Czech University of Life Sciences Prague

Faculty of Economics and Management

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Bachelor Thesis

Global Climate Change Adaptation

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Faculty of Economics and Management

BACHELOR THESIS ASSIGNMENT

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Business Administration

Thesis title

Global Climate Change Adaptation

Objectives of thesis

The aim of the thesis is to explore the financial effects of global climate change on the fishery industry of the EU, in light of the rising global temperature due to climate change. The main goal of the thesis is stated as "What is the annual financial impact of global climate change on the fishery industry in the EU and its future?". The sub-goals of the thesis are stated as:
- Assess the contribution of EU towards global climate change.
- Identify the relationship between the rise of global temperature and the financial indicators of fisheries within the EU.
- Estimate the annual cost of rising temperatures on the fisheries within the EU.

The outlined goals of this thesis are achieved through regression analysis and financial assessment of the exploratory analysis and statistical results.

Methodology

The methodology begins with gathering data on the global average temperature rises within the EU, and the use of different energy sources that are used in the EU cumulatively, as well as globally in order to identify the contribution of EU towards the global climate change. The use of the Granger Causality test, ANOVA regression analysis and impulse chock response tests will be utilized in order to measure the extent of the contribution more accurately. The findings based on the statistical analyses will determine the projection of related variables onto the Fishery industry based on the affected regions, seasonality and their annual revenue. The results would imply whether there is a negative, a positive, or no relationship between the rising temperature with the revenue of the fishery industry. As well as determining the indirect costs that may affect an average EU consumer. The results of the study will be discussed with consideration of the EU Vision for carbon neutrality and prospects for the year 2030 and 2050.

The proposed extent of the thesis

40 pages

Keywords

Analysis, Change, Climate, EU, Financial, Fishery, Industry, Regression

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Recommended information sources

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Prague on 14. 03. 2024

Declaration

I declare that I have worked on my bachelor thesis titled "Global Climate Change Adaptation" by myself and I have used only the sources mentioned at the end of the thesis. As the author of the bachelor thesis, I declare that the thesis does not break any copyrights.

In Prague on 14th March, 2024 Daniyar Zulupkarov

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I would like to thank doc. Ing. Petr Procházka, MSc, Ph.D. for his guidance and support during the writing process of the thesis. I would also like to thank my family for their emotional support.

Global Climate Change Adaptation

Abstract

Global climate change is currently a large topic of discussion within the world amongst consumers, as well as affecting the political arena of the world. Global temperature rises have been observed in different parts of the world, as well as rising ocean temperatures and sea levels. This thesis analyses the EU contribution towards the global climate change and the economic effects of global climate change on its fishing industry. The minimal annual cost has been estimated to be 260 million euros annually, with a relationship being established between the loss of revenue and a temperature rise above 28 degrees. Furthermore, the lack sustainability of the EU fishing industry has been evaluated to produce a far greater loss due to inefficient fishing practices. The findings are discussed in accordance with the EU Vision 2030 and 2050, highlighting the importance of developing alternatives to diesel, improving efficiency of the fishing industry to minimize lost revenue in order to offset losses associated with global climate change while EU is undergoing its transition towards a net zero carbon footprint.

Keywords: Analysis, Change, Climate, EU, Financial, Fishery, Industry, Regression

Adaptace na Globální Změnu Klimatu

Abstrakt

Globální změna klimatu v současné době ve světě je významným tématem diskusí mezi spotřebiteli i na politické aréně. V různých částech světa byl pozorován globální nárůst teploty, stejně jako zvyšování teploty oceánů a hladiny moří. Tato práce analyzuje podíl EU na globální změně klimatu a ekonomické dopady globální změny klimatu na její rybářský průmysl. Minimální roční náklady byly odhadnuty na 260 milionů eur ročně, přičemž byl zjištěn vztah mezi ztrátou příjmů a nárůstem teploty nad 28 stupňů. Dále bylo vyhodnoceno, že nedostatečná udržitelnost rybářského průmyslu EU způsobuje mnohem větší ztráty v důsledku neefektivních rybolovných postupů. Zjištění jsou diskutována v souladu s vizí EU do roku 2030 a 2050, přičemž je zdůrazněn význam vývoje alternativ k motorové naftě, zlepšení účinnosti rybářského průmyslu s cílem minimalizovat ztráty příjmů, aby se kompenzovaly ztráty spojené s globální změnou klimatu, zatímco EU usiluje o přechod k uhlíkové neutralitě.

Klíčová slova: Analýza, změna, klima, EU, finanční, rybolov, průmysl, regrese

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Introduction

Global climate change is currently a large topic of discussion within the world amongst consumers, as well as affecting the political arena of the world. Global temperature rises have been observed in different parts of the world, as well as rising ocean temperatures and sea levels. This prompts the need for increased study on the effects of global climate change on certain industries, as well as the economic costs that are subsequently incurred.

The fish industry of the European Union currently generates a revenue of $118 billion, with EU consumers witnessing an increase in fish prices that are not in line with inflation. This prompts the need to investigate the fish industry and the economic effects of the global climate change, as there is a significant lack of studies being conducted on this topic. Furthermore, it is important to recognize that the financial impact is not only incurred by the companies that are performing the fishing activities, but the costs are ultimately distributed onto the consumer.

The main objective of this thesis is to assess the revenue impact of global climate change on the fishing industry of the EU. The subgoals of this thesis to evaluate the sustainability practices and its economic effects on the EU fishing industry, assess the EU contribution towards rising global temperatures, and assess the economic impact on the average EU consumer associated with the findings.

The theoretical part of the thesis will evaluate the global climate change and its historic development, as well as the steps EU has taken to address the issue. Furthermore, previous studies will be evaluated in the context of rising global temperatures and its economic effects. The fishing industry will be covered, including the most contributing countries and the most affected countries of the EU because of global climate change. The theoretical part will conclude with an overview of the remedies that are currently in place to rectify and mitigate the effects of the global climate change, particularly the EU Vision 2030 and 2050.

The practical part of the thesis will be supplemented by methodology to describe the statistical tests that will be performed within it. The EU contribution towards the global climate change will be assessed using data aggregated by the author. The EU fishery revenue and its impact will be assessed in order to calculate the annual costs. The forecast for the industry will be discussed and the implications of the findings in line with the EU Vision 2030 and 2050. The study will conclude with a further discussion of the overall findings.

1. Theoretical Part

1.1. Global Climate Change

The National Aeronautics and Space Administration (2024) reports that there is "unequivocal evidence" that the Earth is warming up, as well as human activity being the "principal cause". The concept of humans being able to alter their environment dates back to prehistoric times, where the Greeks have recognized the power of humans to alter environments through irrigation and deforestation practices. The scientific progress regarding climate change has remained relatively uncovered until Joseph Fourier proposed that the Earth exists in a complex energy exchange system between its inner atmosphere and outer space. The basic principle is energy that enters the atmosphere from the sun is reflected from the surface, with residual energy being trapped under the atmosphere, which contributes towards the warming of the planet – the Greenhouse effect. This discovery has contributed towards the work of Eunice Newton Foote and John Tyndall that have developed to test which gasses contributed towards the warming of the planet, finding correlations between humidity and carbon dioxide levels with rising temperatures in isolated systems in glass cylinders (Onion et al., 2017).

The findings stemmed from the discovery of the permafrost layers, which have suggested the presence of an ice age, which could be traced back through the use of radioactive decay of carbon items trapped in the layer. Svante Arrhenius found in the late 19^{th} century that there was a correlation between carbon dioxide levels and temperature rises by 5 degrees if the carbon levels at the time could be halved, or the reverse being observed if the carbon dioxide levels doubled. His estimations were proven to be close to the truth. Following the industrial revolution, Stewart Callendar has noted that the average temperatures have increased by 2 degrees, which contributed towards the Keeling Curve discovery by Charles Keeling, which mapped the relationship between the carbon dioxide levels and the rising temperatures. This curve will be essential for the practical part of the thesis, as it will be investigated to measure the contribution of the European Union (EU) towards the global climate change (Onion et al., 2017).

By the year of 1990, the discussion about the global climate change gained attention worldwide, during the finalization of the formation of European Union as we know today. The Intergovernmental Panel on Climate Change (IPCC) was established under United

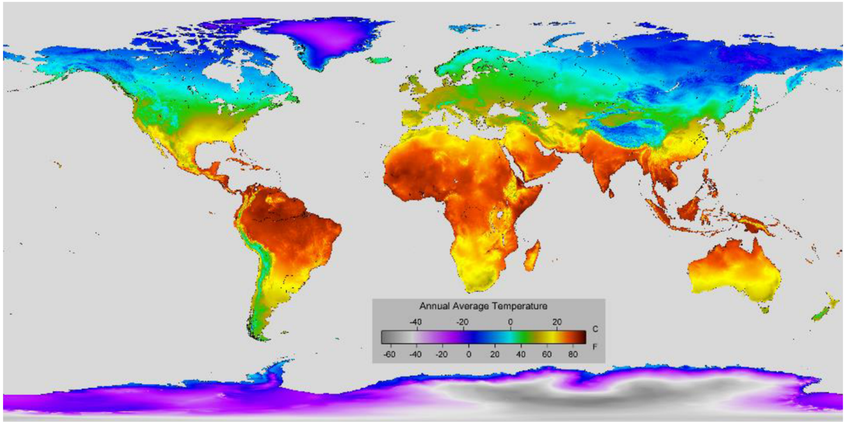
Nations in order to track the development of climate change, with predictions of how the global climate change can cause rising sea levels and temperatures, contributing to droughts, heat waves and hurricanes which damage multiple industries and cause economic effects. Few major agreements were created, such as the Kyoto Protocol (which operationalized United Nations Framework Convention on Climate Change) and the Paris Climate Agreement which resulted in 197 countries pledging to set targets for their greenhouse gas emissions and preventing a global temperature increase by 2 degrees. The 2-degree limit was seen to be crucial as it would have devastating effects on the environment and lead to economic consequences and decrease of human welfare (UNFCCC, 2013a; 2013b).

1.1.1. Economic Effects of Global Climate Change

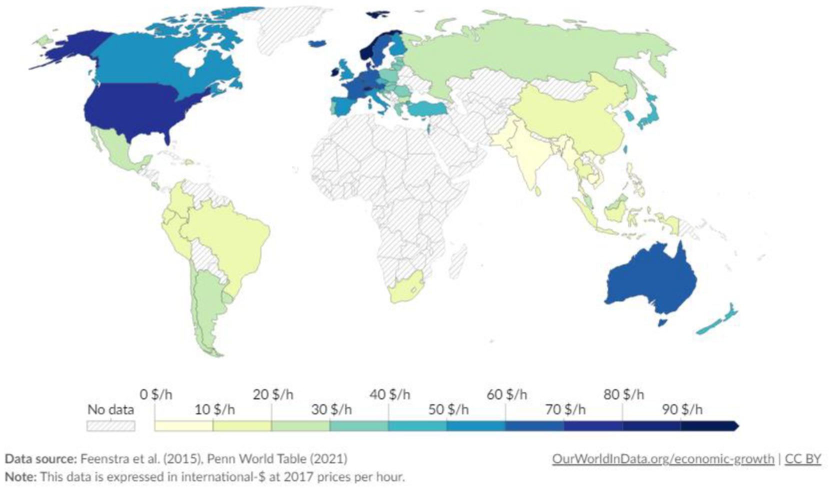
The economic effects of global climate change can have differing effects depending on the location. The study conducted by Wade et al. (2014) stated that there are countries that would benefit from the global climate change, as well as countries that would face negative economic consequences as a result of the rising temperatures. It is important to recognize that global climate change can affect multiple different factors that contribute towards economic loss. Such factors include and are not limited to – damage to property, security concerns, mass migration and productivity loss by the population. It is important to recognize that immediate effects of global climate change may be positive for a countries GDP (Gross Domestic Product), as certain damages can contribute towards the development of jobs and increased economic activity to repair any damages, however, once the increased temperatures become the norm the overall effect would be a decrease in GDP.

