Franzen and Mader 2018).

The other big downside of PBM is carbon leakage. This phenomenon is defined as a situation where a company decides to move its production process (or part of it) to another country that has less strict rules in terms of emission limitation. This concept is closely related to the pollution haven hypothesis that was described in section 2. The rationale for doing this is to avoid being subject to the more challenging climate policies of the country where the firm

was initially located. To avoid this phenomenon, industries in which carbon leakage is more likely to happen are generally given higher emissions shares or a free allowance to pollute. Indeed, they receive more permits to pollute than other industries. The industries covered by this system of permits are clearly listed so that there is no possible confusion, nor for the companies, neither for the law enforcement people (EU, 2020).

So, the problem with carbon leakage is that companies may tend to move their production into another country with less stringent pollution rules and then move back the finished product to the more restrictive country. By doing this, it decreases the emissions in the more restrictive country while increasing in the less restrictive one. This carbon leakage theory suggests that reduction in one country is generally related to increase in another one, so that carbon-intensive good production is only reallocated to another place. This does not solve the problem of global warming, which is a global problem that needs to be tackled in the whole world, and not only in developed countries. This suggests that Annex B countries can achieve their emissions goals by relocating their polluting companies elsewhere (Fan, Hou et al. 2016, Franzen and Mader 2018).

3.3 How is the consumption-based method calculated (CBM)?

The principle that is used when calculating with the consumption-based method is that the consumers of a specific country bear the responsibility for all emissions associated with their consumption. This accounting method is demand-based. The consumer does not produce but still has to bear the responsibility of the emissions generated in the production process of its consumption. This is based on the final use of the product or service and imputes the burden of production to the final user. So, to calculate with this method, one subtracts from a country's production emissions the emissions due to all exported goods (including transportation emissions) and adds the emissions due to all imported products (including transportation emissions). This gives us the formula [Consumption-based method = production-based emissions – embedded CO₂ in exported goods + embedded CO₂ in imported goods] (Munksgaard and Pedersen 2001, Fan, Hou et al. 2016, Franzen and Mader 2018).

We see that the consumption-based method is itself based on the production-based method. It produces an alternative indicator that cannot be dissociated from the initial one.

This method should then be able to correct for the carbon leakage. It should also tell us whether the KP has helped to reduce emissions or has just fostered relocation of carbon-intensive production away from Annex B countries. However, Franzen and Mader (2018) find in their work that there is no evidence of carbon leakage from developed to developing countries. So, it suggests that switching eventually from production to consumption-based method would not significantly affect the results of the Protocol.

In contrast, Fan, Hou et al. (2016) conclude their analysis by saying that the CBM is still a good instrument to use, maybe in parallel with the PBM. They support their opinion by using the example of China, which is responsible of 24.4% of global emissions under the PBM, and 20.8% under CBM. This gap is quite large and cannot be overlooked. They see both approaches as complementary rather than mutually exclusive. Their comments suggest to use the CBM as another method that can help understand better GHG emissions and country awareness of the urge to become carbon-neutral.

3.4 Advantages and disadvantages of both methods

3.4.1 General discussion

Munksgaard and Pedersen (2001) try to assess which is the best option for an open economy, they take Denmark as their subject for the study. They construct a CO₂ trade balance, which consists of subtracting the results of one method of accounting from the other, in order to see the evolution of this balance throughout the years. For example, if we subtract the results obtained using the PBM from the results obtained using the CBM and get a positive number, this means that consumption exceeds production over the concerned territory and that the region is a net importer of CO₂.

Denmark's trade balance has gone from +0.4 million tons (1987) to -6.9 million tons (1994). It means that the country has become a net exporter of CO₂. This is due to the increase of foreign demand for Danish products. This occurred before the KP introduction (1997). Still, Kyoto considers the base level of 1990 and uses the PBM to account for emissions. In 1990, Denmark's trade balance was in a deficit of more than 4 million tons. This deficit means that the country will have to undertake more efforts to counter the increase in foreign demand (and therefore of home production and emissions) than if the base year was, for example, in 1987

when the country had a positive trade balance. This increase in foreign demand stimulates domestic production and emissions and leads to a worsening of the CO₂ trade balance. That is why one should better take an average over a defined period rather than a reference year decided unilaterally when a base year is chosen (Munksgaard and Pedersen 2001).

This paper also shows the limits of the PBM. Net exporter countries, China for example, may be more reluctant to accept global policies based on the PBM. Indeed, since their trade balance is negative, they are a net exporter of CO₂, which means they produce more emissions than what their consumption inside their borders is responsible for. The PBM is more policy oriented, more global whereas the CBM is consumer-oriented, where bad consumer habits lead to more imports of CO₂ intensive goods. With the PBM, “bad” consumers have no real incentive to consume foreign greener goods, because they know that no matter what, the burden of emissions will be placed on the producing country rather than on their own country. The paper also shows the drawback of the choice of a base year (1990 for Kyoto), this arbitrarily defined base year can create some bias such as in this case with the energy-exchange program that exists between Denmark, Norway and Sweden. In 1990, Denmark had imported a lot of energy from its neighbors and this has driven its production emissions downwards, not reflecting the current situation (Munksgaard and Pedersen 2001).

One of the major problems of CBM is that, as mentioned before, it is complex to calculate; it requires precise, disaggregated sectoral computations of international trades, generally in the form of Input-Output matrices. The CBM also violates the principle of product liability, which states that the producer is the one responsible for the quality of its product. Quality is a broad term, but pollution can potentially be understood as a quality determinant by some people. According to Franzen and Mader (2018), the balance of small upsides and relatively important downsides would suggest keeping the PBM.

Steininger, Lininger et al. (2014) have analyzed the implications of a possible switch from PBM to CBM, especially in terms of justice and environmental cost effectiveness. First, justice is here not only about who is responsible of the emissions of GHG, it is mainly about the possible implications of a change in policy in terms of redistributing the burden of the pollution fairly. So, any policy that serves to redistribute best this burden should be recommended from this perspective. Over the cost effectiveness, they mean that it demands that any policy taken up in one region should not increase the costs of any other region on a

global level. Costs are not only monetary here, because pollution is considered as a cost for society.

The authors further explain that if a CBM would finally be established through border carbon adjustments, revenues of this measure should go to emerging economies in order to help them develop. It would also compensate the eventual burden for them of having diminishing exports to the developed countries that face this adjustment measure. A carbon border adjustment is a tax imposed on any imported product from a country without a carbon pricing plan (such as tax on carbon or a cap-and-trade system). Ideally, it would adjust the price of the imported goods so that the final price in the region that imported it matches the price of those goods as if they were produced at home. Also, they encourage the transfer of clean technologies from developed to developing countries, so that they start their expansion with more advanced and environmentally friendly technologies. The authors say that further analyses have to be made concerning the impacts on the whole supply chain of policies using CBM (Steininger, Lininger et al. 2014).

3.4.2 Comparison over some territories

Here, I compare the differences between the 2 methods, based on the territory and the level of income of different regions. They represent the share of CO₂ emissions, by production and then by consumption, for each group of countries. The goal is to see if there is a link between the level of income of a region, and its CO₂ emissions, and to see the PBM/CBM ratio.

Figure 3.1: Production VS Consumption-based methods

Income or regional group	Share of population (%)	Share of production-based CO ₂ emissions (%)	Share of consumption-based CO ₂ emissions (%)
High income	16%	39%	46%
Upper-middle income	35%	48%	41%
Lower-middle income	40%	13%	13%
Low income	9%	0.4%	0.4%
North America	5%	17%	19%
Europe	10%	16%	18%
Latin America & the Caribbean	9%	6%	6%
Asia	60%	56%	52%
Africa	16%	4%	3%
Oceania	0.5%	1.3%	1.3%

Source : OurWorldInData.org, 2015 Data : Global Carbon Project

From Figure 3.1, we can rapidly identify that high income countries produce 7% less emissions than what they consume. They are CO₂ net importers. The relationship is inversed for the upper-middle countries with 7% more emissions on the production side, they are CO₂ net exporters. Curiously, this trend does not follow through to the lower middle income and low income countries- they have identical figures for PBM and CBM. Together, countries in these categories are responsible for only 13,4% of world emissions, whereas they have nearly half of world population (49%). The contrast is highlighted by the figures from high income countries. By consumption, they are responsible for 46% of global emissions (39% for production), yet they have only 16% of total population.

Perhaps different figures were expected for less developed countries, with production emissions higher than consumption emissions. But this is not found in the figures. The figures from the income groups show no evidence of the presence of carbon leakage between high income and low income countries. The only carbon leakage is between the high income and the upper-middle income countries such as Brazil, China, ...

However, when we group countries differently, by taking the regions rather than the level of income, we see that Asia and Africa produce more emissions than they consume, which is more in line with the expectations. The absolute difference between the 2 methods for Africa is only 1 percentage point (from 3% on the consumption side to 4% on the production side). This may seem small, but in fact it means that they produce 33% more than what they consume. In Asia, the same calculations show that, in absolute terms, they produce between 7% and 8% more than what they consume. This may maybe lead to a different understanding of the PHH. This could be seen as a displacement of polluting industries to other less developed continents in general, rather than a movement from the rich countries to the poor ones.

On the other side, Europe and Northern America consume respectively, in absolute terms, 12.5% and 11.7% more than what they produce on their territories. These are significant figures.

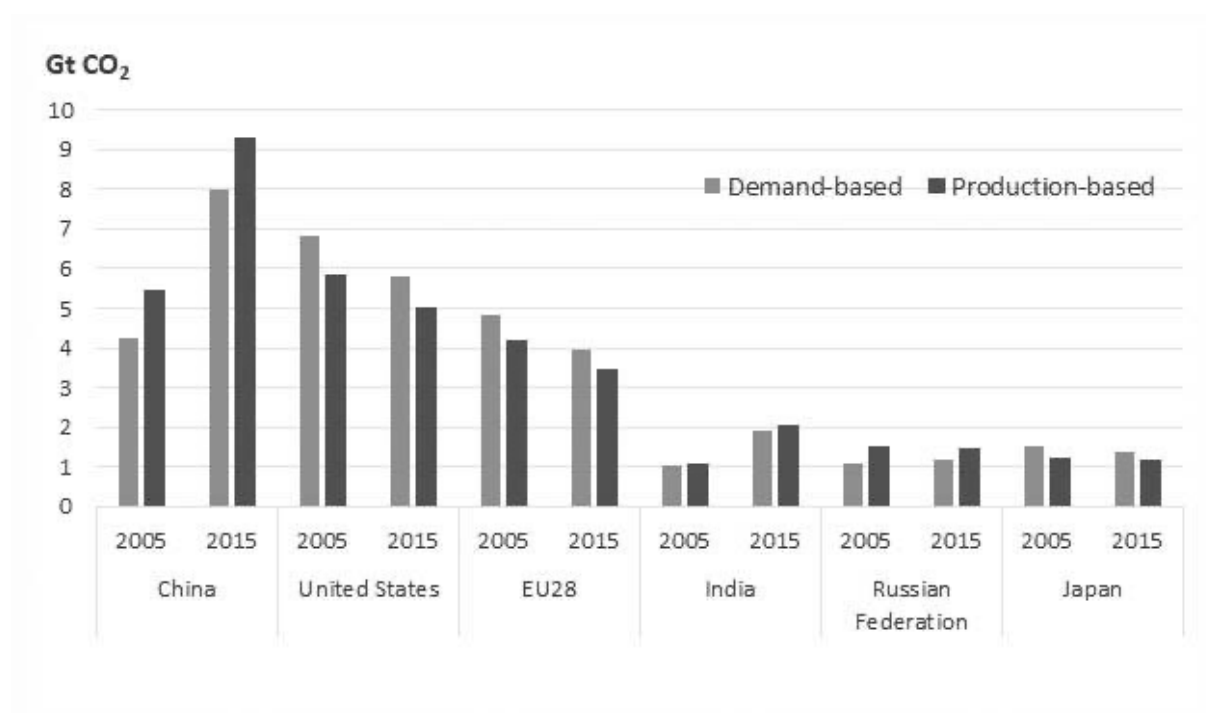
Note here that consumption data was not available for all countries. This illustrates, once more, one of the principal weaknesses of this method of accounting. However, the missing countries together account for less than 3% of global emissions – so only small changes would result if all data were available.

