Department of
Corporate Finance

Desk of
Asset Pricing

The impact of Climate Change events on asset classes. An empirical analysis to extract a Climate Change risk premium .

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Introduction

Recent years have seen the growth and development of an environmental conscience among human beings, that is progressively changing the way human beings act. This renewed awareness is triggering virtuous mechanisms whereby everything does not have to be done only for the sake of maximum economic profit; in fact, choices can also be made to make man's coexistence in the environmental ecosystem more sustainable and to preserve the habitat in which he lives.

International climate agreements, national carbon pricing systems, and the growing competitiveness of alternative energy sources, such as wind and photovoltaics, compared to fossil fuels, are the prominent trends that could change the current energy paradigm, shifting the structure of the current production, industrial, building or manufacturing landscape towards a more environmentally friendly target.

The Fifth Assessment Report on Climate Change (AR5), published in 2013 by the Intergovernmental Panel on Climate Change (IPCC) and sponsored by the United Nations, required countries around the world to come to an international agreement to take action to limit the maximum temperature increase to 2°C by the end of the century. The annual greenhouse gas emissions must be reduced (between 50% and 60% by 2050) and then reduced to zero (between 2080 and 2100) over the century to have a good chance of achieving the target. Since 65% of annual greenhouse gas emissions are carbon dioxide, mainly emitted by the combustion of fossil fuels, plans must be devised to reduce CO_2 concentrations by replacing fossil fuels with renewable sources, increasing energy efficiency and capturing the CO_2 generated.

Irrespective of international agreements, 39 nation-states and 23 federal states have already implemented a system that puts a price on emitted carbon dioxide (carbon pricing), thereby disadvantaging fossil fuels.

Currently, the system covers 12% of total world emissions, but in the coming years, this percentage, the number of countries adopting carbon pricing and the unit price (currently USD 7 per tonne of CO_2) look set to rise. Nevertheless, the real news is narrowing the competitive gap between renewable sources such as wind and photovoltaics and traditional fossil fuels: in the most favorable conditions, the generation costs of these technologies are now close to those of gas and coal plants. In the United States, over the period 2009-2014, the cost of a kilowatt-hour fell by 78% for PV and 58% for onshore wind, approaching wholesale electricity market prices. By 2040, both technologies' cost could fall further (-40% or more in the case of PV, where increased efficiencies, currently just over 20% at best, could play a decisive role). Installed capacity has also improved at a high annual rate (+49% photovoltaic and +21% wind in 2007-2015), reaching levels well above the most optimistic past scenarios' expectations.

However, their impact on the world's energy supply remains marginal: in 2013, wind and solar accounted for only 0.7% of the world's total primary consumption (3.496 of electricity generation). Evolving and rising to the challenge does not imply an immediate and sudden change, of course, but requires immediate preparation to tackle partly unknown issues and develop new models.

The aim of this thesis work is to investigate the effects that the focus on issues related to climate change and climate change may have on stock markets and stock returns for Italian companies.

The strands of analysis on which the contents of the thesis are developed are mainly two:

1) the first one is aimed at assessing what are the effects on the markets caused by extreme climate events and their consequences in Italy;
2) the second concerns the ESG theme and, in particular, aims at analysing the link between risk and the climate-environmental component within the ESG factor attributed to specific Italian companies.

The increasingly widespread attention to climate-related issues has led many companies to adopt environmentally virtuous corporate policies, which have enabled them to achieve high scores in terms of the *"E" = Environment* component of the ESG factor.

The study conducted in this thesis is aimed at assessing whether this high score translates into something economically and financially tangible when an uncommon climate event occurs or in terms of investor attractiveness and risk variation in equity markets. The thesis is divided into five chapters, of which the first two introductory ones are the necessary premise for a complete and explicative understanding of the topic on which the analyses conducted in the following sections are based. The third and fourth chapters, on the other hand, present the empirical analyses carried out to verify each of the two study hypotheses on which the work focuses, while the third and last section is the shortest and corresponds to the conclusions, where the results are interpreted and possible subsequent lines of research are mentioned.

In particular, Chapter One introduces the issue of climate change by giving a brief and concise introduction on the origins of the topic and explaining why this issue has become of primary importance in the last period both for the global macroeconomic scenario and for individual companies, especially those operating in markets where environmental and climate features play

a critical role, such as the oil and gas sector.
In the second chapter, the economic effects of climate change are discussed, differentiating the impact of these changes according to the particular economic sector considered and applying the analysis to the Italian economic context. It also introduces the ESG theme and discusses the methodologies for calculating the components linked to these factors and the main databases that deal with the calculation and dissemination of these indicators.
The third chapter, on the other hand, focuses on an Event Study carried out to determine whether there is an effective impact of extreme climate events on the performance of the shares of companies affected by such events. A new and original study is carried out that, by combining information obtained from different types of sources, manages to create a sample of events that have occurred in recent years in Italy involving the production sites of listed companies in order to assess whether the occurrence of such events has had tangible repercussions on the market performance of these companies, and if so, what elements may have determined it.
The fourth chapter instead investigates the effect that having a high value of the Environment ("E") component of the ESG factor for Italian companies can have in terms of Risk Premium: the extent and nature of this effect has already been widely debated in the international scenario, but the originality of the analysis conducted concerns the fact that it focuses on the climate-environmental factor rather than on the aggregate ESG factor, and is focused on the Italian stock market.
The results of the analysis of the last two chapters are commented on in the final chapter, in which an attempt is made to argue some interesting points for reflection: in particular, an attempt is made to make considerations based on the results of the third chapter that can be used by companies to gain a competitive advantage when extreme events occur. On the other hand, with regard to the fourth chapter, an attempt is made to make interpretative hypotheses on the positive relationship found between the environmental factor "E" and risk; starting from what is found in the literature, various reasons are hypothesised to explain this result, which has given contrasting and controversial values in various parallel studies applied in economic contexts or time periods. The proposed interpretations seem to be well adapted to the Italian reality in which perhaps not enough weight is given yet to the communication and dissemination of information relating to the results achieved by companies in terms of environmental issues and in which the reality of small companies can generate cyclical mechanisms related to GDP that can distort the dependencies that intuitively could be assumed.

Chapter 1

1 CLIMATE CHANGE

1.1 The importance of Climate Change today

In recent years, ongoing climate change and the transition to a model of sustainable economic development have taken on central importance for the financial system, calling into question the various players involved - central banks, companies, national and international government bodies - who are taking up the challenges posed by these phenomena in their institutional and investment activities.

Attention to the economic effects of climate change is high. The most up-to-date scenarios outline a further rise in global temperatures during the 21st century, with effects on the frequency and intensity of extreme natural phenomena and critical implications for ecosystems and human health. The link between human activity and climate change highlights the need to refound the model of development in a sustainable direction, starting with the progressive abandonment of fossil fuels, which have so far guaranteed unprecedented prosperity.

Economic activity is both the cause and the victim of climate change. It causes it through the use of fossil energy: three quarters of greenhouse gas emissions are generated by the combustion of energy. At the same time, climate change affects human activities: higher average temperatures, with more marked fluctuations, are increasingly affecting all activities, starting with those - such as agriculture - that are most exposed to natural events; more frequent and intense hydrogeological phenomena and heat waves can cause huge economic damage; and the progressive rise in sea levels is endangering coastal communities all over the world.

The understandings reached by the international community, enshrined in the various international agreements, call for a rapid decarbonisation pathway aimed at reducing interference with natural processes and mitigating their consequences by limiting temperature growth to within 1.5-2°C of pre-industrial levels. The commitments made by countries to this end, despite their good intentions, are largely insufficient and are revised periodically.

On the other hand, the reconversion of the economic system towards sustainability is not an immediate process, not least because of its global nature, and is exposed to many factors of uncertainty. In order to understand the way forward, it is therefore necessary to analyse the effects

of climate change on the economy and to quantify the risks that could materialise - in the event of a disorderly transition to a low-carbon economy - even in the short term.
In addition to the risks associated with future climate events, referred to as physical risks, there are also risks arising from the transition itself for those sectors and economies that will find it most difficult to adapt to the new paradigm based on the marginalisation of fossil fuels, the so-called transition risks. The latter will be greater the more the transition is not governed and guided by a programmatic plan but is the result of untimely and uncoordinated decisions at international level.
In recent years, the international community has made a growing commitment to tackling climate change. This has given great impetus to the analysis of related economic risks, arousing strong interest in the world of finance: scores relating to social, environmental and governance sustainability aspects, which have been drawn up for years for listed assets on the markets by specialised providers, have begun to be carefully considered by investors alongside the economic and financial characteristics of companies. Sustainable finance has grown strongly in recent years and is now a real market trend. This orientation, potentially beneficial also for stimulating the conversion towards a green economy, is however not without risks. First and foremost, there is the risk of greenwashing, i.e. investors financing activities with only the appearance of sustainability. This risk is increased by the lack of a universally recognised and comprehensive taxonomy of sustainable activities.
In the following paragraphs, before starting to describe what action has been taken and what the effect on the economy is, an attempt has been made to briefly describe what the underlying causes of the problem are and what the effects are, in order to understand how, from the analysis of these effects, it is possible to grasp the real and concrete economic consequences on the productive and industrial sector. This effect is complex and follows dynamics that are very difficult to predict and are often governed by site-specific factors that are closely dependent on the nature of the extreme event that generated them.

1.2 The causes of Climate Change: the GreenHouse gas (GHG) effects

In the modern era, there is no humanly organized activity for which there is no need to produce energy to sustain countries' economic growth, which is satisfied by the energy produced by burning fossil fuels. However, the combustion of coal, oil and natural gas (methane) releases substances into the environment that are harmful to the atmosphere, including the six climatealtering gases known as greenhouse gases.

Among these, the most important and well-known of the Greenhouse Gases (GHG) and responsible for about 60% of the greenhouse effect increase is carbon dioxide. Carbon dioxide has been present on earth for more than 4 billion years in even greater proportions than today, but with the industrial revolution, its concentration has risen sharply by around 30%, especially in the northern hemisphere

CO2 remains in the atmosphere for about a hundred years. It is produced during many of our daily activities, such as the use of cars, heating houses, household consumption, but also the production of electricity, industrial activities, intensive agriculture, in which large quantities of fossil fuels are burned, releasing the CO2 stored millions of years ago into the atmosphere.

It is also produced by some natural sources: by plant putrefaction (humification), volcanic eruptions or as a waste product of animal respiration. It is instead removed by water, especially from the oceans' surface, and by plants, through photosynthesis.

In addition to these emissions is the impact of deforestation, which results not only in a release of CO2 stored in trees but also in a reduced area of forest uptake (through chlorophyll photosynthesis).

