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**CLIMATE CHANGE, FINANCIAL (IN)STABILITY AND
MONETARY AUTHORITIES:
Fiscal vs monetary authority**

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**CLIMATE CHANGE, FINANCIAL (IN)STABILITY AND
MONETARY AUTHORITIES**

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INTRODUCTION

The focus of the thesis is on climate change, financial instability and monetary authorities in the world. Climate change became a problem due to an increase of greenhouse emission in the last years worldwide, creating a rise of the average global temperature. In order to decrease the consequences of climate change, creating environmental consequences and financial instability, central banks could cooperate in the mitigation process, as financial and monetary authorities. The problem is that the mandate of these authorities does not include mitigating climate change risks instead, it is in the fiscal authorities' mandate. Anyways, many central banks around the world instead, decided to start collaborating in the climate change fight.

The analysis of the thesis surrounds the concept of whether monetary authorities should take a position in the climate mitigation process and if yes, how these authorities can take actions.

The relationship between climate change and its impact on the economy is fascinating. This is what led the topic of the thesis to be how financial and monetary authorities could help avoid a catastrophe in the stability of the economy. All of these are part of the world's future, and overall, the unstable situation and the unforeseeable future caught my attention and made me eager to dedicate my thesis to. This thesis provides a sparkle of hope for the future of our world, drawing important institutions' attention such as central bank to their responsibilities to focus on climate change consequences in an economical and financial view. Changes in the structure of the mandates of these institutions are needed to achieve this goal.

The thesis will start by covering the concept of climate change, the economic damage and the risks raised by it. Later on, it will talk about the fiscal and monetary authority and different central banks' actions on climate change. In the end, it will introduce the European Union and the European Central Bank and how they are handling the climate mitigation process. In this way, the thesis fully covers the concept of how climate change impacts the world and the economy and finishes with the economic and political union where I live, the European Union. This allowed me to gain much information on the subjects globally, and more in particular in the place I was born and raised. All these reasons led to structuring the thesis in the following way.

The thesis is structured in three chapters. These will be presented through an extended summary providing a detailed description of what the thesis will discuss to reach the thesis's goal mentioned earlier.

Chapter one will introduce how climate change impacts the world and aims at showing the financial-economic consequences of climate change. The chapter will start by delivering the most significant cause of climate change: global emissions. Global emissions have been increasing steadily due to a rise of the Greenhouse Gases emission. These emissions have different impacts on the world, such as rising temperatures and environmental disasters (hurricanes, flooding & others). The impact of climate change is very different for every industry, sector and country. Some countries, such as India, will have the worst consequences from climate change, as these catastrophic climate events will hit them more because of their geographic location and lack of overall development.

Overall, all countries around the globe will be hit by the consequences of climate change in more or less devastating ways. The damages created can be divided into damages to the population's welfare and damages creating utility losses and loss in the ecosystems. Some examples of these damages are disruptions in production, decreased work productivity and the default of industries hit by environmental disasters. All these damages influence the financial (in)stability worldwide.

This is where the relationship between climate change and financial stability rises. Central banks and monetary authorities play a crucial role, as they are responsible for a stable financial system. Stable financial systems are needed to continue the normal growth of the economy. Safeguarding the future by mitigating climate change is required to pursue this goal.

Although the collaboration of everyone in the world would be needed in this fight, some countries are more incentivized than others to participate. This is also defined as the "*tragedy of horizons*", where the generation living today does not take care of the climate change risks as the consequences will be felt more in future generations.

Overall, although the mitigation procedures for climate change and the timeframe are unclear, the financial risks created by climate change are evident. These risks are divided into transition,

physical, liability, operation and transition path risks. Transition risks are the financial risks created by new policies toward an environmental-friendly energy-based economy. Moreover, physical risks are the climate change events such as flooding, droughts and heatwaves. Liability risks are the ones that consider the parties responsible for the consequences of climate change, such as parties accountable for policies on high carbon emissions. Operational risks are an interruption in the regular operation of a business. Lastly, transition path risks are government mitigation policies such as policy changes due to potential government debt, financial institutions, or securities markets that can cause financial instability.

Transition and physical risks are the ones that have the most impact on financial stability and have several microeconomic transmission channels: credit, market, liquidity and operational. Credit risks are increases in bank's loans risks due to failed loan commitments and possible default in the recovery of loans. Market risks, instead, are the chances of the value of financial assets due to the volatility created by climate changes. Liquidity risks are the risks of changes in the bank's liquidity and the creation of defaults and bankruptcies. Lastly, operational risks are the alteration of the normal operation ability of banks created by natural disasters or other climate change risks. One of the solutions to these risks is using macro-prudential policies. This makes macroprudential policymakers responsible for the financial aspects of climate change risks. Overall, the conclusion is that governments and central banks need to work together toward creating mitigation procedures for climate change.

Additionally, worldwide entities have been created for this fight to develop international regulations. Many entities and framework such as the United Nations Framework Convention on Climate Change, the Network for greening the financial system, the Task Force on Climate-related Financial Disclosures and many more have been created to help this fight. Other than entities, agreements have also been created to push countries toward reducing gas emissions. The Kyoto Protocol, the UNFCCC and the Paris Agreement are the most significant deals toward mitigating climate change risks.

Overall, chapter one clarifies that climate change is a global issue causing financial stability and, the intervention of many different authorities in the world is needed in this fight.

After this introduction on climate change mitigation, chapter two will start by presenting the

public intervention of different entities to tackle climate change. The two main authorities are the political and the delegated authorities. Political authorities are identified as parliaments, governments, ministries and other public institutions; instead, delegated authorities are recognized as central banks and financial supervisors.

These two authorities have limits on the actions that they can take. This raises the problem of the distinguishment between fiscal authority (political authorities) and monetary authority (delegated authorities). Often central banks can only do tasks within their mandate and ,only fiscal authorities can change policies and add functions to central bank's mandates.

This is the case of climate change mitigation; it is in the hands of governments to create policies to mitigate climate change. The chapter focuses its attention on whether central banks and other financial institutions should try to tackle climate change issues.

Central banks are institutions controlling the money in circulation and mainly controlling inflation and stability in the economy. Climate change creates a problem for the central bank as it threatens the usual way of work and creates a source of financial risk. This is why mitigating climate change should be now considered to fall under the mandate of holding financial stability.

Unfortunately, fighting climate change risks is not officially stated in the mandate as a task and financial policymakers cannot create any policies and cannot take any action. The only role central banks can play at the moment is adjusting the market efficiently to climate changes. Nevertheless, central banks are needed to take a position on climate change, as stated in several research papers: Bradlow (2021), Campiglio and al. (2018), Cochrane (2020) and Dikau and Volz (2021). In the last years, central banks have been including many more green activities and are taking more environmental issues into account.

These authorities can help mitigate climate change by using monetary policies; different central banks are deciding to implement different policies. Almost all central banks recognize climate change as a threat and acknowledge that climate change mitigation needs to be part of their goals. The mandates given to central banks worldwide are often very similar, such as just mentioned, keeping prices stable and financial stability. Overall, nearly all central banks decided to participate in climate change mitigation and are willing to do what is possible and in their power

to mitigate climate change.

Chapter three focuses on how the European Union (EU) and, more specifically, the European Central Bank (ECB) deal with the challenges that come with climate change.

Since the European Union was created, it has shown significant leadership in climate mitigation and the Paris Agreement. The EU would like to be the first climate-neutral continent (European Green Deal) by setting several steps to be followed throughout the years and regular meetings to check on the improvements.

The EU is strongly committed to the objectives. It created several action plans, such as the EU taxonomy, to correctly define what is considered a sustainable economic activity, the European Trading system, to limit emissions and creating a trading system of allowances for greenhouse gases that can be emitted. It also introduced green bonds and a green bond market to transition toward a more sustainable economy. The green bond market aligns with the definition of sustainable economic activities given by the EU taxonomy and it has been increasing steadily lately, with the Euro being the main currency for the trading of green bonds.

The ECB's mandate states that its responsibility is to maintain price stability in the Union. Although its mandate does not include any climate change mitigation, several Articles in the mandate mention the requirements of pursuing environmental objectives. Overall, these Articles say that the ECB should consider environmental targets and the ECB has the right to act to mitigate climate change risks concerning its price stability objective. For these reasons, the ECB created a climate center cooperating with the Euro system to take into consideration climate change in the monetary policy framework.

What the ECB can do to tackle the risks is use monetary policy. Including climate change consideration in monetary policy has been one of the duties of the ECB in the last years. The ECB created many actions to implement the monetary policy to fight climate change. All of the actions have the purpose of going towards an environmental-friendly future. The actions ensure that the new monetary policy for climate change is adequately prepared and does not create any catastrophic economic shock in the Union. It will also help the ECB implement green measures in its policy framework while standing in its price stability mandate.

The ECB prepared all the actions to implement monetary policy considering climate change. Still, it also needs to consider the way climate change impacts the regular operation of the conduction of monetary policy. The main transmission channels of monetary policies used in the Union are weakened by climate change. Acknowledging these and including the climate change risks allows the ECB to maintain the price stability goal while implementing new monetary policies.

Overall, it will be seen in the thesis that monetary policy alone cannot sustain environmental transitions. It is in the governments' hands to create policies to mitigate climate change. Central banks must support their decision and do everything possible to implement and follow the guidelines given, always taking into consideration that, central banks have an important role to hold the financial stability considering the possible consequences of climate change. All of this will be adequately argued and discussed during the thesis.

CHAPTER 1: CLIMATE CHANGE AND FINANCIAL RISKS

CHAPTER 1.1: INTRODUCTION TO THE CHAPTER

The objective of this chapter is to show the financial-economic consequences of climate change and how these can have an impact on today's relatively stable economic situation in the world. To start with, the global emission and global warming that have been increasing in the last years and their consequences will be discussed. The main causes of climate change will be presented. This will be followed by looking at the main industries hit by climate change and the consequent damages. After that, a light will be shed on the relationship between climate change and financial risks, followed by a description of the main risks that climate change brings with it and how these might have an impact on the economy. It will be seen that both policies and climate changes affect the economy and there is a trade-off between the consequences of climate change and the policies' costs. These climate change risks will also be analyzed regarding the financial stability problem of central banks and the actions that they can take to mitigate it. Several unions worldwide, introduced later in this chapter, are making plans for climate mitigation and reducing the possible consequences. The main regulations adopted, and the associations created to mitigate these risks will be presented at the end of this chapter to show how climate change mitigation process is going.

CHAPTER 1.2: CLIMATE CHANGE

The term climate change is one that is used frequently and in all layers of society. However, many will not be able to give a clear description of what it means exactly. NASA defines climate change as *"a long-term change in the average weather patterns that have come to define Earth's local, regional and global climates."* Global climate change poses a *"threat to the well-being of humans and other living things through impacts on ecosystem functioning, biodiversity, capital productivity, and human health"* (Goulder and Pizer, 2006). In short, it is a long-term change in the world's climate that includes a big risk for humanity.

The most significant cause of climate change is the rise in Greenhouse Gases (GHG) emissions and its consequences is global warming. An increase in quantity of substances such as hazardous chemicals and increase in Carbon Dioxide (CO₂) in the air. Greenhouse gases are gas constituents of the atmosphere that can be both natural and anthropogenic, which absorb and re-emit

radiation at specific wavelengths¹. Fossil fuels, instead, come from decomposing plants or animals. Humans burn fossil fuels to make fuel. Unfortunately, once these fuels are burned, they release Carbon Dioxide (a Greenhouse Gas). These GHG emissions get trapped in the world's atmosphere by the “*greenhouse effect*” and cause global warming. The greenhouse effect is the process by which a part of the radiation produced by the sun that should be reflected in the hearth gets reflected back in the atmosphere. This effect happens due to a high amount of GHG emission in the atmosphere, and, as a consequence, it adds heat to the lowest layers of the atmosphere and the earth’s surface (Masson-Delmotte and al., 2013). Carbon emissions and other GHG emissions created by humans are causing temperatures to get higher. The most significant amount of gas emission due to human activities is the emission of Carbon dioxide (CO₂). Other famous greenhouse gases are water vapor (H₂O), nitrous oxide (N₂O), methane (CH₄), and ozone (O₃).

Global emissions from fossil fuels have been increasing steadily since 1900. CO₂ emissions have increased by almost 90% since 1970, this is primarily due to fossil fuel combustion and industrial processes. The second biggest causes of the increasing presence of greenhouse gases are the agriculture sector and deforestation. The emissions coming from fossil fuel combustion and industrial processes are 78% of the total. The country emitting the most emissions is China, followed by the United States. On the other hand, countries like Russia and Japan have minimal emissions compared to these big polluters².

Several studies proved a linear relationship between the increase in emissions and the global temperature change (Concordia University, 2009). That means that slowing down emissions should slow down the change in the earth’s temperature. Unfortunately, the economic growth of industrialized countries in the last decades, which increased the living conditions of millions of citizens, often is driven by economies using tons of carbon emission gases. This makes it very unlikely for these countries to cut down on these emissions if there is a lack of decent alternatives.

¹ Information from United States Environmental Protection Agency. Overview of greenhouse gases. Retrieved from: <https://www.epa.gov/ghgemissions/overview-greenhouse-gases>

² Information from United States Environmental Protection. Global Greenhouse Gas Emissions Data. Retrieved from: <https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data>

Chapter 1.2.1: Climate change impacts the world

As it will be seen now, the collaboration of all countries in the world is needed to limit catastrophic events. The data analyzed by NASA's Goodard Institute for space studies (GISS) shows how in the last 150 years, globally, the temperature raised steeply. GHG emissions have been increasing a lot since the industrial revolutions, which brought the world temperature to rise steadily in the last years. The average increase in temperature is 1°C from 1880 to 2020, and it is expected to reach an increase of 3.2°C by 2035 and 5°C by the end of the century under a business-as-usual scenario (IPCC, 2018). Extreme temperatures have been more common in the last years, and weather records like the driest month or hottest summer are in the news every day. Overall, the decade from 2010 to 2020 was the worst period for climate change consequences, where catastrophic events related to changes in the world's climate frequently happened, which led to significant difficulties in the lives of millions of people. There are now several proofs that climate change has disastrous impacts on the ecosystem and human society. More and more, humanity is starting to understand that climate change has a huge impact on the economic system and human society, and it is time to act (Freedman et al., 2020).

To limit the number of catastrophic events, global warming should be limited to 1.5°C compared to the average temperature before the industrial revolutions. There is just more or less a decade to do this (IPCC, 2018).

Besides just an increase in temperatures, climate change brings several other impacts on the world that led to environmental disasters such as hurricanes, flooding, and many other catastrophic environmental events. Severe environmental disasters have increased by 29% since 2012 (Slubowski, 2017). In 2020, there was a record in the number of hurricanes, wildfires, and floods globally, which caused around \$210 billion in damage. Just in Asia, the losses came to be about \$67 billion, and only \$3 billion was from insurance for the disasters (Newburger, 2021). In the financial stability review of May 2021, the European Central Bank estimated damage due to natural disasters during 2019 that are *"around 1% of the GDP of the euro area"* (Gili and Rizzi, 2021). This could lead to a twenty billion loss euros every year and cause huge damage to firms with long-term effects on their productivity. This is only an example of the consequences that climate change can have. Overall, *"the largest impact of climate change is that it could wipe up to 18% of GDP off the worldwide economy by 2050 if global temperatures rise by 3.2°C"* (Marchant, 2021).

Global warming is happening in very heterogeneous ways and will have different impacts on the economy, depending mainly on the location. Some countries, such as India, will have the worst consequences from climate change, such as a loss of between 50 to 100 dollars of damage per metric tonne of CO₂ emitted (Caldeira, 2018). Global carbon emissions affect the globe's temperature and it is essential to analyze how temperatures are affected.