This figure shows that the 2 methods are not necessarily opposite, they can be very interesting to study together to make comparisons as in the previous paragraphs. They give us insights about the differences between the production on a domestic territory and the consumption of its citizen. Remember that, in order to reduce global warming, everyone needs to aim in the same direction : governments, businesses and the people.

3.4.3 Comparison between the top 6 CO₂ emitting countries

The OECD have undertaken a similar analysis than the one in the previous section, focusing on countries. In this analysis, Europe (the EU28, including the UK) is considered as a single country because it conducts a harmonized climate policy.

Figure 3.2 : Top 6 CO₂ emitters 2005-2015.



Source: OECD (2019), CO₂ emissions embodied in international trade, <http://oe.cd/io-co2>

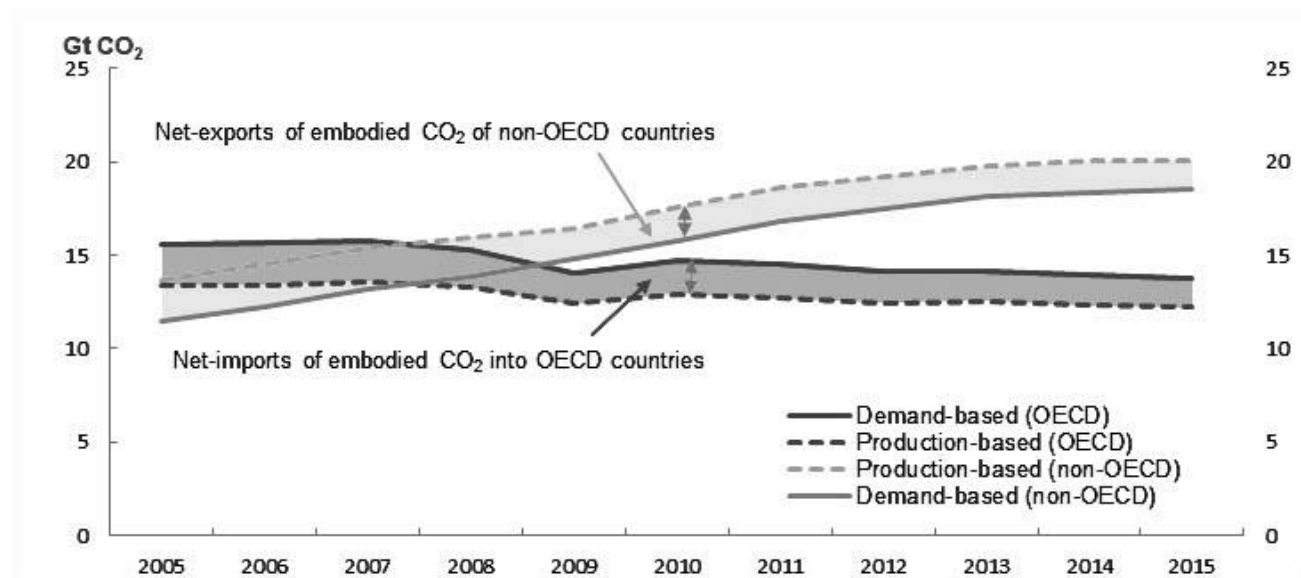
This graph illustrates the Gt of CO₂ emitted by the consumption / production of a country on a global level. For example, although US per capita consumption-based CO₂ emissions were (in 2015) 3 times higher than those in China, the overall emissions from China are substantially higher than for the US by 2015. We see that China's and India's emissions have increased greatly over the 10 years period, whilst the opposite is happening in the US and in Europe. For Russia and Japan, the emissions seem to remain relatively stable.

More developed countries (USA, Europe, Japan) have, as expected, a higher level of consumption-based emissions than production based emissions. Less rich countries (China, Russia) have on the other side a higher level of production than consumption. These 2 countries are considered as developing, but are rich enough to ensure a relatively high level of production (and are amongst the top 6 world emitters), as shown on the figure. India has also a higher level of production than consumption, but the difference seems to be rather weak and stable.

Over the 10 years period, the USA and Europe have both decreased their consumption emissions and their production emissions whereas China and India have nearly doubled both of their figures. Such an increase cannot be attributed only to the population growth rate for example (which is around 5% over the 10 years for China, 14% in India). This increase is

probably due to the enhancement of the wealth of these (still) developing countries. Russia and Japan do not seem to have experienced major changes in their balances.

Figure 3.3 : Net export-imports from (non)-OECD countries



Source: OECD (2019), CO₂ emissions embodied in international trade, <http://oe.cd/io-co2>

The graph in Figure 3.3 is a little more tricky to understand but shows the evolution of the behavior of OECD countries (considered as developed countries) compared to non-OECD countries (considered as underdeveloped/developing) over the same 10 years period as in Figure 3.2. The coloured area between the continuous and the dotted curve represents the net imports (dark grey) or exports (light grey). As expected, OECD as a whole is a net importer of products that created CO₂ emissions, but the gap (the net imports) seems to be slowly reducing over time. Note that this trend does not hold for all OECD countries. For example, Canada was in 2015 a net exporter, Brazil (non-OECD) a net importer.

We see that for non-OECD countries the production keeps growing over time. More surprisingly, consumption follows a similar path, a similar increase. This is certainly mostly driven by India and China, due to their huge increase in consumption over the period (seen in Figure 3.2). For OECD countries, production seems to have reduced and stabilized since 2005. Consumption also follows a similar path.

3.5 Time to switch to the CBM?

As explained before, the differences that can occur between the figures of a same region depending on which of the 2 methods we use mainly depend on trade. Countries that are net exporters of carbon intensive goods will generally have higher production than consumption and conversely for mainly importing countries. Consumption trends differ between the countries.

Within a same country, consumption also differs. Harris, Weinzettel et al. (2020) have studied the impact that cities have on emissions in Europe. They state that cities are responsible for over 60% GHG emissions. They compare 2 scenarios, BAU (Business As Usual) and PC 2050 (Post-Carbon in 2050). They find that in both cases, production-based emissions fall (-31% for BAU, -68% for PC 2050). However, consumption emissions rise for 8 of the ten studied cities (+33% and +35% respectively), which is really alarming. This increase is linked to the increase in GDP and spending. It totally overrides the positive effects of the expected decrease in production of GHG intensive goods. They state that the focus should then be put on the way households and companies consume rather than the way they produce in order to decrease global emissions. From this standpoint, CBM could certainly lead to better policies in rich countries.

In both scenarios, no city is expected to reach carbon neutrality by 2050. Overall, technological progress leading to cleaner production will not be able to compensate for the rise in consumption that is expected and its associated pollution. They support the fact that even if cities reach the goal of being carbon-neutral using PBM, it will not have a large impact on global pollution, because they will have rapidly increasing CBM (Harris, Weinzettel et al. 2020).

Grasso (2017) reviewed the potential strategies in order to implement and use the CBM on a global level, especially for the Paris agreements. He thinks that it is the ideal time to take the decision of changing our accounting method. He puts forward the strategy to adopt in order to switch to the CBM. CBM will of course not cure the problem of emissions but it may help to focus on the core of the problem : the high-consumption lifestyle. He supports the opinion of not using the CBM on its own, but to use it as an additional indicator in order to evaluate the role of each country in the global “carbon budget” (the maximal amount of emissions

authorized in order not to exceed +2°C by 2050). It ensures more justice in the international actions undertaken to at least stabilize the level of CO₂ in the atmosphere. The burden will no longer be put on those who produce (generally least developed countries) but on those who consume these pollution intensive goods (developed countries).

The author suggests an effective way for the implementation of this drastic change. The first stage must be carried out by a limited number of big emitters (developing and developed). This will reduce transaction costs of the implementation. Then, the UNFCCC should develop a formalized process in order to incorporate all countries. Such a change should be taken gradually because of our highly heterogeneous world driven by private interest rather than common good. Strong governance must be applied in order to keep track of the countries' behavior (Grasso 2017).

3.6 Closing remarks on this chapter

Through this chapter, we have reviewed the two most common ways of calculating emissions of a state or region. We have seen the advantages and disadvantages to both, and it depends very much on the point of view that is taken. Considering justice, a switch to the CBM should be taken rapidly, but the reality is quite different. Developed countries are generally richer, and their citizens consume pollution intensive imported products. Switching from the PBM to the CBM will generate new costs for them, since they will have to do extra-efforts in order to reach the goals that are set globally. On the contrary, for developing countries, such a switch will enable them to get a breath of fresh air in their efforts against global warming. This shows the diverging interests of emitters and the difficulty in finding a consensus over an eventual agreement.

In my opinion, the problem is that every country acts first for its own purpose, then for the global purpose. If every country were to think collectively and for the sake of our planet's preservation, and not putting its personal interest ahead, the agreement would be a lot faster to reach. It seems that countries always try to pass the buck to the others and to keep to the minimum of their efforts. This is kind of logical since the more efforts towards reducing emissions, the more costs induced to that country.

4. Data analysis with focus on Belgium

4.1 Introductory remarks

In this section, I will analyze and present many graphs and data concerning consumption and production-based accounting of emissions. First, I explain the methodology that I will use and the provenance of the data. Then, in section 4.3, I will explain and show that the type of accountancy used (consumption or production) and the type of figures used (total or per capita), has major implications on our understanding of progress made, and on the governance and policies that need to be put in place to reduce our impact on the environment.

More importantly, the major focus of this thesis will be put on Belgium. First I will explain the different figures we have in Belgium and then the consequences and conclusions take we can draw from the results. After, another analysis will be made to compare Belgium with another country, similar in area but different in a matter of development and population. This country is Albania. The choice of the country is explained in section 4.5.1.

The analysis will always concern the same period: 1990-2017. The choice of this period comes from the fact that the data for consumption is only available widely since 1990 and up to 2017. This time horizon of 28 years is large enough to show if the recent climate policies have had an impact on pollution. Since 1990 is also the base year of the Kyoto protocol, it will allow the reader to see the potential impact of the implementation of this protocol.

4.2 Methodology of this chapter

4.2.1 Data provenance

Unless otherwise stated, all the data used in this 4th chapter come from the website “www.globalcarbonatlas.org”. All tables and graphs are done with Excel by myself; using the data retrieved from the website above-mentioned. This website lists all data available for the major part of the countries in the world. It has the advantage to list production emissions as well as consumption emissions (since 1990). It uses different provenance of data depending on which type of emissions they account for. Since the data use is conditional on citing the sources, here is the list :

- For fossil fuels emissions : Gilfillan et al. (2019), UNFCCC (2019), BP (2019).
- For cement emissions : Andrew (2019).

- For consumption emissions : updated from Peters et al. (2011), Peters et al. (2012).
- For Land-Use change emissions : Updated from Houghton and Nassikas (2017), Hansis et al. (2015).
- Population (in order to calculate per capita terms) : UN (2018).

Data for fossil fuel emissions and land-use change emissions are based on estimations and so are preliminary for the year 2017.

4.2.2 Methodology used

This thesis aims to focus on comparing emissions as measured by consumption or by production. Production measurement of emissions is relatively easy to find and comparable between countries in terms of methodology. However, consumption methods sometimes slightly differ when reporting on different countries. In this set of data, they use the consumption method of accounting developed by Peters, Davis et al. (2012). Below, I will explain the methodology in question. The advantage is that in this set of data, each country's consumption accounting uses this same methodology, which allows comparability between countries.

The method of calculation for production emissions is well known. It would not add value to repeat an explanation of that methodology here. I will then focus on consumption. To reallocate territorial emissions to a consumption perspective concerning international flows, Peters, Davis et al. (2012) consider carbon associated with industrial production as well as with household activities. Industrial emissions are reallocated throughout the supply chain, even if it is across borders.