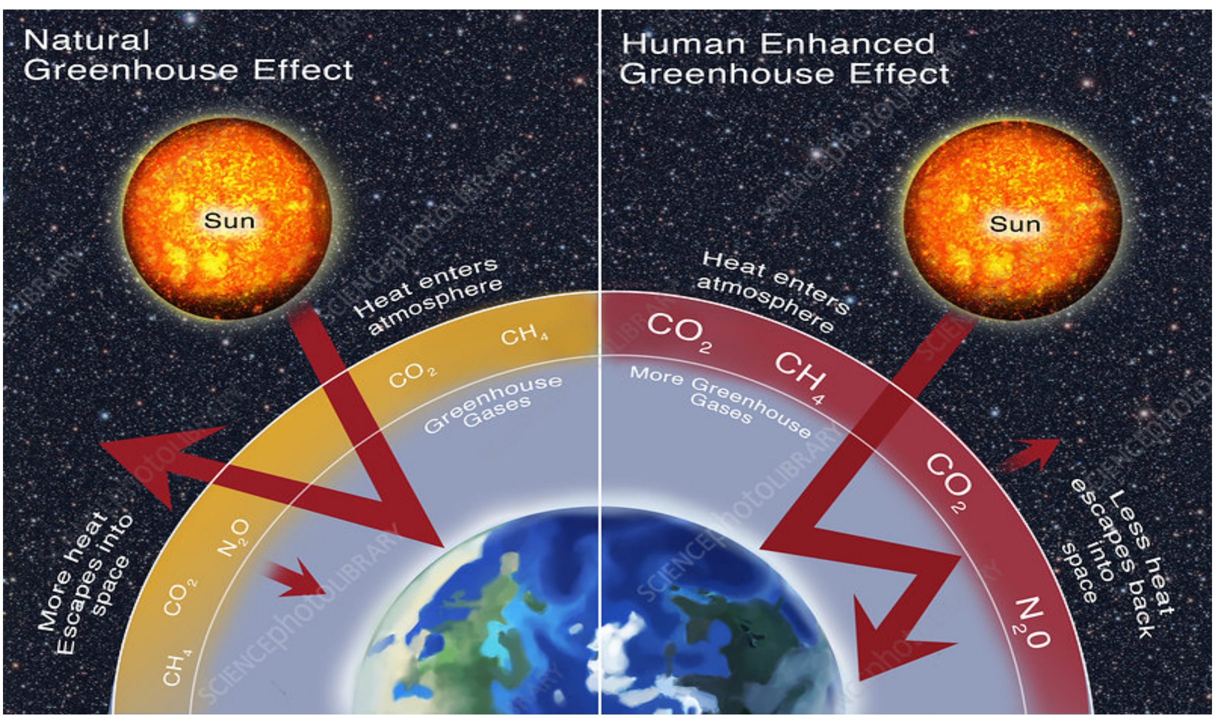


Fig. 1.1- Natural and Human Enhanced Greenhouse Effect

The other five greenhouse gases are:

1. Methane: although less present than CO2, it produces 21 times the latter's heat and is responsible for 20% of the increase in the greenhouse effect. Methane is produced by

bacteria responsible for the of organic matter, by landfills and by the normal biological activity of many animals, such as the millions of cattle on earth. Methane is also emitted during the production and transport of coal and natural gas. Methane is sequestered from the atmosphere in the natural process of water formation and remains in the atmosphere for 11-12 years, less than many other greenhouse gases.

2. Nitrous oxide: Most of this gas in the atmosphere comes from microbiological processes. In soils and waters, the main sources of N2O emissions are nitrification and denitrification processes, the latter being the main culprit for N2O emissions in underground environments. Uptake of nitrous oxide by the oceans has also been observed, but to date, there is too little knowledge about how soil and marine systems act as sinks for this gas to consider their importance on a global scale.

3. Halocarbons: the best known are CFCs (chlorofluorocarbons), HCFCs (hydrochlorofluorocarbons) and HFCs (hydrofluorocarbons). The concentration of these gases in the atmosphere is deficient, but their warming potential is 3,000 to 13,000 times greater than CO2. Halocarbons do not result from natural processes; their presence in the atmosphere is mostly attributable to human activities. Until the mid-1970s, CFCs were widely used as propellants in aerosol cans, solvents and some adhesives. In 1987, with the signing of the Montreal Protocol, the world's nations agreed to reduce the use of these atmospheric ozone-depleting gases drastically. CFCs have largely been replaced by HCFCs, which are less harmful to the ozone layer but still have a greenhouse effect by contributing to global warming. So while the concentration of CFCs decreases, the one of other gases increases. These gases are not only very strong but able to remain in the atmosphere for very long periods, up to 400 years.

4. Ozone is an essential component of the atmosphere. However, while in the upper layers, it is useful because it filters the sun's ultraviolet radiation towards the earth, in the lower layers, in the troposphere, it is to be considered a pollutant (although its potential as a greenhouse gas compared to CO2 has not yet been calculated). Ozone is naturally created and destroyed by ultraviolet radiation, with the strongest creating it from oxygen and the weakest destroying it. Some ozone is produced in air pollution processes.

5. Water vapour is the main contributor to the natural greenhouse effect on our planet. The concentration of water vapour in the atmosphere varies widely: in polar regions, since cold air holds little water, the atmosphere contains very little water vapour; in the tropics, on

the other hand, it is very humid, and the atmosphere can therefore contain up to 4% water vapour. Water vapour is an important element in climate change processes as an increase in temperatures can lead to an increase in global water vapour, leading to a rise in the greenhouse effect. In general, human activities have a low impact on water vapour levels in the atmosphere.

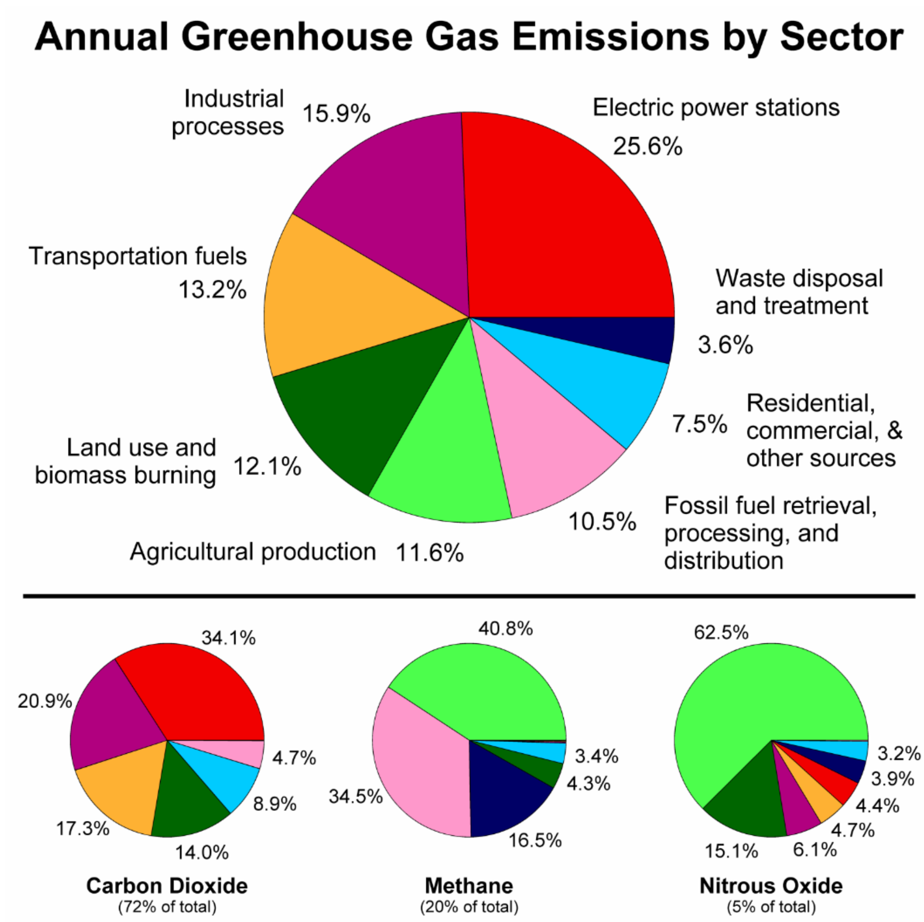


Fig. 1.2- Greenhouse production distributed by economic sectors

Rising concentrations of CO2 and other greenhouse gases, caused largely by fossil fuels' combustion, are contributing to global warming and climate change. Increased consumption of fossil fuels will continue to increase energy-related CO2 emissions over the period.

Driven by higher energy demand in 2018, global energy-related CO2 emissions increased by 1.7% to an all-time high of 33.1 Gt CO2.

This is the highest growth rate since 2013 and 70% higher than the average increase since 2010. Last year's growth of 560 Mt was equivalent to the total emissions of international aviation.

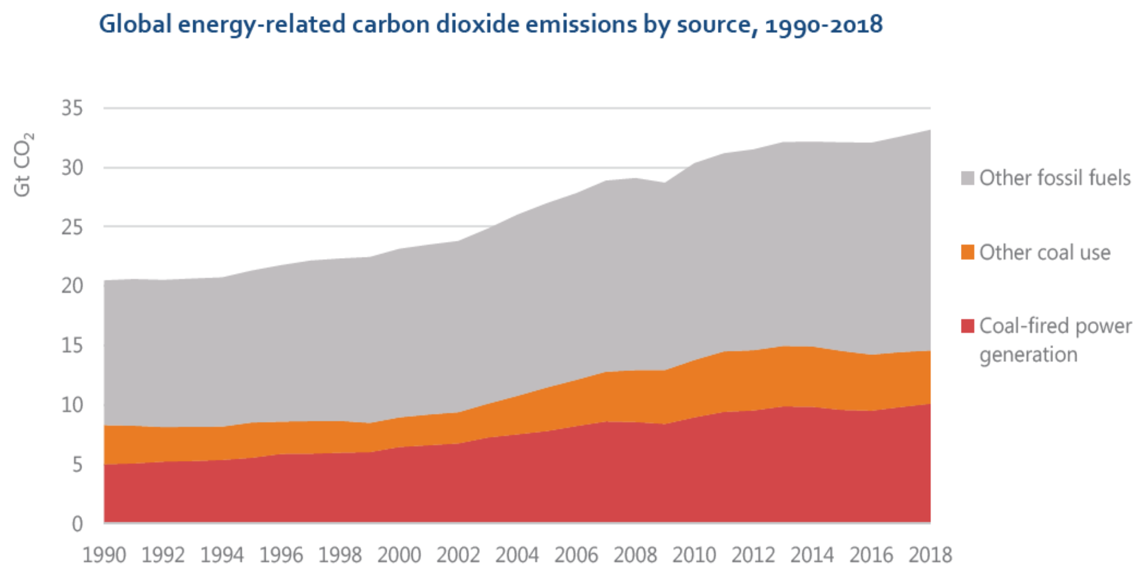


Fig. 1.3 – Global energy-related dioxide emissions by source. Source IEA, 2020

While emissions from all fossil fuels increased, the energy sector accounted for almost two-thirds of emissions growth. The use of coal for electricity generation alone exceeded 10 Gt CO2, especially in Asia. China, India and the US accounted for 85% of the net increase in emissions, while emissions fell for Germany, Japan, Mexico, France and the UK.

The increase in emissions was driven by higher energy consumption resulting from a robust global economy and weather conditions in some parts of the world that led to increased energy demand for heating and cooling.

CO2 emissions remained stable between 2014 and 2016, even as the global economy continued to expand. This decoupling was mainly the result of great improvements in energy efficiency and low-carbon technologies, which led to a decline in coal demand.

However, the dynamics changed in 2017 and 2018. Increased economic growth was not matched by increased energy productivity; low-carbon options did not scale back quickly enough to meet increased demand.

The result was that CO2 emissions increased by almost 0.5% for every 1% increase in global economic output, compared to a 0.3% increase on average since 2010. However, renewables and nuclear power have impacted emissions, rising 25% slower than energy demand in 2018.