Studying global warming is not as easy as it looks. It is essential to consider how temperatures have been changing over the years and that the world is developing simultaneously and adapting to these changes. These effects of climate change will not be the same for every individual, but it differs based on many factors such as income, locations, sectors, and many more. People who have their welfare most affected by these changes will move away towards places with better expectations and more stability, giving more economic power to a location unaffected by these conditions (Alvarez and Rossi-Hansberg, 2021).

Chapter 1.2.2: Damages of climate change

Overall, climate change is, although indirectly, caused by the economic activities done by humans. While most of the time, the population acknowledges this problem and recognizes themselves as a cause of climate change, they still expect governments and big political parties to deal with it without acting themselves (UNDP, 2021).

To assess the possible damages, climate change can be divided into market and non-market damages. Market damages are the welfare impacts due to productivity changes and price changes or the quantities of marketed goods. This includes changes in productivity caused by climate change in all sectors, such as agriculture, forestry, and energy services. Instead, non-market damages are utility losses from climate changes in the world and the lost ecosystem services and biodiversity. Non-market damages are hard to quantify (Goulder and Pizer, 2006).

Given this definition, policies on climate changes are very hard to implement as it is tough to assess the population's willingness to pay. Mainly for the non-market damages, the loss in biodiversity is not directly comparable with price changes or observable demands. This creates an issue in developing policies and regulations to limit this damage (Goulder and Pizer, 2006).

Regarding the market damages, it will hit economic activities of every type by creating disruptions in the production and delivery of goods and services due to climate changes. The most apparent economic risk consequence of climate change is in the sectors using natural resources such as agriculture, fisheries, and forestry (European Commission, n.d.). Other sectors affected by climate change are the infrastructure sector, the energy system, the insurance market, and tourism. These industries could be highly affected due to flooding, global warming, and other climate catastrophic events. Another problem for the sectors, but mainly the agriculture sector, is the changes in seasons due to changes in temperatures. Due to climate changes, agriculture production will lower by 40 to 190 billion per year (CMCC, 2018). At the same time, the agriculture industry is the most significant contributor to climate change, as it creates a tremendous amount of pollution. It can be said that they cause their problems, as they are the producers of emissions and also the ones that suffer from it.

Another significant damage due to an increase in temperature causes is a decrease in working productivity (a type of market damage): temperatures above 27°C could decrease humans' productivity by as much as 4% per degree, which has a considerable impact on today's economy (Singh, 2018). The demand for heating products will decrease; meanwhile, demand for cooling products such as air conditioning will increase. The availability of water supplies will decrease, leading to a decrease in the possibility of using hydroelectric power.

Furthermore, the impact of climate change on the profitability of these industries might cause defaults. These could have catastrophic consequences. Lower profitability in these firms arises from debt and bank losses. Furthermore, lower profitability and climate change might make investors lose their confidence. This would raise the use of liquidity and a "*fire sale of the financial instruments issued by the corporate sector*" (Dafermos and al., 2018). Investors should pay substantial attention to future investments in the sectors most damaged by these changes. At the same time, investors should look out for firms that could have an important policy change and a possible stop in production (e.g. firms with high carbon emissions). Regarding the issue of meeting the financial debts, climate changes disasters could lead to the situation where creditors (such as firms hit by hurricanes) will not be able to meet their obligations. This could decrease the availability of loans ceded by banks to populations exposed to these types of risks.

Moreover, the way in which economic resources are used can change under climate change. In a case of a hurricane, there is a massive need for economic resources, which would typically be used in different ways. All examples described until now create risks in the stability of the financial market.

So far, several economic consequences have been mentioned, creating a problem in the world's financial stability. Disruptions in production, decreased work productivity, and the default of industries leads to a shake in the world's financial stability. A stable financial system is defined as *“a system capable of efficiently allocating resources, assessing and managing financial risks, maintaining employment levels close to the economy’s natural rate, and eliminating relative price movements of real or financial assets that will affect monetary stability or employment levels”* (The World Bank n.d.). All these crucial pillars for financial stability can be hurt by climate change. Mitigating these risks means keeping the economy of countries and the world in general, stable and safeguarding the future. Central banks are the main entities with the main goal of maintaining financial stability; they play an essential role in this fight against climate change. Currently, policies and solutions are trying to be found to limit the consequences.

In the last ten years, investments in renewable energy sectors have increased steadily. This is the foremost possible source of change, together with focusing on investments in green industries. The hope is to get rewarded by “new” technologies and investments to mitigate the climate change risks (Lins and al., 2014).

CHAPTER 1.3: CLIMATE CHANGE AND FINANCIAL STABILITY

As mentioned so far, climate change creates several problems in the everyday “life” of firms, entities, and people by creating economic consequences leading to difficulties in the financial stability. Climate change could very well be the cause of the next financial crisis (Heutel and al., 2021).

Several important financial supervisors, such as the G20 Financial Stability Board, the International Monetary Fund and the European Central Bank, expressed their concern about climate-related financial risks. Several parties started fighting to include climate change in central banks duties.

Central banks have their principal mandate of holding financial stability. As climate change can mitigate the stability of the financial system, they are needed to help tackle climate change. The Network for Greening the Financial System (NGFS) mentioned that *“climate-related risks are a source of financial risk and that is in (central banks) mandates to ensure the financial system is resilient to these risks”*. Furthermore, the NGFS stated that *“climate change is a source of structural change in the economy and financial system and therefore falls within the mandate of central banks and supervisors”*. Financial supervisors now explicitly recognize climate change as a new source of financial risk (NGFS, 2019). The problem to pursue this goal is the limited legal authority central banks have compared to the government's authority.

Climate change's impact on financial stability is *“highly path-dependent”*. It is mostly reliant on avoiding the worst-case scenario and the most extreme climate changes and trying to have a well-organized transition³. As of now, it is still possible to make changes and avoid catastrophic events and, *“which path we follow is, for now, still in our own hands”* (Löyttyniemi, 2021).

The risks in the financial investments (financial risks) are possibly the key to mitigating climate risks. Financial risks can change the investment decisions of investors, if investors will start investing in more secure businesses such as green sectors, making some sectors riskier. In this way, companies and financial institutions are forced to consider climate risks when making choices.

Climate and finance are interrelated in two directions, both in payoffs and risks. That is also why a term like 'climate finance' came up. Climate finance is defined as *“local, national or transnational financing—drawn from public, private and alternative sources of financing—that seeks to support mitigation and adaptation actions that will address climate change”*⁴.

The climate change impact on finance can be divided into two types: direct and indirect. Direct impacts are all the possible shocks due to climate change, such as hazards to physical assets (e.g. hurricanes). Indirect impacts are adjustments that need to be made to mitigate the climate

³ Information from European Central Bank. Climate Change and the ECB . Retrieved from: <https://www.ecb.europa.eu/ecb/climate/html/index.en.html>

⁴ Citation from United Nations Climate Change. Introduction to Climate Finance. Retrieved from: <https://unfccc.int/topics/climate-finance/the-big-picture/introduction-to-climate-finance>

change risks and the possible scenarios that need to be accounted for, the estimates of results, and the transmission channels.

Until now, it is clear that it is very important to discuss the climate change risks in the economy and how firms, people, investors, and everyone should consider them for the future. To understand what to do, it is important to analyze the effect of climate change on the economy. Different nations want to comply with different policies to mitigate climate change's risk. At the same time, there are discussions on whether new regulations should be introduced to prevent climate change both on a national and an international level. In recent years, more and more international and domestic climate change policies have been introduced to lower gas emissions, with higher standards for lowering environmental effects and promoting technology (Goulder, 2006). At the moment, financial entities need to consider the costs and benefits of any changes, trying to reach an economy with a lower carbon emission without causing a financial breakdown. The expenses of lowering carbon dioxide emissions are not easy to determine, but they can be based on substitutes available in the world. The bigger the number of substitutes available, the lower the costs for countries to switch to lower emission policies.

Chapter 1.3.1: The tragedy of the horizon

The economic and financial consequences of policies on climate change require central banks to start acting soon. As already mentioned, central banks are enormous institutions that could play a crucial role in helping to fight the climate change problems.

The first-time climate change risks were mentioned as a risk for the financial market was by the Head of the Central Bank of England, Mark Carney, in the *"tragedy of horizons"*. This sentence comes from the famous saying, the *"tragedy of commons,"* by Warren G. Harding. Citizens cannot be stopped from having optimal climate conditions, and at the same time, others cannot be stopped from ruining them.

The environment and the climate are public goods, which by the definitions means they are non-rival and non-excludable. Everyone should be allowed to benefit from them. In the tragedy of commons, some countries will not be incentivized to reduce their emissions as it is their right to access "public goods" and will force other countries to deal with the consequences and find solutions for their actions (Carney, 2015).

Furthermore, climate change will have catastrophic events felt more in future generations than in the generation living now, very much beyond the horizon of the population now; this is why it is called the tragedy of “horizon”. People do not think about the consequences that much as they will not experience the consequences. The horizon for a monetary policy is generally around two or three years; instead, for financial stability it is almost a decade (Carney, 2015).

By the time *“climate change becomes a defining issue for financial stability, it may already be too late”*. *“The effects of climate-related natural events (as well as an abrupt transition to a low-carbon economy) have potentially far-reaching consequences for the economy and the financial system”* (Carney, 2015). This statement was against other members that did not agree with the relation of central banks with climate change risks (Signorini, 2017). In addition to this far perception of the future, there is much misinformation about climate change which creates some misunderstanding in the population and represents climate change as *“abstract, distant and even controversial”* (Watson and al., 2016). All this creates a massive challenge for central banks.

The pressure for them to include the risks in their daily duties increased in the last years, leaves central banks with uncertainty of what to do as they find themselves unprepared and, at the same time, unable to create any policies.

Data on the impact of climate change risks on the economy and financial banks have been starting to rise in the last years, giving only low credibility and uncertainty of the actual possible impact. It is essential to state that the financial governors can have considerable roles in an environmental future. Still, it is important to work together with other energetic, environmental, fiscal, and industrial policies to propose a common strategy to mitigate these risks.

Overall, climate risks mitigate financial stability. Financial entities are needed to avoid an economic breakdown and keep a stable financial system. Several actions need to be taken to manage financial climate change risk and, it is important not to lose sight of the several implications to consider.

CHAPTER 1.4: FINANCIAL RISKS

The financial risks raised by climate can be categorized. Financial risks can be mainly identified by transition and physical risks. Several other risks could mitigate financial stability, such as the transition path, liability, and operational risk. To understand more about the subject, it is necessary to know the content of these risks. In this way, it is possible to understand in-depth how financial stability problems arise from climate change.

Chapter 1.4.1: Transition risks

Transition risks are created when moving towards a greener economy—moving from an economy using carbon resources and fossil fuels to a more environmental-friendly energy-based economy. Firms located in countries with lower economic development that rely on fossil energy, and have less inclusive political systems, will suffer from more significant short-term transition risks. Instead, countries with stricter domestic climate policies will suffer more from long-term transition risks. These countries can suffer more from government policies such as carbon taxes, regulations, or government policies (Bolton and Kacperczyk, 2021). Some sectors will be influenced more by these transition risks, where more changes due to climate will occur. Moreover, countries with intensive carbon emissions are more vulnerable. These risks are relatively new, and new technologies are emerging to find new solutions to climate change. In the meantime, firms are trying to invest in more stable sectors and do not use gas emissions to avoid dealing with possible future policies. It is important to study whether possible climate change policies can cause macroeconomic instability (Stroebel and Wurgler, 2021).

Transition risks also lead to the creation of “stranded assets”, which are assets whose value could decrease due to the introduction of new policies and regulations to mitigate climate risk based on the decrease in the use of fossil fuels and carbon-emission. The stranded asset risk is the “*risk related to the re-evaluation of carbon-intensive assets as a result of this transition away from a carbon economy*”, which could cause a firm to default (Beyene and al., 2021).

Transition risk is also the most prominent risk to banks and financial stability, as these can suffer the change in investment decisions and new policies created. The economic costs related to transition risks can differ from country to country and depend on political, technological, and socioeconomic conditions. However, these costs are expected to be lower than taking no action toward climate change and could even be offset by a positive “green growth effect”

(NGFS, 2019). Green growth is defined as “fostering economic growth and development while ensuring that natural assets continue to provide the resources and environmental services on which our well-being relies”⁵.

A possible theory called the “Porter Hypothesis” is that aggressive policies to lower greenhouse emissions could boost innovation and creativity towards new technologies creating new job positions and reducing production costs. Unfortunately, such a change has never happened before, so there are several theories on the possible effect of these in the future (Porter, 1995). It is just guess-work which theory is right.

Transitions risks will have an impact on banks and firms and a client’s level. To help these firms, ClimateWise was created as part of the center for sustainable finance. It helps support the society to respond to risks and opportunities linked to climate change, such as identifying the transition risks. They have the primary goal of reducing the impact of climate change on the insurance industry and society⁶.

Transition risks can be mitigated from a global level with international entities and banks. Nevertheless, investors, shareholders, and regulators also consider the climate change risk for future investments and planning. A paper by ClimateWise, shows how investors, among others, should assess climate-related risks. Before investing in a firm, investors need to understand the possible scenarios of the interested firm, such as the exposures it withholds and the potential policies' effect on climate change on the business and the potential responses.

Chapter 1.4.2: Physical risks

Physical risks impact society directly and have the potential to affect the economy as well. These risks are directly manifested in the world due to climate change. Examples of physical risks are increased flooding, droughts, heatwaves and storms, which are starting to happen more frequently. Physical risks cover mainly chronic changes. Most people see the physical

⁵ Citation from OECD. What is green growth and how can it help deliver sustainable development?.
<https://www.oecd.org/greengrowth/whatisgreengrowthandhowcanithelpdeliversustainabledevelopment.htm>

⁶ Information from European Commission. Overview of sustainable finance. Retrieved from:
https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/overview-sustainable-finance_en

risks as the riskiest part of climate change over the next 30 years (Stroebel and Wurgler, 2021). These risks can have a very harsh impact on both firms and individuals. Considering a household has insurance, in case of a hurricane or flooding, it is the insurance company's duty to repay the damages, which could lead to the insurance company's failure. At the same time, if the household did not have any insurance, it would need to use all its resources to rebuild the house and lower their potential demand for goods. If these climate shocks hit firms, the supply could be reduced. These are just some of the potential problems caused by physical risks (NGFS, 2019).

Transition risks can be inversely correlated with physical risks. While going towards a greener economy, fewer physical risks will happen, but transition risks will increase. The reason is that with more policies, the less catastrophic event will happen due to a decrease in emissions. At the same time, risks created from a transition and the introduction of policies will increase. This happens more often in countries with higher physical risks, as a higher number of natural disasters leads to stricter policies (Stroebel and Wurgler, 2021).

Chapter 1.4.3: Liability, Operational, and Transition Path risks

Furthermore, there are other types of risks, such as the liability risks, which consider the parties who have to live with the consequences of climate change and want compensation from the ones who caused it and are responsible. These risks consider the future implications for the parties held accountable for such changes as firms with high carbon emissions. This risk is also called third-party liability risk. The insurance companies are the very affected by these types of risks and could have several levels of speculation and could appear to have a severe number of claims in the future. The insurance sector needs to keep the impact of climate change risks in mind while writing contracts for firms as they could get all the claims back in the future. Additionally, these risks also apply in cases where the new regulations in force have failed to be followed and where firms polluting, and emitting gases must face reality. Liability risks on borrowers can cause an increase in default rates and convert into credit risks for banks. Together, all these risks can lead to market risks for banks (Migliorelli and Dessertine, 2020).