For the reallocation of carbon embodied in international trade along the supply chain, Peters, Davis et al. (2012) use the so-called MRIOA approach (Multi-Regional Input-Output analysis). First of all, the definition of consumption is important. There is a difference between “apparent consumption” and “final consumption” when it comes to the environment. Apparent consumption is closely related to the physical good and is defined as “the amount of a product produced within a region plus imports minus exports” (Peters, Davis et al. 2012). It assumes that there is no transformation of products, the good is consumed in the state it is imported. It neglects the distinction between intermediate and final consumption. By comparison, “final consumption” is defined in the SNA (System of National Accounts) as “the goods and services

used up by individual households or the community to satisfy their individual or collective needs or wants” (United Nations et al., 1993). It excludes goods consumed as inputs in production processes. The authors use the example of timber to differentiate between apparent and final consumption. Apparent consumption does not consider timber that would be transformed as paper or other furniture whereas with final consumption, the distinction is made. The method that is chosen is the final consumption using MRIOA. The main reason for this is that the method represents the entire economic structure (Peters, Davis et al. 2012). It is also the method for which there is better availability of the data. The key thing is to ensure that the same method is used for each country, for each year.

MRIOA studies the supply chain from top to bottom, including all processes. So, it covers all emissions, from the producer to the consumer. It is designed to analyze large data bases. The authors say : “We allocate emissions to country X using the following definitions :

- Production: Emissions occurring on administered territories over which X has jurisdiction (territorial-based emissions);
- Exports: The production-based emissions occurring within X to produce exports to both intermediate and final consumption and hence including the domestic supply chain only;
- Imports: The emissions in each country (other than X) required to produce final consumption in X and including the global supply chain;
- Consumption: The global emissions required to produce the final consumption in X and including the global supply chain”. (Peters, Davis et al. 2012)

An important issue is the emissions during transport (e.g. by ship). The EU recommends the bunker fuels used for international transport to be allocated to the country of residence of the company operating the mean of transport (European Commission, 2009). The methodology then follows that recommendation for production. For consumption, it ultimately falls into the consuming country.

When allocating externalities derived from emissions with the consumption method, the emissions are allocated to the final consumption on the good, no matter the sector. So, it may be that emissions that have occurred in agriculture end up allocated to food consumption.

The next step is to consider CO₂ embodied in trade. The authors review the literature and find that different studies show similar results. The variation between studies come from the data bases used by the various authors, or the definitions they use for consumption.

Since I will only work with one method and one database in this thesis, the results will be able to show trends that are comparable between countries (or group of countries). But, as explained by the authors, absolute results may differ between this thesis and other works that have been done previously using other methods. The results that will be obtained should then be used and handled carefully.

4.3 Differences arising from which method is used

4.3.1 Production emissions

When one talks about big emitters, countries that contribute the most to global warming on earth, we generally think about China, India, USA, ... In absolute terms and from a global perspective, this is true! These countries are the biggest emitters in the world. Also, a country like China has recently seen a boom in its production emissions going from 3349MtCO₂ (1MtCO₂ = 1 Megaton of CO₂ = 1000 tons of CO₂) in 2000 to 9839MtCO₂ in 2017! This represents a 293% increase in emissions over 17 years.

Conversely, the EU28 taken as a whole has diminished its production emissions from 4184MtCO₂ in 2000 to 3518MtCO₂ (18% decrease) over the same period. The difference can partially be explained by the level of development of each entity and by the Kyoto Protocol. China has started developing later and is still considered as an industrializing economy, whereas Europe is already considered as a developed entity. It has been previously shown that in order to grow and develop, a country generally has to produce more and so, typically, although not always, to pollute more. As mentioned before, the EU had to reach a target reducing its GHG emissions by 8% compared to 1990 levels by 2012 (note that this was originally the target set for EU-15).

However, when we change our standpoint from absolute terms into per-capita terms, the result can be different. China, which is the #1 polluter in absolute terms, is the 39th ranked country in per capita terms (2017). This means that, when we adjust for the population of the country, China's pollution per inhabitant is much lower than many other countries. At the top

of the podium of production emissions per capita is Qatar. In 2017, Qatar had territorial per capita emissions of 40tCO₂ (1tCO₂= 1 ton of CO₂), whilst China “only” had 6.9tCO₂ per person. In 2017, the EU28 had an average of 6.9tCO₂ per capita. So, if we talk about production per capita, the EU28 was, in 2017, as bad as China.

From this per capita perspective, the worst polluter is Qatar. In these terms, it pollutes much more than China. Though, one needs to be careful before making the assumption that Qatar needs to undertake more efforts than China. Indeed, air pollution such as CO₂ pollution is a problem that needs to be tackled globally. A ton of CO₂ released into the air has the same effect on the atmosphere whether it is rejected in Alaska or in Sahara. Another argument is that the size of the country. Take Qatar, and imagine the country multiplies its emissions by 200% for the year 2017, this is an enormous increase in percentage terms! But in absolute terms, Qatar only emitted 108MtCO₂ in 2017, so this increase would lead to 108MtCO₂ more in the atmosphere. This appears insignificant compared to the total 35811MtCO₂ emitted in the world in 2017 (it represents a 0.3% increase in global emissions). Contrarily, if we apply the same rationale with China and double its 2017 emissions, this yields a massive 9839MtCO₂ increase, it represents a global emission increase of more than 27%!

This previous paragraph shows that, of course, every single country needs to undertake policies in order to reduce its CO₂ emissions. But it is crucial that big emitters reduce drastically their emissions for the sake of our common planet and environment. Emissions in absolute value do not have to be neglected and remain important and critical when undertaking environmental policies.

Per capita figures remain essential when comparing countries. Indeed, it allows comparison between countries of different sizes on equal terms (inhabitants) and it also enables to view emissions from an equity standpoint as one human being is one human being; so, saying that Chinese individuals should pollute less because the country is very big is a shortcut that cannot be taken.

4.3.2 Consumption emissions

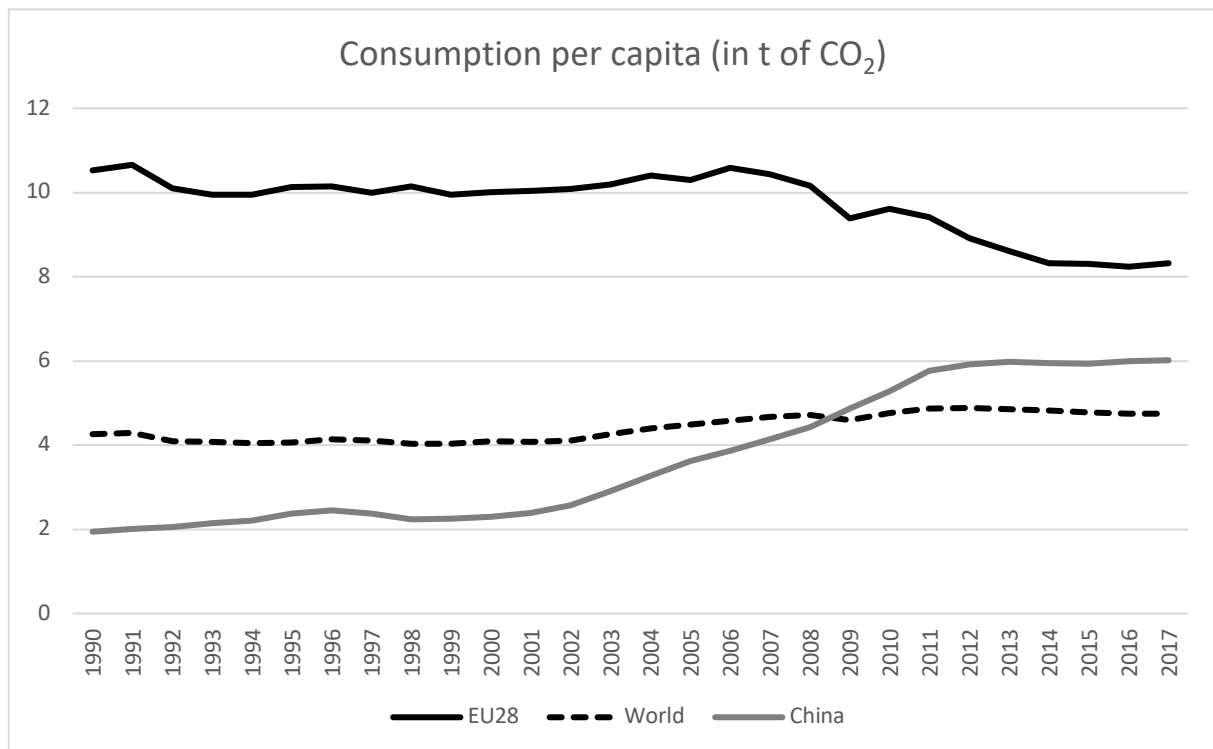
The same reasoning that the previous section (4.3.1) will be made in this section. With no big surprise, the top 3 emitters in terms of consumption are the same than if we look in production

emissions (#1 China, #2 USA, #3 EU28). China consumed 8549MtCO₂ in 2017 alone. Compared to production, this is 1290Mt lower, meaning that China is a net exporter of CO₂. Over the period 2000-2017, consumption emissions in China grew from 2961Mt to 8549Mt, which represents an increase of 288%, slightly lower than the increase in production (293%), but still huge. This highlights again the fast development of the country.

Concerning EU28, its CO₂ consumption emissions went from 5017Mt (in 2000) to 4246Mt (in 2017), showing an 18% decrease over the period. This is the exact same drop in percentage as in production emissions. Still, if it seems to show that Europe has had more ease to decrease its emissions, this trend could certainly be explained by its advanced level of development and also by the policies set out in the Kyoto Protocol.

When taking per capita terms, the overall picture is different. Still, EU28 has a diminishing curve and China a growing one. Indeed, Europe has gone from 11t to 8.3t per capita (32,5% decrease) while China has gone from 1.9t to 6t per capita (315% increase) over the period. However, when computing both on a graph (see in Figure 4.1 below), we see that Europe is still higher than China on per capita terms. This graph tells us that, even if Europe is making progress in diminishing its emissions, it is still too high and way over the world average, and we see that by comparing it to the world emissions (the dotted curve). Europe, even though showing real progress, is still a huge consumer of CO₂. On the other hand, China is since 2009 above the world average but nevertheless remains below Europe and it shows growing CO₂ emissions until recently since per capita emissions seem to stabilize over the last decade.

Figure 4.1



On the top of the podium lies Qatar again (in consumption terms) with 30t per capita (10 ton less than in production terms, meaning Qatar is still a net exporter). Again, one should not extrapolate these results as this represents a really small fraction of global emissions and the same reasoning that the one done in the previous section must be done.

4.4 Focus on Belgium

This section will be the core of the analysis, the purpose of this thesis: Analyzing more deeply one country, which is Belgium.

4.4.1 Why Belgium?

First of all, I decided to opt for Belgium because it is my homeland, and I have always lived here and am concerned about the environmental policies that we, as a country, must put into place in order to ensure a brighter environmental future for our future generations. By studying our production and consumption in CO₂, I hope to better spot the structural problems that may (or not) obstruct our road to the ultimate goal of the long-term preservation of our environment.