For the first time, the IEA assessed the impact of fossil fuel use on global temperature increases. It found that CO2 emitted from coal combustion was responsible for more than 0.3°C of the 1°C increase globally annual average surface temperatures above pre-industrial levels.

This makes coal the main source of global temperature rise. The global average annual concentration of CO2 in the atmosphere averaged 407.4 ppm in 2018, up 2.4 ppm from 2017. This is a significant increase from pre-industrial levels, ranging between 180 and 280 ppm.

1.3 The consequences of the Greenhouse Effect

The greenhouse effect is in itself a natural, and useful, phenomenon that ensures the warming of our planet thanks to certain gases naturally present in the atmosphere such as carbon dioxide, ozone, water vapour and methane (described above). These gases act as a kind of transparent glass that surrounds the earth, allowing radiation from the sun to pass through but retaining some of the radiation, and therefore the heat, emitted by the earth. Just like in a greenhouse, the temperature tends to rise. Without the greenhouse effect, the average global temperature would in fact be unbearable: -18°.

However, human activities and current energy consumption scenarios (in particular: energy produced by burning fossil fuels and deforestation) have the effect of releasing heat and increasing the concentration of greenhouse gases in the air. The artificial intensification of this process, caused by the increase in the concentration of certain gases in the atmosphere, starting with carbon dioxide, is a very dangerous phenomenon that risks triggering uncontrollable climatic changes and alterations in the environmental balance on which life on our planet rests.

As mentioned in the previous chapter, there is now a general scientific consensus on the evidence of climate change and its causes. In its Report "SR15", the authoritative *Intergovernmental Panel on Climate Change (IPCC)* confirms that, if current trends do not change, the concentration of carbon dioxide in the atmosphere could double by mid-century, leading to an increase in the earth's temperature of between 1.5°C and 3.5°C, estimating, according to a study by Enea *Ente per le Nuove tecnologie, l'Energia e l'Ambiente.* and the IPCC, that in 2050 the average temperature will be about 2-3 degrees higher.

The sensitivity of the hydrological cycle to variations in temperature and precipitation will lead to significant changes in soil moisture, surface water run-off and river and lake flows. This will expose ecosystems and human communities to substantial changes in water availability (the scenarios outlined in the study predict that hundreds of millions of people will be without water in 20 years' time), water quality and the risk of floods and droughts. Research indicates that water stress may increase in many countries including Australia, North Africa, southern Africa, southern Europe, the Middle East and Latin America and decrease in Asia and equatorial Africa. Models indicate a trend towards increased risk of floods and droughts in most areas.

Climate change will then create significant imbalances in ecosystems over long periods of time and this will lead to a reduction in biodiversity. Changes in the distribution of animals and plants have already been observed and will continue in the years to come, with shifts of 400-600 kilometres northwards for an increase of only a few degrees Celsius. Where these shifts are not possible, or are too slow in relation to climate change, climate change could threaten or irreversibly damage some systems and species.

Significant changes are also expected in the oceans: in particular, a reduction in ice areas at the North Pole (thawing of *permafrost*), changes in salinity and currents, and a reduction in fishiness. Many coastal areas will also experience an increase in seawater encroachment, erosion and salinisation of groundwater. The risk is particularly high in tropical and subtropical areas.

With regard to human health, changing climatic conditions could lead to an increase in deaths due to heat waves, an increase in the frequency and intensity of extreme weather events such as floods and cyclones with their consequences, and an increase in the spread of diseases such as malaria even in non-tropical areas (by 2080 between 260 and 320 million people living in non-risk areas today will be exposed to this disease).

The projected changes will vary significantly between different regions of the globe. The consequences for developing countries, which are the most vulnerable due to their low adaptive capacity, will be particularly severe. In the agricultural sector, for example, developing countries are likely to face increasing uncertainty about food availability and even an increase in the frequency and duration of famines. Reduced food availability could lead to increased migration of populations in search of more suitable territories for the development of normal living conditions. For industrialised countries, the most significant impacts will be on the intensity and frequency of extreme events, the hydrological cycle and water availability, and health. The experience of some recent extreme events suggests that, for urban areas, adaptation processes could be costly and involve high social costs.

For southern Europe as a whole, the climate changes predicted by the IPCC climate scenarios (year-round increase in temperatures, reduction in summer precipitation, increase in intensity and frequency of heavy rainfall) will lead to reduced availability of water resources, increased risk of flooding, deterioration of soil quality, increased frequency of fires, increased erosion and loss of wetlands in coastal areas.

The picture of the expected impacts is particularly critical for Italy, which suffers from hydrogeological instability that compromises the regeneration capacity of its resources and its ability to mitigate the effects of extreme climate events. In fact, the most recent analyses of meteorological series carried out by the CNR show that, even today, the trend of the main climate parameters is in line with that found at global level and forecast by the IPCC for the 21st century.

In general, the Italian climate has been getting warmer and drier, particularly in the South, since 1930. At the same time, throughout northern Italy, the intensity of precipitation has been increasing over the last 60-80 years, with an increased risk of flooding in this region, particularly in the autumn season when the risk of flooding is at its highest also as a consequence of melting glaciers.

Finally, according to Nicholas Stern, the author of a recent report commissioned by the British government, climate change could in the long term have massive economic consequences: 5 to 20% of the world's gross domestic product will have to be committed annually to repairing the damage caused by the new climate patterns.

Early action to reduce emissions, on the other hand, would achieve mitigation of the effect of climate change at a much lower cost, which the economist estimates at 1% of global GDP per year.

The direction of investments over the next 10 to 20 years will therefore have a profound effect on climate and will considerably influence the future of the planet: the costs of stabilising emissions are significant but bearable, while delaying action could be dangerous and much more costly. The costs of stabilising emissions are significant but bearable, and delaying action could be dangerous and far more costly. It should be noted that, alongside investments to mitigate the effects of climate change, investments must be made now to enable the planet to adapt to the damage already done.

1.4 The economic effect of climate change events

As stated above, climate change is already manifesting itself in our country with chronic phenomena, such as the increasing deviation of temperatures and precipitation from historical trends. According to the available scenarios, which describe the various possible evolutions in the concentration of greenhouse gas emissions in the atmosphere, these trends will continue, accompanied by the intensification of acute phenomena, such as floods or heat waves. The effects of climate change on the economy, already in the next decade, could be significant in the most exposed economic sectors and geographical areas. In aggregate terms, however, the effects are only significant in the case of extreme scenarios, but available estimates are subject to important limitations in terms of the data and methods used.

Sustainable finance is currently focused on the effects of climate change on our economic system. However, it is not always clear how to move between these issues, finding oneself disoriented by information amplified by the media that oscillates between an over-emphasis (where every natural event is linked to climate change or where there are only a few years left before the end of life on earth) and a skepticism that undermines the scientific basis with specious arguments.

Attributing extreme natural events to climate change is a complex science. A presentation of the degree of knowledge on the subject can be found in a useful map in Carbon Brief (https://www.carbonbrief.org/mapped-how-climate-change-affects-extreme-weather-around-the-world). It is a mechanism that has obvious analogies with the current pandemic: 'only draconian measures can save us' or, at the other extreme, 'the epidemic is an invention to keep us in the house'.

In order to understand what is reasonable to expect from climate change in our country, it is possible to look at what is happening to the surrounding environment, both in terms of the worsening of climate anomalies, by which we mean the fact that temperature and precipitation are increasingly far from their historical values, and in terms of the increased frequency of extreme climate-dependent natural events, such as hydrogeological events and heat waves.

Meanwhile, there is no doubt that in our country, as in the rest of the world, the climate is changing: 2019 was the third hottest year since observations began (ISPRA, 2020), after the records already recorded in 2015 and 2018. The latter was the hottest year in the entire historical series compiled by ISPRA since 1961 and, according to studies that reconstruct the climate in the more distant past, the hottest year for at least two centuries; 2017 had already been characterised by a worsening of climatic conditions with significant drought phenomena over much of the national territory and serious consequences on water resources.

What may seem paradoxical is that as temperatures and droughts increase, so does extreme precipitation. According to an indicator measuring precipitation anomaly, 2019 is the 11th wettest year since 1961.

Abnormal rainfall occurred mainly in the North, where the intensity of these phenomena, again in 2019, was the fifth highest since 1961 (ISPRA, 2020).

In addition to these chronic effects, climate change is also likely to underlie other acute phenomena, such as flooding events and landslides. Climate change, by influencing the precipitation regime, can lead to an aggravation of the hydrogeological risk, to which our country is traditionally exposed (ISPRA, 2018). In making these considerations, on the other hand, one must avoid considering all these natural phenomena as dependent on climate change. In some cases this link is also based on the misunderstanding that confuses the increase of events with that of their effects: sometimes the disastrous impacts of events are not due to a greater intensity of natural events but rather to phenomena, such as poor urban planning or excessive soil sealing, which amplify their impacts.

Climate anomaly indicators can be projected into the future by means of climate scenarios, which allow us to assess what we can expect under different hypotheses of rising temperatures. Climate scenarios are 'stories' which, on the basis of certain assumptions about socio-economic development and its impact on energy use and greenhouse gas emissions, reconstruct possible futures in climate terms. Assessments that zero emissions are needed by mid-century to limit temperature increases to within 2°C, or that not reducing emissions will lead to some loss of output, are based on the results of these scenarios.

A central piece of information in the scenarios is that which indicates a certain trajectory in terms of greenhouse gas concentrations (*Representative concentration pathways* - RCP) and thus temperature rise. The trajectory depends on the evolution of emissions: if emissions continue to grow at a high rate, the RCP8.5 scenario is realised; if, on the contrary, emissions are drastically reduced, the RCP2.6 scenario is considered. Between these two extremes there are two intermediate scenarios: RCP4.5 and RCP6.06.

1.5 Climate scenarios: what can happen from different angles

The effects of climate change are assessed by constructing 'stories' about how the climate might evolve in the future. The different stories are the climate scenarios and are based on the combination of two elements. One component describes the possible alternative evolutions of a set of economic and social variables (*Shared Socioeconomic Pathways* - SSP) concerning population, per capita product and its distribution, degree of urbanisation and level of education. Another component assumes an evolution of energy demand and therefore of greenhouse gas emissions, which involves a certain trajectory in terms of concentration (*Representative concentration pathways* - RCP) to which a number is associated indicating the expected intensity of climate change (the "radiative forcer1"), linked to human activity and estimated at the end of the century compared to the pre-industrial period.

There are five SSPs (Rihani et al., 2017):

- SSP1. sustainability, a green growth path;
- SSP2. middle of the ford, an intermediate route;

- SSP3. conflict between areas of the world, a bumpy ride;
- SSP4. strong inequalities, a divisive path;
- SSP5 fossil growth, a path where only economic growth matters.

There are four RCPs used in the latest IPCC assessment report (IPCC, 2014) and they are numbered according to the change in expected radiative forcing at the end of the century compared to historical values:

- RCP2.6, reducing emissions;
- RCP4.5, emissions reach a plateau at the end of the century;
- RCP6.0, emissions grow slowly;
- RCP8.5 emissions continue to grow steadily.

The concentration corresponds to a certain increase in temperature through a relationship known as *climate sensitivity*.