Another risk is an operational risk. These can appear when damages such as floods ruin the regular operation of the business and lower the productivity or staff's productivity (Migliorelli and Dessertine, 2020). The Basel Capital Framework defines these risks as "*the risk of loss*

resulting from inadequate or failed internal processes, people and systems or external events". An example is a firm that cannot work anymore due to climate events and has to interrupt the regular operation of the business.

Lastly, transition path risks are government mitigation policies such as policy changes due to potential government debt, financial institutions or securities markets that can cause financial instability. These risks are the risks toward a greener economy after new policies have been introduced. They also cover investment risks such as innovations proven wrong regarding climate change or new technologies.

These are the most important risks creating financial instability. This thesis will mainly focus on transition risks and physical risks as they concern the most central banks and financial authorities.

CHAPTER 1.5: FINANCIAL IMPACT OF TRANSITION RISKS AND PHYSICAL RISKS

There are several financial risks identified by the Basel Committee in the paper "*Climate-related risk drivers and their transmission channels*" regarding transition risks and physical risks.

From a financial point of view, it can be summarized that transition risks can have a huge impact on financial stability. This happens when emissions need to be lowered or stopped. For example, firms working with fossil fuels could fail in the case of a "carbon budget" (tool to halt the rise of temperatures). These policies lead investors to start selling companies' stocks. As a consequence, firms fail to repay debts to banks, creating a huge impact on economic growth. On the other hand, physical risks interfere with the normal functioning of firms, which could lead to a decrease in the worthiness of the collateral given to banks to get credits. These are just some of the economic risks these climate changes can have on society (Faiella, 2019).

The transition and physical risks have several microeconomic transmission channels. These are the ones that impact a bank's financial stability (Basel Committee, 2021). These channels can be divided into credit, market, liquidity, and operational risks.

Chapter 1.5.1: Credit risks

The credit risks caused by transition risks and physical risks are the ones that increase a bank's credit risks when a loan is failed to be repaid. Moreover, credit risks also happen when the collateral pledged by borrowers is ruined, and there is a default in the full recovery of the loan borrowed.

Firms working with assets that can become forbidden due to climate change policies and firms not following specific regulations may have problems catching up with open loans due to transition risks. Whether these risks will happen and their impact depends on the policies and the actions taken in the upcoming decades. New government policies can affect corporate firms and lower product sales and profitability. The possible policies and taxes on GHG emissions can lower firms' revenues and increase expenses, causing a lower firm's creditworthiness. This leads to higher credit costs for existing loans. Furthermore, it interferes with the ability to repay them, creating risks in the banks' portfolios. The most significant climate change risk to the financial system is introducing a disorderly way of policy measures.

This is the case of "stranded assets" where, as already mentioned, due to climate regulations, infrastructures or firms are not able to continue their normal business cycle and are obligated to stop working. This can create bank crises due to unmet loans, creating risks for owners, lenders, and investors. These assets are then not able to earn any economic returns anymore.

Physical risk drivers affect the quality of a bank's credit portfolio due to people who cannot pay out debts or meet obligations due to climate events. The missing information about when physical risks could happen, in what locations, and with what intensity can cause higher volatility in financial markets. Physical risk can impact borrowers, who could lose everything they own due to flooding and cause considerable losses to themselves and banks. All these damages could cause either default on the loans or reduce the value of assets and the borrower's wealth. These risks also decrease the output capacity of entities and households and generate less income.

Altogether, the physical risks can have many different impacts on sovereigns and subnational institutions. Lower tax revenues by sovereigns can come from both locations hit by physical events or from households with lower income revenues due to climate events leading to reductions in output. This causes governments to increase their spending to mitigate climate

events. Governments could face higher borrowing costs or limited access to debt created by increased public expenditure to minimize the financial and economic impacts and adaptation costs to climate change risks. All mentioned above can cause a government to have a higher risk of default. In countries more hit by climate change, there could be an increase in the sovereign bond yields and spreads compared to countries less influenced by the risks. Overall, there is an increase in credit risks due to physical risks (Basel Committee, 2021).

Chapter 1.5.2: Market risks

The market risks caused by transition and physical risks are related to the impact on the value of financial assets. Higher volatility increases due to uncertainty of extreme weather conditions can higher the costs of investments.

Both transition and physical risks can also alter the reality and information about the future economic conditions causing *“downward price shocks and increase in market volatility in traded assets”* (Basel Committee, 2021). Furthermore, climate change could *“lead to a breakdown in correlation between assets, reducing the effectiveness of hedges and challenging banks’ abilities to actively manage their risks”* (Basel Committee, 2021). The costs of climate change are already being considered in the economic analysis, but the costs of price movements can still be reduced.

Changes in policies due to transition risks could change the relationship between investors and financial markets. Investors could demand a higher premia to bear for firms' risks using carbon production. Researches on these risks, both on borrowers and investors, do not satisfy the results expected. This is because the time horizon in which it is expected to see the transitions effect is more long-term than investors' time length.

Physical risks such as severe weather events and catastrophic disasters increase the volatility of financial markets, which increases the market risks. Possible consumption shocks due to changes in income can create higher price volatility and create more volatile markets.

Chapter 1.5.3: Liquidity risks

Liquidity risks are the ones that impact the bank's liquidity. This can happen in two ways: directly and indirectly. The direct risks are the bank's ability to liquidate assets or raise funds,

and the indirect risks are the customer's demand for liquidity. Often liquidity risks are related to physical risks regarding the liquidity problems a bank can face after climate events. The liquidity risks of a bank as a consequence of transition risks are less evident due to the time length and lack of technology to research it. In the case of climate events, central banks might be called up to maintain/re-establish financial stability due to a high increase in demand for liquidity from different entities such as households, financial institutions, and corporates. These entities might start withdrawing much money from the bank's deposit, leaving the bank with no liquidity (Basel Committee, 2021).

A decrease in a bank's liquidity creates potential defaults and bankruptcies, leading to financial instability.

Chapter 1.5.4: Operational risks

Banks have a particular way of operating with specific mandates. Operational risks happen when the bank's normal operational ability might be sabotaged by a physical hazard such as natural disasters that ruin the infrastructure. Litigations and lawsuits could damage the typical work environment of corporates and banks. This leads to disruptions of normal working behavior and high costs associated with climate-sensitive investments.

There are mainly two ways to fight these risks: adaptation or mitigation. Adaptation measures aim to reduce the impact of climate change on land, water, and physical assets. Instead, mitigation measures are aimed at reducing GHG emissions. Together they can decrease the climate change risks (Basel Committee).

Chapter 1.5.5 Conclusion on financial risks

Until now, all the risks mentioned will have a massive impact in today's economic world and could create default in several banks and entities. The NGFS recognized that physical and transition risks could have significant implications for the macroeconomic and financial variables, which are the bases for achieving the goals of central banks' mandates, creating financial stability problems.

Overall, even if there are a lot of risks and uncertainties due to climate change, taking action is better than just waiting. Understanding and quantifying the costs of these risks related to

climate change is challenging (Hernandez de Cos, 2021). This is due to the gaps in information on these risks on the one side and the lack of past events that can be compared to the climate change risks on the other side.

CHAPTER 1.6: SOLUTIONS FOR FINANCIAL STABILITY

Several ways are now being found and researched to help the transition towards a more sustainable economy. F. Restoy, *Chairman of Financial Stability Institute*, Bank of International Settlements, discussed how macro-prudential policies could be used to facilitate the transition. Macro-prudential policies need to consider the impact of climate-related risks on financial institutions. The ECB explains that the so-called macroprudential policymakers have an essential role today *“in identifying and mitigating the financial aspects of climate-related risks”*. Climate and macroprudential policies work the best when they *“are used as complements, rather than substitutes”* (Carattini et al., 2021). The macroprudential policy can be used to mitigate transition risks. Several analyses proved how macroprudential policy and prudent financial regulation could be enacted to lower the impact of climate policy and avoid a recession in the economy.

Furthermore, Löyttyniemi explains that prevention, resolution, and restoration can be used to mitigate financial stability risks. The existing processes for prevention, resolution, and restoration of government debt, banking and securities market can also be used for climate risks, and if anything changes, there will be enough time to adjust them. Prevention is setting up policies and regulations, monitoring and supervising actions. Resolution means dividing the action for financial stability in times of crisis, and restoration is the plan if there is a crisis and a need to restore stability in the economy. Restorations happen when there has already been an impact on the economy and stability needs to be restored.

Governments need transparency in the policies used for grey (polluting) and green industries to go towards a greener future. These policies might need to be used abroad internationally in times of crisis. The regulators and supervisors must try their best to create a policy to mitigate the impact of climate change risks. Regulators and supervisors must try to guarantee financial stability. Risks can be lowered by identifying their drivers and transmission channels, measuring the potential economic and financial impact, and creating mitigation techniques and solutions to these risks (Hernández de Cos, 2021).

Investors need to assess the potential climate-change risks in their decision. More data about climate change is still required. To gather more and better data, the ECB and many other entities are developing stress tests to simulate the scenarios to assess the climate change risks to the financial stability. The stress test run by the ECB, based on 4 million companies worldwide and 1,600 consolidated banking groups in the euro area, shows that the long-term benefits of adopting policies for a transition towards a carbon-free economy offset the short-term costs of the transition.

NGFS, for the first time in 2019, set out physical and transition risks to the financial stability and provided six recommendations for central banks, supervisors, policymakers, and financial institutions to mitigate and fight the effect of climate change. These recommendations aim to include climate risk into financial stability monitoring, integrate sustainability factors in their portfolio, and build a brighter future. The first four recommendations focus on inspiring central banks, supervisors, and financial institutions to take best practices toward a better future. Instead, the last two recommendations concern policymakers and the possible actions that can be taken to help central banks and supervisors to work towards a more sustainable future.

To avoid catastrophic events, everyone must make changes, but this must come mainly from governments. Governments should create policies toward a more environmental-friendly future, while firms should develop business plans and strategies to achieve sustainability. What is needed is a *“global collective leadership and coordinated actions”* (NGFS, 2019).

All the policies and recommendations seen until now are being used or will be used to slow down climate change and go towards a more sustainable future. Several entities worldwide have been created since the fight against climate change started. Some are on a national level, and some are on a more international level, but all are fighting for the exact same cause.

Chapter 1.6.1: Worldwide entities and policies

International entities are lately gathering to make a joint decision on international regulations to mitigate the effects of climate change. Making predictions about future changes is not that easy, as the policies being created are new and the possible consequences are unknown. Until now, no optimal policy approach has been found. It is hard to put together worldwide ideas to

fight climate change and gather different countries to agree on future projects to mitigate its risks.

All the presented organizations have contributed to the fight against climate change and are essential in the climate mitigation process. New regulations are adopted yearly, increasing the number of entities and nations collaborating in the climate change fight. Unfortunately, it only concerns countries taking part in these treaties, which leaves some other countries to continue polluting.

For the first time in 1992, an international treaty was created called United Nations Framework Convention on Climate Change (UNFCCC). The UNFCCC is now in charge of addressing the threat of climate change. This was a crucial step toward a better future for the world, combatting climate change by *“limiting average global temperature increases and the resulting climate change and coping with impacts that were, by then, inevitable”*⁷.

In 1997 the Kyoto Protocol was adopted. This protocol legally binds developed countries that are part of it to limit and reduce gas emissions. The UNFCCC asked all the participating parties to adopt policies to mitigate the risks and make periodical reports to check on the targets reached. An important role of the Kyoto Protocol was how it established a mechanism of a flexible market based on emissions permits and the possibility of trading them. The Protocol recognized that developed countries were primarily responsible for the current level of greenhouse gases in the atmosphere. Consequently, they had a duty to contribute more toward GHG emissions reduction. This means that GHG reduction has to start in developing countries, where it can have a huge impact and the stimulation to make green investments. To help countries include new policies to mitigate climate change risks, an “adaption fund” was created to give money to developing countries to reach their goals⁸. The United Nations Climate Change holds regular meetings called Conference of the Parties (COP), organized every year⁹.

⁷ Citation from United Nations Climate Change. The Convention. Retrieved from: <https://unfccc.int/process/the-convention/history-of-the-convention>

⁸ Information from United Nations Climate Change. What is the Kyoto Protocol?. Retrieved from: https://unfccc.int/kyoto_protocol

⁹ Information from United Nations Climate Change. Conference of parties. Retrieved from: <https://unfccc.int/process/bodies/supreme-bodies/conference-of-the-parties-cop>

Next to the Kyoto Protocol, the Paris Agreement was created. The “Paris Agreement” is the first-ever universal, legally binding global climate change agreement, adopted at the Paris climate conference (COP21) in December 2015. The Paris agreement establishes a goal to limit the global temperature rise of this century well below 2°C (above the pre-industrial level) and, even more, limit the increase to 1.5°C by reducing emissions. Furthermore, this agreement supports countries in their decisions toward climate change regulation and helps them deal with the possible impact. This agreement is a fundamental pillar in the fight against climate change. It is the first time that several states, other than just developed countries, gathered to decide how to fight the impacts created by global warming. They finally recognized that climate change threatened human beings and the planet. Governors understood that it is very important to slow down emissions as soon as possible. Another central element of the agreement is the aim of getting countries together every five years to control the climate change and check the progress. The goal is to be more transparent and accountable for decisions, support each other in mitigating the new regulations and operate in fighting losses and damage due to adverse effects of climate change.

The implementation process of the Paris Agreement can illustrate an aspect of transition risks. To achieve the goal set by the agreement, aggressive policies need to be used, and policymakers need to enact legislation and regulation to reach zero greenhouse gas emissions by 2050. These aggressive policies (will) significantly impact the economic uncertainty related to physical and transition risks (Skinner, 2021). The Paris Agreement increased the amount of attention on the financial stability risks and implications for financial supervisors and central banks caused by climate risks. To limit global warming to 2°C as required by the Paris Agreements, there is a need for a proactive role of financial systems to go towards green investments and allocation of capital to lower carbon activities.

Having international regulations is an important step for the world because climate policies created at a local level tend to have zero or even a negative effect on reducing climate change risks. Individual private firms tend to try to escape the new policies by moving to less regulated countries and making them move away from these states (Bartram, 2021).

During one of the Conference of Parties of the UNFCCC, governors decided to try to mitigate climate change risks in developing countries. It was finally realized that even parties not

participating in the Paris Agreements were needed to create efficient mitigations strategies. During this meeting, all countries not taking part in the agreements were asked to participate in the climate change movement, promote cooperation with the other states, and consider the risks to their nations and economies.

The UN Climate Change Conference of parties reunited for the 26th time at the COP26 in the autumn of 2021 to accelerate the goals of the Paris Agreement. In the COP26, they decided to keep the goal of limiting global warming below 2°C and not higher than 1.5°C. The Paris agreement has a big deficit, not including developing countries in the targets. The decrease in emissions by some countries was offset by an increase in emissions from other industrialized and developing countries. Furthermore, aviation and shipping sectors were not included in the Paris Agreement targets, allowing them to continue to pollute. These sectors alone account for about two percent of global GHG emissions¹⁰.

Other international organizations or initiatives saw the light next to the Kyoto Protocol and the Paris Agreement. The Intergovernmental Panel on Climate Change (IPCC) was founded in 1988 to help governments with information to help develop good climate policies. The Intended Nationally Determined Contributions (INDCs) was created to reach the Paris agreements goals. Each party should aim at a list of activities and several commitments given by the INDCs. In this way, different national governments can communicate the goals achieved internationally and the projects they are following. Activities and plans for the mitigation process are usually included in the INDCs. Still, some countries also described how they would try to reduce the vulnerability of their territory, trying to create adaptation plans to avoid catastrophic consequences to their economy.