The global production function is an important aspect, as it suggests that the average temperature and its fluctuations based on seasons have a direct correlation with the productivity of the economy. Generally, temperatures that remain between 5 and 25 degrees contribute towards the economic output the most, this can be seen when comparing the average temperature map with the global productivity map, as demonstrated in the following figure:

Figure 1 – Global Temperature (Top) and Global Productivity (Bottom) Map



Source: Rhode (2014) and Feenstra et al. (2015)



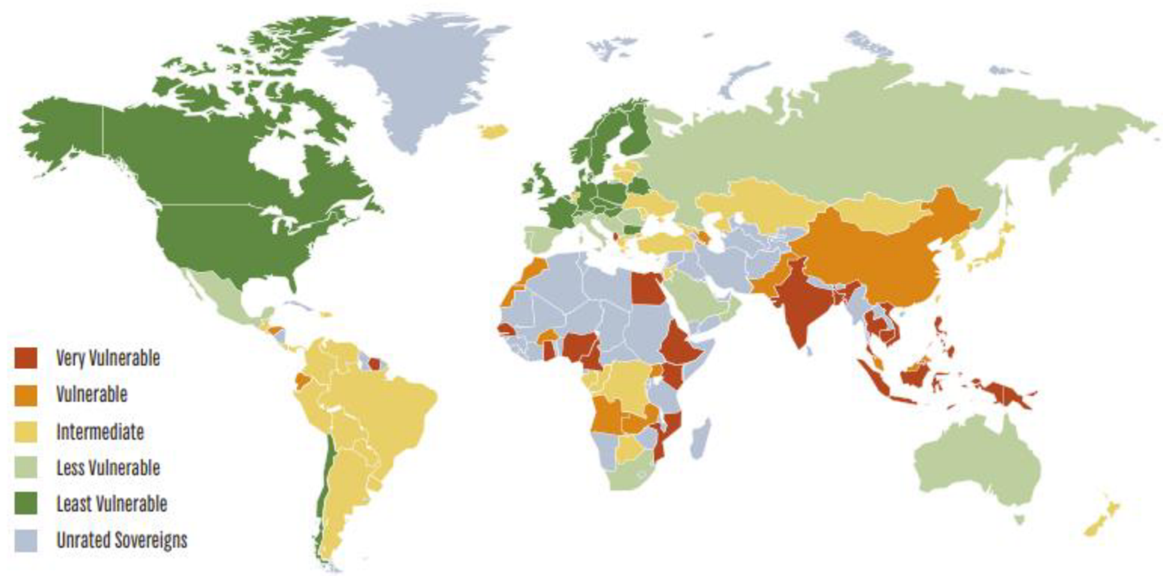
It is evident that countries that see lower average temperatures see higher wages and higher GDPs. Certain countries have lower wages; however, they contribute towards the productivity of the country with larger populations such as India and China.

Other economic consequences of global climate change is inflation, as there may be shortages that emerge due to the agricultural and fishery industries being affected, leading to the rising costs of food production and lower yields. The initial effect may cause a shift in the agricultural production of certain countries. For example, while Italy becomes less sustainable for agricultural production, countries such as Poland or Finland may be able to produce more agricultural output than previously due to the rising temperatures. However, as the rising temperatures become aggregated, the food price and inflation will begin to rise and mitigation tactics of shifting production will become less effective (Wade et al., 2014).

Other economic consequences which are becoming increasingly evident today, is the rising of energy production costs through renewable means. Rising temperatures generally lead to an increase in energy consumption in order to cool down the environment and warming up households during harsher winters. Furthermore, energy generation methods could become less efficient with an increase in global temperatures, as certain methods such as hydropower may see a decrease in water supply or shifts in the wind leading to less production from turbines.

Currently, Standard and Poors (2014) report that the EU is one of the least vulnerable areas of the planet that will see minimal initial effects of the global climate change. The following figure demonstrates the created risk map:

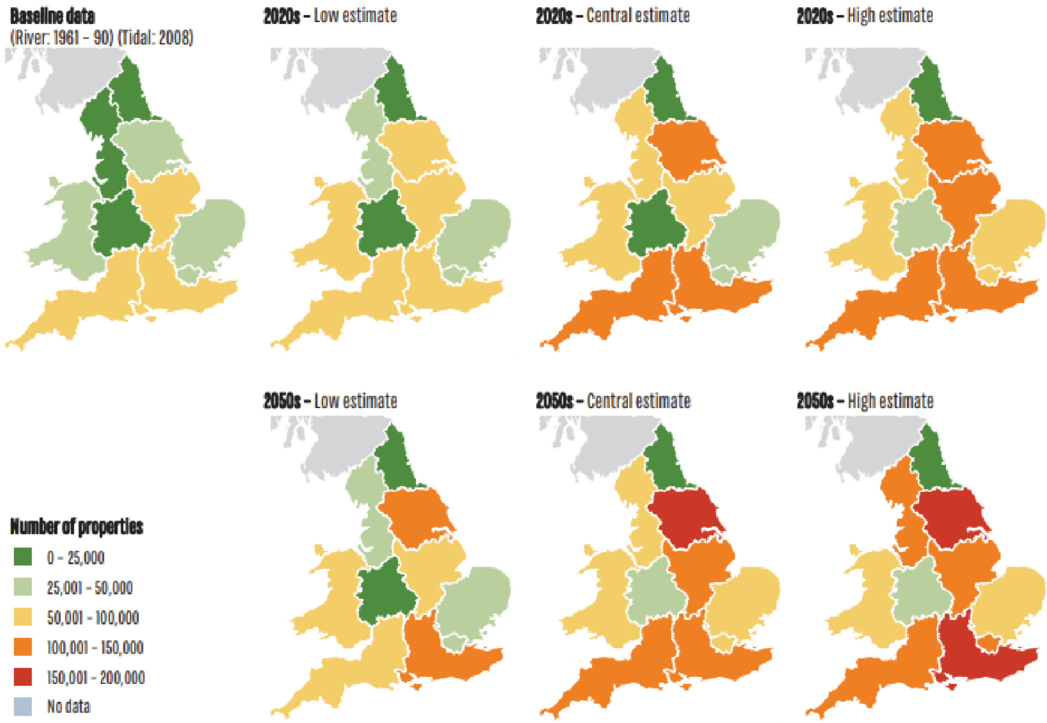
Figure 2 – Sovereign risk to climate change



Souce: Standard and Poors (2014)

Nevertheless, parts of the European region are already estimated to face heavy damages to properties through flooding. For example, in the UK Climate Change Risk Assessment in 2012 have forecasted the damage to different regions of United Kingdom for properties. The following figure demonstrates the results:

Figure 3 – UK Climate Change Risk Assessment



Source: Government of United Kingdom (2012)

Currently, the European Parliamentary Research Service (2022) has recognized the effects of global climate change in terms of mass migration. Although Europe may not be currently heavily affected by rising temperatures on its productivity, the affected countries in Africa and surrounding countries have contributed towards their mass migration to Europe. The report "The Future of Climate Migration" released by the research services approximates that water shortages will displace 700 million people by 2030, and the World Bank announced a study where approximately 216 million people due to internal climate displaced, which is more than the population of Germany, Italy and France combined (World Bank, 2021).

1.1.2. Previous Studies

The global climate pacts that were established are not proving to reduce the rise of global temperatures as predicted. For example, at the meeting of COP26 in Glasgow, the projected target of global temperatures pledged by multiple countries has been 1.5 degrees by the set date of 2021, however, the results suggested that temperatures have increased by 2.4 degrees (without any effort, they would have increased above 2.7 degrees). This places the efforts of the Paris Climate Agreement to be largely unachieved, as these results exceed the set 2-degree limit (Kilfoyle, 2022; Rincon, 2021).

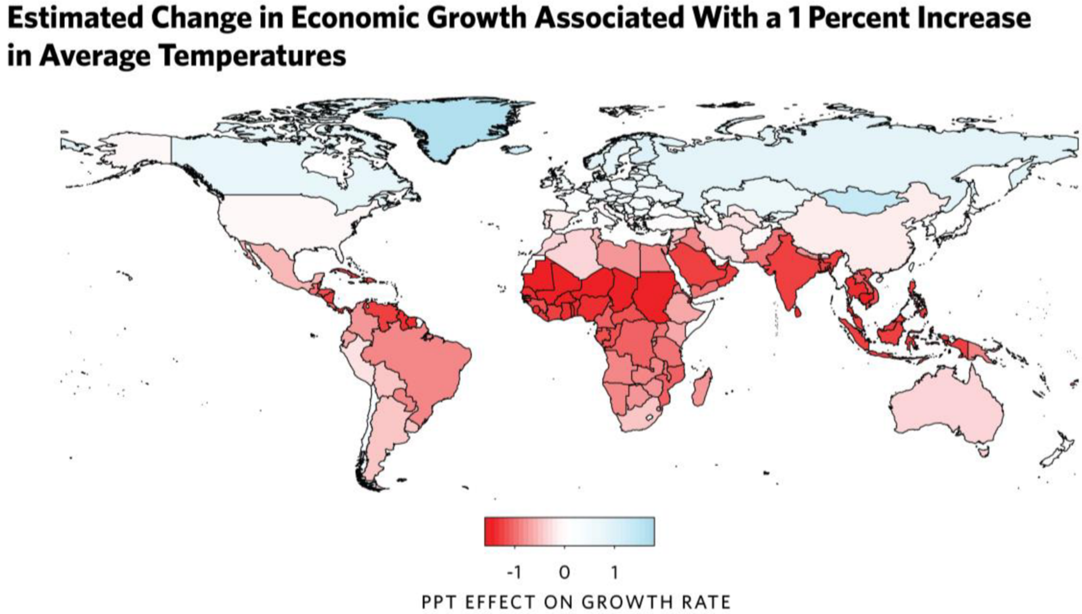
The study conducted by Hemous (2021) reports that developing countries account for more than 60% of the global climate change, despite this, the non-developing countries are suffering from the effects through increase of poverty, threatened food security through droughts and decreased economic output. Larger heat waves were seen in the past decade, with the Pacific Northwest region of Africa being affected the most, killing more than 200 people in 4 days alone.