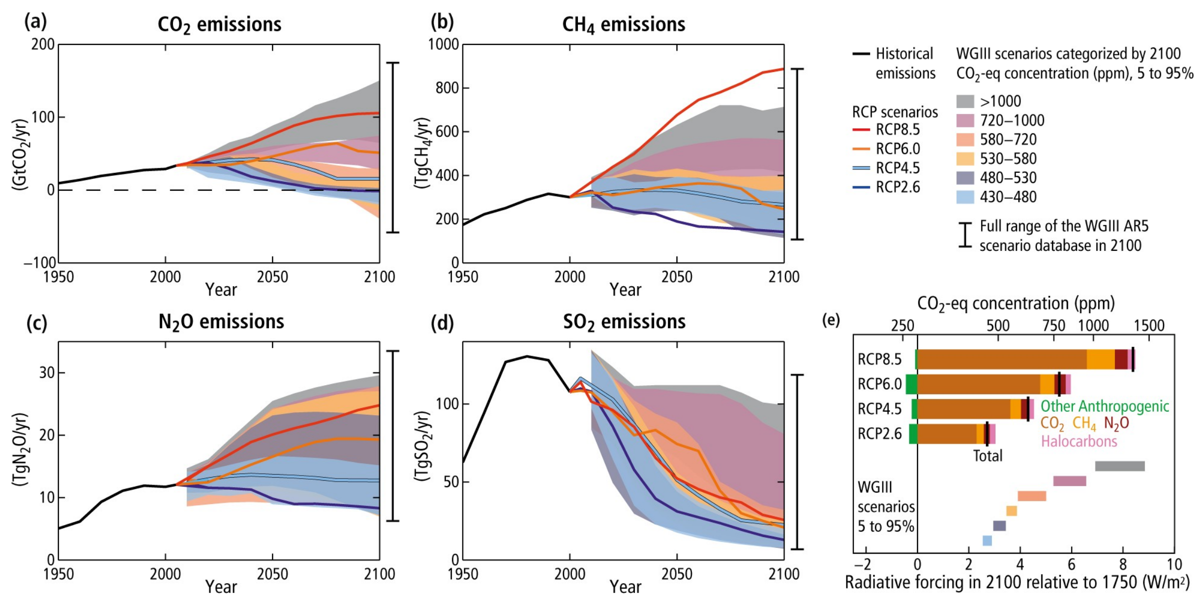


Fig. 1.4- Emission scenarios and the resulting radiative forcing levels for the Representative Concentration Pathways (RCPs, lines) and the associated scenarios categories used in WGIII. Panels a to d show the emissions of carbon dioxide ($_{CO2}$), methane (CH4), nitrous oxide (N2O) and sulfur dioxide (SO2). Panel e shows future radiative forcing levels for the RCPs calculated using the simple carbon cycle climate model, Model for the Assessment of Greenhouse Gas Induced Climate Change (MAGICC), for the RCPs (per forcing agent) and for the WGIII scenario categories. Souces: IPCC, https://ar5-syr.ipcc.ch/topic_futurechanges.php

The scenario is therefore a combination of different possible economic and social pathways (the SSPs) and emission developments linked to possible energy system developments (the RCPs).

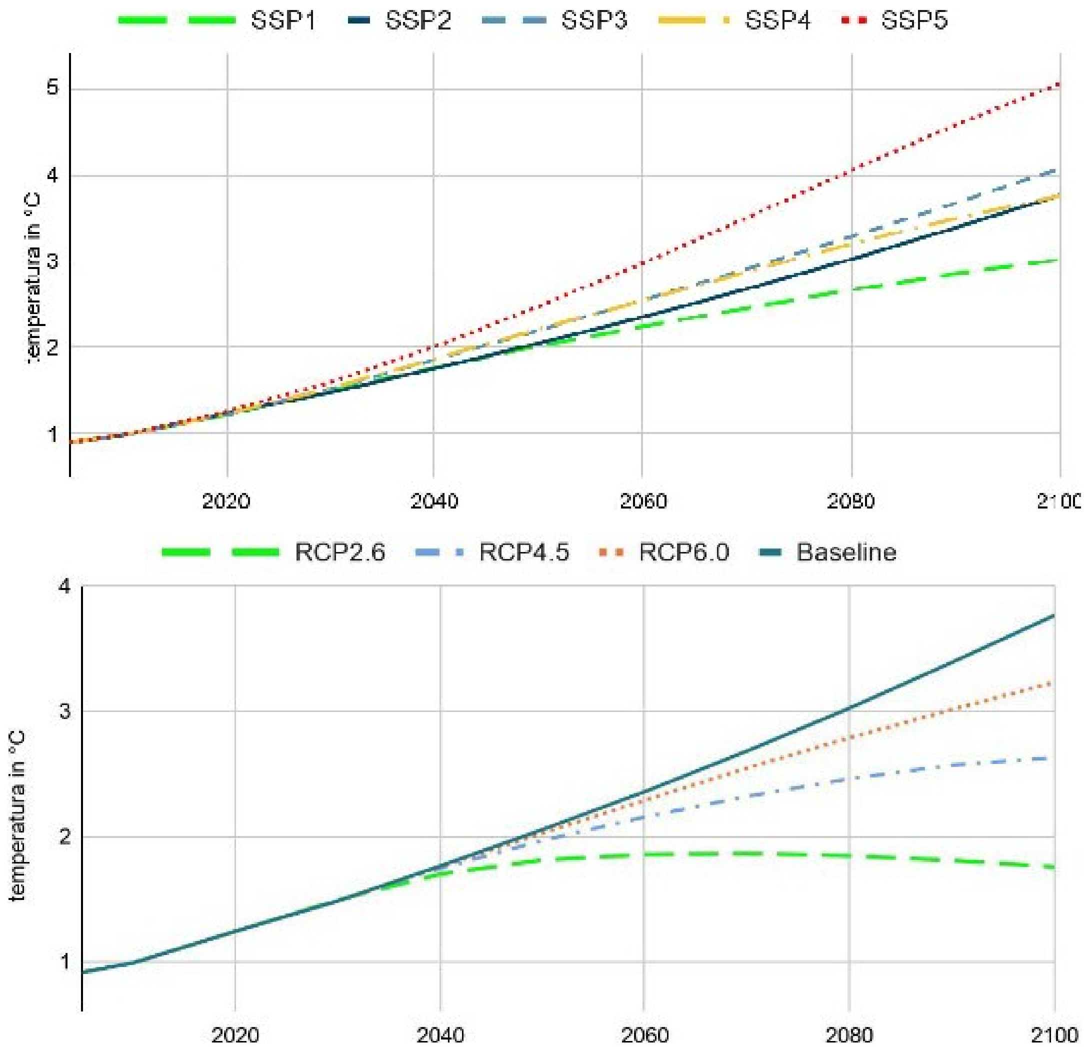


Figure 1.5 a) and b) - The temperature anomaly in the SSPs and the different RCPs.
Source: elaborations on SSP Public Database (Version 2.0) https://tntcat.iiasa.ac.at/SspDb

Figure 1.5 (panel a) shows how the different pathways lead to different temperature rises at the end of the century in the scenarios with no action to reduce emissions (*baseline* scenarios): the sustainable pathway (SSP1) would end the century with a temperature rise of around 3°C while the pathway where fossil fuels continue to dominate (SSP5) would lead to a temperature rise of over 5°C. Figure 1.5 (panel b) shows the expected increases assuming an intermediate pathway (SSP2) but with more or less intense action to limit GHG emissions leading to four different levels of radiative forcing (and hence climate change 'intensity'). Only in the RCP2.6 scenario does the temperature increase remain within 2 °C, in line with the Paris CoP target, while in the two intermediate scenarios it is between 2.6 and 3.2 °C.

Overall, climate models predict a temperature increase of between 0.3°C and 4.8°C by the end of the 21st century compared to the average observed over the period 1986-2005; three out of four scenarios estimate an average temperature increase of more than 1.5°C (Table 1.1).

2046-2065			2081-2100	
Scenario	Media	Range	Media	Range
RCP2.6	1	0,4-1,6	1	0,3-1,7
RCP4.5	1,4	0,9-2,0	1,8	1,1-2,6
RCP6.0	1,3	0,8-1,8	2,2	1,4-3,1
RCP8.5	2	1,4-2,6	3,7	2,6-4,8

Table 1.1. Expected increase in the Earth's temperature for each hypothetical greenhouse gas emission scenario, compared to the period 1986-2005. Source: (IPCC, 2013)

In order to understand how the energy system might change to meet the Paris target, one can assume that the world evolves along the SSP2 pathway. No country-specific scenarios are available, so we focus on what would happen in the highest income countries (OECD countries).

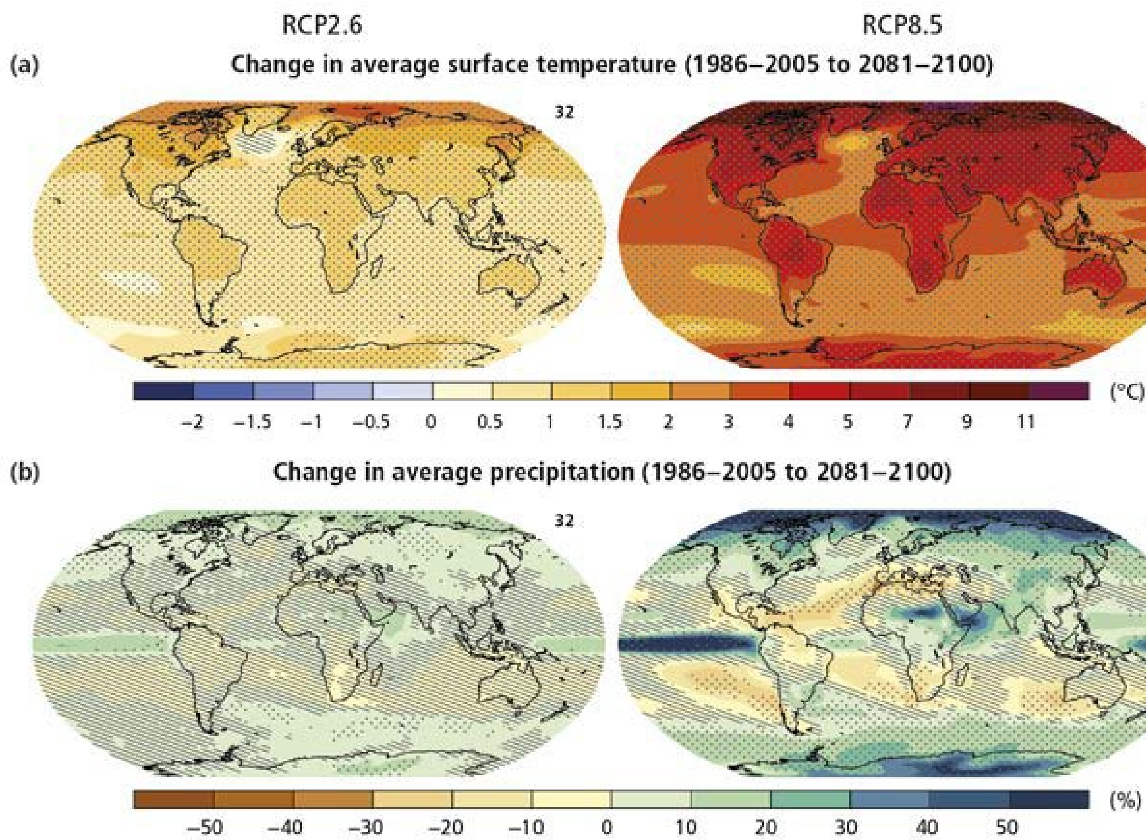


Figure 1.6. Average change in terrestrial temperature (a) and percentage change in precipitation (b), according to greenhouse gas emission scenario RCP2.6 (left) and RCP8.5 (right). Source: (IPCC, 2013)

The frequency of extremely hot days will increase, while the frequency of very cold days will decrease. The change in precipitation levels will not be uniform across the globe: at high latitudes and in the equatorial Pacific, precipitation is likely to increase; in dry regions in the central and subtropical latitudes, precipitation will decrease; and in humid regions, precipitation is expected to increase (Figure 1.6). Heavy rainfall events will be more frequent in all mid- latitudes and humid tropical regions.