Several other organizations, such as the World Meteorological Organization (WMO) and the United Nations Environmental Programme (UNEP), are also trying to help with climate change. WMO was started in 1873 to facilitate the exchange of weather information across national borders and is now contributing to the fight against climate change¹¹. The UNEP,

¹⁰ Information from European Commission. COP26 Climate Change Conference. Retrieved from: https://ec.europa.eu/clima/news-your-voice/events/cop26-climate-change-conference_en

¹¹ Information from World Meteorological Organization. Who we are. Retrieved from: <https://public.wmo.int/en/about-us/who-we-are>

founded in 1972, is the global authority for the environment with programs focusing on climate, nature, pollution, sustainable development, and more. These entities concluded that global warming is happening and that it would be better if governments started to consider establishing an international convention on climate change¹².

Moreover, the Network for Greening the Financial System (NGFS) was created. The NGFS is a network of central banks and supervisors that promotes green investments in the financial systems. It now includes thirty-four members, including the World Bank. This voluntary organization was created in 2017 to address climate change risks and has an on-growing number of members increasing every year. NGFS is working to provide central banks and supervisors with the right tools to fight climate change and correctly identify the risks in the financial system (NGFS, 2019).

Another organization, the Task Force on Climate-related Financial Disclosures (TCFD), develops voluntary climate-related financial risks disclosures for private companies. The TCFD helps investors make the right choices and prepares long-term investors for a future economy focused on low-carbon emissions. Furthermore, it provides recommendations on how different entities such as lenders, insurance companies, and investors need to deal with the climate-financial risks (TCFD, 2017).

Although all these new organizations were created, until now, all countries failed to meet the emissions reductions promised in the Paris Agreement. There is a need for proactive roles in transforming energy systems, production systems, and consumption patterns to achieve these goals in a limited time window. Investors need to focus new investments on low-carbon activities, allocating existing investments toward low-carbon activities.

CHAPTER 1.7: CONCLUSIONS ON MONETARY POLICY AND CLIMATE CHANGE RISKS

Climate change is now a global issue that causes extreme damage in many economic sectors. The biggest problem causing climate change is the GHG emission in the world. Developing countries have most of their economy based on high-emissions sectors, so it is tough to lower

¹² Information from UN Environment Programme. Sustainability. Retrieved from <https://www.unep.org/about-un-environment/sustainability>

their emissions. Instead, more developed countries are trying harder to transition to lower-emission sectors.

Overall, climate change is causing many risks to the economy. This is why the world is moving towards minimizing these risks while transitioning to a system trying to minimize climate change.

Climate change creates considerable problems for the financial stability of countries and the world, leading central banks to take a position on the topic. At the same time, central banks' mandates do not allow them to create any policies to fight it. This puts banks in a difficult situation in the fight to maintain stability while taking part in mitigating climate change.

Financial risks can be mainly classified as transition risks and physical risks. Transition risks are the business-related risks that happen when an economy is trying to shift to a more-climate friendly future. Instead, physical risks are possible chronic events such as extreme heat, drought and hurricanes.

Moreover, moving towards a lower carbon economy has its pros and cons for the world and the economy. There is a trade-off between the positive impacts of creating policies on climate change and the effects of climate change in the world. Policies reduced the possibility of certain firms working, leading several countries with very high-carbon emissions with the need to find new businesses. At the same time, climate change creates significant impacts such as a rise in temperatures, lower work productivity, and risks in the infrastructures.

Several less developed countries did not start being part of this movement to limit climate change, and several entities have been created to reach everyone's attention and collaborate.

Many organizations are now working to fight climate change, all of them with the same goal but none of them with the ultimate solution. The hope is that they will find a way to collaborate and bundle power and knowledge to higher the odds of a way to turn around the drastic changes that the world is facing. The Paris Agreement is the first worldwide agreement that reached popular attention and includes a very high number of countries in this fight. Unfortunately, aggressive policies need to be used to achieve the Paris Agreement goal, which

increases financial risks. However, waiting too long to make decisions and create policies can have catastrophic consequences.

Overall, several data have been gathered lately to tackle climate change, hoping to go towards a low-carbon emission future with higher green investments.

CHAPTER 2: MONETARY AUTHORITY VS FISCAL AUTHORITY: CLIMATE CHANGE AND CENTRAL BANKS

CHAPTER 2.1: INTRODUCTION TO CHAPTER

Different entities are intervening to change the world's future while creating new regulations to improve the environment and mitigate climate changes. This chapter will focus on the public interventions made to tackle climate change. It will discuss the need for financial policies for climate change and the need for regulators to take care of these policies. All these regulators often have boundaries on the regulations they can set within their mandate. Therefore, their limitations will be analyzed.

The main differentiation between the fiscal authority and the monetary authority will be explained, focusing on how central banks as a monetary authority can help in the climate change fight. Other than the differentiation of the two, the problems of handling climate change between the fiscal and the monetary authority will also be inspected. This chapter will end by analyzing central banks from all over the world and explain how they deal with climate change.

CHAPTER 2.2: PUBLIC INTERVENTION IN CLIMATE CHANGE

Entities intervening in tackling climate change usually have two motives: promotional and prudential. The "promotional motive" is the public intervention aiming to mitigate climate change while allocating resources to lower-carbon activities. This is consistent with the goals of the Paris Agreement. Instead, the financial stability goal of public interventions is referred to as the "prudential motive". Often the two motives, prudential and promotional, come close together. Promotional policies can cause some promotional consequences and vice versa (Baer and al., 2021).

Regulators' public intervention can happen in several ways, mainly distinguished by informational, incentive and quantity-based policies.

Informational policies have the goal of helping financial market players by providing them with proper climate-related information such as definitions, rules, and instruments to avoid any asymmetric or incomplete information. Incentive-based policies create incentives for financial actors toward lower-carbon assets or allowing them to keep investing in high-carbon assets with

higher costs. Last, quantity-based policies are the toughest policies as they directly introduce quantitative controls on financial flows. The last one is more direct. All these policies together can be used to tackle climate changes both for promotional and prudential reasons (Baer and al).

Authorities taking care of the various policy objectives and of the ways to achieve them are typically distinguished into political authorities (PAs) and delegated authorities (DAs).

PAs are the *“public organisms in charge of determining the direction of economic development on behalf of their populations, deciding between competing interests”* (Schmidt, 2013). These are identified as the parliaments, governments, ministries, and other public institutions.

DAs are defined as *“autonomous or semi-autonomous organisms with specific mandates given to them by the PAs. Their legitimacy lies in the nature and limits of the delegation and specified mandated and in their ability to fulfill their missions”* (Scharpf, 1999). These usually are identified as the central banks and financial supervisors.

This differentiation brings us to the distinction between fiscal authority and monetary authority (Baer and al., 2021).

Chapter 2.2.1: Fiscal and Monetary Policy

When the boundaries between PAs and DAs cross each other, it creates a problem between monetary and fiscal authority. Furthermore, as will be seen in the following pages, sometimes DAs (such as central banks) are required to do tasks outside their mandate, where they do not withhold any power.

Fiscal policies are mainly decided by the national governments and have a fiscal nature, such as the public expenses and taxes. These are widely used in case of a need for economic recovery. Fiscal policy is *“the use of government spending and tax policies to influence economic conditions, especially macroeconomic conditions, including aggregate demand for goods and services, employment, inflation, and economic growth”* (Hayes and Boyle, 2021). The definition of fiscal policies derives from John Maynard Keynes, stating that governments can influence macroeconomic productivity by increasing (or decreasing) the fiscal levels and public expenditures. This is done by using the aggregate demand to increase or decrease public spending and stabilize fiscal policies (Jahan and al., 2014).

Monetary policy instead, can be defined as *“a set of tools that a nation’s central bank has available to promote sustainable economic growth by controlling the overall supply of money that is available to the nation’s banks, its consumers, and its businesses”* (Hayes and Boyle, 2021). Fiscal policy is *“contrasted with monetary policy, which is enacted by central bankers and not elected government officials”* (Hayes and Boyle, 2021). Central banks establish monetary policies to control inflation, using interest rates and credit control. As already mentioned, the main mandate of central banks is to keep the economy stable: keeping unemployment low and protecting the currency.

Both fiscal and monetary policies can have expansionary and contractionary policies. Expansionary policies are defined as such because they aim to boost the economy by increasing the demand using monetary and fiscal policies. Instead, contractionary policies concern reducing public spending (deficit spending), raising taxes or reduction in the rate of monetary expansion by a central bank.

Fiscal expansions are used to make the government-run budget surpluses. For example, the government can issue tax stimulus rebates to increase aggregate demand in a recession. The government also has other options, such as increasing the income of consumers and businesses, increasing demand and increasing employment (Hayes and Boyle, 2021). Fiscal contractionary policies are done by raising taxes or reducing government spending. These policies try to slow down the private markets concerning unsustainable production. The contractionary policies are very often connected with monetary policies, whereas the central banks are used to change interest rates.

The monetary expansion aims at *“increas(ing) economic growth and expand(ing) economic activity”* (Investopedia and al., 2021). In this case, the behavior expected is often to promote spending and make people save less money due to a lower interest rate, so a better condition for borrowing. This policy is often used in high unemployment caused by a recession. On the other hand, monetary contractionary is trying to reach the opposite goal, bringing down inflation and slowing down the money supply, trying to make people spend less money by making borrowing very expensive. This is often used to stabilize the prices. Expansionary policies are coherent with the Keynesian theory (by John Maynard Keynes mentioned earlier), where the increase in aggregate demand can increase the GDP and inflation.

CHAPTER 2.3: THE FIGHT FOR CENTRAL BANKS AGAINST CLIMATE CHANGE

Creating policies to mitigate climate change is in the hands of government but, central banks could do their parts. The question now is: Should central banks and other financial institutions try to tackle climate change issues? And if yes, why?

Carney (2015) stated that *“financial policymakers will not drive the transition to a low-carbon economy. It is not for a central banker to advocate for one policy response over another. That is the government to decide”*. From this definition, it seems like central banks should not try to tackle climate change, but that is not the what the author meant. Carney’s definition means that it is not the central banks’ role to create policies, but they need to tackle climate change. Let us show this.

A central bank is defined initially as a *“public institution that manages the currency of a country or group of countries and controls the money supply – literally, the amount of money in circulation”* (European Central Bank, 2015). This means that their biggest concern is keeping financial stability by fighting inflation, which they try to keep in line with interest rates, raising the interest rate when inflation goes too high to slow down growth and vice versa (Lien and al., 2021). The inflation rate determines the amount of money and credit in a country’s economy.

Under normal circumstances, it is not the place for central banks to participate in climate change actions. This is because financial policymakers cannot create any policies towards a green economy. This means that, although central banks are interested in transitioning to an environment-friendly future and help make these decisions to ensure stability in the financial system, it is not in their power.

Nevertheless, in the last few years, central banks’ included climate change fight in their duties in order to comply with their many roles and work properly towards a future with financial stability. The reason is that the more persistent climate change is, the more the shocks to the economy are, the more financial stability issues there will be and the more central banks and financial supervisors are needed (Baer and al, 2021).

This brings us to the main reasons why central banks are needed to deal with climate change: they will be affected by it. Setting interest rates can have a crucial impact on the prices of the goods and services and, consequently, influences the way people consume and climate change.

For example, if droughts and floods increase, there can be a negative impact on the amount produced. This can lead to inflation. Moreover, people could lose their jobs due to climate change events that cause damage to buildings and land and debts to the banks. These are just several reasons central banks need to act now (Bradlow, 2021).

The answer to the initial question is obvious. Central banks are needed to take a position on climate change. The role of central banks in the climate change fight has been studied in many academic papers, policy notes, and articles, particularly by Baer and Campiglio (2021), Campiglio et al. (2018), Cochrane (2020), Heutel (2021), Meldkadze and Carattini (2021), NGFS (2019) and others. They all state that central banks should consider climate change in their monetary interventions.

History has already shown that the main rules stated for central banks to protect financial stability are important to be followed, and any attempt to change is dangerous (Löyttyniemi, 2021). Overall, it is not suitable for central banks to get too involved with climate change policy. By focusing on going towards green investments, central banks might forget to keep taking care of their primary goal, with the possibility of losing their independence and authority. Losing its independence means losing the possibility to control inflation and financial crisis (Cochrane, 2020). Also the NGFS stands in its position of knowing that central banks and their supervisors need to address climate-related risks (NGFS, 2019).

Nonetheless, the primary responsibility for a low-carbon emission future is still in the elected governments' hands (Campiglio and al., 2018). Also, implementing the Paris Agreement objectives is not in the hands of central banks but of governments. This means that central banks should not replace policymakers, but they need to acknowledge the consequences of climate change on financial stability and take action.

Chapter 2.3.1: Monetary policies, central banks, and climate change

So far, it is clear that central banks can help mitigate these climate change problems, but it is not sorted out yet how they should do it.

One of the possibilities is using monetary policies. The problem is: Can the monetary policy be used as a policy instrument? How and to what extent can it be used as a policy instrument? So far, the central banks and monetary policy have not been decently involved with climate change

policies because fiscal instruments were considered to be enough.

Moreover, standard central banks' targets are short-term, with inflation targets and price stability; on the opposite side, climate changes are more long-term. Right now, the role of central banks has become more important over time. This is because stabilization in the short term of the employment and output is very important while new fiscal policies are introduced. This is why central banks are now needed to support the climate change policies, leading them to take care of both short-term and long-term issues (Economides and Xepapadeas, 2018).

Besides, climate change can be seen as a negative shock to the economy; this is why regulators are needed. Climate change can lead to higher prices and possible output reduction, affecting the countries' economies in the short-term and long-term - monetary policies can be used to fight it. Some possible positive effects of climate change on the economy are also present, although negative effects from climate change are most likely to happen (Mendelsohn and al., 2000).

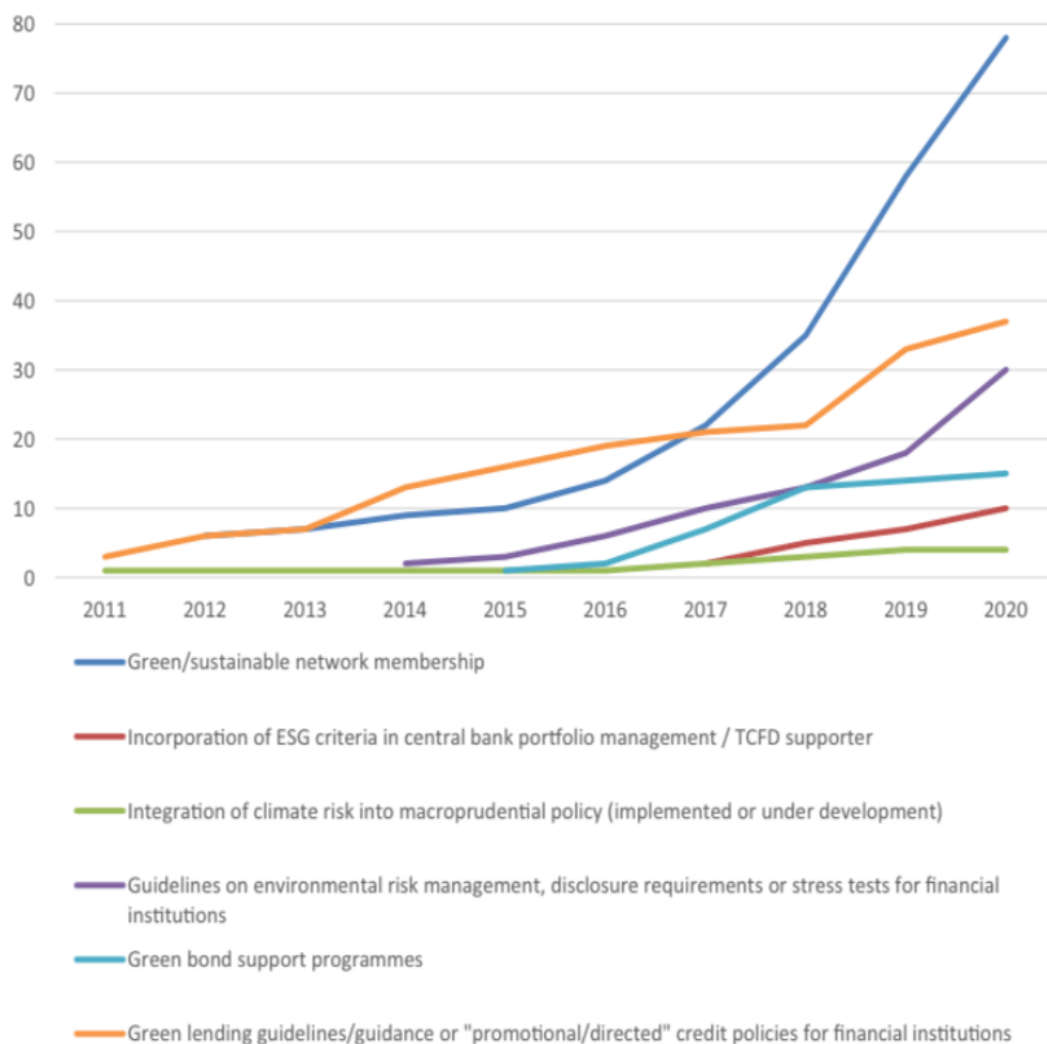
The problem arises since central banks are not only required to take part in this movement against climate change. They are asked to concentrate on specific climate policies, turning investors away from high-carbon industries and towards less fossil fuel industries and green advertising projects. Central banks are now forced to give out funds to these green projects, leading fossil fuels industries to be risky and with a high probability of default (Carattini and al., 2021).