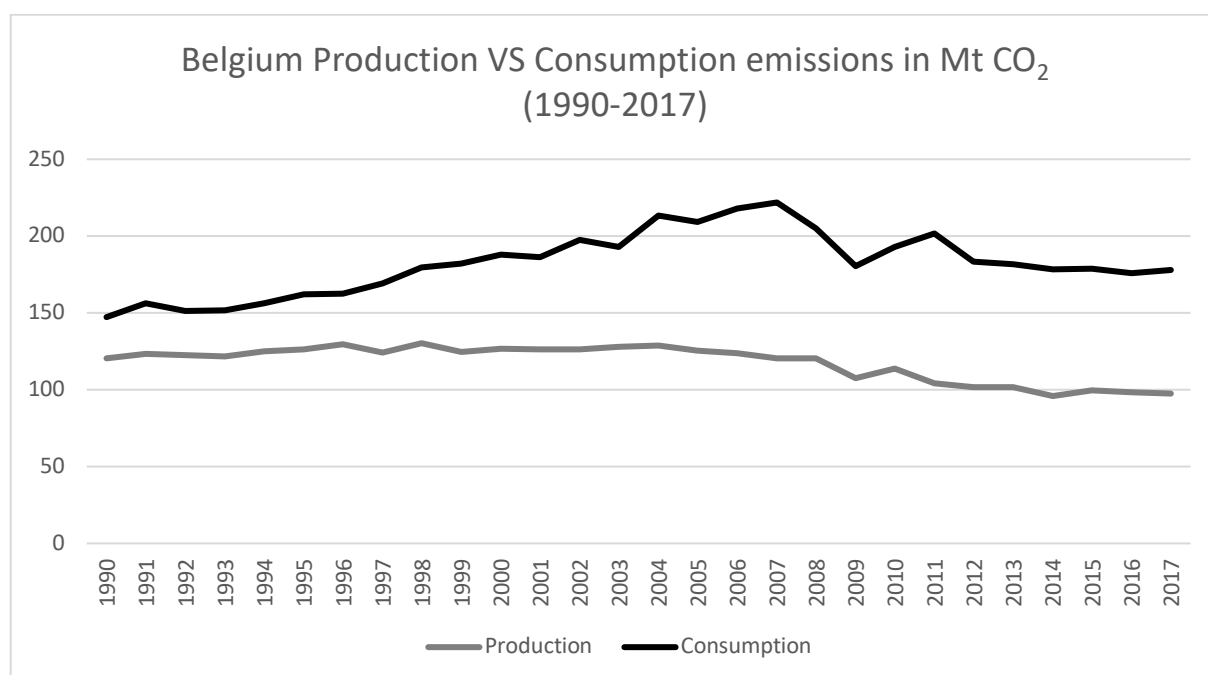
Also, to the best of my knowledge, I do not think that such an analysis has already been done for Belgium. By doing this work, I hope to contribute to overall understanding and to the existing literature in a new way.

The particularity of Belgium is that it is a founding member of Europe, that it trades a lot abroad because of its relatively small size, that it has access to the sea with relatively important ports. The country is developed and is oriented towards services rather than manufacture.

4.4.2 General picture of the situation in Belgium

This section will explain the current situation of Belgium on the time horizon 1990-2017. Each graph's title explains the method used to compute the data and the units.

Figure 4.2



This figure shows the evolution in gross terms for Belgium between production and consumption. We see that consumption always remains above production, meaning that Belgium is a net importer of CO₂. In other terms, Belgium produces less CO₂ than it really consumes.

Even more interesting, we see a diminution in production emissions over the period (from 120Mt to 97Mt), which at first glance, seems fine. This should mean that Belgium has undertaken successful environmental policies that have led to the reduction of emissions on the territory. This may be the result of the several agreements to which Belgium is a party (such as the ones described in Chapter 2 and notably the Kyoto Protocol).

However, when we account for the emissions resulting in consumption in Belgium, we see a steady increase from 1990 to 2007 and a downward trend thereafter – even though this recent downward trend does not compensate the earlier increase. It rose from 147Mt to a peak of 221Mt in 2007 and since then a decline (on average) up until 2017 with 178Mt. This poses the question of the effects of global agreements such as the Kyoto protocol. From the KP perspective, Belgium has done well because it has decreased its production emissions. But we see on the figure that, in fact, consumption of CO₂ in Belgium has not diminished, and has even risen. One reason of this could be that Belgium has lowered its CO₂ production in order to comply with the new environmental goals and standards, but has, on the other hand imported more CO₂ intensive goods from industries abroad, thereby creating a sort of carbon leakage.

This previous paragraph shows that there is conflicting results when accounting for CO₂ emissions in Belgium. In my opinion, from what I have heard when discussing about this thesis, most people think that we are doing well on GHG emissions, but this exposes it is not the case. People may tend to blame producers for the worsening of environmental conditions, but this shows that the problem seems to lie within our own consumption, or at the minimum, it may mean that consumers are less environmentally conscious, or even simply environmentally informed, than they should be.

What we can see on this graph that is also striking is that the gap between consumption and production has increased over the period, with an increase in consumption and a decrease in production if we look at both evolution on the whole period. It is a bad signal for the trend in the coming years. This will be highlighted in Figure 4.3 below.

Then, Belgium seems to be in need of more consumption-oriented environmental policies in order to reduce its consumption emissions. It also needs to include policies for final consumers and for industries that import products for their production processes. Such a consumer-oriented policy would add an additional responsibility for our country's

environmental behavior. Each of the inhabitants would have his share to play in order to reach a goal previously set (in the case of a “new” consumption-oriented policy), always keeping in mind this objective of the reduction of emissions. It is not because Belgium has decreased its CO₂ emissions and has complied and attained the goals set by the Kyoto Protocol (which is a production-oriented policy) that the country is an example for his peers in this regard. As shown on Figure 4.2, consumption does not seem to slow down that much.

Figure 4.3

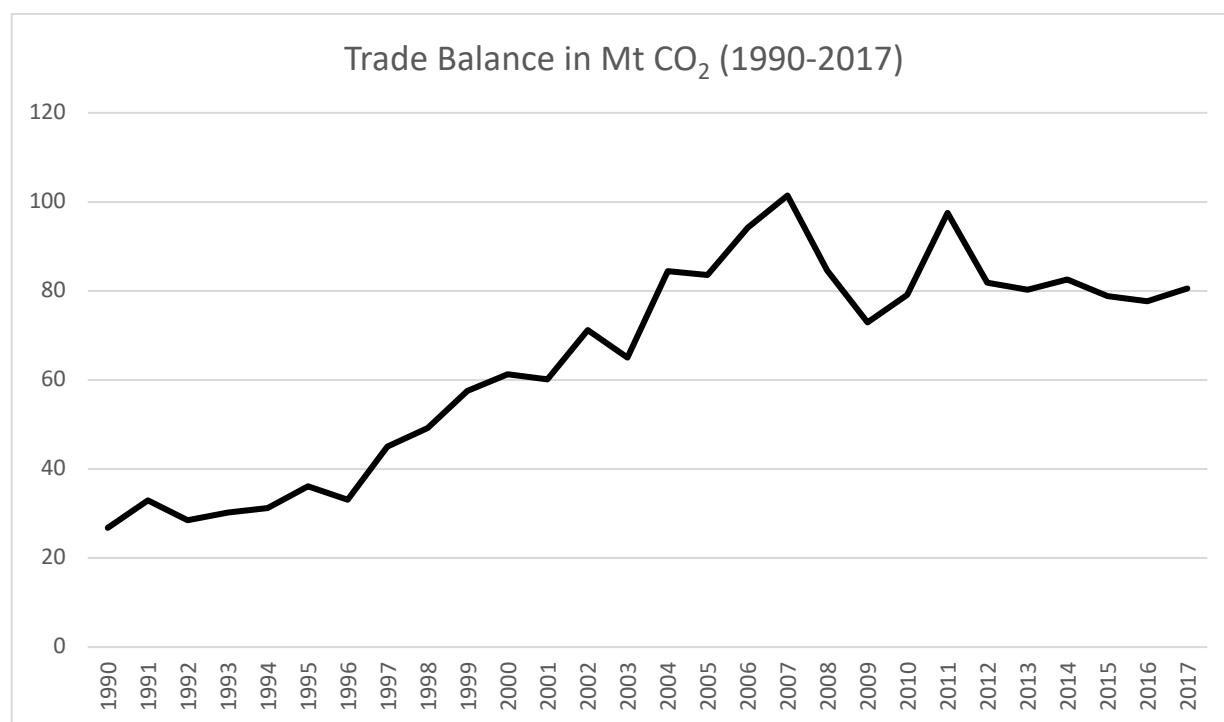


Figure 4.3 shows the trade balance of Belgium over the period in question. It basically represents the net amount of CO₂ imported in Belgium (= Consumption emissions – Production emissions). This graph represents the gap between consumption and production, as exposed in Figure 4.2. We see that the trend was steep for over 15 years, but seems to have stabilized (at a high level) now. For example, in 2007, we consumed 101 Mt more than what we produced (which was 120Mt). Figure 4.4 below will bring to light more evidence of the CO₂ consumption problem in Belgium.

Figure 4.4

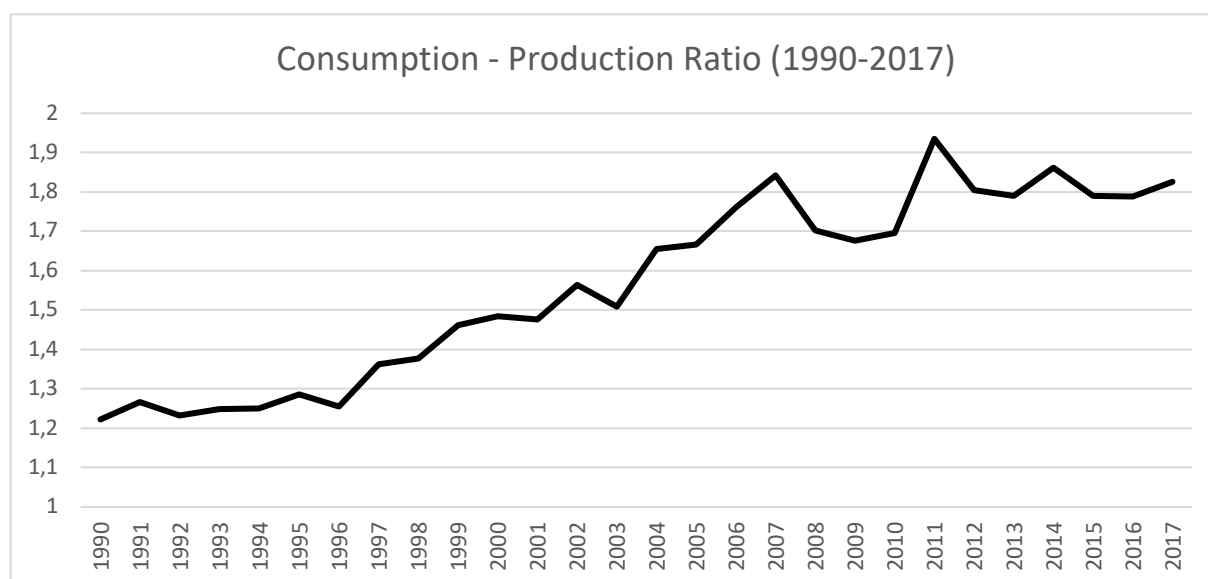


Figure 4.4 represents the ratio between consumption and production. Its calculation method is pretty easy, it simply represents overall consumption divided by overall production (of CO₂). For example, if the ratio equals 2, it means that the country consumed 2x time CO₂ than it produced over the year in question.

For Belgium, the ratio shows again a bad image of our country in CO₂ terms. In 2011, the peak of the ratio was reached, with a ratio = 1.93, which is really bad. It means that Belgium consumed 1.93 times more CO₂ than it produced! It is even more alarming when we see the trend of this ratio. From 1997 (KP's entry into force year), the ratio has gone from 1.36 (which is honorable for a small and high importing country) to 1.82 in 2017. Since 1997, the ratio has grown nearly every year. And if we compare this Graph to Figure 4.3, we do not see the stabilization towards the end of the period but rather, a continued worsening trend.

That being said, one must not forget the Kyoto mechanisms developed in section 2.3.2.1. As a quick reminder, developed countries can provide help to developing countries in order to reduce emissions abroad via technology transfers for example. Then, the developed country “receives” an amount of credit (in t CO₂) that he is now allowed to pollute on its territory. This reminds us that the pollution problem has first to be seen globally. So, some countries might have still high production figures, but it has to be kept in mind that this might result – at least partially - from successful policies undertaken by the country in developing countries. It must never be forgotten that the pollution problem is global and must not be viewed too narrowly.