The phenomenon of ocean warming will continue and extend into the deep ocean, which may alter ocean circulation in the South Atlantic. Arctic ice will most likely continue to retreat and thin and the global ice volume will decrease. These two factors will contribute to sea-level rise of between 0.26 and 0.82 m by the end of the century (Table 1.2.).

2046-2065			**2081-2100**	
Scenario	Media	Range	Media	Range
RCP2.6	0,24	0,17-0,32	0,40	0,26-0,55
RCP4.5	0,26	0,19-0,33	0,47	0,32-0,63
RCP6.0	0,25	0,18-0,32	0,48	0,33-0,63
RCP8.5	0,30	0,22-0,38	0,63	0,45-0,82

Table 1.2. Expected sea level rise for each hypothetical greenhouse gas emission scenario, compared to the period 1986-2005. Source: (IPCC, 2013)

The panels in Figure 1.6 show what would happen in the absence of action to limit climate change (the baseline represented by the orange solid line) and in a scenario where mitigation reduces emissions to zero before the end of the century (the RCP2.6 scenario represented by the blue dashed line). This would entail a reduction in primary energy demand, i.e. the total energy required by a country; it comes from the use of energy products available from natural sources (such as fossil fuels before processing and renewable sources). Almost always, primary energy has to be converted through an energy conversion technology in order to be transformed into a more easily usable fuel (such as fuels from crude oil refining or electricity from thermal power plants). A contraction in energy demand would therefore lead to a contraction of the fossil component to one third of the total.

The contribution of the renewable component linked to wind and photovoltaic energy production would also increase.

This shift in the energy mix from fossil to renewable sources (which assumes an intensive electrification process) would only be possible through policies that put a price on emissions, for example by imposing emission taxes or tightening emission trading schemes. By the end of the century, a price per tonne of CO2 of just under USD 1 000 (in 2005 prices) would be needed, compared to a current average price of around USD 2 per tonne (World Bank, 2020). The transition would result in a different profile of growth in per capita output: on average over the period 2050-2100, this would be 1.5% lower in the case of mitigation.

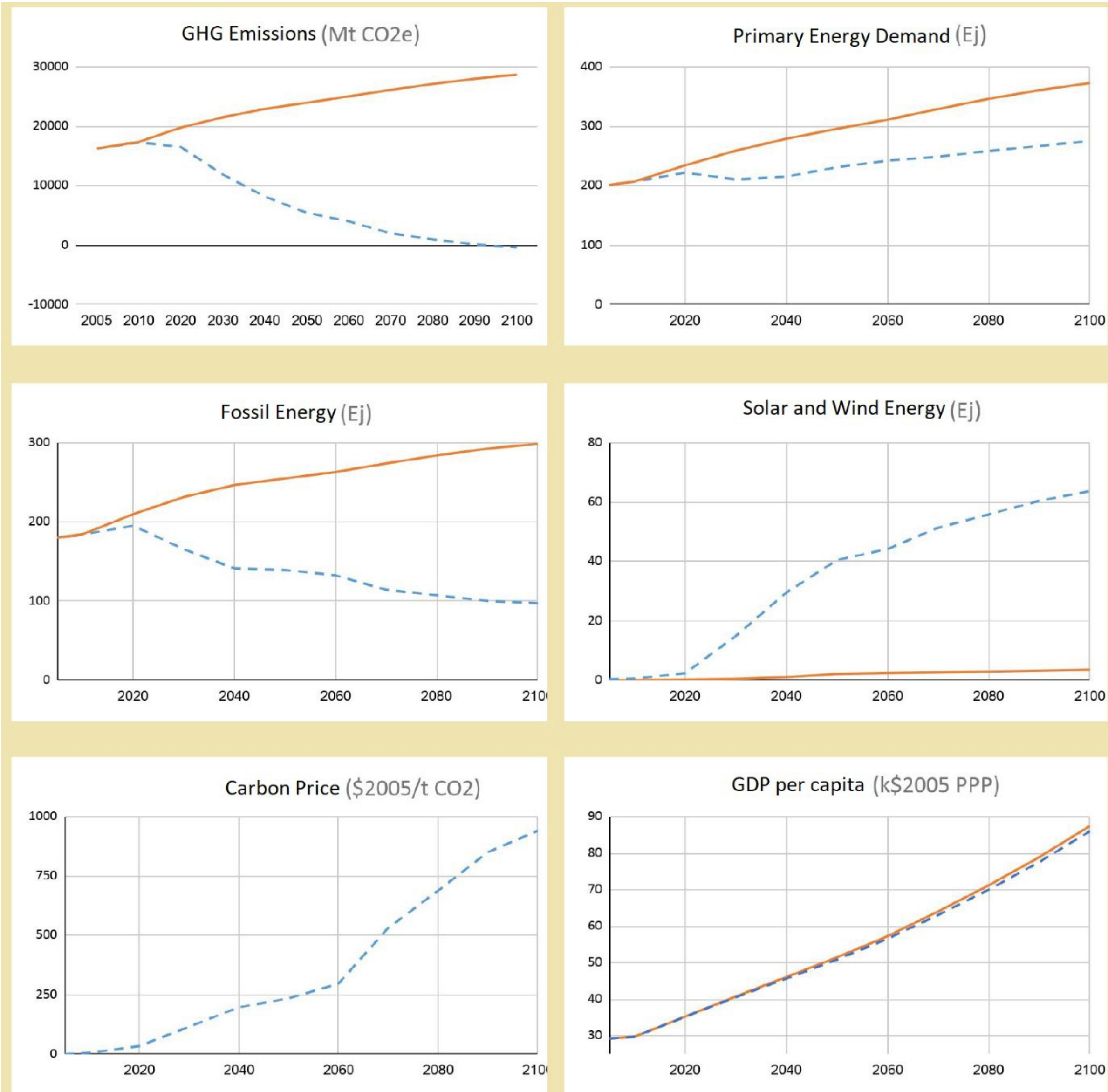


Fig. 1.7 - AIM/CGE model simulations referred to the OECD area. Ej=exajoule, equal to 1018 joules. 1 Ej is equal to 23.9 million tonnes of oil equivalent. Source: elaborations on SSP Public Database (Version 2.0) https://tntcat.iiasa.ac.at/SspDb.

These scenarios are used to make projections on certain indicators such as extreme indices of temperature and precipitation; expectations about these indicators allow for the representation of climatic weather extremes and their changes over time.

A recent report by the *Euro-Mediterranean Center on Climate Change* (*CMCC*) shows the possible evolution of some of these indicators in two scenarios, RCP4.5 and RCP8.5 (Spano et al., 2020). The climate models considered using these two scenarios indicate a temperature increase of up to 2°C in the period 2021-2050, compared to the average of the period 1981- 2010. In the RCP8.5 scenario, summer temperature peaks of 5°C would be reached in the Alps at the end of the century. Precipitation, the effects of which are more uncertain to establish, would decrease in the summer period in the Centre-South, while it would increase in the North. In general, extreme precipitation would increase. While the scenarios outline what happens to the energy system and some key variables in the economic system under different mitigation assumptions (i.e. policies to reduce emissions), the scenarios themselves can provide useful information on what happens depending on the strength of those policies.

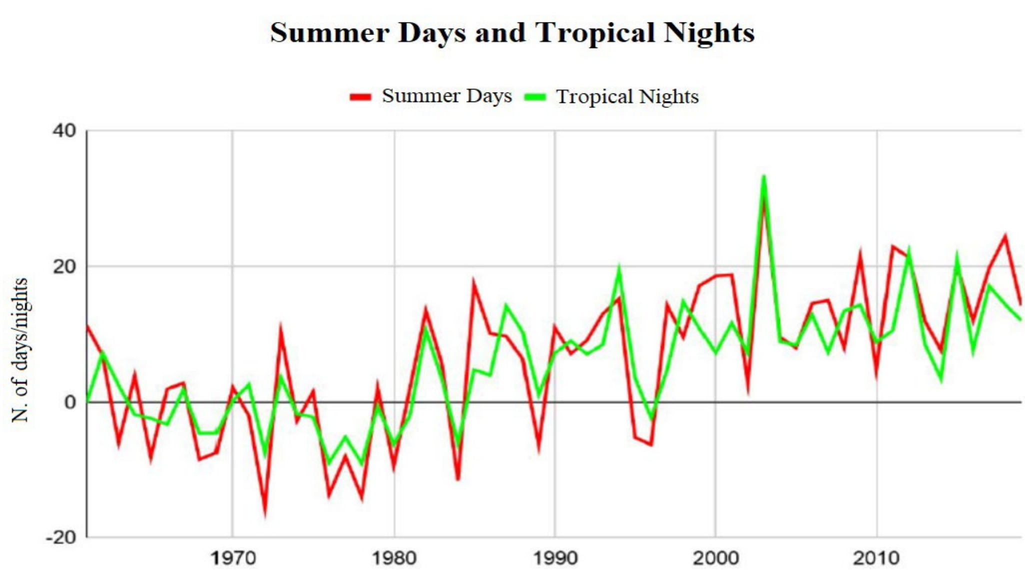
A certain level of greenhouse gas concentration (which varies according to scenarios) is associated with the frequency and intensity of extreme natural events (such as heat waves, periods of intense rainfall or drought), which have major impacts on life, affecting health and activities. In order to measure climate weather extremes and their variations over time, which is important information for defining a climate change adaptation strategy, some indicators such as extreme temperature and precipitation indices can be analysed. As precipitation projections are more uncertain than temperature projections, this box focuses only on the latter.

Some extreme temperature indices are shown in the table below.

Name and symbol	Description
Tropical nights - TR20	Average number of days per year with minimum temperature > 20°C
Summer days - SU25	Average number of days per year with a maximum temperature > 25°C
Prolonged and intense hot days	Number of days in the year when the maximum temperature is above the 90th percentile of the WSDI respective normal climatological distribution for at least 6 consecutive days

Table 1.3. Extreme temperature indices period. Source: (IPCC, 2013)

In the meantime ,we can see the historical trend of these indices in our country. Figure 1.8 shows that, since this century, there has been a steady increase in both summer days and tropical nights. The same applies to the indicator measuring heat waves (approximated by prolonged periods of heat), which peaked in 2003 but has since remained at high levels (+29 days in 2019).