Furthermore, there is a trade-off between the positive and the negative impacts of monetary policies on climate change. It is not easy to decide which approaches to use as there is not that much data on climate change and, at the same time, the consequences of policies are still unknown. The use of fossil fuels in the economy increases firms' productivity, increasing their output and creating a positive impact. At the same time, fossil fuel produces GHG emissions, which cause the higher temperatures in the world, thus making negative impacts. Then, should fossil fuel policies be adopted by banks or not? A decrease in fossil fuel does negatively affect the short term, but it increases the economy's productivity and output levels in the long term. From an economic point of view, it is important to analyze the trade-off between the positive and negative impacts of dealing with the different policies.

Chapter 2.3.2: Central Banks taking actions

Almost thirty central banks have now taken part in the NGFS to head towards better management of climate-related events and environmental risks. The NGFS,, includes the World Bank as a member. The NGFS acknowledged that *“climate change is a source of structural change in the economy and financial system and therefore falls within the mandate of central banks and supervisors”*. The efforts made until the last years were not enough towards climate change. Furthermore, the NGFS published a paper in 2019 called *“A call of action: climate change as a source of financial risk,”* asking for immediate actions by central banks and financial sector supervisor authorities to fight against climate change.

Figure 1: Number of Central Banks that Have Adopted “Green” Activities (by Type) -(Dikau and Volz, 2021). Y-axis= n° of central banks



In the picture, it can be seen that in the last years' central banks started to take more and more positions on climate change issues, and as of now, almost 80 central banks are taking part in green/sustainable network membership(Dikau and Volz, 2021).

The losses related to weather events have increased steeply in the last ten years, with weather-related catastrophes higher than ever. Central banks started taking the situation seriously and taking environmental problems into account. The environmental, social, and governance (ESG) risks are considered more. These risks include the ones related to climate change and how it impacts mitigation and adaptation measures. Other environment-related research and regulation have also increased in the last years.

Since the Paris agreement in 2015, the research conducted on climate change and how to mitigate it has increased. The climate change risks seen until now can highly affect how banks make decisions and their portfolios. Overall, in the last years, central banks have taken the environmental issue more and more into account and made climate change mitigation one of the most important goals.

CHAPTER 2.4: INTRODUCTION TO SOME CENTRAL BANKS

Central banks worldwide have different mandates with often similar purposes. Their position on tackling climate change risks often is different. There are more than two hundred central banks globally and coordinating them with the same goal is not easy. Often they work together to reach common targets, and climate change is one of them.

The biggest central bank based on assets globally is the Federal Reserve System, followed by the Bank of Japan and the People's Bank of China. The European Central Bank only comes in as the tenth biggest central bank in the world¹³.

The total assets of central banks between 2002 and 2020 have increased steadily by almost 40 trillion U.S. dollars¹⁴. Many central banks have had a significant increase in their balance sheet since 2006. One of the reasons for the increase in the assets in central banks stands as the result of the “*non-standard*” monetary policies that were made after the 2008 financial crisis and the COVID-19 crisis. The bank of Japan currently holds a balance sheet at 130% of the GDP; this

¹³ Information from Sovereign Wealth Fund Institute (SWFI). Top 100 Largest Central Banks Rankings by Total Assets. Retrieved <https://www.swfinstitute.org/fund-rankings/central-bank>

¹⁴ Information from Statista. Total assets of central banks worldwide from 2002 to 2020. Retrieved from: <https://www.statista.com/statistics/421201/assets-of-central-banks/>

shows how central banks have no limits on their balance sheets and can adjust them how they want. Central banks have the power to implement different policies whenever they need to change several indices and reach targets (Cerclè and al., 2021).

Different central banks will be seen now, analyzing their mandates and their efforts to mitigate climate change. The mandates of central banks will be shown in order to understand what can be done by central banks to hold financial stability. It is important to remember that when mandates of most central banks were created, climate changes were not yet considered an issue. This is one of the reasons why almost no central bank has green finance goals in their mandate. Furthermore, when sustainable goals are mentioned in central banks mandates often, they do not refer to low-carbon emission investments but more to broader development goals (Dikau and Volz, 2021). The mandates of several central banks and their role in climate change mitigations will now be seen.

One of the most common solutions used by central banks to fight climate change by standing within their mandate is issuing green bonds. The World Bank was the first institution to issue green bonds, lending money for climate-related projects by raising money from fixed-income investors. In 2013, the International Finance Corporation issued the first market's green bonds. The World Bank defines green bonds as *“financial instruments that finance green projects and provide investors with regular or fixed income payments”*. These offer investors a way to hedge against climate change risks while, at the same time, might be able to earn money on the investment. These are just some of the solutions suggested for fighting climate change. Other central banks in the world decided to act differently.

Chapter 2.4.1: The US Federal Reserve

The US Federal Reserve (Fed), the central bank of the United States, has a dual mandate: keeping full employment and price stability. The Fed monitors the banking system's stability risks and controls the price stability in the countries due to the possible implications of climate change. Like the ECB, the Fed has limited powers and responsibilities delimited by law.

The Fed does not consider climate risk a significant credit risk that could lead to safety issues and threaten the bank's solvency right now (Skinnier, 2020). Anyhow, the Fed's objective of climate change mitigation is supported by several key goals such as being part of international

approaches to climate change, adopting climate disclosure aligned with the Task Force on climate-related financial disclosure (TCFD), and many others. The US Federal Reserve entered in 2020 as an NGFS member. Furthermore, the Fed created two committees to deal with climate change: the supervision climate committee and the financial stability climate committee. These are useful for gathering data and reports on climate-related financial risks.

Chapter 2.4.2: The Bank of Japan

As its primary mandate objective, the Bank of Japan has to achieve price stability, thereby contributing to the sound development of the national economy. The Bank of Japan acknowledges that supporting the efforts on climate change and mitigation procedures helps achieve their mandate, which is why they decided to have an active role in the goal of climate change. The Bank of Japan created funds to provide to institutions to avoid high-carbon investments and is ready to play its role in the actions. In this way, the central bank can avoid getting too involved in climate change but at the same time do its part to go green. The Bank of Japan entered in 2019 as an NGFS member (Dikau and Volz, 2021).

Chapter 2.4.3: People's Bank of China

The People's Bank of China (PBOC) has a primary mandate to maintain price stability and promote economic growth. PBOC is one of the banks with more active roles in climate change.

They are using monetary policy to enable a low-carbon transition. They are focusing on only high-carbon assets and are adding more green bonds to their reserves. Furthermore, they included green bonds and green credit as collateral in the central bank's lending facilities. PBOC's Bank Governor Yi Gang is aware that "*central banks could contribute to the net-zero goal in many ways*" (Gang, 2021). In 2017, PBOC and other entities launched a Green Credit Policy to create environmental protection and prevent credit risk. Later on, in 2015, PBOC and other entities published criteria and categories for green bond projects. In 2017, they entered as an NGFS member (Dikau and Volz, 2021).

Chapter 2.4.4: The European Central Bank

The only mandate of the European Central Bank (ECB) is to keep price stability in the Union.

The European Central Bank wants to consider the possible impacts of climate change in the monetary policy framework by using the power in its mandate¹⁵.

The ECB set up a climate change center to support and bring together the ECB to work on climate and the environment. This is used to show the commitment of the European Central Bank towards making changes and a better future by creating climate change policies and trying to create a stress test to see the future effects of climate change on the European Union. The ECB faces problems creating regulations and addressing the climate change problems due to its limited legal authority. The European government and parliaments are responsible for combating climate change and, the ECB has limited power (Ainio, 2021).

Chapter 2.4.5: The Bank of England

The Bank of England is the seventh biggest central bank globally¹⁶. The mandate of the Bank of England is *“to promote the good of the people of the United Kingdom by maintaining monetary and financial stability”*¹⁷.

The Bank of England was the first central bank in 2019 that set supervisory expectations for banks and insurers. It did this by setting expectations on climate-related financial risks, covering governance, risk management, and scenario analysis by analyzing the future and predicting possible management approaches to these risks. Moreover, the Bank of England was one of the first banks committed to achieving net-zero greenhouse gas emissions by 2050. The main goal is to transition towards a net-zero economy by mitigating the climate change risks and holding on to a stable financial system. Due to all the financial risks that climate change can bring, the Chancellor of England recently sent a recommendation letter to the Bank’s policy committees to set out what boundaries should play a role in climate change mitigation (Bailey,

¹⁵ Information from European Central Bank. Introduction. Retrieved from: <https://www.ecb.europa.eu/mopo/intro/html/index.en.html>

¹⁶ Information from Sovereign Wealth Fund Institute (SWFI). Top 100 Largest Central Banks Rankings by Total Assets. Retrieved from: <https://www.swfinstitute.org/fund-rankings/central-bank>

¹⁷ Citation from Bank of England. Bank of England Market Operations Guide. Our Objectives. Retrieved from: <https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwj-ZvJ59D3AhUkyoUKHS7UDswQFnoECBIQAw&url=https%3A%2F%2Fwww.bankofengland.co.uk%2Fmarkets%2Fbank-of-england-market-operations-guide%2Ffour-objectives&usq=AOvVaw3Bc11TRarlYXzO3OchbIOH>

2021). In 2019, the Bank of England created the Climate Financial Risk Forum, also referred to as CFRR, to help financial regulators and industries to analyze and tackle climate change risks¹⁸.

Chapter 2.4.6: Asian Banks

Asian banks have several very different sustainability objectives depending on the countries. The main mandates of several central banks will now be reviewed and, the respective climate change goals will be discussed.

The National Bank of Cambodia has the objective to maintain price stability to facilitate economic development within the framework of the Kingdom's economic and financial policy. The Bank of Indonesia has to conduct monetary policy on a sustained, consistent and transparent basis, considering the general economic policies of the government. The Bank of Negara Malaysia promotes monetary stability and financial stability conducive to the sustainable growth of the Malaysian economy. The Central Bank of Myanmar has to support the general economic policy of the Government conducive to the sustained economic development" of the country. The Bangko Sentral ng Pilipinas in the Philippines has to maintain price stability conducive to a balanced and sustainable growth of the economy. The Monetary Authority in Singapore maintains price stability encouraging to the sustainable growth of the economy. The Bank of Thailand promotes a stable financial environment to achieve sustainable and inclusive economic development. The State Bank of Vietnam has a broader role: stabilizing the value of the Vietnamese currency, ensuring safe and sound banking operations and the system of credit institutions, ensuring the safety and efficiency of the national payment system, and contributing to socio-economic development under the socialist orientation. The Reserve Bank of India needs to support the country's balanced, equitable, and sustainable economic growth (OECD, 2005).

Overall, banks in Asia are not taking sufficient actions in mitigating climate change and are under-estimating their exposure to high-carbon assets. Furthermore, these banks are not taking enough measures to reach the Paris Agreement goals (Scanlan, 2022). An Asian Green Bond Fund has been created to focus investments on low-carbon emissions. This is very important in Asia as the development rate of the countries is high, with a significant need for

¹⁸ Information from Bank of England. Climate change. Retrieved from: <https://www.bankofengland.co.uk/climate-change>

infrastructure investments. In this way, central banks in Asia can invest in green bonds. This bond fund was mainly created to allow central banks to focus on mitigating climate change, allowing them to expand green finances and align with the Paris Agreement objectives' (Tiware, 2021).

CHAPTER 2.5: CONCLUSION ON CENTRAL BANKS' MANDATES AND CLIMATE CHANGE

The mandates given to central banks often have very similar goals, such as keeping prices stable and financial stability. Almost all the banks seen until now have the same purpose.

Moreover, it has been seen that almost all central banks now recognize climate change as a threat to their goals, and this is why climate change needs to be high on the agenda of the central banks. Climate change is a source of financial risk, and mitigating climate change falls under the mandate of holding financial stability.

The division between the fiscal authority (such as governments), which can create policies to fight climate change, and monetary authority (central banks), which can only do what is in their mandate, is still really wide. Nevertheless, most central banks still decided to take action and create, for example, green bonds funds to increase green investments. All the efforts made are within the goal of reaching the Paris Agreement objectives and reaching zero-emission goals.

Overall, central banks are taking active participation in climate change and are willing to do what is possible and in their power to mitigate climate change.

CHAPTER 3: EUROPEAN UNION, EUROPEAN CENTRAL BANK, AND CLIMATE CHANGE

CHAPTER 3.1: INTRODUCTION TO THE CHAPTER

This chapter focuses on the European Union and, more specifically, on the European Central Bank. Beginning with the history of the creation of the European Union and the European Central Bank, it will move on to their connection with climate change.

The role of the European Union in climate change will be discussed, presenting the climate change mitigation strategies used in the Union. Further on, this chapter will focus on the mandate of the European Central Bank and on why the European Central bank must mitigate climate change.

The tools of the European Central Bank to fight climate change risks will be discussed, focusing on how monetary policies can be used. The monetary policy implementation channels under climate change will be shown. At the same time, the problems in the transmission channels raised by climate change risk of monetary policy will be discussed.

Overall, this chapter will show the reasons why the European Central Bank needs to take a position on mitigating climate change to keep price stability in the European Union and, in the meantime, show how monetary policy can be used to do so.

CHAPTER 3.2: CREATION OF THE EUROPEAN UNION AND THE EUROPEAN CENTRAL BANK

The creation of the European Union (EU) is one of the most significant achievements in creating a consolidation between European states. The design of the European Union will be slowly introduced together, reaching the creation of the European Central Bank.

Several important institutions already existed before the creation of the EU, such as the European Commission and the European Council. In 1958, the European Commission was created to "*promote the general interest of the EU by proposing and enforcing legislation as well as by implementing*

policies and the EU budget"¹⁹. The European Council was created in 1974, with the heads of states of the EU's member states. Its purpose was to " *establish an informal forum for discussion between heads of state or government*"²⁰.

These institutions had a contribution to the creation of the EU. The EU was created in 1992 with the "*Maastricht Treaty*". In this Treaty, twelve states became official members of the European Union. Starting from 1995, the European Council met up to decide on the common currency that would become the currency used in the European Union, the scenario of adoption, and the money's changeover. A conversion rate was determined for each national currency to be converted into euros. The goal was to reach a European monetary policy (Scheller, 2004).