The study conducted by Park (2022) has shown that there is a decrease in economic output amongst workers that is linked with rise in global temperature. Graff and Neidell (2014) assessed the implications of temperatures on productivity of countries, emphasizing how increasing temperatures play an increasingly important role in the planning of a day for people living in high temperature areas, effectively decreasing their working time due to unworkable hours of the day. The study conducted by Colmer (2021) support these results, suggesting that there is a shift in labour allocation due to heat waves and prompting the migration of people as shortages begin to develop. The study conducted by Somanathan et al. (2021) suggests that certain industries are impacted more than others, as well as heavily dependent on the working conditions. For example, Indian manufacturing among the hot climate may be limited due to the lack of air conditioning, as well as leading to an overall reduction of economic activity.

Another study conducted by Park et al. (2020) suggests that educational attainment is also affected by global climate change, with students being less receptive to learning and information given at educational institutions due to rising temperatures and poor learning conditions that are not adapted to higher temperatures.

Chandy (2023) suggests that countries that are already being affected heavily by global temperature rises must adopt alternative ways for economic growth that take the rising temperatures into consideration, as 1 degree increase in temperature resulted in 1.4 percent decrease in per capita income, as the result of lower agricultural yield, lower physical and cognitive productivity of workers and increase in crime rate. The study conducted by Burke et al. (2015) have suggested that the decrease in economic output in comparison to global temperature rises are non-linear, indicating that there may be a function to describe the relationship, as well as placing an emphasis on resolving the issue before each increase in degrees brings heavy consequences on the world economy. The following figure demonstrates the projected effect on the economic output based on 1% increase in global temperatures:

Figure 4 – Estimated change in economic growth associated with 1 percent increase in average temperatures



Source: Burke et al. (2015)

1.2. Fishery Industry of EU

The Publications Office of the European Union (2022) reports that currently there are more than 73,000 fishing vessels operating within its waters, with more than 56,000 active vessels being present every day, providing employment to more than 124,000 fishers. During the year, these vessels spent more than 5.3 million days at sea, and consumed more than 1.9 billion litters of diesel to produce 3.9 million tonnes of seafood. The Gross Value Added (GVA) and its gross profit were reported to be at 3.3 billion euros, and 1.16 billion euros respectively.

In 2022, the household spending on fishery and aquaculture has been reported to increase by 11% in comparison to 2022. The justification for this increase as stated by the European Market Observatory for Fisheries and Aquaculture Products (EUMOFA) (2023) has been the rising prices due the inflation linked with the Russian invasion of Ukraine, as well as lasting effects from the COVID-19 pandemic which has led to an increase in cooking at home by consumers which prompted for a higher expected demand. However, the consumption at home of fish has decreased by 17% in 2022, primarily due to substitution effects of people opting for cheaper animal protein in order to avoid purchasing more expensive fish. The reports suggest that there is a 1.5% decrease in the volume of fish caught, however, there is a 20% increase within the nominal value of the fish caught. This suggests that it is important to consider the economic ramifications of this development as the fishery industry of the EU may continue to generate profit and maintain its industry, however, the economic consequences may be distributed onto the consumers as well as reduction in labour as the price of fish increases. For example, in 2020 the economic performance of the member states did not report a gross loss from fishing, however, Finland, Germany, Estonia and Cyprus reported that they suffered a net loss by the end of that year.

Furthermore, the EUMOFA (2023) reports that the deterioration of the EU trade balance has contributed to the decrease in volume of fish, as imports of fish have increased in cost while decreasing the amount of volume being delivered (primarily from the United States and Japan).

The main affected species that were impacted by reduced yield of catching are wild salmon, which resulted in 3% decrease in imports and the value increase by 28%. Shrimps have seen an increase in import volume by 2% from countries such as Ecuador, Argentina, India and Vietnam, however, have seen an 89% increase in value. Cod has seen an increase in value by 29% which caused a subsequent increase of 20% in import value, with contributing countries of Norway and Russia.

Finally, the international exchange rate had an affect on the revenue of the fishery industry in EU, primarily due to the depreciation against the dollar by 6.2% in 2023. However, the euro appreciated against other currencies that are crucial for the functioning of the fishery industry, such as the Great British Pound by 3.6%, the Norwegian Krone by 4.4% and the Icelandic Krona by 3.2% (EUMOFA, 2023).

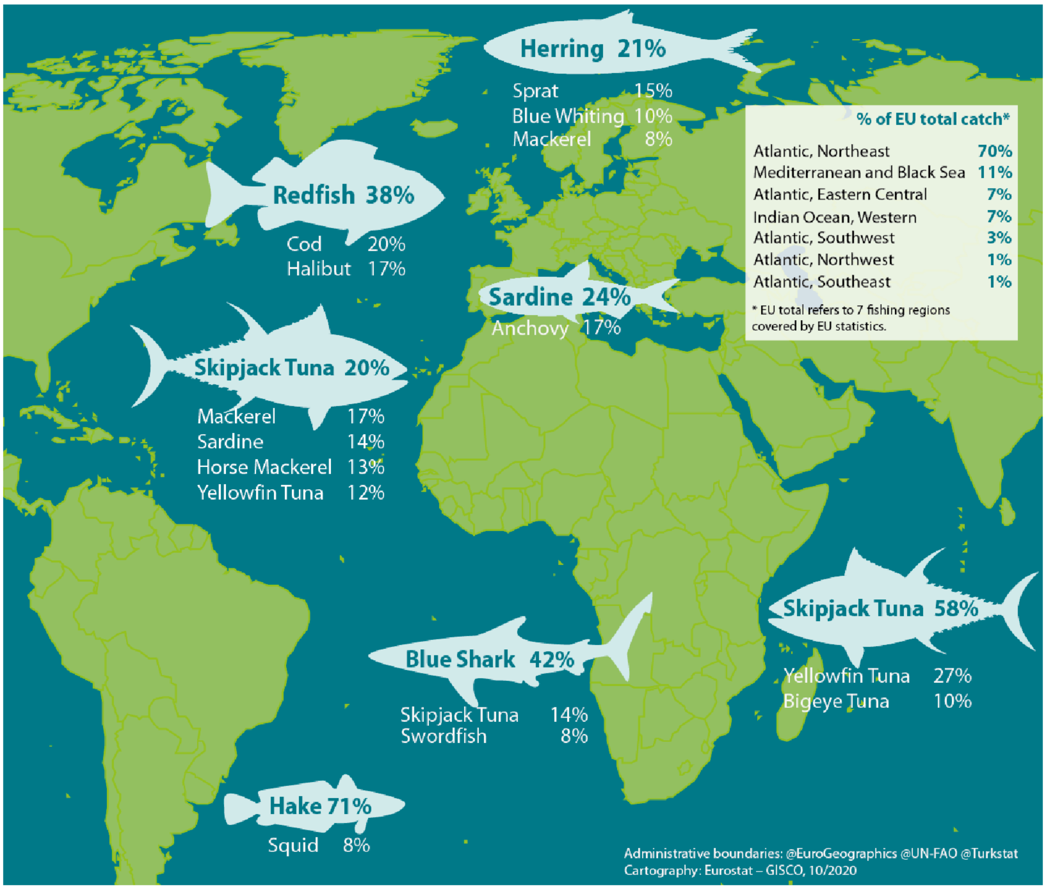
In 2021, the EU in terms of its production in fisheries and aquaculture has contributed only by 2%, with a decrease by 5% from the previous year, showing a large decline. It is important to note that although majority of fish in the world are supplied by China (at 39%), the primary method of production for Asia as a continent is through aquaculture instead of catching techniques. Europe’s production consists of 79% of catches, and 21% of aquaculture. The primary five species that make up for more than 50% of the production of EU is the herring, Alaskan pollock, cod, blue whiting and mackerel. This information may be of use during the assessment of the impact of global climate change, as rising temperatures may change the favourable conditions for these fish species.

1.2.1. Most contributing countries

Eurostat (2020) reports that the most contributing member countries towards the fishery industry of EU are Spain (20.6%), Denmark (15.3%) and France (12.9%) of the total EU live weight catch of fish, with 70% of the fish being obtained in the Atlantic, Northeastern part of the Ocean. Around 11% of the fish was caught within the Mediterranean and the Black Sea, primarily sardines and anchovies, where the primary countries involved in fishery within the region is Italy (40%), Greece (19%), Spain (17%) and Croatia (15%).

The following figure demonstrates the regions and distribution of species that are caught in the various locations in the Atlantic Ocean and surrounding seas of EU:

Figure 5 – EU Catches by marine fishing area in 2020



Source: Eurostat (2020)

By comparing the global rising temperature map, it is evident that the skipjack tuna, sardines and anchovies, as well as the blue shark and swordfish may decrease in yield as a consequence to global climate change.

1.2.2. Affected countries by Global Climate Change

The University of British Columbia (2023) have announced that European fisheries may be under threat. This is primarily due to species that are further down the food chain such as the sardines and the anchovies being under threat, as well as predators which are higher up the food chain such as sharks. Due to overfishing concerns that occurred in the early 2000s, the yield of fishing has decreased by more than 50% since the 1960s. Currently, the forecasted decline in catch due to rising temperatures is estimated to be around 310,000 tons per year. The global climate change may also impact the type of species that are being caught, as higher temperature waters favour fish with a lower metabolic system and that live a shorter life. This may cause larger species with slower metabolic systems to migrate to other parts of the ocean, further north. This particularly places EU countries around the Mediterranean Sea such as Croatia, Greece, Italy and Spain under threat. This may also affect the yield from the central Atlantic Ocean, as well as the Indian ocean.

Bastardie et al. (2022) reports that the EU fishery industry is highly resilient to shocks, however, is not currently prepared for long-term effects. This conclusion is attributed to the economic resilience being reliant on the current economic performance, which suggests that the industry will be able to absorb small shocks in yield, as well as due to well managed communication between marine institutions and fisheries. This allows for a well-managed allocation of resources that aims to maximize the profit generation of the industry.

Europa (2017) states that countries surrounding southern parts of Europe and the United Kingdom may face increasing pressure as rising temperatures of the ocean cause decreased oxygen in the water and higher levels of acidity. This primarily affects the species that are at the very bottom of the food chain, such as molluscs and plankton in forming their skeletal structure, which would lead to an overall shift of the food chain and declining fish numbers.

1.3. Remedies for Global Climate Change

The main remedy that exists for any country is to discovery methods of either capturing the carbon dioxide present in the atmosphere or reducing the unnecessary greenhouse gas emissions while compensating for the unavoidable emissions. Few of the most efficient methods of carbon capture is available from nature, as trees, oceans and soil capture carbon and use it for growth of flora.

Alternative technologies are attempting to be developed that use a chemical method of carbon capture, used by machines. U.S. National Grid (2023) reports the conclusions of IPCC to fulfil the ambitions of the Paris Agreement, stating that natural alternatives such as trees may not be enough as it takes a longer time for capturing the carbon dioxide. Technologies must be used in conjunction with natural methods for carbon capture and storage (CCS) which can be utilized during economic activities and capturing carbon released directly from the processes and storing it underground. Currently, there are 73 projects in Europe that utilize this technology and capture over 90 million tonnes of carbon dioxide released every year.