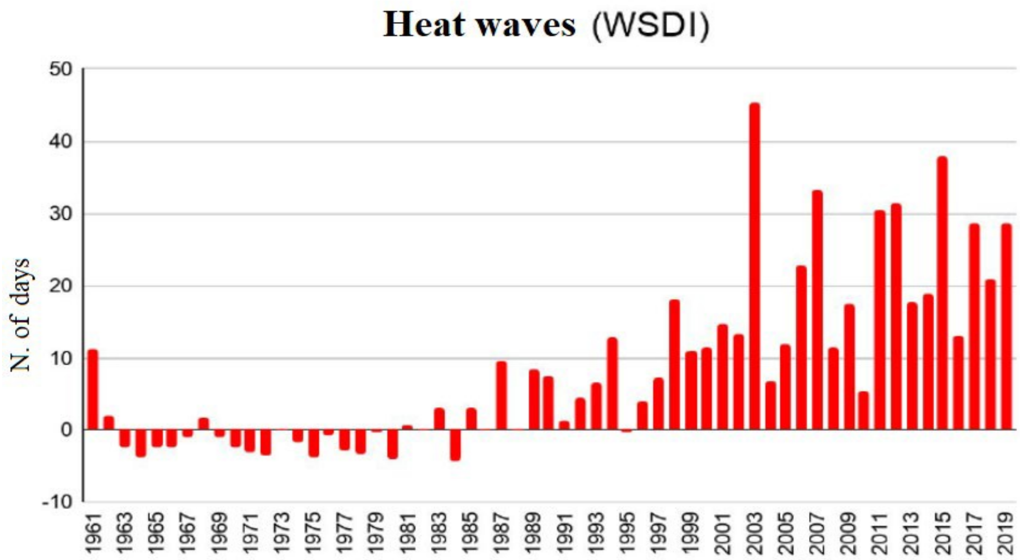


Figure 1.8 a) and b) - Warming in Italy according to some indicators. Source: elaborations on ISPRA data, Yearbook of Environmental Data 2020.

Using RCP scenarios, it is possible to assess how temperature and precipitation might evolve if the scenario that keeps greenhouse gas emissions low at the end of the century (RCP2.6) occurs compared to a scenario where they increase more (RCP4.5).

In Italy, the average temperature increase would stop at 1°C for the RCP2.6 scenario (Spano et al., 2020) while it would rise to 1.8 and 3.1°C in the RCP4.5 scenario (ISPRA, 2015). In the RCP4.5 scenario, heat waves as well as tropical nights and summer days continue to increase. Over the 2061-2090 time horizon, tropical nights (TR20) are projected to increase on a national average between 14 and 35 days, summer days (SU25) between 19 and 35 days and the WSDI index between 30 and 93 days (ISPRA, 2015).

Average temperature rises and more frequent heat waves can affect urban centres in particular (forming heat islands) with negative effects on the risk of fires, the quality and availability of water bodies and ecosystems. It also affects air quality (increased tropospheric ozone pollution), with repercussions on the health of the most vulnerable people, and can increase the transmission of infectious diseases. It also leads to greater demand for energy for cooling while reducing productivity in the use of various factors of production (labour, cultivated land). But it can also affect energy supply: considering that hydropower accounts for more than a fifth of installed electricity capacity, periods of low rainfall can significantly reduce the contribution of this resource, which provides energy at a very low cost.

Simulations of the future effects of climate change agree more on the trend of rising temperatures than on the precipitation anomaly, as is well explained on the CarbonBrief website[1]. Thus, greater caution is needed with regard to precipitation anomalies, to which the prediction of a greater hydrogeological risk to our country is linked.

Finally, when these effects are given an economic value (e.g. in terms of the statistical value of a life to assess excess mortality), it is possible to construct a damage function that 'translates' the physical effects of climate change (measured by simulating indicators such as those seen above) into monetary losses.

Adaptation policies are therefore needed to locally reduce the consequences of climate change and complementary and comprehensive mitigation policies to reduce its causes.

The variation of these indicators can in turn be associated with effects on the economic system, which can have a profound impact on the economies and well-being of citizens particularly in countries, such as Italy, located in southern Europe. The PESETA project coordinated by the Joint Research Centre provides a multi-sectoral assessment of the future physical and economic impacts of climate change in Europe for the horizon 2071- 2100 (Ciscar et al., 2018 and Szewczyk et al. 2020).

Climate anomalies can affect individual well-being either directly or indirectly. Among the former are those that affect labour productivity: the progressive increase in temperatures results in a reduction in labour productivity, affecting in particular those sectors that involve working in the open air (such as agriculture and construction). According to some studies, particularly hot days lead to a loss of productivity of more than 22 per cent due to increased heat stress (Deryugina and Hsiang, 2014); according to a recent ILO report (2019), the phenomenon would lead to a global contraction of working hours of 2.2 per cent by 2030, with an impact on GDP of $2.4 trillion.

In addition, a prolonged period of hot and humid days increases workplace accidents and the likelihood that workers may contract infectious diseases transmitted by insect vectors (Levi M., Kjellstrom and Baldasseroni, 2018).

The rise in temperature also affects the consumption activities of individuals: households will have a greater need to ensure a minimum level of comfort in their homes during summer periods, with a higher cost incidence for the most vulnerable households (OIPE, 2020); furthermore, prolonged periods of heat have a negative impact on the amount of retail purchases made by households (the so-called "shopping productivity", Starr-McCluer, 2000). In Italy, cooling-degree-days (CDD, an index associated with energy consumption for cooling) are expected to

[1] https://www.carbonbrief.org/explainer-what-climate-models-tell-us-about-future-rainfall

increase significantly under the RCP4.5 and RCP8.5 scenarios (Spinoni et al., 2018). CDDs have already increased by 33 per cent in Europe between the period 1950-1980 and 1981-2017[2].

Finally, rising temperatures could themselves lead to worsening human health and increased mortality. The most recent assessments estimate that in the absence of mitigation policies, 100,000 deaths directly related to extreme climate events could occur in Europe by 2100. More than half of these effects would be concentrated in southern Europe with a particular relevance in Italy, Spain and France (Szewczyk et al. 2020).

In addition to the direct effects on humans and their activities, climate change also affects economic activity through the damage caused by extreme weather events in the surrounding environment.

In recent years, there has been an increase in the frequency and intensity of extreme rainfall events, the effects of which are amplified by excessive soil sealing and poor drainage systems. This type of acute risk affects the various economic activities across the board (e.g. all those affected by damaged infrastructures) and is concentrated on a circumscribed territory. These risks, especially those of a hydrological and hydraulic nature, are likely to be greater in northern Italy, where there has been an increase in the number of rainy days in recent years; those of a geological nature, on the other hand (e.g. landslides, coastal erosion) are widespread throughout the country.

On the one hand, higher temperatures facilitate the melting of snowpacks and glaciers, increasing water availability in the short term during the winter period. On the other hand, increased evapotranspiration could make water availability scarce in the long term, particularly in the south. Moreover, climate change will affect not only the quantity but also the quality of water bodies: the presence of extreme events alternating with long periods of drought favours the proliferation of algae and decreases the presence of nutrients naturally present in water resources (Spano et al., 2020).

Once the main channels through which climate change affects economic activity have been analysed, if we want to quantify its effects, it is necessary to apply methodologies to give an economic value to the effects of the changes resulting from the various climate scenarios that are considered.

One of the methodologies used for this purpose is related to the damage function in which, using micro-sectoral information, the various costs are valued under the assumption that different climate scenarios are considered. Another approach uses econometric techniques for an overall

[2] https://www.eea.europa.eu/data-and-maps/indicators/heating-degree-days-2/assessment

assessment of the expected damage at macroeconomic level.

A recent paper analyses the relationship between territorial GDP per capita and the average temperature level recorded between 1990 and 2015 (Ronchi, 2019). The authors, using a reduced form model, find a U-shaped relationship between these two variables that indicates that extreme temperatures, particularly high or low, are associated with a lower level of GDP per capita, which is highest around 11.5°Celsius (identified as the optimal temperature).

Using the estimated coefficients, the authors estimate the effects on GDP up to 2080 if the RCP8.5 scenario were to occur. In this extreme scenario GDP per capita would fall by 3.7% in 2050 and 8.5% in 2080. The decline in GDP would be small or zero for the north of the country, while the south would suffer a loss of between 5 and 15 per cent of GDP in 2050 and up to 25 per cent in 2080. Thus, climate change could contribute to a further increase in territorial gaps and inequalities.

This approach has two types of limitations:

1. The purely statistical nature of the analysis does not allow the channels contributing to these results to be qualified and quantified.
2. does not take into account possible evolutions in adaptation actions and in the evolution of technologies.

An element that suggests particular caution in the interpretation of the study is above all the fact that an extreme climate scenario is assumed, which, despite being the most widely used in the economic literature, is recognised as unrealistic. The effects estimated with a scenario compatible with RCP4.5 would be reduced by more than half, a result that remains on average higher than estimates contained in other works.

A considerable proportion of studies on the expected impacts of climate change make use of the RCP8.5 scenario. This scenario is often referred to as business as usual (BAU), suggesting that it would materialise if no effort was made to reduce GHG emissions, and has been used in thousands of papers (Pielke and Ritchie, 2020). Some major works using this scenario as BAU find that climate change at the end of the century:

1. between 5% and 43% of countries, based on growth assumptions, would find themselves with a lower per capita income in 2100 than today (Burke et al., 2015);
2. will cause the income of the poorest third of American counties to contract by between 2 and 20 per cent (Hsiang et al., 2017);
3. bank failures will increase (+26/+248 per cent) with bailout costs for insolvent banks of between 5 and 15 per cent of GDP per year leading to a doubling of the debt-to-GDP ratio (Lamperti et al., 2019).

However, the use of RCP8.5 as a BAU is not as suggested by the originators of this scenario themselves (Rihani et al., 2011), who indicate that there is no probability or preference assigned to the modelled scenarios. Moreover, some recent studies point out that the assumptions underlying the RCP8.5 scenario are totally unrealistic (Hausfather and Peters, 2020) and suggest that it should not even be used as a worst-case scenario. For these reasons, the RCP8.5 scenario is not considered in the IPCC Sixth Report, to be published in 2022, or in the Network for Greening the Financial System scenarios. The development of emissions assumed in RCP8.5 is in fact based on an unprecedented increase in the use of coal, in an amount that even exceeds its physical availability (Ritchie and Dowlatabadi, 2017).