But the way to create a unique monetary policy in the European Union goes much further back. The first proposal by the European Commission to create an economic and monetary union was in 1962. Before that, there was the "*Treaty of Rome*" in 1950, where the European Economic Community (EEC) was created. It was created to have a better economic system and exchange of goods between member states. At that point, there was no intent to create a customs union yet. It was expected that the exchange rate stability would not need the creation of international arrangements and a common currency (Scheller, 2004).

The European Investment Bank (EIB) was founded in 1958 by the Treaty of Rome. The EIB is now the lending arm of the EU and is the largest provider of climate finance. In fact, since its establishment, the EIB has focused its activities on climate and environment, development, innovation and skills, small and medium-sized businesses, infrastructure and cohesion²¹.

In 1971, the realization of an economic and monetary union was agreed upon between the member states of the EEC. Creating the European Monetary Union (EMU) was challenging and created a need to divide the process toward a European monetary policy into different stages. In

¹⁹ Citation from European Union. European Commission. Retrieved from: https://european-union.europa.eu/institutions-law-budget/institutions-and-bodies/institutions-and-bodies-profiles/european-commission_en

²⁰ Information and citation from European Council. History. Retrieved from: <https://www.consilium.europa.eu/en/history/?filters=2031>

²¹ Information from European Investment Bank. EIB at a glance. Retrieved from <https://www.eib.org/en/about/at-a-glance/index.htm>

1989 the European Council agreed on the realization of EMU in three phases starting the following year. After extended agreements, all the restrictions on the movement of capital between members were removed. The goal of the EMU was to achieve price stability in the Union thanks to the European Central Bank. The EMU was finally created in 1992, together with the "*Maastricht Treaty*" mentioned before, being one of the crucial achievements for the European Union towards integration, creating one monetary policy for the entire Union.

The creation of the European Central Banks (ECB) and the European System of Central Banks (ESCB) followed the creation of the European Union and the EMU. Only in 1998 was the ECB established together with the ESCB. Only after their creation, starting from February 2002, the Euro was the sole legal currency in the euro area members (Scheller, 2004).

The creation of the European Union was quite a long process that led to a stable economic environment in the Union.

CHAPTER 3.3: EUROPEAN UNION AND CLIMATE CHANGE

The EU has an essential role in mitigating climate change risks globally. It is set in its goal to reach all the climate mitigation actions decided during the Paris Agreement. Furthermore, the EU would like to become the first climate-neutral area by 2050.

To reach the climate mitigation goals, several targets have been set. These are mainly divided into the goals for 2020 (which have been achieved), 2030, and 2050. Moreover, several systems have been created to mitigate climate change, such as the EU Taxonomy, the Emission Trading System, and the Green Bond market. These will be introduced now.

Chapter 3.3.1: The EU's role in the Paris agreement

To recap, the Paris agreement is the first agreement about global climate change involving close to 190 parties worldwide. The EU showed and still shows global leadership in mitigating climate change risks and leading the goals of the Paris agreement. The European Union is strongly committed to its goals. In the last Climate Change Conference (COP26) in 2021, it was decided

that the EU needs to help speed up the implementation of actions to reach the goal worldwide and try to head towards more sustainable and green investments²².

Chapter 3.3.2: EU strategies on climate change

The EU created the European Green deal, a commitment to become the *first-neutral climate-neutral continent* by 2050. This deal aims to have no net emission of greenhouse gases by 2050 through an inclusive transition by having a clean and circular economy without leaving anyone and anything behind and reaching a sustainable environment²³. To achieve this goal, the EU created several strategies & targets for the future years: the 2020, 2030, and 2050 climate & energy packages.

The 2020 climate & energy package was created to reach the targets set in 2007 and enacted in legislation in 2009. These are the three main targets: decreasing 20% of the greenhouse gas emissions compared to 1990's levels, improving by 20% the European energy from renewable and improving by 20% the European energy from energy efficiency. To reach these targets, several directives and programs have been established by the Union to support it²⁴. According to the European Environment Agency (EEA), the EU has reached these goals. A significant drop in emissions that allowed Europe to achieve the goals set is also related to the Covid-19 pandemic. The greenhouse emissions were 33% lower compared to 1990 (EEA, 2021). Reaching this goal allowed the EU to work towards the 2030 target.

The 2030 climate & energy framework is focused on objectives to be reached by 2030. In this target, greenhouse gases emissions will be reduced by at least 40% compared to 1990. Besides that, renewable energy and energy efficiency has to improve by 32%. It is essential to keep improving the same objectives as in the 2020 package and move toward the final target, a

²² Information from European Commission. Paris Agreement. Retrieved from: https://ec.europa.eu/clima/eu-action/international-action-climate-change/climate-negotiations/paris-agreement_en

²³ Information from European Commission. 2050 long-term strategy. Retrieved from: https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2050-long-term-strategy_en

²⁴ Information from European Commission. 2020 climate & energy package. Retrieved from: https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2020-climate-energy-package_en

climate-neutral economy. The EU agreed to lower greenhouse gas emissions by 55% compared to 1990, which is more than what was decided in the 2030 framework of the Paris Agreement²⁵.

As mentioned earlier in the European Green Deal, the 2050 long-term strategy aims to reach a net-zero greenhouse emission economy. A European Climate Law has also been introduced to ensure that all European members contribute to achieving the goal planned²⁶.

Chapter 3.3.3 EU taxonomy to reach the Green Deal

To reach the European Green Deal and the Paris Agreement targets, the European Union created the EU taxonomy. The EU taxonomy defines a proper action plan to develop clear definitions of what is considered "sustainable". The EU taxonomy is defined as "*a classification system, establishing a list of environmentally sustainable economic activities*"²⁷. This taxonomy represents '*an essential step in supporting the flow of capital into sustainable sectors in need of financing*' (Aquaculture Advisory Council, 2021). It can help different firms and companies have a clear list of sustainable activities, making the companies more environmental-friendly and having more green investments. The Taxonomy Regulation was published in 2020 and is based on six environmental objectives. These are climate change mitigation, climate change adaptation, sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention, control, and lastly, protection and restoration of biodiversity and the ecosystem. The Taxonomy Regulation tasks the Commission with the environmental objectives through delegated acts.

The EU taxonomy plays a significant role in implementing the European Green Deal with a specific definition of what should be done to become more climate-friendly and mitigate climate change²⁸.

²⁵ Information from European Commission. 2030 climate & energy framework. Retrieved from: https://ec.europa.eu/clima/eu-action/climate-strategies-targets/2030-climate-energy-framework_en

²⁶ Information from European Commission. European Climate Law. Retrieved from: https://ec.europa.eu/clima/eu-action/european-green-deal/european-climate-law_en

²⁷ Citation and information from European Commission. EU taxonomy for sustainable activities. Retrieved from https://ec.europa.eu/info/business-economy-euro/banking-and-finance/sustainable-finance/eu-taxonomy-sustainable-activities_en

²⁸ ibidem

Chapter 3.3.4: The European Trading System

Moreover, the European Union created other strategies to fight climate change, reach the targets set for 2030 and become the first climate-neutral continent, such as the European Emission Trading System (ETS). The ETS is part of the European policies to mitigate climate change.

The ETS was created in 2005 and is the biggest carbon market and the first emission trading system. It helps "*limit(ing) emissions from around 10,000 installations in the power sector and manufacturing industry, as well as airlines operating between these countries and covers around 40% of the EU's greenhouse gas emissions*" (European Commission, 2022). This system sets caps on how much greenhouse gases can be emitted and ensures that it gets lower and lower over time. In this way, companies can trade emission allowances as they wish. The allowances are the main currency of the EU ETS. These allowances can be traded by anyone with an account in the Union registry and, the trade can be made either directly between companies or through intermediaries (European Commission, 2016).

Moreover, the EU ETS focuses on emissions that can be measured, reported, and verified. This helps take track of progress and changes. The EU ETS regulates around 45% of the total EU greenhouse emission by covering approximately eleven thousand power stations and manufacturing plants. Overall, the ETS is a crucial tool for cutting greenhouse gas emissions from extensive facilities and mainly in the aviation sector²⁹.

Chapter 3.3.5 EU Green bond

The European Union also uses green bonds to reach all of its goals. Green bonds are any type of list on unlisted bonds or capital market debt instruments committed to helping fight climate change. These are used to transition towards a lower gas-emission company and a more sustainable future.

Governments and companies now use green bonds to finance the transition to a more sustainable and low-carbon economy; these are traded in the green bond market. The green

²⁹ Information from European Commission. EU Emissions Trading System (EU ETS). Retrieved from: https://ec.europa.eu/clima/eu-action/eu-emissions-trading-system-eu-ets_en

bond market is where the money raised is used exclusively for environmental-friendly projects. The green bond market needs to grow faster to achieve the goals set for the following years (European Parliament, 2022).

Currently, the green bond market is still small compared to the overall bond market. The EU Commission is trying to establish a standard for green bonds to align with the EU taxonomy, following the sustainable definitions. These contribute to the EU's sustainable finance policy objectives.

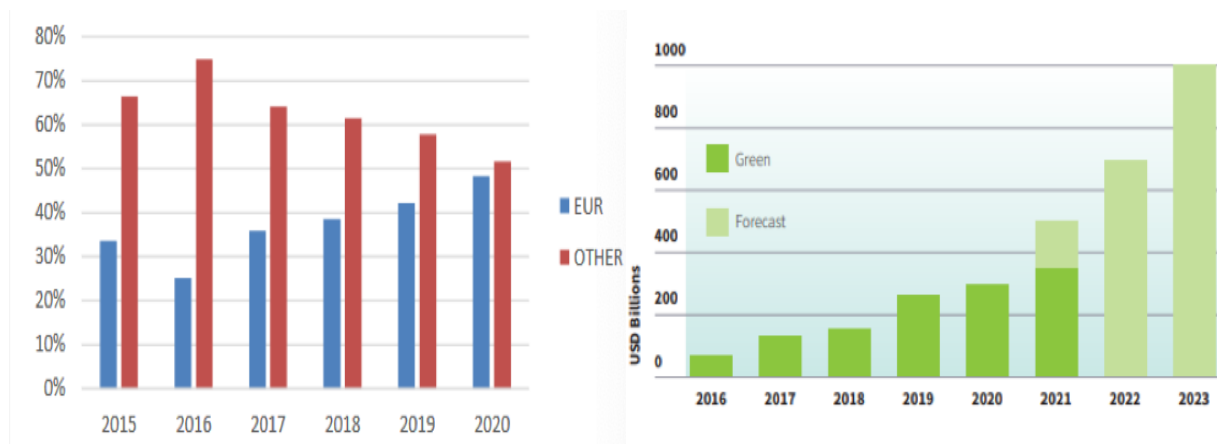
Overall, green bonds are becoming one of the main instruments regulators are starting to use to green the economy and financial sector.

Chapter 3.3.5.1: Data on green bond

The EU has issued 48% of global issuances of green bonds in 2020 denominated in Euros (Figure 2). The amount of bonds issued increases every year, with an average of 50% per year between 2015 and 2020 (Figure 3). To reach the Paris Agreement, there is a need for rapid growth faster than the one happening.

Figure 2 (left): Share of global green bonds issued in Euro (Spinaci, 2022)

Figure 3 (right): Green bonds issued by year (globally) - (Spinaci, 2022)



Although, as mentioned earlier, the green bond market is not very big compared to the overall bond market. The Euro, at the moment, is the leading currency for green bond issuance and trading, which improves the development of euro area capital markets.

CHAPTER 3.4: THE EUROPEAN CENTRAL BANK

The European Central Bank (ECB) is a central bank responsible for conducting the monetary policy for all the Euro area members. Up to now, all the states part of this monetary policy are autonomous. Furthermore, not all the members of the European Union are part of the European Monetary policy. This is why there is a difference between the ECB and the European System of Central Banks (the ESCB). This difference will be seen now.

Moreover, the primary responsibility of the ECB and the ESCB will be discussed, understanding what is stated in the mandate of the ECB and what is in its power.

Chapter 3.4.1: The mandate of the ECB

With the creation of the Euro, there was the creation of the ECB and the ESCB. The difference between the two is that the ESCB comprises the ECB and the National Central Banks (NCBs) and has to carry out the central banks' function for the Euro but has no legal personality. The ECB and the NCBs have the legal power. The ESCB will exist as long as members in the European Union are not part of the European Monetary Union, as it includes all the NCBs (also the ones not in the EMU).

The Treaty on the Functioning of the European Union (TFEU) states that the primary responsibility of the ESCB and the ECB is to maintain price stability to avoid having changes in inflation and deflation. The goal is aimed at keeping price stability by not letting investors hedge on the risk of inflation and demanding compensation for the risk.

The mandate for the ECB does not give them any other direct responsibility other than the one of price stability by using the monetary policy, although some secondary objectives are mentioned. The actions within the "secondary objectives" are limited to keeping price stability and limited to the fact that the ECB does not bear the responsibility for the policies emended and does not have to make the policy autonomously (Drudi, 2021). Based on that, "*without prejudice to the objective of price stability*", the ECB "*shall support the general economic policies in the Union to contribute to the achievement of the objectives of the Union*" (Art. 127, Official Journal of the European Union). Meaning that the ECB should always work with the support of the European Union and, the ECB only has to help reach the objectives set by the Union.

The price stability in the Euro system, the primary responsibility of the ECB, is established such that inflation should be maintained "*below but close to 2% over the medium term*" (Gerdesmeier, 2011). This means that inflation should be avoided, but at the same time, deflation should also be avoided. The ECB uses two "pillars" to assess price stability risks, defined as economic and monetary analysis. Analyzing these pillars helps reach the primary objective by assessing economic dynamics and shocks and analyzing monetary trends.

Furthermore, the ECB has guidelines and instructions that must be adopted and carried out by the NCBs and prevail over national legislation and law. The Governing Council has the responsibility to make sure that the ECB follows all the legislation by requiring all the necessary information to ensure the compliance of the ECB with the guidelines and instructions. They do this by having regular meetings twice a month to assess possible issues related to the ECB's tasks³⁰.

Chapter 3.4.2: Conclusion on the ECB

Since the European Monetary Union was created, the ECB and ESCB became the most important monetary authorities for the Union. The ECB and the ESCB exist because some European countries are not inside the Eurozone. The primary responsibility of the ECB and the ESCB is to maintain price stability, and it has several ways to do so. Both institutions are very dependent on fiscal authorities, such as governments limiting their authority. This can put some limits on their actions in their mandate.

CHAPTER 3.5: THE EUROPEAN CENTRAL BANK AND CLIMATE CHANGE

The mandate of the ECB only includes price stability, which means that climate change mitigation is outside the mandate of the ECB. This is incompatible with the fact that climate change threatens the price stability objective of the ECB.

The question to answer is now: should the ECB take action in climate change mitigation anyways?

³⁰ Information from European Central Bank. Governing Council. Retrieved from: <https://www.ecb.europa.eu/ecb/orga/decisions/govc/html/index.en.html>

A discussion on its role and the possible actions that can be taken will be seen now.

Chapter 3.5.1: Should the ECB take action?

The ECB should take action because climate change and the consequent policies could affect the outlook for price stability. Climate change can have an impact in several ways, such as affecting the financial and price stability of the European Union.

As seen, the ECB has to preserve "*without prejudice the objective of price stability*" (Art 3, Treaty on European Union); this is why the ECB needs to act. In this way, the ECB is not directly pursuing climate change actions, but it is achieving its price stability goal, which requires pursuing environmental objectives. Furthermore, Article 18.1 of the ESCB/ECB Statute requires "*the ECB and the national central banks to conduct credit operations with lending based on adequate collateral*". This means the ECB should make an operation that does not lead to any losses in its monetary policy operations. This means that in the case in which climate change creates risks in the collateral of the ECB's balance sheet, the ECB has the right to act to mitigate these risks (Drudi, 2021).