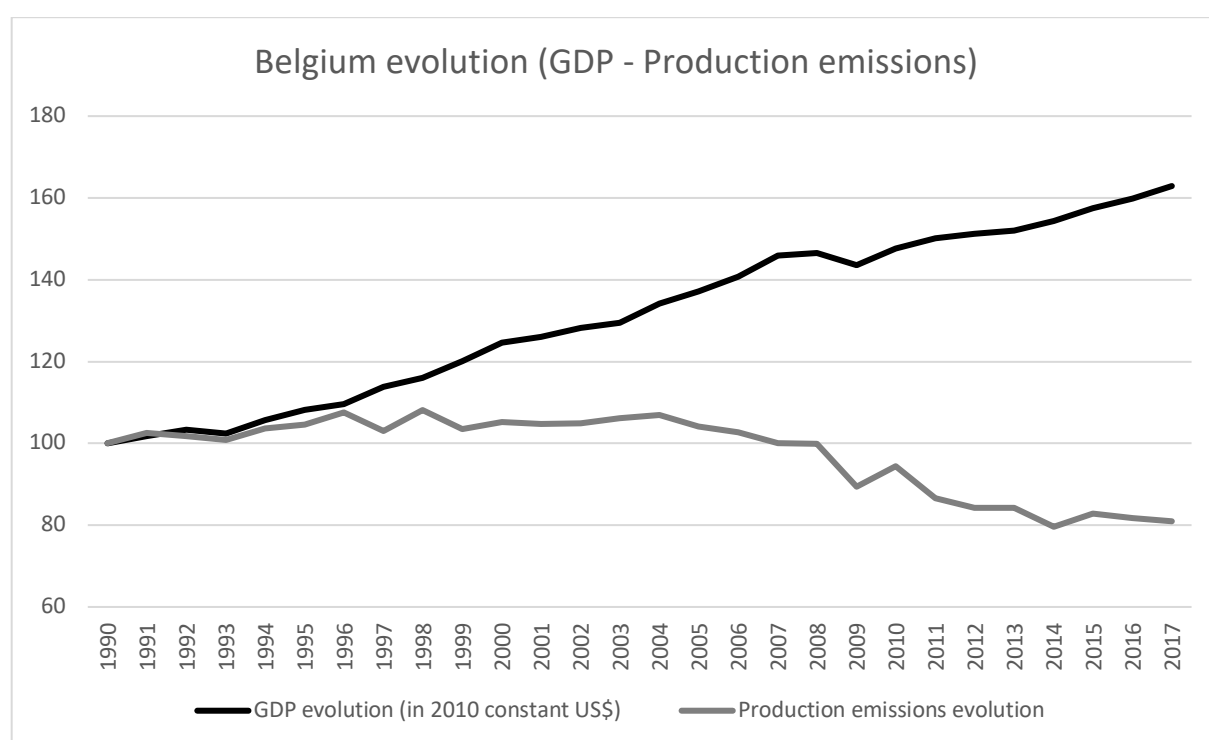
4.4.3 Decoupling in Belgium

4.4.3.1 Preamble

Decoupling is generally associated with GDP (computed at constant prices, and in absolute values or per capita) and emissions (with the production-based method). There is a relative decoupling if the economic growth (represented by the GDP) grows faster than the emissions. There is an absolute decoupling if economic growth is positive and emissions are decreasing. Coupling is used when both follow the same path.

4.4.3.2 Application of the general definition of decoupling in Belgium

Figure 4.5



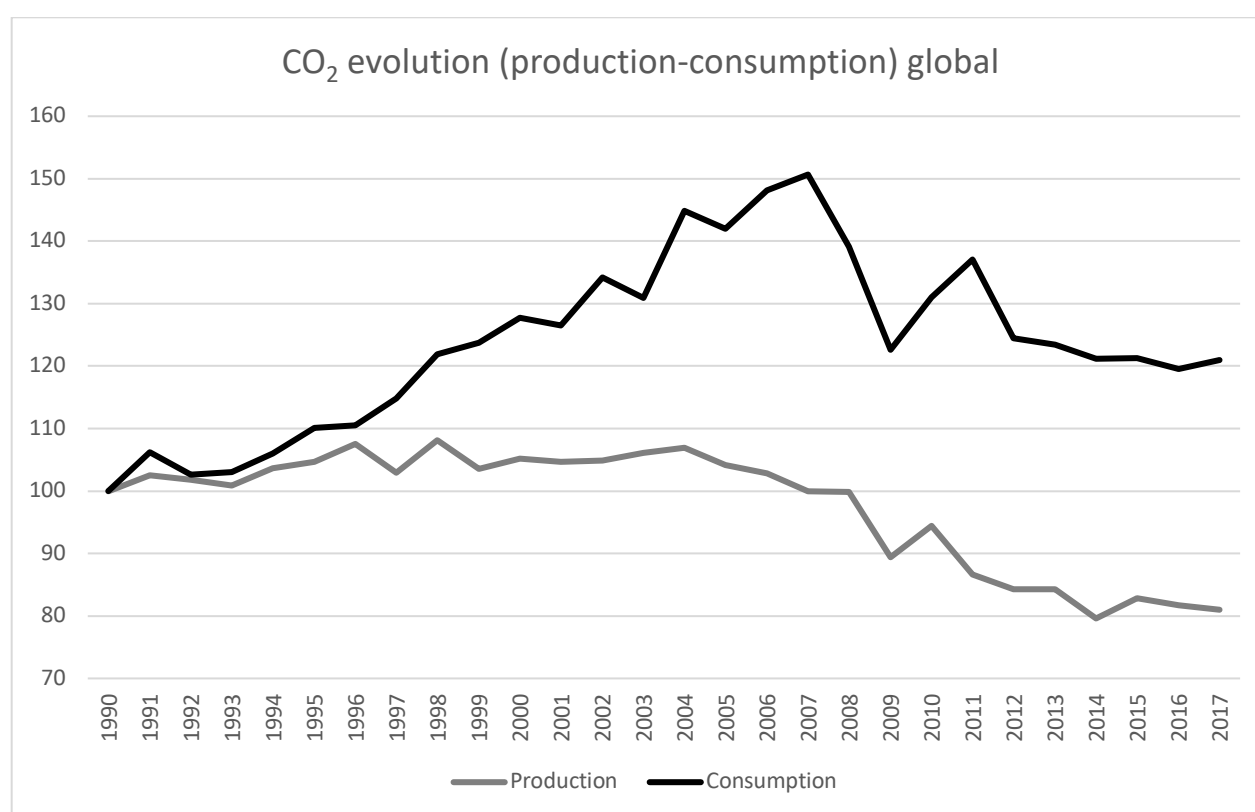
This figure 4.5 represents the evolution of the GDP (in 2010 constant US\$) and the one of the production emissions in Belgium. Both variables are indexed at 100 for 1990 for ease of exposition. As expected, production emissions follow a downward trend, and GDP an upward trend. Generally speaking, we can see a coupling between 1990 and 1996, and then a relative decoupling (on average) between 1996 and 2004. Finally, an average absolute decoupling between 2004 and 2017. The date of the beginning of the decoupling matches within a year with the date of introduction of the Kyoto Protocol. It seems the KP may have had an impact on emissions once again. It shows that the country has succeeded in reducing its CO₂ emissions

in parallel with having a positive growth. Once again, the emissions are calculated in production terms.

4.4.3.3 Application for CO₂ emissions using both methods

In this section, this reasoning will be imitated for production and consumption emissions in Belgium, in order to see if the trends go hand in hand or separate ways with opposite growth signs. In order to see the trend that both production and consumption have followed since 1990, I have put them on the same graph using the same base year method (1990) as in the previous graph. This allows us to see the trend that both have followed since 1990, and to see if we can see similar shocks with a common scale. Has production and consumption followed a similar increase or have their paths parted?

Figure 4.6



This figure 4.6 clearly shows a kind of decoupling. This term means that once a certain threshold is reached, consumption and production follow opposite paths:

- The period 1990-1994 shows a coupling between both methods of accounting
- Then, from 1995 to 2004 there is a relative decoupling, with a relatively constant level of production, and a growing level of consumption of CO₂.

- Finally, from 2003, the downward trend is heavily pronounced on the production side (close to 25% for that sub-period) while it is much more imprecise and minor on the consumption side (10% and an increasing path for the last year of the sample, thereby creating a potential risk of absolute decoupling).

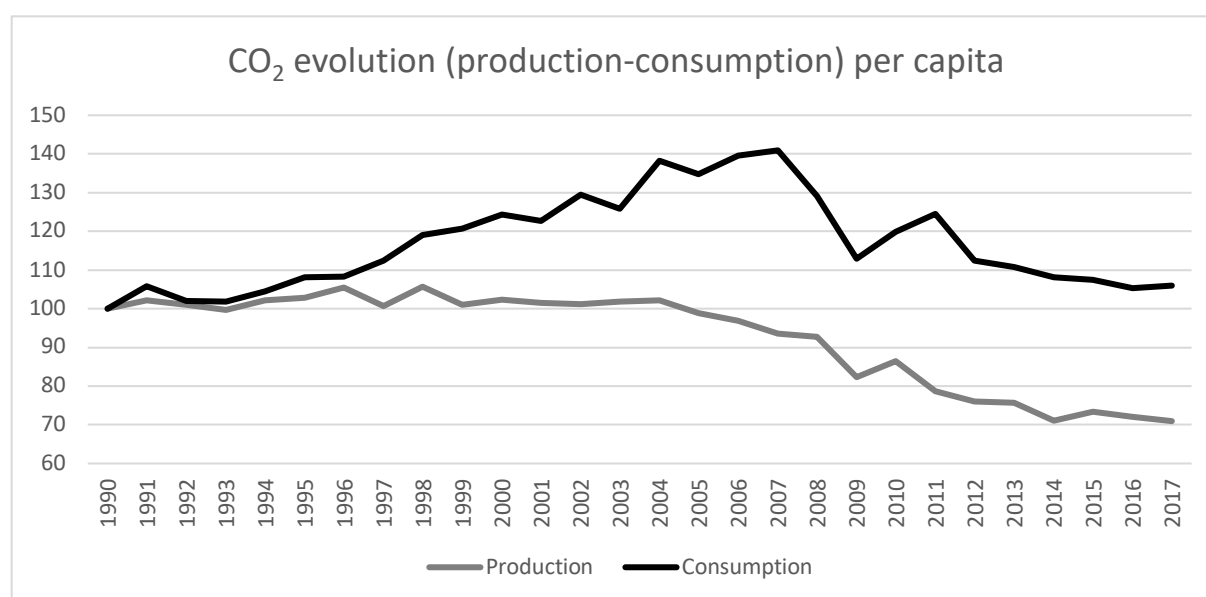
If we take the gap between consumption and production (Figure 4.6), we see that it has substantially grown over the period. We see that both curves do seem to be confronted with some common shocks. The consumption negative shock between 2007 and 2009 seem to have an impact on production (that has also decreased over the period) but this impact is clearly softer for production than for consumption.

More optimistically, we can see that from 2011, both trends do not suffer high positive shocks and are downwards sloping. This trend needs to keep its descent in order to reduce our CO₂ releases in the atmosphere.

With the production curve taken alone, we see, as expected, a decrease in the production of around 19% over the total period (from 100 to 81). This goes in line with the gross terms of CO₂ production in Belgium explained before (Figure 4.2).

Now on to the consumption curve. This one turns out to be more problematic. Indeed, over the total period, consumption emissions have risen by nearly 21% in Belgium, with a peak of 50% in 2007. This shows again the problem of consumption in Belgium. Consumers need to be more aware of the provenance and more importantly the CO₂ footprint of the goods they consume. More consumption-oriented policies need to be put into place, for example policies that encourage local consumption and circular economy generating less waste and fewer purchases of new products, that are generally more polluting than second hand or recycled products in general.

Figure 4.7



When accounting for the evolution, but in per capita terms this time, both curves seem to follow more similar paths, compared to their gross terms. However, when we look more into details the figures obtained, it shows a more positive image of the country's situation. Over the period, consumption has increased by only 5% (compared to 21% in gross terms), and production has decreased by 29% (compared to 19%). This shows that one of the reasons for the increase in consumption can be simply the population's growth. However, this cannot be taken as an excuse since the atmosphere does not account for the number of people living on the planet. Pollution needs to be reduced no matter how many human beings live on earth.