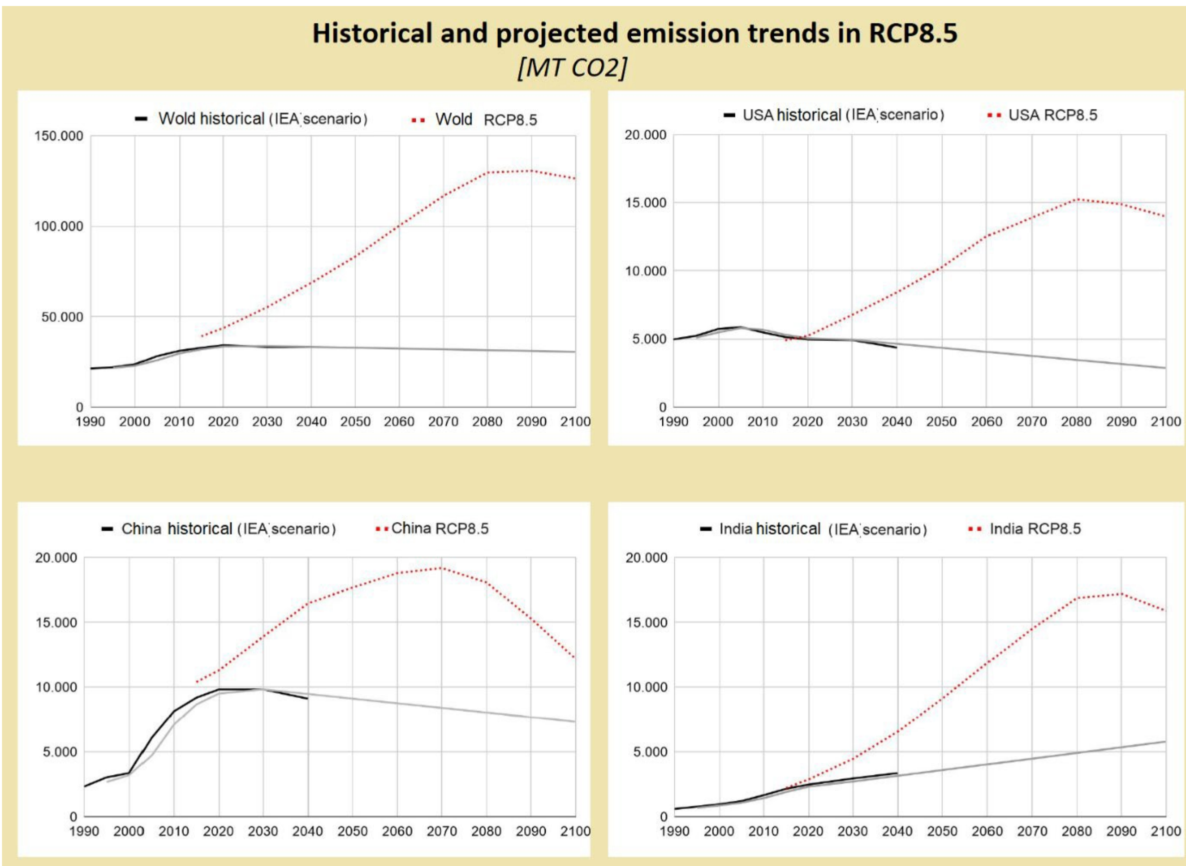


Fig. 1.9 - Historical and projected emission trends in RCP8.5. Source: our calculations on SSP Public Database (Version 2.0) https://tntcat.iiasa.ac.at/SspDb, BP Statistical Review 2020 and IEA (2020). Stated policies scenario values from IEA (2020) are added to historical data (source BP) for 2030 and 2040. The RCP8.5 scenario reports values from the REMIND-MAGPIE model - SSP5-85.

The left-hand panel of Figure 1.9 overlays historical trends in global emissions with those projected under RCP8.5. Global emissions from energy use were 34.2 billion tonnes CO2 in 2019. If the International Energy Agency's baseline scenario (i.e. the one in which only current policies apply - the so-called Stated policies scenario - IEA, 2020a) is taken into account for 2030 and 2040, the extrapolated emissions would be just below this value by 2100. By contrast, RCP8.5 would put emissions at over 126 billion by the end of the century.

Other studies, using general economic equilibrium models, propose a lower estimate of the impact. Carraro et al. (2008) estimate for Italy a cumulative loss by 2050 ranging from 0.12 per cent in the case of a temperature increase compatible with an RCP2.6 scenario to 0.2 per cent of GDP in the case of RCP4.5 (with a lower discount rate it would reach 0.36 per cent).
More recent estimates (Feyen et al., 2020), based on a model considering different sectors and countries, indicate economic losses related to global warming for southern European regions of less than 1% of GDP in the case of a 1.5°C increase in temperature by 2030; the losses would rise to just over 1% and just under 3% in the case of scenarios with temperature increases of 2°C by 2050 and 3°C by 2070 respectively. This quantification would be mainly related to the economic valuation of excess mortality related to climate change. However, these estimates, which are in the middle compared to the previous ones, underline that the importance oflosses could be significant for some sectors, such as agriculture, which could see yields fall by up to around 5%, and energy, which would see costs increase by up to 1%.

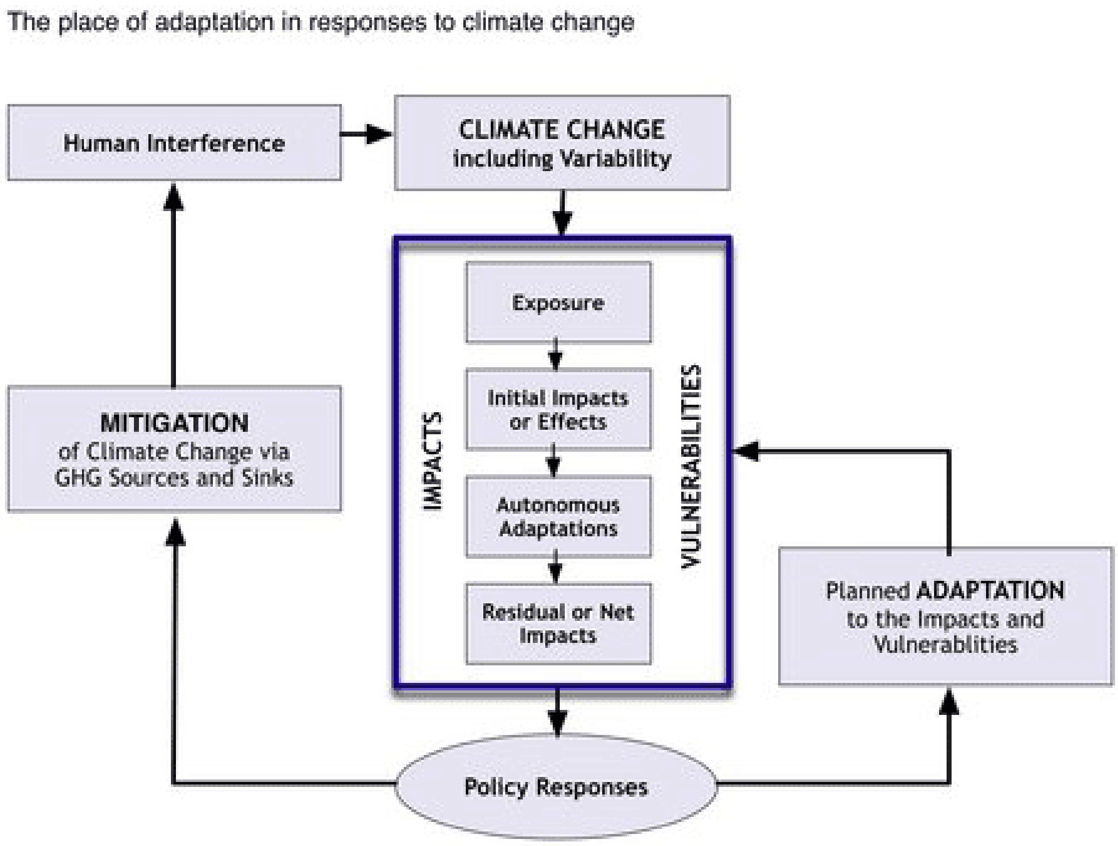


Fig. 1.10 - Climate Change effect Flow Chart. Source: IEA, 2019

Ultimately, climate change will have an economic impact in the future that will affect the entire economy across the board, becoming relevant, in view of the specificities of production, for certain sectors due to the concentration of risks that characterise them (Fig. 1.10).
Climate disruption will increase risks to natural and human systems and create new ones. Rising

temperatures increase the likelihood of severe, pervasive and irreversible impacts on humans, species and ecosystems, with negative consequences for economic development and the production of essential goods, primarily water and food. These risks will be unevenly distributed across the planet and will mainly and most severely affect the poorest countries and weakest segments of the population (Figure 1.11).

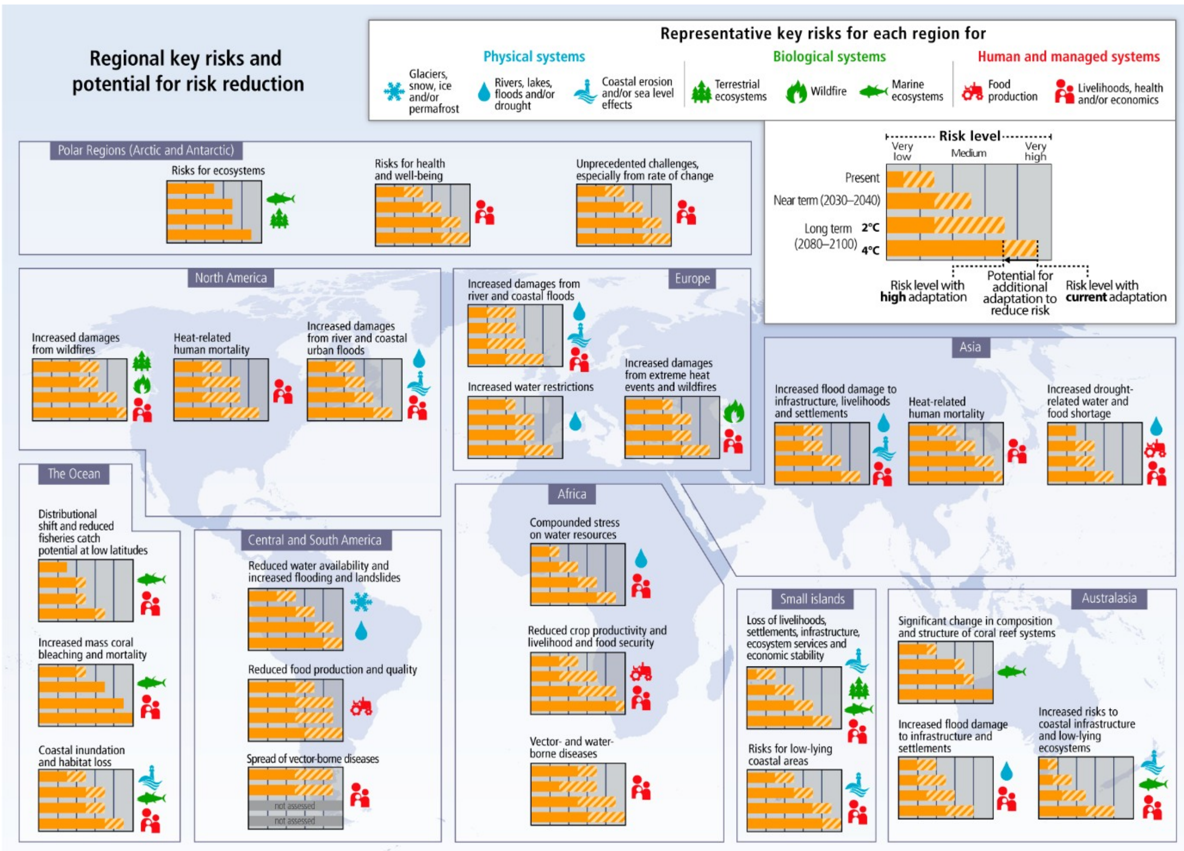


Fig 1.11 - Representative key risks for each region, including the potential for risk reduction through adaptation and mitigation, as well as limits to adaptation. Source:IPCC, https://ar5-syr.ipcc.ch/topic_futurechanges.php

"Identification of key risks was based on expert judgment using the following specific criteria: large magnitude, high probability or irreversibility of impacts; timing of impacts; persistent vulnerability or exposure contributing to risks; or limited potential to reduce risks through adaptation or mitigation. Risk levels are assessed as very low, low, medium, high or very high for three timeframes: the present, near term (here, for 2030-2040) and long term (here, for 2080-2100). In the near term, projected levels of global mean temperature increase do not diverge substantially across different emission scenarios. For the long term, risk levels are presented for two possible futures (2°C and 4°C global mean temperature increase above pre-industrial levels). For each time frame, risk levels are indicated for a continuation of current adaptation and assuming high levels of current or future adaptation. Risk levels are not necessarily comparable, especially across regions. "IPCC, 2014 (https://ar5-syr.ipcc.ch/topic_futurechanges.php.)