Other articles suggest that the ECB should include climate change mitigation in their tasks. Articles 8 to 13 of the TFEU set out that ECB "*must comply with other treaty provisions which do not establish a legal basis for action, but rather duties with which it must comply in all policies and activities*". Together with article number 11 of TFEU, stating that "*environmental protection requirements must be integrated into the definition and implementation of the Union's policies and activities, in particular with a view to promoting sustainable development*", the conclusion is that the ECB should "take account of" environmental objectives (Article 11, Treaty on the Functioning of the European Union). The ECB must include environmental goals in its duties and set them out as a requirement in the ECB's tasks.

These are just some articles that suggest the ECB should take action in the climate change fight.

Besides the price stability problem, climate change can impact the value and the risk profile of different assets held on the Euro system's balance sheet, creating volatility. This is another reason that leads the ECB to act.

Furthermore, the ECB has a crucial role in supervising European banks closely to transition towards a more sustainable world. If the climate-related risks are adequately shown on the bank's balance sheet, they might be adequately priced. In this way, banks will take risks into account and, as a consequence also, households and companies will start considering them more (Drudi).

Many sources conclude that central banks need to help to mitigate climate risks. The Vice-Chair of the Supervisory board and member of the executive board of the ECB, Frank Elderson, states that the whole European financial system is mainly bank-based, meaning that banks need to be part of the climate mitigation process to keep financial stability. Furthermore, Frank Elderson repeatedly said global joint actions (including banks) are vital to a zero-emission world by 2050. This means that the answer to our question, should the ECB take action, is yes, central banks' actions are needed to reach the goals set.

Chapter 3.5.2: The ECB actions

It is now clear that climate change's challenges will only increase from now on and that the ECB should take all the actions possible within its mandate to keep stability³¹.

For the first time in 2017, the EU Commission V. Dombrovskis suggested the introduction of a bank capital requirements called “green supporting factor”, making mandatory holding a certain amount of assets in green activities. Thanks to this requirement, banks investing in sustainable activities would receive a higher profit. This principle was introduced in the Sustainable Finance Action Plan only later on by the European Commission, in 2018 (Baer and al, 2021). The Action Plan on Sustainable finance has the objectives of channeling financial investments towards green activities, consider financial instability created by climate change and promote transparency and long-term investments (European Commission, 2018). This action plans helps the ECB and the banks in Europe to promote low-carbon investments and try to mitigate climate change risks.

Furthermore, the action plan created in 2021 by the ECB's Governing Council also included

³¹ Information from European Central Bank (2021). Climate Change and Central Banks: Analysing, Advising and Acting. Retrieved from: <https://www.ecb.europa.eu/press/key/date/2021/html/ecb.sp210711~ffe35034d0.en.html>

sustainable activities. The European Central Bank set up a climate change center to put together all the ideas from different bank parts. "Climate change affects all of our policy areas," and the "climate change center provides the structure we need to tackle the issue with the urgency and determination it deserves" (Lagarde, 2021). Everyone working on the climate center team focuses on climate-related topics and sustainable finance.

Chapter 3.5.2.1: Data on ECB Climate losses

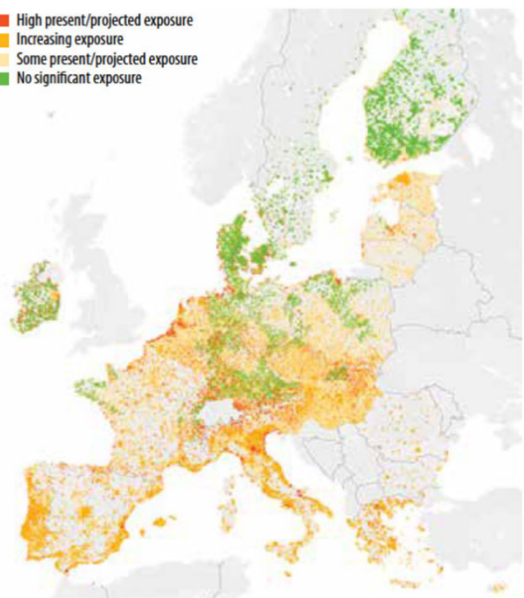
Since the beginning of climate change, the ECB registered several losses in terms of GDP. Some data on this will be presented. Furthermore, it will show how certain areas in Europe are more hit by climate change than others. Another differentiation can be found in different economic sectors, where some sectors are more struck by climate change than others. At last, the exposure to climate risks on different banks' loans in different sectors will be seen.

The ECB included for the first time in May 2019 the climate and environmental factors in the Financial Stability Review, to analyze the financial system in the Eurozone. In the financial review for 2021, the ECB estimated economic damage of around 1% of the GDP of the Eurozone as a consequence of natural disasters that have happened in 2019.

Figure 4: Firms across Europe and physical risks (Alogoskoufis and al., 2021)

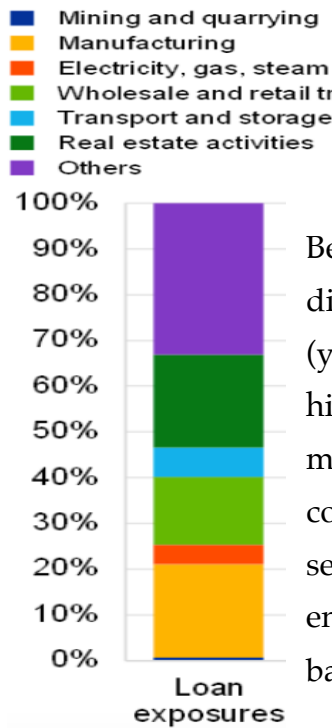
At risk
 Firms across Europe are subject to physical risks from climate change, which can pose a threat to financial stability.

- High present/projected exposure
- Increasing exposure
- Some present/projected exposure
- No significant exposure



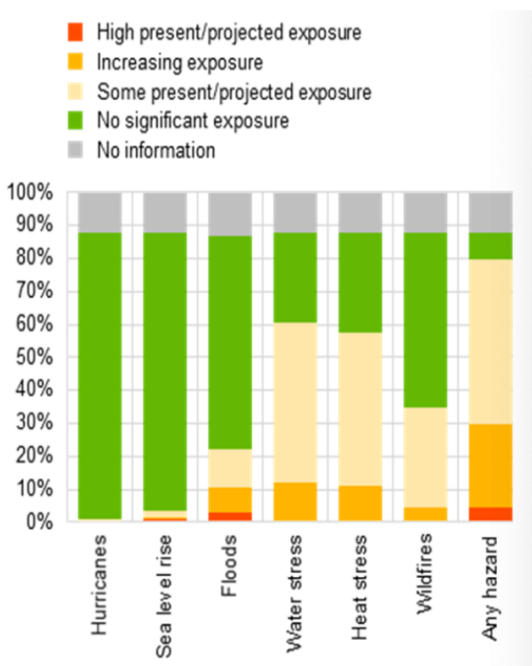
It can be seen that the location of firms and subsidiaries can increase the exposure to climate change risks. The South of Europe is more impacted by climate change risks (Figure 4). High-risk profile firms for climate change risks such as fire and drought are located in the south of Europe, with a percentage of 18% (Gili and Rizzi, 2021).

Figure 5: Bank's loan exposures and share of corporate emissions in each sector (exposures: 2020, emission: 2019) (Alogoskoufis and al., 2021)



Besides the location, the loan exposure of the European banks can be differentiated in different sectors (Figure 5). The manufacturing industry (yellow) is around 20% of the banks' portfolios and is associated with a high emission (risky sector). Securities with a portfolio similar to the manufacturing one (purple) hold around 30% of the bank's equity and corporate bond portfolio with high emissions. The mining and energy sector (blue) holds 5% of banks' loan exposure. Although mining and energy sectors have high carbon emissions, they have low exposure to bank loans (Alogoskoufis and al., 2021).

Figure 6: Share of euro area banks' credit exposures to firms by corporate physical risk level (Alogoskoufis and al., 2021)



Around 80% of loan exposures are to firms with at least some exposure to physical risks. Overall, about 30% of Euro area banking system credit exposures to non-financial corporations are to firms subject to "high or increasing risk due to at least one physical risk driver" (Alogoskoufis and al., 2021), (Figure 6). These exposures can increase rapidly if actions to fight climate change are not taken. Furthermore, these firms subject to physical risks are secured by collateral. If these collaterals are damaged, significant losses for banks can happen. If insurance does not cover all the expenses for the damage, the potential losses for banks increase even more.

Some banks share more physical risks than others, giving more than 70% of banking system credit exposure held by only 25 banks. These banks tend to be as diversified as possible and try to share these risks with other important banks (Alogoskoufis).

Chapter 3.5.3: Conclusion

All of this together led to the conclusion that central banks in general, particularly the ECB in the European Union, have a vital role in helping to mitigate the climate change risks. However, the ECB does not have the primary responsibility for climate change; it still needs to take action and incorporate it into the policy framework.

CHAPTER 3.6: HOW CAN THE ECB TAKE ACTION? MONETARY POLICY

Given that until now, it has been understood that governments and parliaments have the primary responsibility to fight climate change, the question is how the ECB can take action.

The only way to tackle climate change for the European Central Bank is to consider its monetary policy strategies. Due to these reasons, one of the biggest concerns lately has been to change the monetary policy framework to meet the obligation of the EU treaties and reach the goal of the 2030 and 2050 targets and the Paris agreement without damaging the price stability of the European Union.

This chapter will discuss how monetary policy can help fight climate change and how the ECB can use monetary policy to fight climate change.

Chapter 3.6.1: Monetary policy commitments for climate change

In the last publication, "*Climate change and monetary policy in the Euro area*" by the ECB, the Governing Council stated, "*to further incorporate climate change considerations into its monetary policy framework*". This includes the future commitment to incorporate the climate change consideration in the monetary policy decisions and expand its analytical capacity in macroeconomic modeling, statistics and monetary policy concerning climate change.

The Council would like to implement the action plan in line with progress on the EU policies and initiatives in environmental sustainability disclosure and reporting. This is why the

Governing Council of the ECB created a schedule throughout the years, planning decisions and showing the commitment to consider the monetary policy for a more sustainable environment.

Chapter 3.6.2: Implementation of monetary policy in climate change

Now, the question is how monetary policy can help fight climate change. With the decision to include climate change in the monetary policy implementation, the ECB correctly states its commitment to incorporate environmental sustainability consideration in its monetary policy and considers climate change of enormous importance. The design for the monetary policy implementation framework will be "*consistent with the price stability objective and should take into account the implications of climate change for an efficient allocation of resources*"³².

The design of the measures taken by the ECB in the implementation of monetary policy for climate change is consistent with the price stability objective. Besides that, these measures take into account the implications of climate change. These actions should consider environmental sustainability disclosure from the EU policies and initiatives. The Council would like to include the climate change consideration mainly in the areas of disclosure support, macroeconomic modelling, statistical data for climate change risks analyses, collateral framework, risk assessment, and corporate sector purchase programme to implement an action plan that is in line with the EU policies.

Chapter 3.6.2.1: Disclosure support

The Euro system plays an essential role in disclosing climate-related information providing inputs to regulators and standard setters to assess climate-related risks better. A possible introduction of disclosure requirements could be introduced for "*private sector assets as a new eligibility criterion or as a basis for differentiated treatment of collateral and asset purchases*" (Drudi, 2021). Together with the disclosure policies and initiatives in the EU in environmental stability, this will promote more disclosure practices and increase the amount of information available on climate change.

³² Citation from European Central Bank (2021). ECB presents action plan to include climate change considerations in its monetary policy strategy. Retrieved from: https://www.banque-france.fr/sites/default/files/medias/documents/press_release_-_ecb_presents_action_plan_to_include_climate_change_considerations_in_its_monetary_policy_strategy.pdf

In case new disclosure requirements are implemented, a pre-announcement should be given. In this way, there is a possibility of an introduction of monetary policy smoothly without catastrophic effects on the market and reaching the goals set.

Chapter 3.6.2.2: Macroeconomic modelling

The ECB will develop theoretical and empirical analysis to monitor the implications of climate change, the financial system, and monetary policy transmission. It will do this by using financial markets and the banking system.

Chapter 3.6.2.3: Statistical data for climate change risks analyses

After developing further analysis, the ECB will also develop indicators for green financial instruments, financial institutions' carbon footprint, and exposure to climate-related physical risks. This is useful for gathering reliable data for climate risk analyses. This will be in line with the EU policies and initiatives.

Chapter 3.6.2.4: Collateral framework

This framework is designed to keep adequate collateral and risk protection while having enough collateral availability across different jurisdictions and economic environments. The purpose is to include climate change risks in the financial market and keep available resources (collateral) to avoid catastrophic events. It is essential to focus on whether the collateral valuation method used considers properly the pricing signals related to climate change risks.

Having enough collateral available enables the smooth implementation of monetary policies. As this collateral will include every kind of risk (including climate change risks), there should be no fear of default in implementing new policies.

Chapter 3.6.2.5: Risk assessment

The ECB should conduct stress tests related to the relationship between economy and climate in the financial system. It should conduct tests on the Euro system balance sheet to assess its exposure to climate change and increase its risk assessment capabilities. Furthermore, the test should analyze the vulnerability to climate change risks, both physical and transition risks.

The credit assessments of the assets should be disclosed "*systematic(ly), consistent(ly) and transparent(ly)*" (Drudi). In this way, the credit risk raised by climate change can be analyzed through-out time. This information is helpful to understand the credit quality of the assets and ensuring protection on the Euro system's balance sheet allowing the implementation of monetary policies for climate change.

Furthermore, credit rating agencies should disclose how they incorporate climate change risks into their credit ratings to appropriately assess the risks of implementing a new monetary policy.

Chapter 3.6.2.6: Corporate sector purchase programme

The last way to implement monetary policies for climate change is the corporate sector purchase programme (CSPP). The CSPP is an asset purchase programme exposed to transition risk. This programme has the possibility of creating exposure to green finance, allocating financial flows in the right direction. An opportunity for the ECB is allocating corporate bond purchases along with climate change goals of the European Union to stay within their mandate.

Chapter 3.6.2.7: Conclusion

All these options will help the European Central Bank implement green measures in its monetary policies while preserving the main objective of its mandate. This means adapting projections and models to the climate change risks while designing consistent measures with their primary goal. This ensures a smooth implementation of new monetary policies while maintaining a stable European environment (Drudi, 2021).

Moreover, it is important that this action plan aligns with the EU policies and initiatives in environmental sustainability disclosures and reporting³³.

Overall the relationship between policy measures toward climate change and monetary policies is now clear. Standing on the primary objective of the European Central Bank, the price stability, the ECB should incorporate climate change consideration in its monetary policy

³³ Information from European Central Bank (2021). Institutional provisions. Retrieved from: <https://www.ecb.europa.eu/pub/pdf/other/ecbinstitutionalprovisions2011en.pdf>

implementation framework. It should do this by using all the actions mentioned before such that they contribute the best to the objectives of the Union.

Chapter 3.6.3: Transmission of monetary policy and problems

The main actions that the ECB can take to implement monetary policy for climate change have just been seen. Unfortunately, as analyzed until now, climate change impacts the European Union's financial stability. This is not all, as it also affects how monetary policy can be conducted.

The main transmission channels of monetary policy in the ECB were analyzed. Now there will be an analysis of how there are implications for monetary policy transmission, focusing on the physical and the transition risks. In this analysis, extreme weather events and persistent warming will be considered for physical risks. Instead for transition risks, carbon pricing and reduction in the emission rate will be considered (Drudi, 2021).