Figure 7.1 and 7.2 in appendices show the evolution from respectively production and consumption in both global and per capita terms on the same graph. It shows that both global and per capita figures seem to suffer from the same shocks, generally a little less from the per capita perspective.

4.5 Comparison Belgium – Albania

4.5.1 Reasons for the choice of Albania

When looking for a country to compare Belgium with, I started by searching for countries that are similar in size. I also wanted a country that is not part of the OECD to see if there is any policy differences between the 2 countries. Albania differs of Belgium for many reasons :

- Its level of development is inferior to the one of Belgium.

- Its wealth (determined here by the GDP) is much lower than Belgium. Its GDP/capita is equal to 5353 USD, whereas Belgium's one is to 46117 USD (World Bank, 2019).
- Its political situation is tense, with many demonstrations.
- Its population is approximately one quarter that of Belgium's (2 870 324 inhabitants for Albania).

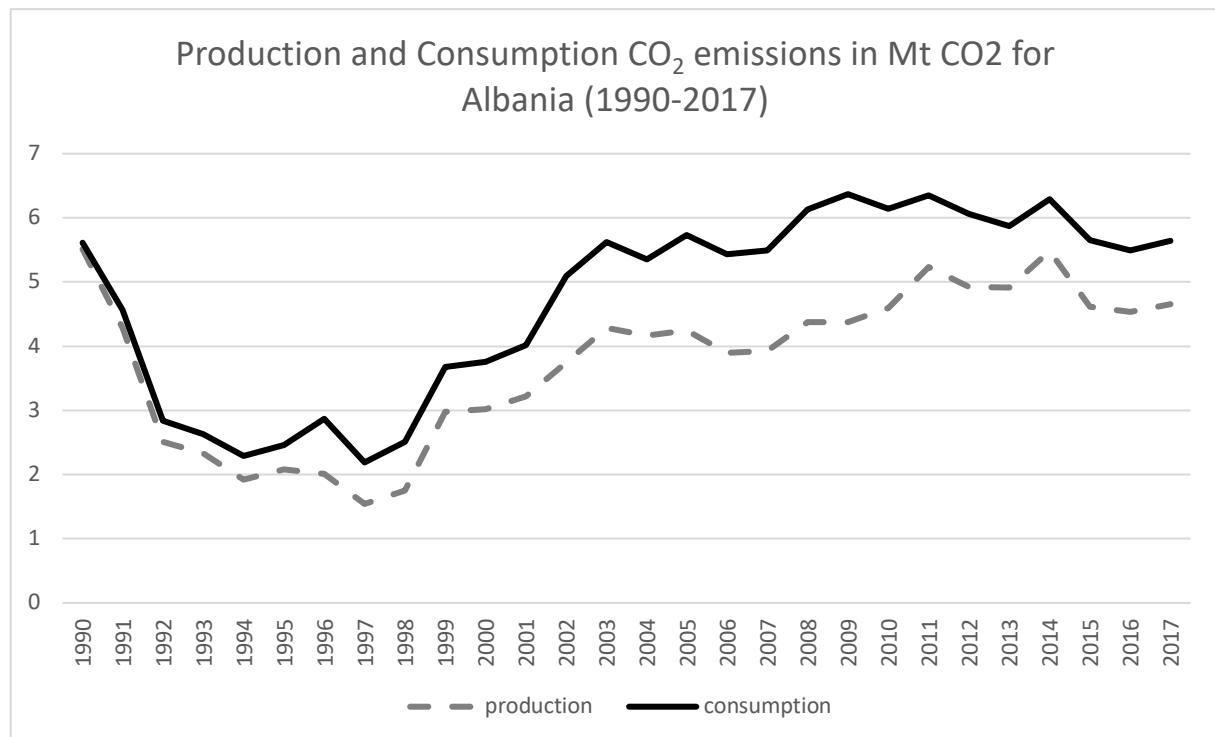
Albania does also share some characteristics with Belgium :

- It has access to sea
- It also has a parliamentary democracy
- It is also part of NATO
- It is situated on the European continent, but is not yet part of the EU28 (application submitted in 2009).

The following sections present data for Albania and compare the situation in Belgium and Albania. In each case, the numbers that will be used will be in per capita terms (excepted for Figure 4.8 below). Indeed, when comparing between 2 countries it is always safer to control for population of those 2 countries.

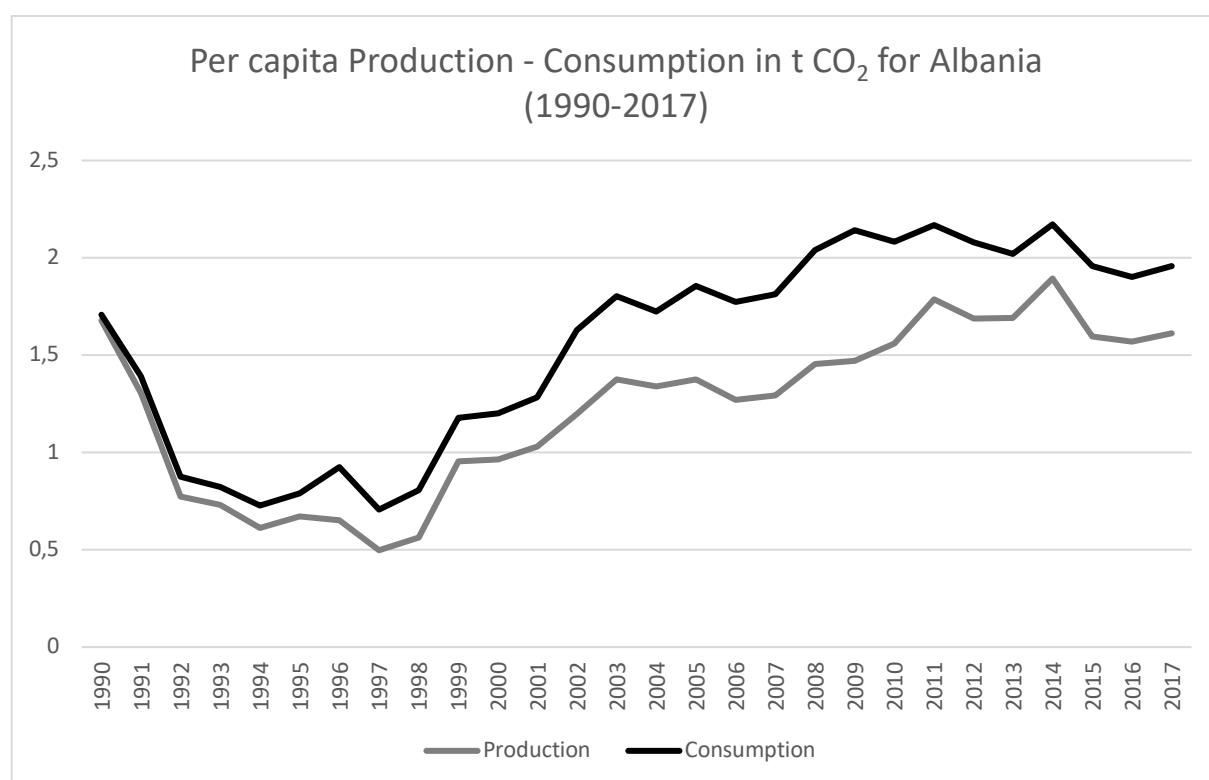
4.5.2 General picture of Albania

Figure 4.8



From this Figure 4.8, we see that over the period, Albania has had opposing figures in terms of growth in CO₂ production emissions (dotted grey on the graph). From the beginning to the end, production emissions decreased by 0.86Mt CO₂. But between 1990 and 1997 production emissions decreased by nearly 4 Mt CO₂. Since then, emissions have risen and now it looks as they have stabilized at around 4.5 Mt. The curve for consumption follows more or less the same movements. Here, we also see that Albania's consumption has always been bigger than its production in CO₂ (at least over the period). It may seem paradoxical that after KP's entry into force, emissions have risen, but Albania entered the Kyoto protocol in 2005. Moreover, it had no target and no obligation in reducing emissions, and started from a low level. However, by entering the Protocol, Albania commits itself to undertake actions in order to stabilize CO₂ emissions (OHCHR, n.d.).

Figure 4.9



When looking in per capita terms, we see that the curves are similar to the ones in gross terms. We see that at the beginning of the period consumption and production were really close and then the gap has increased over the years, even though it stopped worsening over the last decade.

Figure 4.10

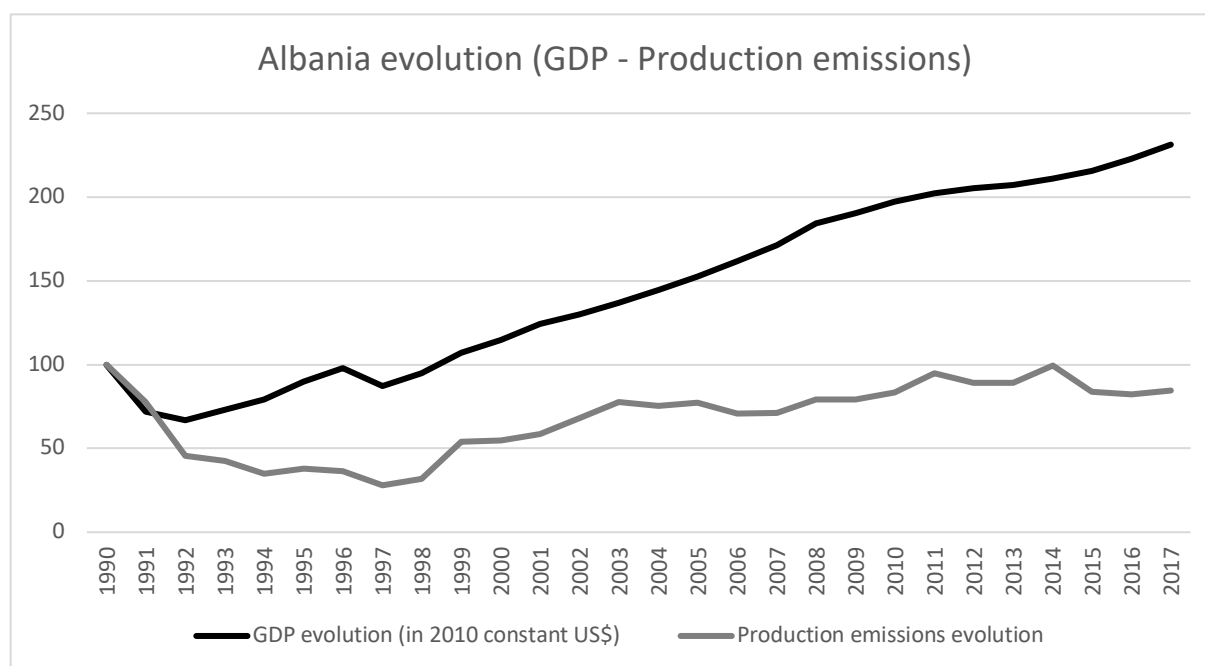


Figure 4.10 shows the evolution of the GDP of Albania (in 2010 current US\$) compared to the evolution of its production emissions over the period. We see a coupling from 1990 to 1992, then an absolute decoupling between 1992 and 1996 and finally, a global and long period of relative decoupling until 2017. Indeed, we see that both are increasing, but that the growth of the GDP exceeds the growth of the production emissions. It shows that the general wealth has grown more rapidly than the environmental damage on the territory the country. Indeed, the gap between both curves has increased since approximately 1999.

4.5.3 Comparison Belgium – Albania

From now on, everything will be done in per capita terms to ensure comparability. First of all, let us see the difference between production and consumption of each country. The general unit for these calculations is in t CO₂ (ton of CO₂).