1.3.1. Energy Sources

Cacciuttolo et al. (2024) reported that coal, oil and gas are the main contributors to the global greenhouse gases (75%) and more than 90% for carbon dioxide alone. Currently, 80% of the global energy production is through the use of fossil fuels, and 29% of electricity being produced through renewable sources. The main arguments that motivate switching from fossil fuel based energy production to renewable energy (apart from global climate change) are primarily economic. Although the approximated cost of switching to renewable energy is at $4 trillion, renewable energy sector can produce more employment for people as 80% of the worlds population live in countries that rely on fossil fuel imports. Furthermore, renewable energy is resistant to fossil fuel price fluctuations and is cheaper to maintain after the initial costs. There may be alternative positive economic effects through the overall increase of health of the worlds population, as the World Health Organization reports that 99% of people breath air that exceeds air quality limits which damages their health.

Currently, United Nations (n.d.) report 6 renewable energy sources that are used to combat Global Climate Change:

- Solar Energy: The production cost of solar panels have decreased dramatically within the last 30 years, and are applicable to any country with varying degrees of effectiveness and can be installed by consumers on their homes.
- Wind Energy: Currently, the worlds technically potential of using wind energy is greater than the total electricity consumption. Wind turbines can be placed in remote locations, as well as offshore to not interfere with the immediate surroundings.

- Geothermal Energy: This method utilizes the heat of the earths inner core to heat fluids which stimulate electricity production. This technology has proven to be effective and operating more than 100 years.
- Hydropower: This method utilizes the movement of water from a higher altitude to a lower altitude to generate electricity. However, this method is vulnerable to global climate change itself and may negatively affect the environment and causing the formation of droughts.
- Ocean Energy: This method is relatively new and still in development, however, it aims at utilizing the tidal movement of the ocean to generate electricity. Similarly to wind energy, the potential exceeds the energy consumption of people.
- Bioenergy: This method involves the growth of organic materials that are then converted into biofuels that can be burnt for energy. Although this produces carbon dioxide, it is produced at much smaller rates than fossil fuels and benefit towards sustainability.

The fishing industry in the EU primary relies on diesel in order to power its fleets. Thus, it is using one of the most unsustainable fuels to operate, which are subjected to price fluctuations that potentially increase its cost of revenue. Despite this, the number of innovations regarding a creation of more sustainable vessels are limited to increasing the efficiency of the motors in terms of its combustion capabilities, rather than switching to alternative and more sustainable fuel sources.

1.3.2. EU Vision 2030/2050

The EU has pledged to fulfil 2030 climate targets that are in line with the United Nations ambitions of limiting the carbon footprint of nations and reducing the global temperature rise. The EU under the Regulation on the Governance of the Energy Union and Climate Action adopted rules in line with the Paris Agreement on reducing greenhouse gas emissions by at least 55% by the year 2030. This affects the areas of climate, energy and transport, as well as taxation policies (European Commission, 2022a). The aim of the vision is to ensure that the transition towards green energy (as part of the Green Deal) will be socially balanced and fair.

In order to fuel innovation and research, the EU has committed to spend 30% of its long-term budget on climate related projects, as well as mobilizing 90 billion euros to assist in the transition mechanism regions that are affected the most by moving towards a low-carbon economy.

As aforementioned, the approximate cost of transition is over 4 trillion euros and to achieve the goal of 2050, which ensures that Europe becomes the first carbon neutral continent on the planet. The aims and goals of fulfilling these targets place countries under legal obligation to fulfill them, which sets a worldwide precedence on commitment to climate change and the environment.

2. Methodology

Subsequent statistical methods will be utilized in the practical part of the thesis, in order to analyse the economic effects of global climate change, estimating its current state and future prospects, as well as the contribution of EU towards rising global temperatures. All statistical tests will be performed in R-Studio.

2.1. Regression Analysis

Regression analysis will be utilized in order to estimate the gradient and the contribution of the EU towards the global climate change through its emissions. Furthermore, the regression line would provide the projected annual increase of the global temperatures, which would highlight whether the current sustainability efforts are affecting the global climate change positively. The exploratory analysis will include a combination of using carbon emissions indicators such as parts per million and total emissions as dependent and independent variables with global temperature, to discover any meaningful results that contribute to the overall assessment of the indicators.

2.2. Granger Causality Test

Granger causality test will be utilized to investigate whether there is a unilateral or bilateral relationship between the different indicators. This would show if, for example, the EU carbon emissions granger cause rise of global temperatures or if the global temperature rises granger cause the rise of emissions within the EU (for example, by increasing energy consumption to combat the rising temperatures).

2.3. Impulse Shock Response Test

The impulse shock response test would be utilized to see how an indicator affects another indicator by applying a 5% positive shock to the data. This is particularly used to assess whether there is a relationship that can be observed through the use of this test. This particularly can be evident if a country is not producing significant emissions, however, are still experiencing temperature increases. This test will be utilized in conjunction with the granger causality test.

2.4. Financial Analysis

The financial analysis that will be utilized in the thesis will be based on the results of the regression analysis. This will provide the coefficient that can be used on the revenue of the fish industry in the EU and individual member countries to calculate the annual cost of global climate change, and any other related factors that increase the cost of revenue. Furthermore, the financial analysis will be utilized in line with previous financial indicators presented by the International Council for the Exploration of the Sea (ICES) to comment on the developments that will be observed following the exploratory data analysis performed on the aggregated data. The main purpose of financial analysis is to form a comprehensive equation that can be used to estimate the annual cost based on the degree increase of global temperatures.

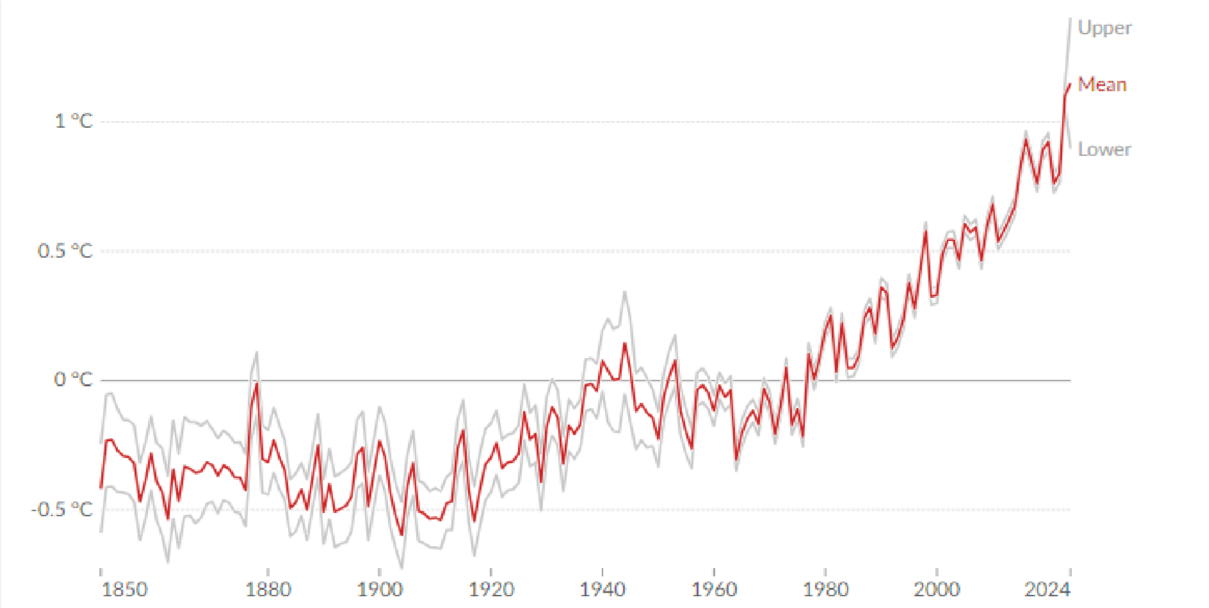
3. Practical Part

The practical part will use the methodology and the statistical analyses described in order to assess the impact of global climate change on the EU fishery revenue, as well as the contribution of the EU towards the global climate change, followed by relevant forecasts for the industry. All of the data for the analysis was obtained from Eurostat (2023), Kaggle (2023), World Bank (2023) and ICES (International Council for the Exploration of the Sea) (2023) and compiled by the author for the purpose of its analysis in R-Studio. Please see bibliography for the all sources of data obtained for the study.

3.1. EU Contribution to Global Climate Change

In order to start the assessment of the global climate change, and the contribution of EU towards it. It is important to establish a relationship between the carbon dioxide levels and temperature. The variables that were chosen for this particular analysis is the carbon dioxide parts per million data by country and global average temperature indicator combined with temperature anomaly errors. In plotting the data, the result is presented in the following figure:

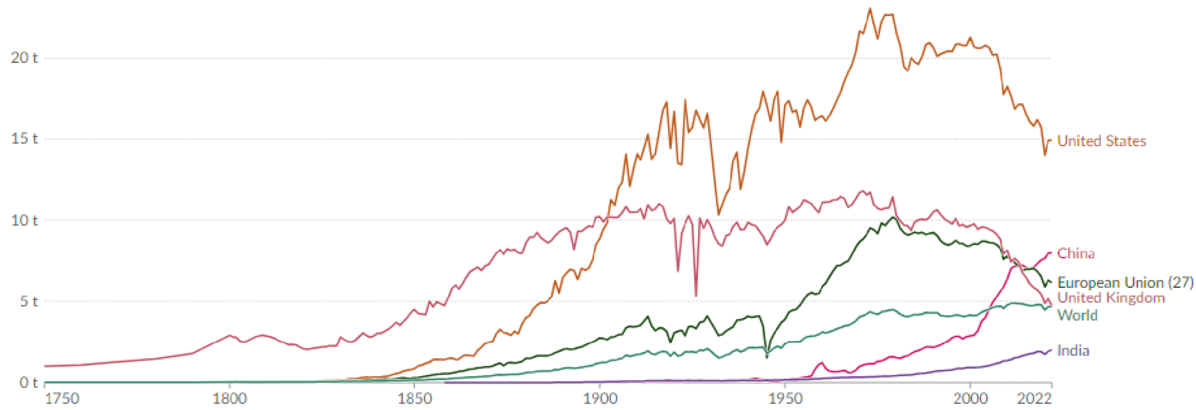
Figure 6 – Global Temperature Rise



Source: Author

For the purpose of the analysis, the mean is being compared to the global average from the 1940, which represents the difference obtained by the EU of the difference surpassing 2 degrees from their date of reference, which has not been specifically indicated but must be from the start of 1900s, as indicated by the data. Following the indicator of the carbon dioxide emissions per capita, the following figure demonstrates the results:

Figure 7 – Carbon dioxide emissions per capita

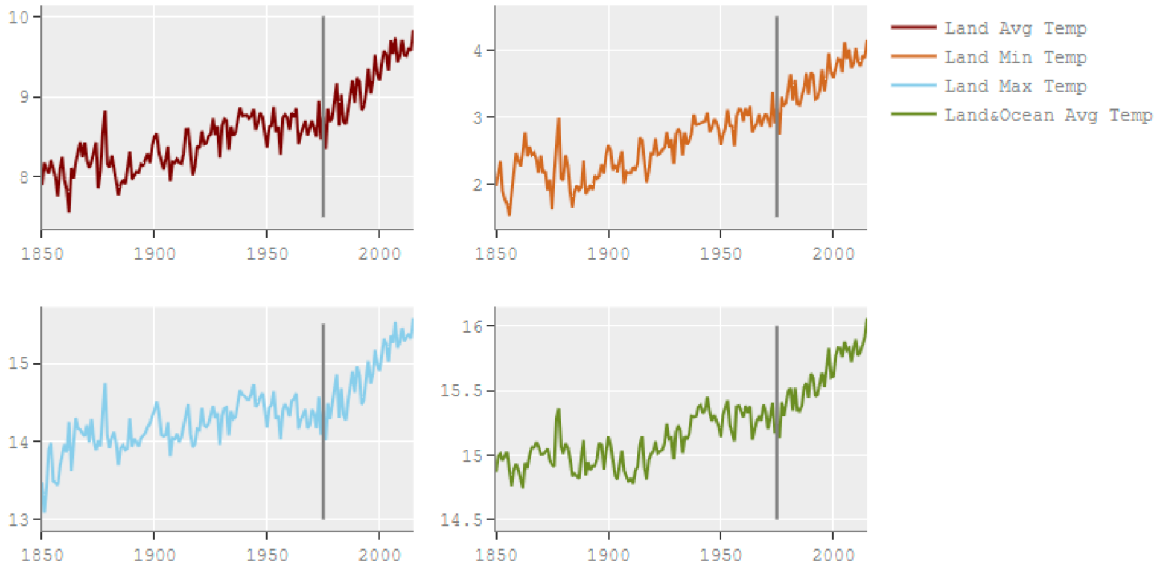


Source: Author

It is evident that the largest contributors towards the global climate change are the United States, China and the European Union, which surpass the average per capita contribution more than the combined rest of the world. In comparison, India which has a population that is more than 1.4 billion people have on average a third per capita carbon dioxide emissions than the European Union. This outlines that the EU is likely to granger cause a rise in global temperatures, along with the U.S. and China. It is also important to note that although there are some countries that have a much smaller carbon footprint per capita, their temperatures are affected by the global climate change caused primarily by other countries more than the major contributors. This indicates that the economic activity and carbon emissions per capita caused by major contributors affects third-world countries more than the first-world countries producing the carbon dioxide.

It is important to recognise when the global temperatures started to rise, as this would indicate whether the issue has been recognized at the appropriate time. Furthermore, it is important to assess the minimum temperatures and the maximum temperatures that were observed each year, and assess whether there was an affect on the ocean temperatures based on the results of the land temperatures. The following figure demonstrates the plotted results:

Figure 8 – Land and Ocean Temperature Breakdown

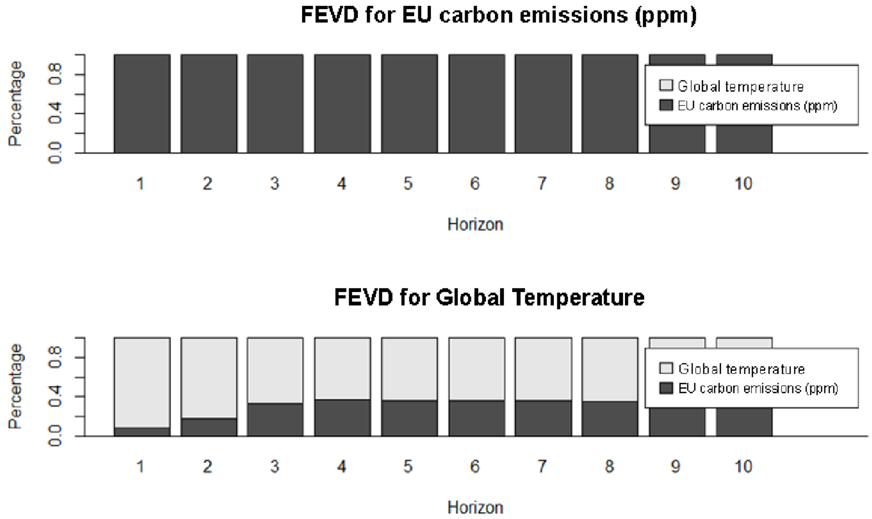


Source: Author

The results suggest that the global warmings acceleration has started around 1970, as previously the increase can be attributed towards the manufacturing boom which occurred during and after the second world war. However, it is clear that there has been a stable increase after that period, and the minimum temperatures have been on the increase since the start of the 1900s. The maximum temperatures have began to increase primarily at the point of 1970s, along with the average. Furthermore, it is clear that the land average temperature coincides with the average temperatures of the ocean, which remains as one of the primary focuses of this thesis as this affects the wildlife of the ocean which is the source of revenue for the fish industry of the EU.

The granger causality test can be utilized in order to test whether there is a relationship between the European Unions carbon dioxide levels (ppm) within its surroundings and the global temperature within the world. This would show the contribution of EU towards the global average temperature rises and the global climate change. The granger causality test results are represented in the following figure:

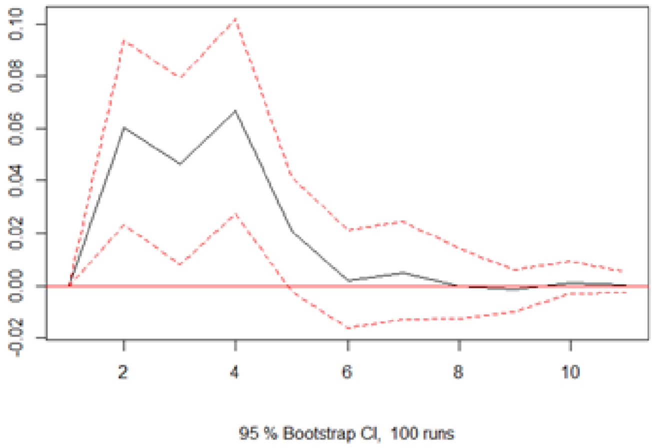
Figure 9 – Granger causality test (EU emissions vs. Global Temperature)



Source: Author

The results suggest that the EU carbon emissions are granger causing the rise of global temperature, however, the global temperatures do not granger cause the EU carbon emissions. The horizon indicates the results based on the data frequency, which is indicated to be monthly. Furthermore, it is evident that the EU carbon emissions do not affect the global temperatures instantly and have a 2 month lag before they are realized in the effects of global temperature increases. Furthermore, a 5% impulse shock response test can be utilized in order to assess the effects of an increase in EU emissions towards the global temperature in order to assess whether the effects would be positive or negative. This is important, as aforementioned, there are countries that do not have a significant to the extent of the European Union in their carbon emissions towards the global climate change, however, their temperatures rise due to other countries. A combination of the granger causality test and an impulse shock response test would show an increase if the European Union does have an affect on the global climate change. Countries that would not produce a significant amount of carbon emissions would see a small difference in the global temperatures even if a 5% positive shock impulse was applied to their carbon emissions. The following figure demonstrates the results of the impulse shock response test:

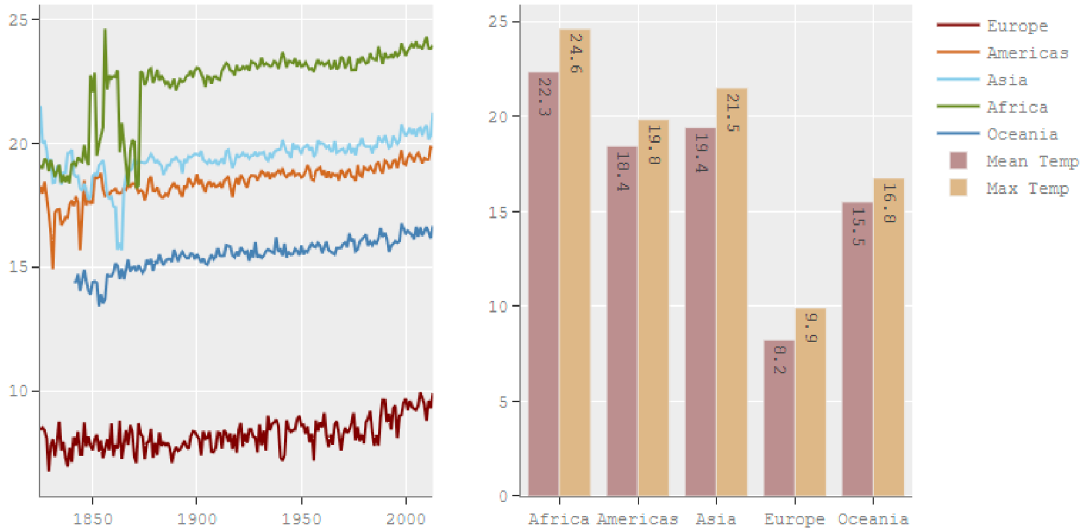
Figure 10 – Impulse shock response test results



Source: Author

The results suggests that there would be an increase in the global temperatures of up to 0.1 degrees in global temperatures if the EU emissions would increase by 5%. This indicates that there is a relationship between the EU and the global climate change and secures its place as one of the major contributors. This signifies the importance of ensuring that the EU does not increase its emissions further and takes urgent action towards ensuring that its sustainability programs are being adopted and implemented to ensure that the increase of global temperatures continues. In order to visualize this effect, the average temperature increases can be visualized based on each continent, in order to understand the effect on the temperatures in comparison to the contribution, the following figure demonstrates this relationship:

Figure 11 – Average temperature increase



Source: Author

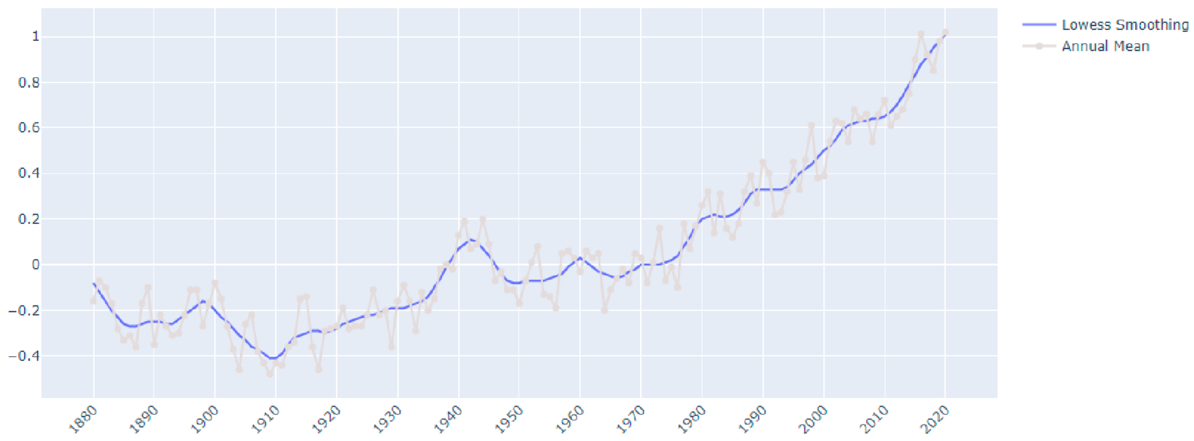
The results suggest that there has been a large increase in Africa and Oceania despite their continents not being a major contributor towards the global climate change. Despite the large carbon dioxide output of the European Union and the United States, their increase have been relatively the same, however, the mean and the maximum temperature remains low, and ideal for the continuation of economic activity. However, Africa has seen a considerably larger effect on its average temperatures, and the situation regarding the global climate change is much more immediate for their region, which supports the findings of the theoretical review in the previous section of the thesis. Europe having an average temperature of 8.2 and 9.9 from the period of 1850s and 2020, indicates that it is the least affected in terms of economic activity.