In the European Union, the main transmission channels of monetary policies are five: the interest rate channel, the credit channel, the asset price channel, the exchange rate channel, and the expectations channel.

Chapter 3.6.3.1: Interest rate channel

Physical risks can lower the power of using interest rate changes for modifying monetary policy. In a business-as-usual situation, if the interest rate rises, the value of a bond or other investment will decline. But in the case of climate change risks and damages, this power of interest might not work. This could reduce the responses of savings and investments based on the change in an interest rate change.

Instead, transition risks affect the natural rate of interest rate due to the uncertainty of people's responses to policy. All of this creates volatility in the interest rates and raises risk premia.

In this way, the sensitivity of the population to changes in interest rate lowers. Likewise, policies on the interest rate will have much lower importance in choices, making the monetary policy less effective.

Chapter 3.6.3.2: Credit channel

Financial losses created by physical and transition risks create substantial risks for borrowers, credit supply, and banks. Sometimes even creating vicious cycles.

Borrowers might lose their credibility due to a loss of net worth, collateral, and profitability. This loss of creditworthiness brings lenders to look out for these risky loans and reduces the amount of supply available given the risk of exposure. Furthermore, non-performing loans (NPLs-loans in default) that did not meet due payments for specific periods negatively affect banks' balance sheets triggering their credit ratings. This also triggers the credit supply available.

Moreover, the uncertainty on market funding (short-term funds) created by climate change increases uncertainty in banks. The possible collaterals available from this funding could be damaged from physical risks creating no resources for refinancing operations. This creates another stress on the credit channel.

The credit channel bears most of the climate change impact on monetary policy because banks are the most significant financial sub-sector and intermediary for transmitting the ECB's monetary policies. Lowering the possibility of working and creating stress on banks reduces the chance of using monetary policies on credit channels.

Chapter 3.6.3.3: Asset price channel

Physical risks, first of all, destroy properties and capital, creating financial losses that lead to a devaluation of firms. Climate change risks and financial losses also increase the probability of a rating downgrade and default in households and firms. Furthermore, these losses impact the population's wealth, creating changes in consumption and demand.

Instead, transition risks make demand shift frequently in sectors and geographical areas. This impacts the return on equity on firms creating "stranded assets". Likewise, "stranded assets" can be created from physical risks (catastrophic events).

Together, these trigger corporate revaluations and impair monetary policy transmissions through asset price channels.

Chapter 3.6.3.4: Exchange rate channel

The exchange rate is often used to strengthen the effect of the monetary policy. By increasing the value of a currency, typically, there is a decrease in economic growth and increases in prices. Unfortunately, physical risks create a devaluation for short-term competitiveness gain due to the long-term effects of climate change. Furthermore, physical risks increase volatility and uncertainty, impairing exchange rate channels' usual way of work.

At the same time, transition risks such as carbon border create a probability of disruption in specific trade routes and the terms of trade of several countries. In case of trading problems, the European Union faces another challenge: trading the exposure of one euro country while strengthening another one. The exchange currency in the European Union must be changed overall, so in case of unilateral shocks, there is a trade-off to face.

Overall, uncertainty and volatility could decrease the effective exchange rate on monetary policy transmission. Climate change can increase differences between countries within the Euro area.

Chapter 3.6.3.5: Expectation's channel

All the possible physical risks from climate change are unpredictable, making the expectation channel uncertain. Even more unexpected is the frequency of the shocks. This creates ambiguity in the possible monetary policies and, even more, causes shocks in the supply and demand.

The frequency of change in the transition policies makes monetary policies less credible and lowers their effectiveness.

Chapter 3.6.3.6: Conclusion on transmission channels problems

Overall, the uncertainty of future expectations weakens the expectation channel of monetary policy transmission. Monetary policy is less credible and all the five channels that can transmit monetary policies are weakened by climate change (Drudi, 2021). The ECB needs to act fast to

solve this problem and needs to consider all the transmission channel problems created by climate risks, making implementing new monetary policies very hard.

CHAPTER 3.7: CONCLUSION ON THE EUROPEAN UNION AND THE ECB

The European Union is working intensively to achieve a climate-friendly Europe without the emission of harmful gases. It can be categorized as one of the locations making the most prominent progressives toward the objectives set in the Paris Agreement.

This is only possible with the collaboration of the European Central Bank. Its contribution to mitigating climate change risks is significant to keeping price stability in the Union and holding a stable environment. The ECB can use monetary policy to implement mitigation toward climate change. Unfortunately, this tool has some limitations given from climate change and can often not be used. This is mainly provided by the uncertainty and volatility created by these risks.

Overall, it has been learned that monetary policy alone from the ECB can only sustain environmental transitions. Only government choices and fiscal policies can make an important decision in the transition (Gili and Rizzi, 2021). There is a need for global collaboration to reach the goal set and end up in a zero-emission world.

CONCLUSION

The goal of this thesis was analyzing climate change and the financial risks created by it, by showing how these are interfering with the way of work of monetary authorities. It started by analyzing the main causes of climate change and the relationship between climate change and financial authorities.

Moreover, a description of the financial risks created by climate change was presented, together with the first organizations to fight the climate change crisis. Financial risks created by climate change were analyzed as a trade-off between creating policies to mitigate them and not creating any policies. Furthermore, it was seen that it is easier for developed countries to include climate change mitigation in their objectives than for developing countries. This is because developing countries' economic growth is very dependent on using greenhouse gases.

After this, an overview of the functioning of the two main authorities, financial and monetary, and the correlation between the two was given. This was done by trying to explain in an exhaustive way how they work and what are their main functions. It was then chosen to focus this thesis on the way the monetary authorities and, more specifically, central banks are fighting financial risks created by climate change.

The thesis continues by looking in particular at different central banks in the world, their mandates and how they deal with financial risks. The focus was then given to the European Central Bank and the European Union and how this Union is dealing with climate change.

Even given that climate change mitigation does not stand in central banks' mandate, the analysis of the mandate of monetary authorities leads to the conclusion that mitigating climate change risks stand in their objectives to keep price stability. Central banks need to take positions in mitigating these risks by using monetary policies, although the main responsibility to fight these risks is on the governments.

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GLOSSARY

Atmosphere *“The gaseous envelope surrounding the Earth. The dry atmosphere consists almost entirely of nitrogen (78.1% volume mixing ratio) and oxygen (20.9% volume mixing ratio), together with a number of trace gases, such as argon (0.93% volume mixing ratio), helium and radiatively active greenhouse gases such as carbon dioxide (0.035% volume mixing ratio) and ozone. In addition, the atmosphere contains the greenhouse gas water vapour, whose amounts are highly variable but typically around 1% volume mixing ratio. The atmosphere also contains clouds and aerosols” (IPCC, 2007).*

Borrowers Borrowers are people or organizations that borrow money, especially from banks.

Brown bonds Brown bonds are bonds funding or raising money to industries generating high-green houses gases emissions.

Carbon dioxide (CO₂) *“A naturally occurring gas, also a by-product of burning fossil fuels from fossil carbon deposits, such as oil, gas, and coal, of burning biomass and of land-use changes and other industrial processes. It is the principal anthropogenic greenhouse gas that affects the Earth’s radiative balance. It is the*

reference gas against which other greenhouse gases are measured and therefore has a Global Warming Potential of 1” (IPCC, 2007).

Carbon budget Carbon budget is *“an amount of carbon dioxide that a country, company, or organization has agreed is the largest it will produce in a particular period of time” (Cambridge Dictionary)*

Climate Climate *“in a narrow sense is usually defined as the average weather, or more rigorously, as the statistical description of the mean and variability of relevant quantities over a period ranging from months to thousands or millions of years. The classical period for averaging these variables is 30 years, as defined by the World Meteorological Organization. The relevant quantities are surface variables such as temperature, precipitation, and wind. In a broader sense, the climate is the state, including a statistical description, of the climate system” (IPCC, 2007).*

Climate change Climate change refers to *“a change in the state of the climate that can be identified (e.g., by using statistical tests) by changes in the mean and/or the variability of its properties, and that persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes*

or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use. Note that the Framework Convention on Climate Change (UNFCCC), in its Article 1, defines climate change as: ‘a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods’. The UNFCCC thus makes a distinction between climate change attributable to human activities altering the atmospheric composition, and climate variability attributable to natural causes. See also *Climate variability; Detection and Attribution*” (IPCC, 2007).

Climate-related financial risks “The potential risks that may arise from climate change or from efforts to mitigate climate change, their related impacts, and their economic and financial consequences” (Basel Committee, 2021).

Climate scenario “A plausible and often simplified representation of the future climate, based on an internally consistent set of climatological relationships that has been constructed for explicit use in investigating the potential consequences of anthropogenic climate change, often serving as input to impact models. Climate projections often serve as the raw material for constructing climate scenarios, but climate scenarios usually require additional

information, such as about the observed current climate. A climate change scenario is the difference between a climate scenario and the current climate” (IPCC, 2007). A worst-case scenario represents the worst climate scenario that can happen in the future.

Drought In general terms, drought is a ‘prolonged absence or marked deficiency of precipitation, a ‘deficiency that results in water shortage for some activity or for some group’, or a ‘period of abnormally dry weather sufficiently prolonged for the lack of precipitation to cause a serious hydrological imbalance’ (Heim, 2002).

Extreme weather event “An extreme weather event is an event that is rare at a particular place and time of year. Definitions of rare vary, but an extreme weather event would normally be as rare as or rarer than the 10th or 90th percentile of the observed probability density function. By definition, the characteristics of what is called extreme weather may vary from place to place in an absolute sense. Single extreme events cannot be simply and directly attributed to anthropogenic climate change, as there is always a finite chance the event in question might have occurred naturally. When a pattern of extreme weather persists for some time, such as a season, it may be classed as an extreme climate event, especially if it yields an average or total that is itself extreme (e.g., drought or heavy rainfall over a season)” (IPCC, 2007).

Global warming *“The estimated increase in global mean surface temperature averaged over a 30-year period, or the 30-year period centered on a particular year or decade, expressed relative to pre-industrial levels unless otherwise specified. The current multi-decadal warming trend is assumed to continue for 30-year periods that span past and future years”* (IPCC, 2018).

Green bond Green bonds are bonds created to fund projects and raise money for projects that have positive environmental climate benefits.

Greenhouse gases (GHGs) *“Greenhouse gases are those gaseous constituents of the atmosphere, both natural and anthropogenic, that absorb and emit radiation at specific wavelengths within the spectrum of thermal infrared radiation emitted by the Earth’s surface, by the atmosphere itself, and by clouds. This property causes the greenhouse effect. Water vapor (H₂O), carbon dioxide (CO₂), nitrous oxide (N₂O), methane (CH₄), and ozone (O₃) are the primary greenhouse gases in the Earth’s atmosphere”* (IPCC, 2021).

Kyoto Protocol The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) *“was adopted in 1997 in Kyoto, Japan, at the Third Session of the Conference of the Parties (COP) to the UNFCCC. It contains legally binding commitments, in addition to those included in*

the UNFCCC. Countries included in Annex B of the Protocol (most Organisation for Economic Cooperation and Development countries and countries with economies in transition) agreed to reduce their anthropogenic greenhouse gas emissions (carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulphur hexafluoride) by at least 5% below 1990 levels in the commitment period 2008 to 2012. The Kyoto Protocol entered into force on 16 February 2005” (IPCC, 2007).

Lenders Lender is a person or an organization that lends money. The bank is the largest mortgage lender in the country (Oxford Dictionary).

Low-carbon emissions Low-carbon emissions are emissions with low quantity of carbon dioxide.

Macro-prudential policy Macro-prudential policy is *“used to mitigate the risk of a disruption to the provision of financial services caused by an impairment of all or parts of the financial system, with serious negative consequences for the real economy”* (Central Bank of Ireland).

Mitigation A human intervention to *“reduce the sources or enhance the sinks of greenhouse gases”* (IPCC, 2007).

Monetary policy Monetary policy “concerns the decisions taken by central banks to influence the cost and availability of money in an economy” (European Central Bank).

Non-performing loans Non-performing loans are in default because the borrower has not made the scheduled payments for a specified period.

Policymakers A policymaker is responsible for or involved in formulating policies, especially in politics.

Risk premia Risk premia are the return in excess of the risk-free rate of return that an investment is expected to yield (Hayes et al, 2021).

Scenario “A plausible and often simplified description of how the future may develop, based on a coherent and internally consistent set of assumptions about driving forces and key relationships. Scenarios may be derived from projections but are often based on additional information from other sources, sometimes combined with a narrative storyline” (IPCC, 2018).

Stranded asset Stranded assets are asset that, at some time before the end of their economic life, is no longer able to earn a financial return due to changes associated with the transition to a low-carbon economy (adapted from Carbon Tracker).

Stress tests The evaluation of a financial institution’s financial position under a severe but plausible scenario. The term “stress testing” is also used to refer to the mechanics of applying specific individual tests and to the wider environment within which the tests are developed, evaluated, and used within the decision-making process.

Green bond Green bonds are financial instruments that finance green projects and provide investors with regular or fixed-income payments. A bond with a “commitment to exclusively use the funds raised to finance or refinance “green projects, assets or business activities” (Kaminker, 2015).

Green emissions See low-carbon emissions

Green investments Green investments are investments in activities that have low-carbon emissions and are environmental friendly.

Uncertainty “An expression of the degree to which a value (e.g., the future state of the climate system) is unknown. Uncertainty can result from lack of information or from disagreement about what is known or even knowable” (IPCC, 2007).

United Nations Framework Convention on Climate Change (UNFCCC) “The

Convention was adopted on 9 May 1992 in New York and signed at the 1992 Earth Summit in Rio de Janeiro by more than 150 countries and the European Community. Its ultimate objective is the 'stabilisation of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system'. It contains commitments for all Parties. Under the Convention, Parties included in Annex I (all OECD countries and countries with economies in transition) aim to return greenhouse gas emissions not controlled by the Montreal Protocol to 1990 levels by the year 2000. The convention entered in force in March 1994. See Kyoto Protocol" (IPCC, 2007).

Paris Agreement *"The Paris Agreement is a legally binding international treaty on climate change. Its goal is to limit global warming to well below 2, preferably to 1.5 degrees Celsius, compared to pre-industrial levels" (UNFCCC, n.d.).*

Volatility *"Volatility is a statistical measure of the dispersion of returns for a given security or market index. In most cases, the higher the volatility, the riskier the security. Volatility is often measured as either the standard deviation or variance between returns from that same security or market index" (Hayes et al., 2021)*

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ACRONYMS

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|--|---|
| CMCC Centro Euro-Mediterraneo sui Cambiamenti Climatici | PA Political Authorities |
| COP Conference of Parties | SWFI Sovereign Wealth Institute |
| CSPP Corporate Sector Purchase Programme | TFEU Treaty on the Functioning of the European Union |
| DA Delegated Authorities | UNDP United Nations Development Programme |
| ECB European Central Bank | UNEP United Nations Environmental Programme |
| EEA European Environment Agency | UNFCCC United Nations Framework Convention on Climate Change |
| EEC European Economic Community | WMO World meteorological organization |
| EMU European Monetary Union | |
| ESCB European System of Central Banks | |
| EU European Union | |
| GDP Gross Domestic Product | |
| GHG Greenhouse Gases | |
| GISS Goodard Institute for space studies | |
| INDC Intended nationally determined contributions | |
| IPCC Intergovernmental Panel on Climate Change | |
| IPCC International Panel on Climate Change | |
| NBER National Bureau of Economic Research | |
| NGFS Network for Greening the Financial System | |
| TCFD Task Force on Climate-related Financial Disclosures | |
| FED The Federal Reserve System | |
| WMO World Meteorological Organization | |
| OECD Organisation for Economic Co-operation and Development | |

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