4.5.3.1 Production comparison

Figure 4.11

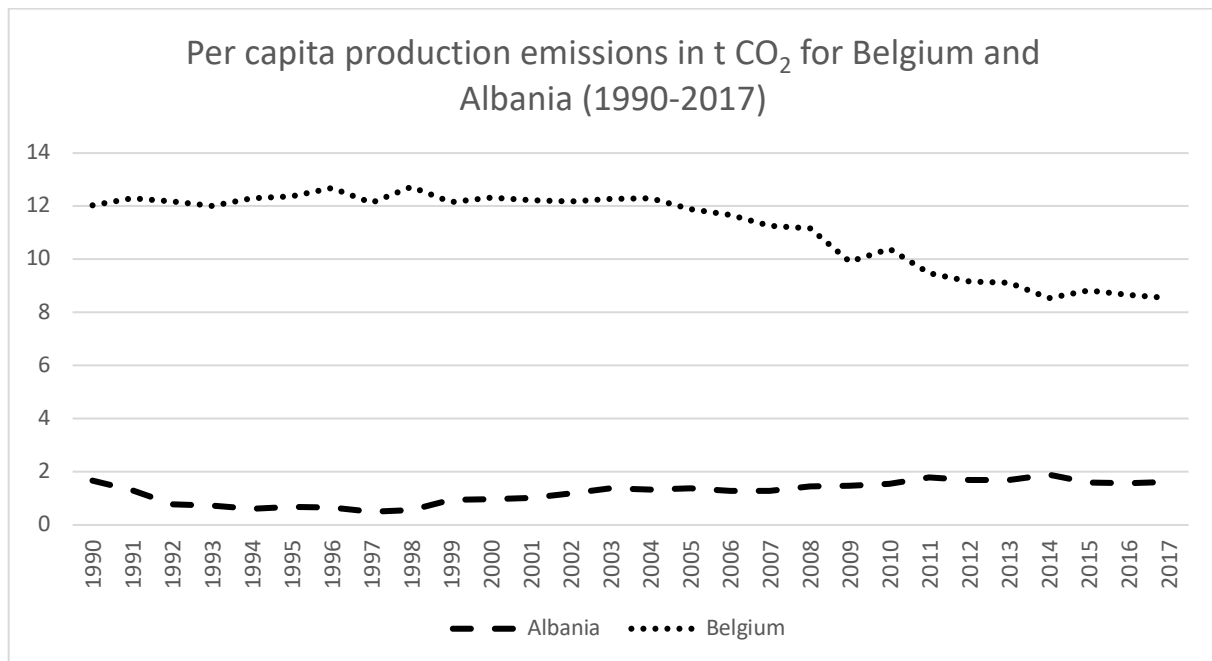


Figure 4.11 allows us to see a huge difference between the production emissions in Belgium compared to Albania. The gap is huge between the 2 countries. It shows how much difference it can exist in production terms between 2 countries that are on the same continent. In 2017, Belgian's emissions are almost 5 times those of Albania.

The difference is getting smaller for multiple reasons. Figure 4.11 also reveals that the gap between the two countries is shortening, and notably that Belgium, who is part of the first signatories of the Kyoto Protocol has seen a decrease in its production emissions since 1990. This makes sense since Belgium is bound to the protocol. On the other hand, Albania's emissions seem stable on the long run. This may be due to two different reasons, each driving emissions up or down : first, Albania is developing and then need to produce more and pollute more, but oppositely, Albania has committed to the KP and tries to undertake actions to reduce its CO₂ emissions. Since 2005 (KP introduction in Albania), the country's emissions have grown by 16%, which is reasonable compared to the growth of its GDP of 61% over the same period!

Figure 4.12

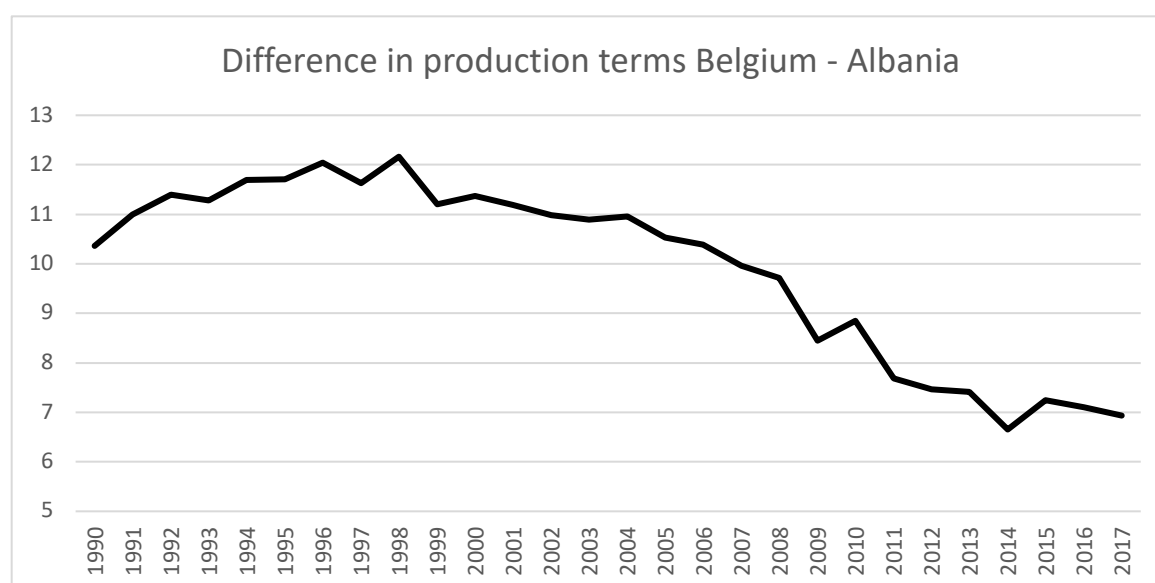


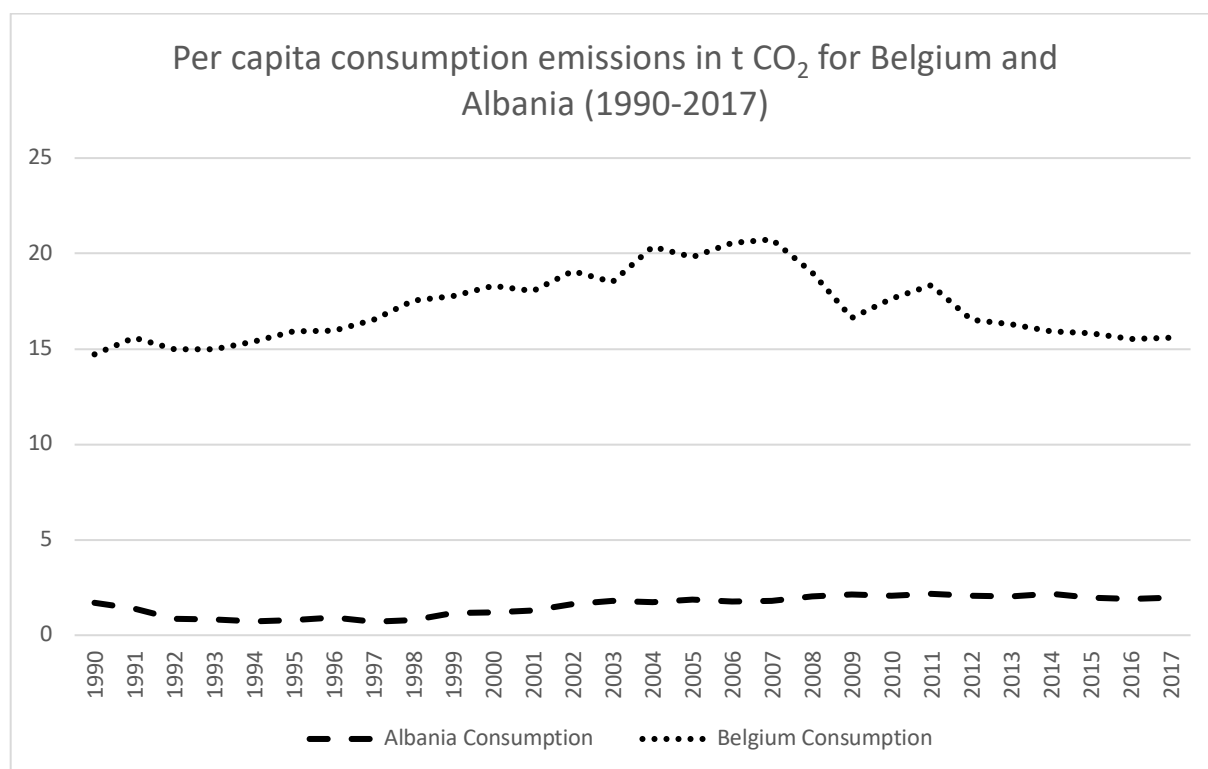
Figure 4.12 illustrates the gap between production terms of Belgium and Albania over the years (It basically represents evolution of the gap in Figure 4.11). Looking at Figure 4.11 and 4.12 altogether, we can explain the shrinking of the gap. Most of this narrowing is explained by Belgium's emissions reduction, the rest is due to the slight increase in Albania's production emissions.

Still, the gap remains quite substantial in 2017 (nearly 7t CO₂ per capita), when we know that Albania's emissions in 2017 are 1.62 ton per capita. Both countries seem to have production processes and specializations that are heterogeneous in emissions.

Taking the figures as they stand, carbon leakage could be an explanation of this reducing gap. Let me demonstrate. Since 1997 (KP introduction), we see that Belgium's emissions have decreased from more than 12t in 1997 to 8.5t in 2017. On the other hand, Albania, which is a developing country, has seen its emissions grow threefold (from 0.5 to 1.6t – see Figure 4.11) over the same period. Could one of the reasons for these opposite paths be that Belgium has exported part of its polluting processes to Albania (we can generalize this by considering Belgium a developed country and Albania a developing country)? This could be one of the possible reasons for Albania's increasing emissions, among many others. Or Albania's increasing production emissions could more simply be the logical continuation of growing consumption and wealth of the country? Let us see that in the next section.

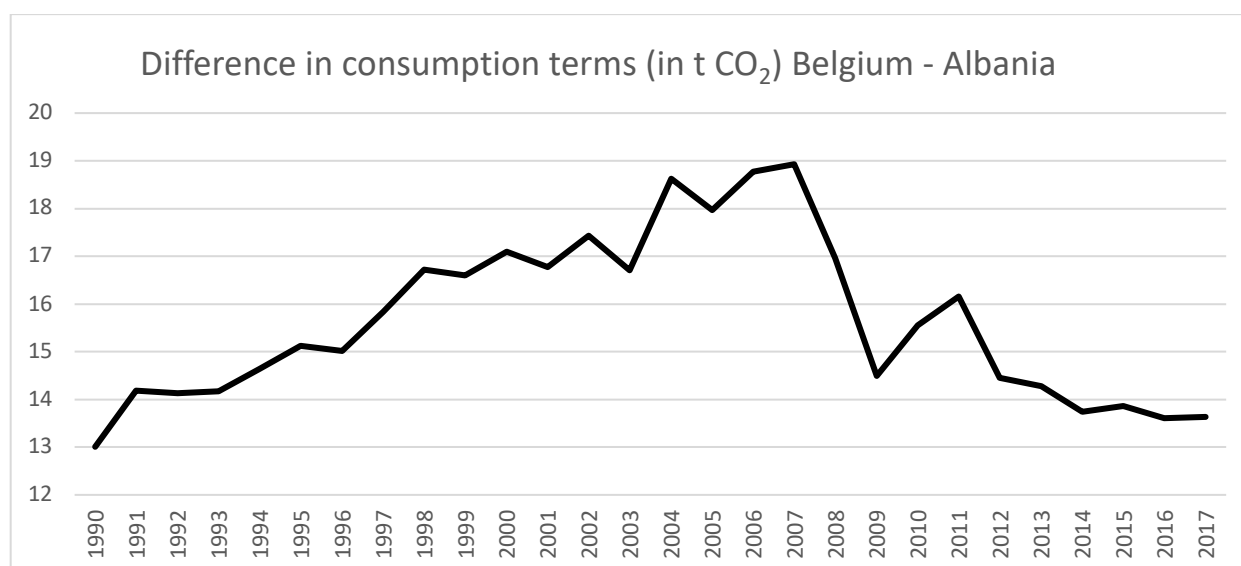
4.5.3.2 Consumption comparison

Figure 4.13



Belgium's consumption path does not follow the same path as its production one. Here, we see that it has globally remained stable, unlike production, which has decreased. For Albania, the consumption path seems similar to the production one, with stable emissions. The gap between the two countries remains quite big. Figure 4.14 highlights that below.