If specific countries are concerned, the increase in average temperatures compared to the indicators in 1970s, the largest increase has been observed in Brazil where the average temperature has increased by 4.61 degrees. Although it can be argued that Brazil has increased its industrial output considerably over the last century, it cannot be argued for the country of Nepal, where the increase of average temperatures has been 4.23 degrees yet its carbon emissions are some of the lowest in the world. In Czech Republic alone, the increase has been by 2.04 degrees and in Germany the increase has been 1.73 degrees, despite it being one of the largest manufacturers in Europe, with Czech Republic although not producing as much as Germany seeing a larger average temperature increase. Therefore, it is clear that although there may not be a large contribution in terms of emissions, the effect of the global climate change may be felt by countries that are not contributing in their emissions to the same extent (and not benefitting economically in any way) yet their temperatures are rising considerably higher. Currently, the regression analysis suggests that there is an increase in average temperatures within the EU at the rate of 0.112 degrees annually, under 95% confidence.

3.2. EU Fishery Revenue Impact Assessment

The temperature of the ocean has clearly risen in line with the surface temperatures. The global land temperature index demonstrates this change, presented in the following figure:

Figure 12 – Global land-ocean temperature index

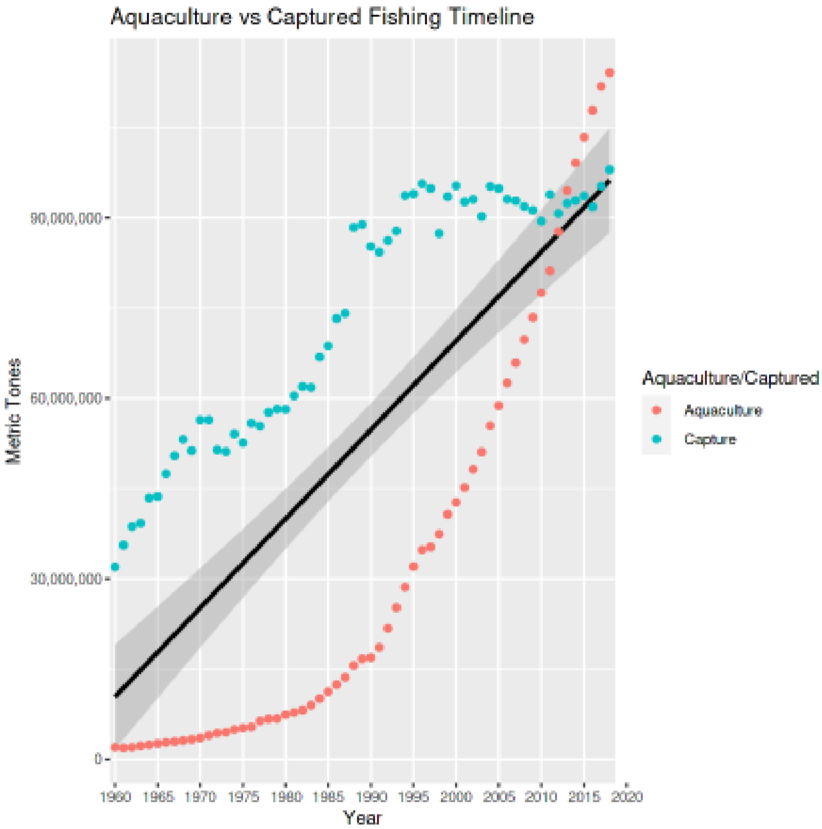


Source: Author

The figure represents that the average temperature has increased roughly by 1 degree since the 1970s, for many species, this can mean an increase in their metabolism leading to a shorter life span, disrupted mating cycles, as well as achieving a lower weight throughout their life which yields overall less catch and has to be substituted by more fish being caught.

After overfishing that occurred during the 1900s and subsequent worries that emerged in the early 2000s, there has been a significant shift in the fishery industry as to how fish is obtained in the European Union. This is primarily expressed in the development of aquaculture. The following figure demonstrates the development of aquaculture within the European Union in comparison to live capture of fish within its industry:

Figure 13 – Acquaculture development in the EU

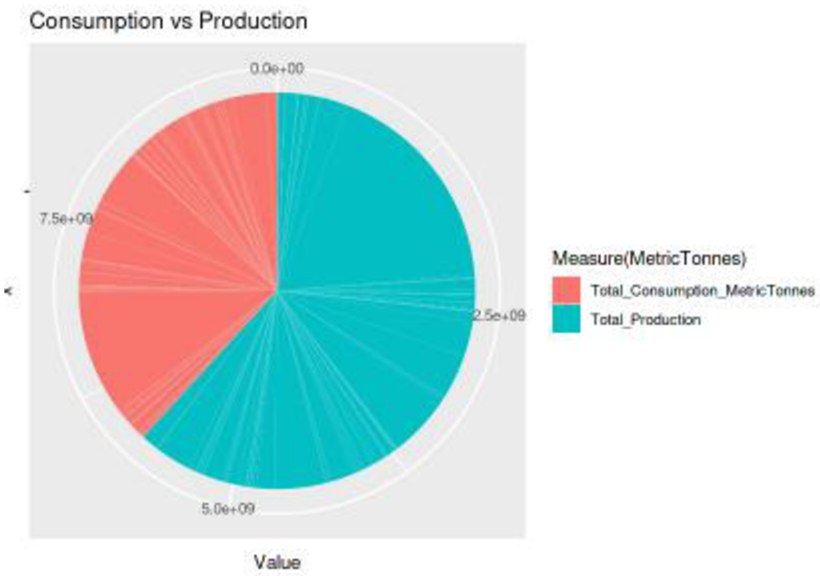


Source: Author

Currently, it is evident that more fish is generated through aquaculture rather than through live capture. The problem of overfishing being noticed in the start of 2000s is also present within the figure, as the capture rates have been relatively maintained above 90,000,000 metric tonnes. Furthermore, it is important to assess whether there is a balance between the production (or capture) of fish and their consumption. This is primarily to evaluate whether there is a surplus of the fish that is being caught, which eventually either rots which leads to loss of sustainability or if there is a relative balance which would suggest that the fishing industry is catching the required amount of fish to meet the demand.

The following figure demonstrates the relationship between the fish consumption and its capture:

Figure 14 – Consumption vs. Fish Captured (2020)

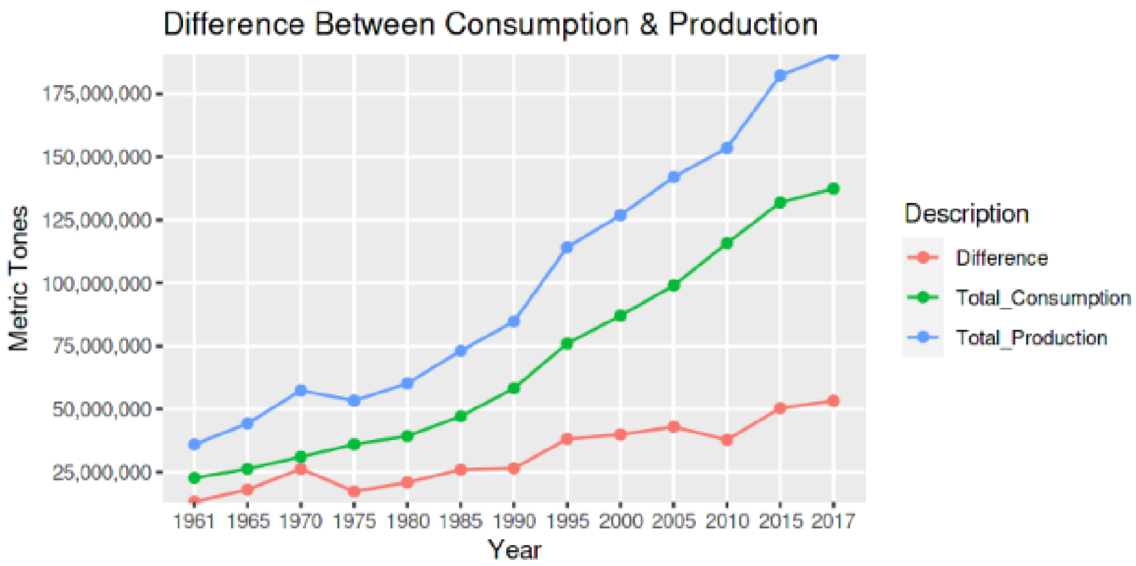


Source: Author

The figure demonstrates that there is a relatively large surplus that is being obtained within the European Union, above 23%. This includes the data available for export, thus concluding that there is a 23% waste of fish being observed within the European Union. Although it is impossible to estimate perfectly the demand that is expected, however, a surplus of 23% suggests that 20,700,000 tonnes approximately of fish is not consumed. There may be alternative ways of processing fish that is not sold, however, these methods are not accounted for in the scope of this thesis. The primary use of expired fish may be for feeding of carnivorous species within aquaculture, however, there is no evidence to support this practice. Thus, in terms of the fishing industry and this finding, the evidence suggests that there is a relatively large room for improvement in terms of sustainability of the fishing industry in the EU.

Furthermore, it is important to assess whether these indicators are present currently, as it can be argued that the year of 2020 has shown such indicators, and the demand has been grossly miscalculated which lead to such a large surplus of fish being captured. The following figure demonstrates the history of the consumption and production of EU:

Figure 15 – Consumption vs. Fish Captured History

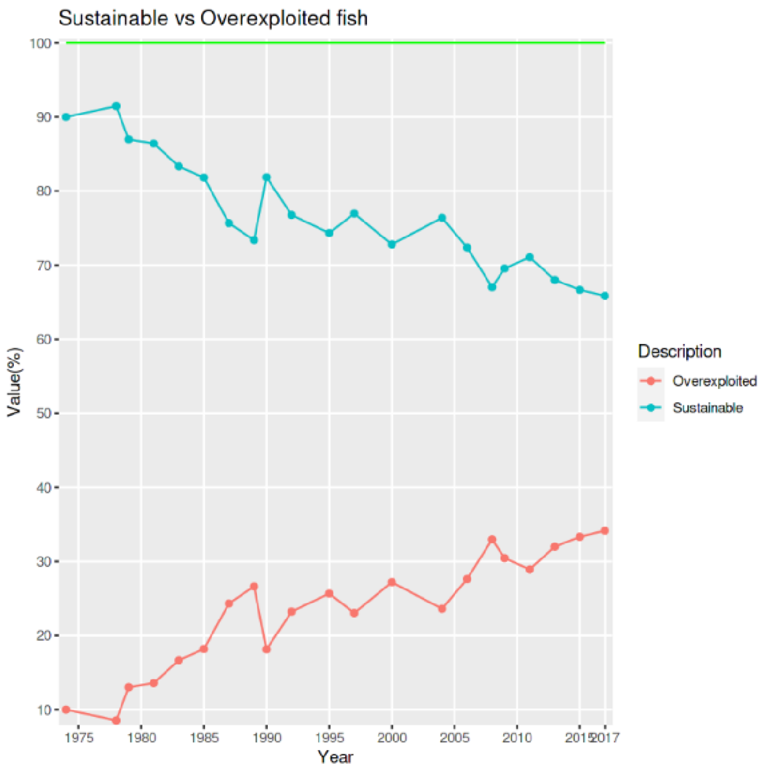


Source: Author

It is evident that the total production is higher than the consumption since the 1960s. Furthermore, it is evident that the difference in the production of fish and its consumption has only increased, indicating that with time there has been loss of sustainability rather than a gain. Thus, the argument that there has been a miscalculation made for the year of 2020 cannot be made, as this has been a present and a systematic error for the last half a century. Even if the population of Europe has been consistently rising during this time, this does not provide an adequate explanation on the consistent loss of sustainability over the years.