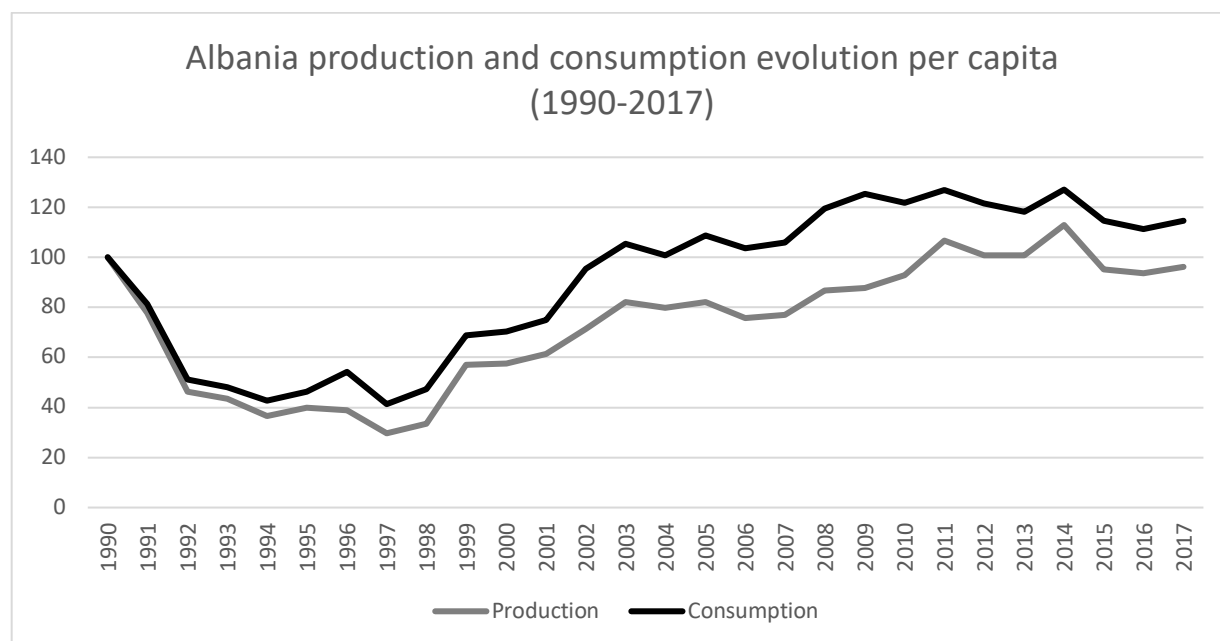
Figure 4.14



These 2 previous figures show us the difference between Belgium's consumption emissions and Albania's consumption emissions for each year of the period. We see that there has been some movement but that over the whole period, the gap is nearly the same at the start and in the end (13t in 1990 – 13.6t in 2017). This means that in terms of the growth rate of consumption emissions over the 27 years period, Albania and Belgium have similar figures when comparing the first and the last figures of the data set.

Let us now see if Albania's production and consumption emissions have increased or decreased together, or if we can see some kind of decoupling. Figure 4.15 will put both on the same starting scale with 1990 as the base year.

Figure 4.15



From this Figure 4.15, we see that production and consumption of CO₂ are closely related in Albania. Excepted at certain precise points, the curves evolve in parallel. The global evolution of the graph is a coupling. We see that per capita emissions have first decreased on the whole (1990-1997) and since then, we see a global overall increase of per capita emissions.

The evolution is therefore very different than what we have seen in Belgium (where curves do not evolve together) but comparison also shows opposite signs in growth rates between production (which has a negative sign) and consumption (positive sign) in both countries. As a matter of fact, Albania, on the one hand, has growing production emissions

since 1997 but on the larger period (1990-2017), it has decreased its emissions by nearly 4%. On the other hand, consumption is following the same path as production but the curve is always above that of production, which results in an increase of 14% over the total period.

4.6 Discussion and concluding remarks on this chapter

From these different perspectives and different countries studied, we see that the perspective we take has an enormous impact on the information we can take away from the data or the graphs. It has been shown that we can differentiate between gross numbers or per capita numbers. Then, if we account for production or consumption. More than that, differences can arise from the use or not of a common base year or not. All these factors need to be set and understood before drawing reliable conclusions.

From KP's perspective, Belgium has done well by reducing its production emissions, but once we look at consumption, we see that the trend is not that good, with slightly rising consumption emissions (in gross terms) on the whole. Again, when we look at the difference between consumption and production, we see that the problem of emissions for developed countries is not in the production itself but in the way we consume. By that last sentence, I mean that Belgian consumers need to be aware of all the pollution associated with the production processes of the products they consume.

In my opinion, policies must be more consumer-oriented (at least for developed countries) in order to reduce consumption-associated emissions. We see that for other countries (Albania in this thesis), production and consumption emissions seem to be closely related. In Belgium it is not the case as previously shown. It highlights the diverging curves that countries that have both signed and ratified the KP can follow. It may be due to reasons such as the date of entry into force of the Protocol, or the level of development of the country.

This Chapter, rather than studying precisely the emissions of one country or another, highlights once again the importance of tackling the pollution problem globally. Each type of calculation has its advantages and disadvantages. Some type of accounting may benefit more the developed than the others, but in the end, the objective that needs to be reached is the reduction of the pollution.

5. Conclusion

This thesis has reviewed some of the major economic theories linked to growth and the environment, and considered recent international policies over climate change/environmental matters such as the Kyoto Protocol or the Paris agreements. The effects of these measures have been reviewed and studied. For all issues, the ability to measure pollution/emissions in a common and accepted manner is important for understanding and selecting policies. Accordingly, an in-depth explanation of the 2 most common measuring (national accounting) methods (consumption-based and production-based accounting) was provided. Finally, a detailed analysis of the figures arising from the usage of these two methods was made for two comparable countries: Belgium and Albania.

The effects of the global policies are hard to measure. We have seen that sometimes, authors cannot agree on the real effects of these measures. It seems that the KP has decreased emissions in the developed countries but that through carbon leakage, polluting activities may have been moved to developing countries with less stringent environmental policies. The final goal is to reduce world emissions, and the figures we have seen show that we are still far from that point.

But what can be done to reverse this trend? One possible way forward would be to switch from production accounting to consumption accounting. This way, the final consumer is considered responsible of the emissions caused by its consumption. This may make it easier to pinpoint causes and take steps to reduce emission. This approach, in general, would help developing countries that have low consumption emissions (and so less pressure to reduce, and so able to continue developing). In general, this approach may constrain the developed countries that have, as we have seen with Belgium, generally much higher levels of CO₂ in consumption terms than in production terms – they would have to take even more steps to reduce emissions. Depending on their level of development, countries will be more or less willing to switch the accounting methods. This questions the introduction of such a switch. Poorer countries are likely to be pro-CBM and richer pro-PBM, so, as said before, how will it be possible to find an agreement? Since richer countries have generally more power in negotiations than the poorer ones, finding an agreement will turn out to be extremely difficult.

One characteristic of climate change is its urgency. We have seen that within a century, environmental damage can be enormous. If we wait even more, world emissions will continue rising and our planet will be wrecked forever. So, it may be time to adopt even more stringent environmental policies, using the consumption method to spur developed countries into reducing emissions.

In the fourth chapter, we have studied Belgium with comparison with Albania. Belgium has a high level of consumption of CO₂, even greater than its level of production. And, although it has made great progress in reducing production emissions, it has not made significant progress in reducing consumptions. We then compared Belgium and Albania and we saw very large differences between the levels of emissions of both countries, despite being both part of Europe and with some common characteristics. For example, the CBM-oriented policy would certainly be more challenging for Belgium than for Albania (even if Albania also has higher consumption levels than production ones).

I personally think that it is time for a switch to a more CBM-oriented way of accounting emissions. It would empower consumers (i.e. individuals) as well as companies that import CO₂ intensive products. It would clarify where the responsibilities lie. It could of course be coupled with the existing production policies as no policy should be exclusive. But we must admit that today, CBM is much less talked about than PBM.

This thesis has also showed the limits of production accounting. As previously said, from KP's perspective, Belgium has succeeded in reducing its emissions, but we see that on the consumption side, the tendency has not gone down. Still, KP's influence should not be shattered. Indeed, we saw that since KP's introduction in Albania, emissions have not risen. Also, one should not forget that each policy taken towards the reduction of emissions is one step forward towards the preservation of our environment.

One last thing to remember and that has been highlighted throughout this thesis is that the pollution problem needs to be tackled globally. From a CO₂ concentration standpoint, the planet "does not care" who pollutes. What needs to be done is reducing emissions, no matter where they come from. Unity is needed. There is only 1 atmosphere and 1 planet earth, we should care more about its condition and try to act as one single entity.

This thesis' analysis was done using only one source of data. Despite the fact that this source is certainly reliable, one should not forget to be careful when re-using this data. Again, all figures cannot be 100% accurate and the goal here was to do a comparison, to see trends and not to study a specific figure in detail. Since all data come from the same source, the comparisons are nevertheless reliable.

To draw more general conclusions, the next step of this thesis could be to enlarge the scope of countries studied. It would be interesting to see if the figures obtained for Belgium and Albania can be generalized or replicated across other countries. Doing a similar analysis with other countries (or groups of countries) could help us to see if the trend can be widespread to a tendency for developed countries and another for developing countries.

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7. Appendices

Figure 7.1

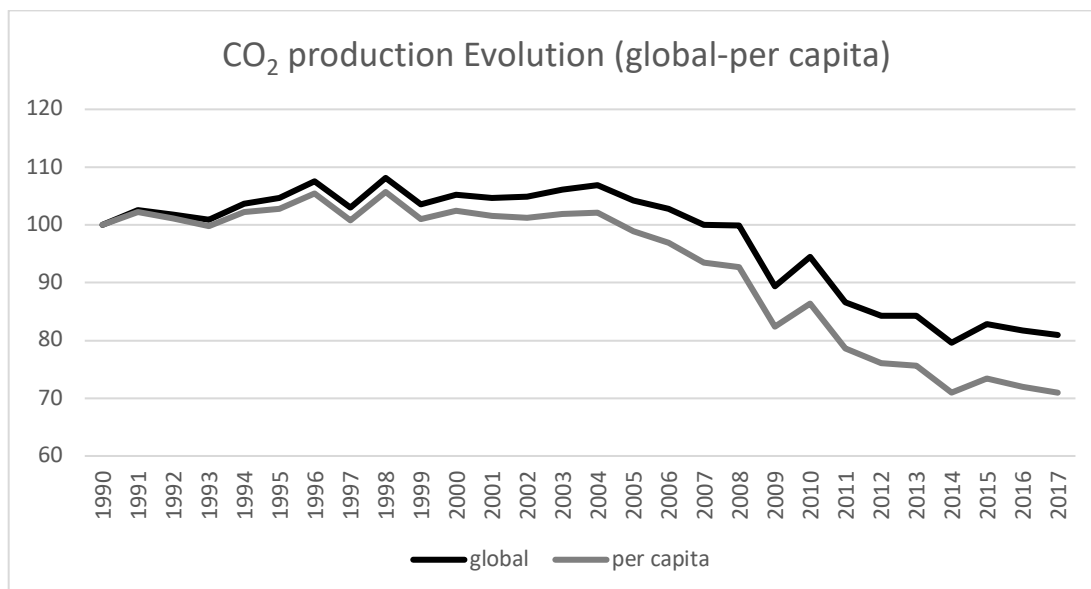


Figure 7.2