The loss of sustainability can be demonstrated within the following figure:

Figure 16 – Loss of sustainability in the EU fishing industry

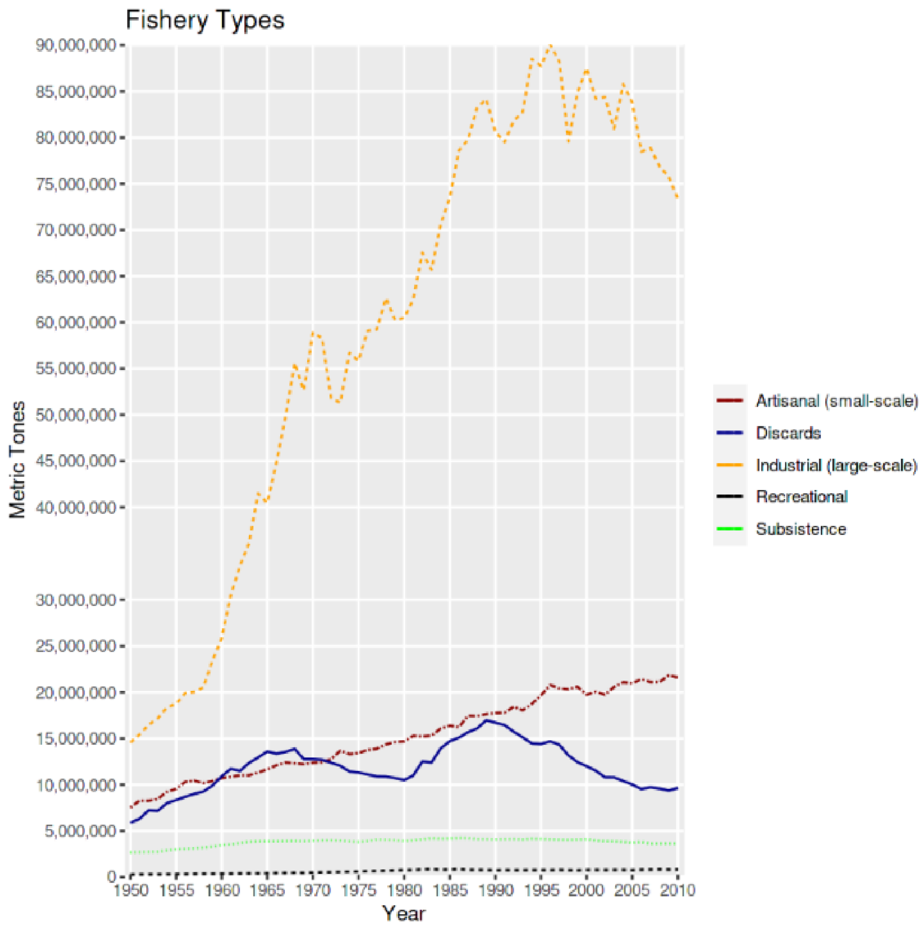


Source: Author

It is evident that in the 1970s and early 1980s, the sustainability of the fishing industry has been much higher, surpassing 85%. However, the fishing industry has only been increasing its overexploitation of the marine life and reducing its sustainability with time. This suggests that as the population of the European Union has been increasing with time, the efficiency of the fishing industry has been only decreasing. Most notably, the discussions surrounding sustainability and efforts towards ensuring a better environment has been ongoing since the start of the 1970s, however, although there is a large progress being made through the introduction of electric vehicles and sustainable methods of production of electricity by moving from a coal-based production towards renewable energy, the lack of sustainability in the fishing industry is largely overlooked.

It is important to assess whether the fishing industry in the EU and its lack of sustainability can be attributed to large companies or an increase of artisanal fishing practices which may lack in efficiency compared to large commercial vessels. The following figure demonstrates the number of fish captured according to the type of fishery:

Figure 17 – Loss of sustainability in the EU by fishery type

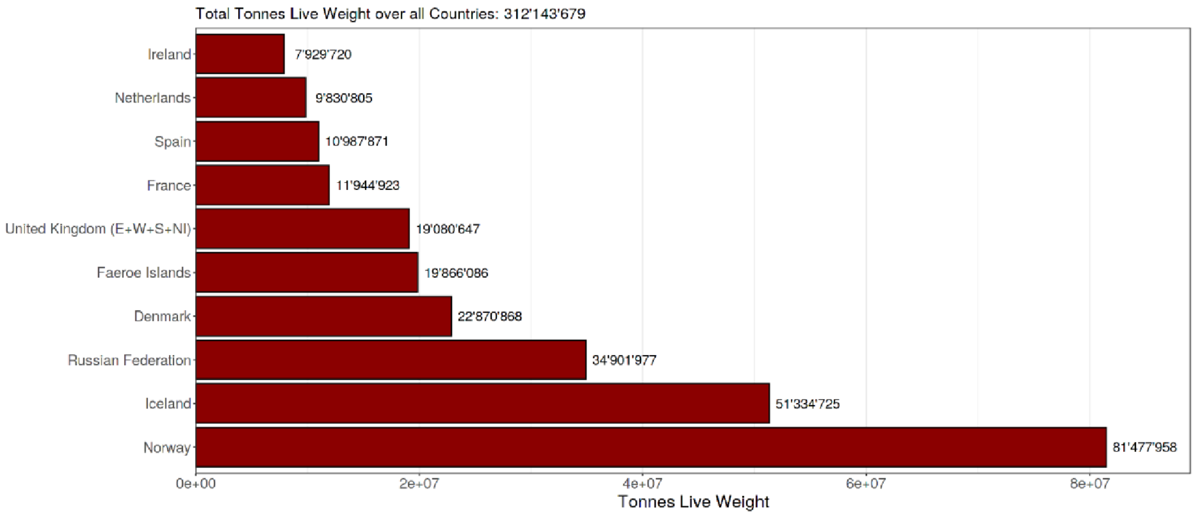


Source: Author

Through this figure, it is evident that the majority of the fish capture is performed by large-scale industrial fisheries, and its rapid growth has been halted around the 2000s, which is in line with the theoretical overview and the findings within this section. However, it is also evident that there has been a significant growth in the artisanal fishery types. Thus, although there has been a small decrease within the industrial and large-scale capture, its decrease is largely compensated by the increase in the artisanal fishery type. Thus, it can be concluded that the production, as well as overexploitation and decrease of sustainability continues to decrease as more fish is being captured each year.

Furthermore, it is important to assess which countries perform the most in terms of the fishing industry within the EU, and surrounding countries. It is important to recognize that although Spain has the largest number of locations out of all countries in the EU of fishing spots, Spain is not the largest in terms of fish production. The following figure demonstrates the top 10 countries by tonnes of live weight fish in the waters where EU fishing is occurring:

Figure 18 – Countries by live weight fish in the EU waters (2023)

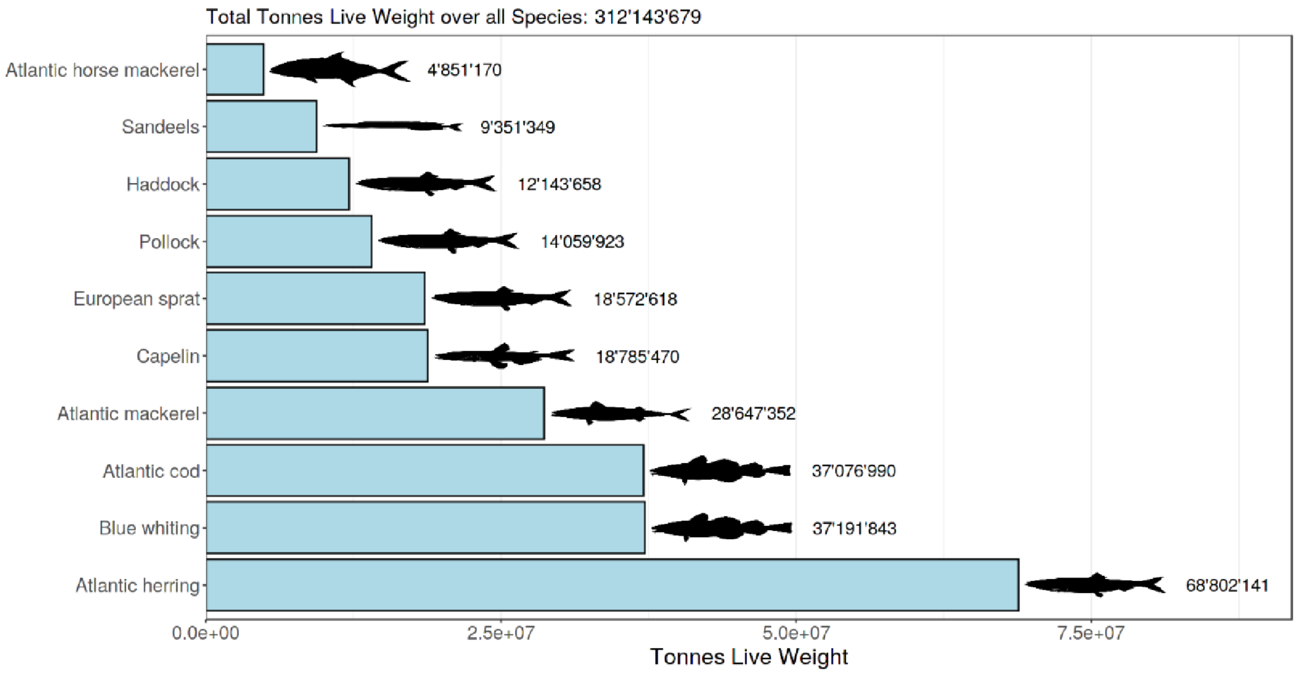


Source: Author

The data provides evidence that majority of the fish is being caught in the Northern waters of Europe, which is supported by the theoretical research. The largest catch is reported by Norway (which is not part of the EU as a member state but contributes in export to the EU and its consumption), followed by Iceland and the Russian Federation (which is not part of the EU, but contributes in export to the EU and its consumption). Furthermore, the Faroe Islands and Denmark are performing fishing activities in the same area. Other countries such as France, Spain and Ireland perform their fishing in the adjacent waters, as well as sending their commercial ships towards the Northern Atlantic waters.

Furthermore, it is important to assess which types of species are being caught by the EU fishing industry. This is particularly to emphasise the species that are being caught and the cost of live weight capture. The following figure demonstrates the amount and types of species that are primarily being caught by the EU fishing industry:

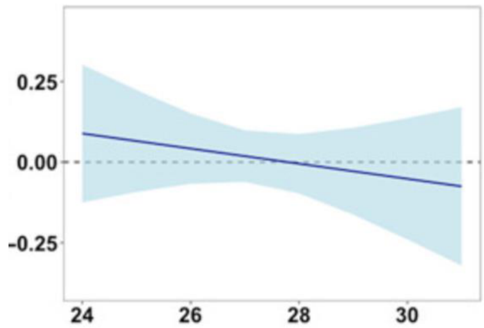
Figure 19 – EU Fishing Capture by Species



Source: Author

It can be concluded that the most captured fish within the EU is the Atlantic herring, followed by the blue whiting and the Atlantic cod. It is important to assess how the live weight of these fish would decrease based on the temperature. The following figure demonstrates the relationship between the fish catch in kilograms compared to the temperatures:

Figure 20 – EU Temperature Increase by Species



Source: Author

The results suggest that the negative change occurs at around 28 degrees, where the live catch begins to decrease marginally by around 0.10, representing 10% decrease. Furthermore, the usage of active gear becomes inversely proportional at the same temperature, indicating that the EU fish industry has to use more equipment to maintain their catch past this temperature. However, it is important to note that this change occurs at 28 degrees and at the Northern region of the EU, where most of the fish is caught, the average temperature is below this factor. Thus, it can be indicated that the fish catch primarily would remain unaffected as long as the temperature is below 28 degrees. This, however, becomes a different issue towards the southern countries of the EU, such as Greece, Italy, Croatia, Cyprus, Spain and Portugal, where the temperature can exceed 28 degrees for more than 5 months per year. This suggests that for every degree increase the catch is reduced by 10%, unless active equipment is used, or the fish is caught during a different season and flash frozen for later use. Although this places these countries under more threat for fresh fish catch, it is important to recognize that the issue is approaching the EU.

3.3. Annual Costs

The fish industry is likely to cause a movement towards fish catch moving further North, which would contribute towards the overexploitation of the region, while decreasing the catch of Southern countries and their ability to generate revenue within the EU. Based on all the data that has been collected, the approximate cost of the fishing industry can thus be estimated which occurs due to global climate change:

$$Minimum\ Annual\ Cost = ((436{,}230{,}617 + 762{,}223{,}362 + 59{,}780{,}369 + 3{,}320{,}621{,}987 + 1{,}430{,}721{,}133 + 219{,}623{,}631) * (0.1) * 0.41666)$$

$$Minimum\ Annual\ Cost = 259{,}545{,}893$$

The minimum annual cost is based currently on the average temperatures above 28 degrees and represents the total cost on the fishing industry. Thus, almost 260 million euros is lost annually by the fishing industry each year, attributed to the most affected countries being Greece, Italy, Croatia, Cyprus, Spain and Portugal where the average temperature exceeds 28 degrees for 5 months of the year. This is a "minimum" cost because it does not account for the increase in costs for using more sophisticated fishing machinery which occurs past the 28 degrees mark. Furthermore, this figure is calculated with the assumption that the catch is maintained annually instead of increasing, which would mean that the cost is even further increased. It also does not account for the price increase that occurs with fish catch being reduced for specific species, as the data is severely limited.

It is important to note that the revenue of the fish industry within the European Union does not decrease, as annually there is an overall increase with some countries showing the maintenance of their financial indicators. In the theoretical part of the thesis, it has already been outlined that the affected countries are the ones that are proven by the statistical analysis. And it is important to recognize that since the financial indicators either increase or remain the same by the fishing industry, these costs are thus distributed onto the consumers. This suggests that for every degree increase, all EU citizens are suffering a loss of 0.60 euros. Furthermore, this considers the scenario where the temperatures within those countries are at 28 degrees. Realistically, the average temperature between each country varies for these 5 months between 28 degrees and 38 degrees. By taking the average of that temperature, every EU citizen cost is 6 euros. Accounting for the younger segment of the population of the EU consisting of citizens below the age of 18, the figure increases to 7.2 euros.

The approximation of 7.2 euros is applied to all citizens aged above 18, without considering whether they consume fish. The citizens that are more conditioned to a diet that includes fish, the cost increases even further. Although 7.2 euros being a cost that applies to all citizens, it is important to recognize that this is the cost which comes from the fish industry alone, excluding all the additional costs that the global climate change is causing in terms of the energy costs, agricultural production, property damage due to extreme weather and the plethora of other costs that are associated with the global climate change.

If the overfishing is accounted into the equation, considering the 23% waste of the fishing industry in the EU. The cost is approximately 193 euros, as the loss of income is still distributed onto the consumers. This is considering the annual revenue of the fishing industry being 118 billion euros, with 23% of the revenue being wasted (totalling to 32 billion euros). If the fishing industry would adopt a more efficient management of its catch, the cost can be mitigated significantly, and its in full control of the fishing industry. Although the average global temperatures cannot be lowered through a more efficient management, as this would hinder the economic performance of member states drastically, adjusting the fishing practices and lowering the catch would maintain the revenue of the fishing industry and lower the costs that are distributed onto the consumer. The loss of revenue is significant enough to state that majority of fish price increases that are beyond the inflation rate is attributable to inefficiency rather than the global climate change.

Even if the fishing industry adjusts its catching routines, or travels into the middle of the Atlantic Ocean, changing locations cannot be an adequate measure to combat rising prices as the extra fuel spent on travelling beyond the immediate waters adjacent to each country would incur costs. Thus, this thesis argues that the total cost of 200 euros per year being an accurate amount.

3.4. Forecast

The fish industry is projected to grow by 11% CAGR by 2028, this suggests that the fish industry in the EU will continue to raise its total production. Following the indicators of its inefficiency with rise of total production, it will continue to increase beyond 23%, further increasing the costs on the consumer despite the fish not being in any shortage. This suggests that the EU fishing industry must adopt more efficient methods of fishing in order to ensure that the cost of revenue is decreased and there is more sustainability within its activities. This would reduce the overall cost of fish and benefit the average EU consumer up to 200 euros per year. The direst scenario for the consumer would be the maintenance of the catch values while the growth of the revenue continues, indicating that fish products would continue to appreciate in their price. The other alternative is for the EU fish industry to forego profit and revenue generation, accepting its inefficiency as a factor that cannot be distributed onto the consumer and restructure its methods used for fishing to ensure more sustainability and increase its profits through efficient practices rather than simply increasing the prices on all the products to compensate for the lost revenue.

3.5. Alternative Scenario

The EU vision 2030 and 2050 goals of ensuring sustainability in terms of carbon neutrality would ensure that there would be less costs from the global climate change. In terms of the fish industry, this would achieve 260 million euros in savings from temperature increases on the fish industry. It is important to note that the EU did not specify the conditions of the fish industry in its vision plans for 2030 and 2050, which would significantly benefit the EU as a whole as this would save up to 32 billion euros if the fishing industry was made to be more sustainable. Although currently the temperature increase following the regression analysis is positive in the EU, the plans specified to prevent a 2-degree rise. Although in some member states this has not happened yet, as aforementioned, in countries such as the Czech Republic the increase of 2 degrees has already occurred. This increase cannot be attributed to Czech Republic alone either, as other member states can affect others more than the countries that are being affected by temperature increases. This has been highlighted in the comparison between the temperature increases in Germany and in the Czech Republic.

Discussion

It is evident that global climate change is currently occurring, and although the average temperatures are still increasing, it is important to consider the complications it has on the EU fish industry and EU consumers. The EU contribution towards the global climate change is significant, as it produces higher carbon emissions than the rest of the world. Despite this, its average temperatures have not increased significantly as in the cases of other countries that have produced less emissions yet were affected more. This serves as evidence that there is a level of responsibility and duty to improve its carbon emissions indicators that have contributed towards the global climate change since the 1900s and contributed towards the economic growth of the region. Currently, higher indicators are only seen within the United States and China, where the United States has withdrawn from the Paris Climate Agreement.

The relationship between surface temperatures and the ocean temperatures have been established, and although majority of the fishing is conducted in the northern Atlantic Ocean where the temperature increases have not exceeded to the point where it would be detrimental to the revenue, there is already 260 million euros in costs for the industry, that are then distributed onto the consumers. During the exploratory data analysis of this study, another concerning factor was uncovered relating to the sustainability of the fish industry in the EU, as 23% of the catch is not consumed. This suggests that there is 32 billion euros of potential damages minimum to the revenue, that are also distributed onto the consumer, which brings an annual cost of 200 euros to the average EU consumer. This surpasses the current cost of 7 euros which is attributed to the global climate change and must be addressed urgently as this is an issue which can be directly affected without a lagging factor as it is the case with the global climate change and temperature rises. Despite EU leading the world in terms of sustainability in terms of alternative sources of energy and transitioning towards renewable energy, the EU fish industry's sustainability has only decreased since the inception of the political discussion of sustainability in the modern age. The industry is currently projected to grow, which suggests that the inefficient practices will continue, and the costs will continue to increase.

Conclusion

The EU contribution to the global climate change has been addressed and estimated, which estimates that even a 5% impulse shock to its emissions would increase the global temperatures by 0.1 degrees. The evidence was confirmed by utilizing the Granger Causality test as well. Furthermore, the impact of the emissions produced by the EU has shown to affect other countries more than the EU itself, which places it to be the most significant benefactor of utilizing unsustainable practices in order to propel its economic growth throughout the 1900s. Nevertheless, the EU is currently leading in its efforts to a more sustainable future with its 2030 and 2050 vision. Unfortunately, this vision does not concern the sustainability of the fish industry in terms of its catch.

The estimated cost of the inefficiency of the EU fish industry is 32 billion euros, whereas the cost of global climate change is estimated to be 260 million euros at the minimum. The EU fish industry would benefit from compensating for the increase in global temperatures affecting its revenue by choosing more sustainable practices, which have significantly impacted the loss of revenue through inefficiency since the 1950s. Furthermore, the fish industry must consider sustainable alternative fuels to diesel, by funding research and collaborating with institutions in order to develop more sustainable technologies. Nevertheless, the EU fish industry must make continuous efforts and urgently to ensure that its efficiency is increased, as 23% of fish being left unconsumed confirms that the overfishing practices since the start of 2000s have not been solved. Alternative methods of mitigating costs by choosing other locations are unsustainable in themselves and carry increased costs of revenue due to the extra distance that will be travelled. Furthermore, it could lead to overfishing in a specific area that will be detrimental to the local species, such as in the case of the Northern Atlantic region where currently most of the fishing is conducted.

The forecast suggests that the industry is projected to grow, however, according to the trendline established as of the year 2024, the inefficiency will continue to progress unless it is addressed. Furthermore, the economic loss due to the global climate change will continue to happen as the gradient of the regression line remains positive. It is paramount that all EU member states, along with the rest of the world accept sustainable practices in order to ensure no further damage is done by the global climate change, specifically towards third world countries that are currently being affected the most.

The limitation of the study is specifically within the availability of data. The research would have benefitted if there was more information available on the specific species that were caught on a more frequent fashion (monthly, rather than annual). Furthermore, the research has been limited by the availability of theoretical information on similar topics, as this subject is particularly left understudied.

The recommendations for future research include more sophisticated financial models to estimate the true cost of the global climate change on the fish industry, as well as the cost related to specific countries. This could include the utilization of GARCH and ARCH models that would be subsequently used to project a forecast on the catch and global temperatures. Other recommendations include investigating the cost of machinery, and the costs of associated with the fluctuation of petrol prices on the fish industry, which then get distributed onto the consumers.

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