1.6 The Decarbonisation Process in Italy

In order to mitigate ongoing climate change, the international community is committed to reducing the concentration of greenhouse gases in the atmosphere, through the reconversion of production sectors towards a low-emission model. Italy has long been engaged in a process of decarbonisation and shares, along with other EU countries, the goal of halving emissions by 2030 and zeroing them by 2050. This process will bring with it, as it did for the Lisbon 2020 targets, an increase in energy expenditure by businesses and households. Despite the fact that our country has achieved almost all the 2020 objectives ahead of schedule, the transition process is still marginal and linked to the diffusion of renewable sources in the electricity and thermal sectors. The pandemic crisis has caused an abrupt reduction in the use of fossil fuels, but this apparent transformation appears to be largely linked to the temporary reduction in electricity demand resulting from the contraction in economic activity.

Decarbonising the economic system requires reducing energy intensity (the energy required for a unit of output) and carbon intensity (the amount of greenhouse gases emitted per unit of energy used). The first objective is linked to increased energy productivity and requires policies that increase energy efficiency; the second is achieved by using technologies that reduce the carbon footprint, such as renewable energy.

Italy has long been engaged in this transformation together with the other countries of the European Union, which as early as 2007 had set itself three different energy and environmental objectives, later incorporated in the Europe 2020 plan: a 20% reduction in greenhouse gases compared to those emitted in 1990; meeting at least 20% of energy needs through renewable sources; a 20% increase in energy efficiency (the latter is a non-binding objective).

In the autumn of 2014, targets for 2030 were agreed as part of the Energy Union project, raising the reduction of greenhouse gases to 40 per cent and the share of renewables and improved energy efficiency to 27. In February 2017, the European Commission approved the so-called Winter package through which, also taking into account the international targets contained in the Paris agreements, energy and climate targets were set for the following years. The Winter package stipulates that each Member State must submit integrated national climate-energy plans (PNIECs) to monitor the targets set; the Commission can request corrective measures if it considers the plans are not aligned with the European targets. Italy sent the final version of the Plan at the end of 2019.

With the aim of achieving climate neutrality by 2050 (the one described by the RCP2.6 scenario, see Box 2.1), the European Commission presented in late 2018 a set of proposals to outline its long-term objectives[3]:

- maximise the benefits of energy efficiency;
- increase the penetration of renewable energies in combination with the electrification of energy uses; implement a "smart" and sustainable mobility plan;
- reorienting the industrial sector towards the circular economy, with a strong use of 'second raw materials', i.e. made from raw material scraps or materials derived from waste recovery and recycling;
- develop network infrastructure for digitisation and smart energy use (smart grids); expand carbon absorption instruments (afforestation and use of the Common Agricultural Policy to reduce the growing emissions from the agricultural sector in Europe);
- consolidate and spread the use of fossil fuels with carbon capture and storage for all those cases where technology does not yet allow the direct use of electricity (for those energy-intensive industries whose decarbonisation is technologically more complex, such as steel and cement, and to cope with residual emissions). Also known as CCS (Carbon Capture and Storage), it is a process of geological containment of carbon dioxide produced by large combustion plants, which is becoming part of the mix of strategies available to deal with the increasing concentration of anthropogenic CO2 in the atmosphere.

These proposals were then finalised with the *European Green Deal (GDE), whose* central objective remains zero net emissions by 2050 and as a result of which the 2030 greenhouse gas emission reduction target has been increased to 55%.

Italy is one of the few EU countries to have achieved all three Europe 2020 targets, in terms of limiting greenhouse gas emissions by 2020, reducing energy demand and penetrating renewables (EEA, 2020). The NIPEC, sent to the Commission at the end of 2019, presents a strategy for further progress to 2030: 30% renewables in gross final energy consumption, a 43% reduction in energy use compared to trend growth and a 40% reduction in greenhouse gas emissions compared to 1990.

[3] European Commission (2018), "A clean planet for all. A long-term European strategic vision for a prosperous, modern, competitive and climate neutral economy'; COM(2018) 773.

1.6.1 European commitments to decarbonisation

According to the PNIEC, emissions are expected to be reduced by 48 million tonnes between 2020 and 2025 and by a further 30 million tonnes between 2025 and 2030, an average reduction of around 7 million per year. A decision to increase the 2030 emission reduction to 55% could require doubling the annual rate of emission reduction (from 7 to 16 million tonnes). An annual reduction that, prior to the pandemic crisis, had never been experienced in our country, not even in the decade that included the Great Recession (when annual emission reductions amounted to 13.5 million), when demand for primary energy fell to 1990 levels.

A number of instruments will be adopted for this purpose:

1) The European Emission Trading System (ETS) will also include emissions from the maritime sector and possibly the construction sector. In addition, to strengthen the price signal of the ETS, emission permits given for free to companies operating in the aviation sector (whose emissions are growing strongly) would be phased out;
2) a revision of the Energy Taxation Directive will be carried out with the aim of introducing a minimum tax threshold linked to the carbon content of the various fuels; in essence, a minimum carbon tax would be established at European level on sectors not subject to the ETS (such as agriculture, waste, transport and heating);
3) In order to ensure that European carbon pricing does not undermine the competitiveness of European companies, a carbon border adjustment duty will be introduced to penalise the carbon content of imported products. This duty would affect countries that do not have carbon pricing policies equivalent to those in force in the EU and, in an initial phase, would be introduced only on certain products and then gradually extended.

In addition, a number of initiatives have been taken to help contain any negative repercussions that climate policies might have on the economic and social fabric:

1) the allocation of resources (through a Just Transition Fund) to support the segments of the population and areas most affected by the energy transition (such as workers in traditional fossil industries or the populations of coal districts). The fund would operate with the same logic as the cohesion fund for supporting rural areas;
2) the definition of an extraordinary sustainable investment plan (Sustainable Europe Investment Plan) to catalyse resources from the private sector and promote green investments. This would involve mobilising a total of EUR 1 trillion in resources over the next decade (it is not clear how much is private and how much is public);

3) the transformation of the European Investment Bank (EIB) into a European climate bank. Accelerating the adoption of the EIB's new lending policy, which is in the process of being approved, it is envisaged that projects involving the use of fossil fuels will no longer be financed.

The European Green Deal includes other (more general and secondary) environmental objectives: a New Circular Economy Action Plan targeting sectors with intensive use of natural and material resources; a Biodiversity Strategy and a Farm To Fork Strategy to protect rural areas and support the farming population by promoting sustainable food.

1.6.2 The effects of the Covid-19 pandemic on energy transition

However, the pandemic crisis changed the situation abruptly. In the first nine months of 2020, Italy's final energy consumption contracted, also leading to a reduction in greenhouse gas emissions of about 33 million tonnes, 14 per cent less than in the same period of 2019 (ENEA, 2020). The decrease stems from the lower use of petroleum products in the transport sector, together with industry the sector most affected by the lockdown.

However, it is not clear how much of these trends are structural in nature. To a large extent, the reduction in emissions is due to lower economic activity and only part is linked to the growth in the weight of renewable energy sources. This, however, is the consequence of a change in the total consumption mix due to a reduction in transport and a growth in domestic consumption (electricity in particular) as a result of remote working and distance learning. It is not easy to predict whether, once the pandemic emergency is over, there will be a return to pre-crisis trends or whether some of these changes will become permanent.

The Covid-19 pandemic and the economic measures to counter its effects are having a major impact on the energy sector1. The decline in business activity and the minimisation of transport and mobility have led to a collapse in global energy demand: the International Energy Agency (IEA) estimates that the contraction in energy consumption in 2020 will be the sharpest ever recorded. Along with quantities, energy prices have also fallen. For example, the price of oil in the Brent quality plummeted during the first phase of the pandemic before settling, by mid-June 2020, at around USD 40 per barrel, more than 20 below the 2019 average.

The decline in energy consumption would be accompanied by a substantial reduction in greenhouse gas emissions worldwide by 2020. This accelerates the process of emissions reductions needed to achieve 'climate neutrality' around 2050, the target of the Paris Agreement.

But the gradual reduction in air emissions will not continue at the same pace once the pandemic and the measures taken to counter it cease. Overall, the Covid-19 shock could have implications for the energy sector and carbon emissions that go beyond its immediate effects. In the medium term, the implications of the pandemic will affect energy demand and could have profound consequences for the global transition to a low-carbon economy.

Some factors related to the outlook for the energy sector and investor preferences could favour a greater penetration of cleaner energy production technologies, accelerating the decarbonisation of the economy. The renewable energy sector has shown particular resilience to the pandemic shock, both in terms of new plant installations, new project financing and market performance, as reported in the IEA's Renewables 2020 report published in September 2020. The trend observed for renewable energy companies could continue and strengthen in the medium term, lowering the prices of energy produced from these sources. On the other hand, oil companies around the world have suffered heavy losses, with a number of defaults and the highest number of industry-wide rating downgrades. According to Rystad 2020, investment in exploration for new fields in 2020 and 2021 is expected to be at its lowest level since the recent financial crisis. Lower exploration investment could reduce production in the medium term, pushing up oil prices as global demand recovers. Another reason to expect sustained oil prices in the medium term is related to the interests of the OPEC+ cartel countries. According to Goldman Sachs (2020b), oil companies in these countries have lost competitiveness compared to European and US companies over the last five years and the oil price threshold for fiscal breakeven has increased. If global oil demand recovers sufficiently and the cartel is able to act in a coordinated manner, prices could remain high in the medium term.

While there are good reasons to think that the transition to a low-emissions economy will gain momentum, there are other reasons that suggest this process may slow down, with the risk of missing the 2050 targets. Achieving zero net emissions, a necessary condition for limiting temperature increases in line with the Paris Agreement, requires $50 trillion of investment by 2050: prolonged effects of the pandemic on economic growth could hamper this process. One study shows that economic recovery following a pandemic is far from immediate: in the aftermath of historical pandemics, the economy's natural real rate of interest fell to a low after 20 years, followed by a recovery lasting another 20 years (Jordà et al., 2020). The Covid-19 shock was such that, due to its magnitude, it generated considerable uncertainty about future economic prospects (Ludvigson et al 2020). From a consumer perspective, this uncertainty has already resulted in a sharp increase in savings in several countries, some of which are considered precautionary. For their part, companies, hard hit by the pandemic, are focused on their short-term needs; if the outlook remains negative for the long term, they may reconsider improving ESG aspects as a non-priority.

It is unclear whether the ambitious European targets are achievable in such a short timeframe. Past experience shows that energy transitions are slow: coal took half a century to overtake wood and become the dominant energy source, and oil took 60 years, alongside and not replacing coal (Smil, 2016).

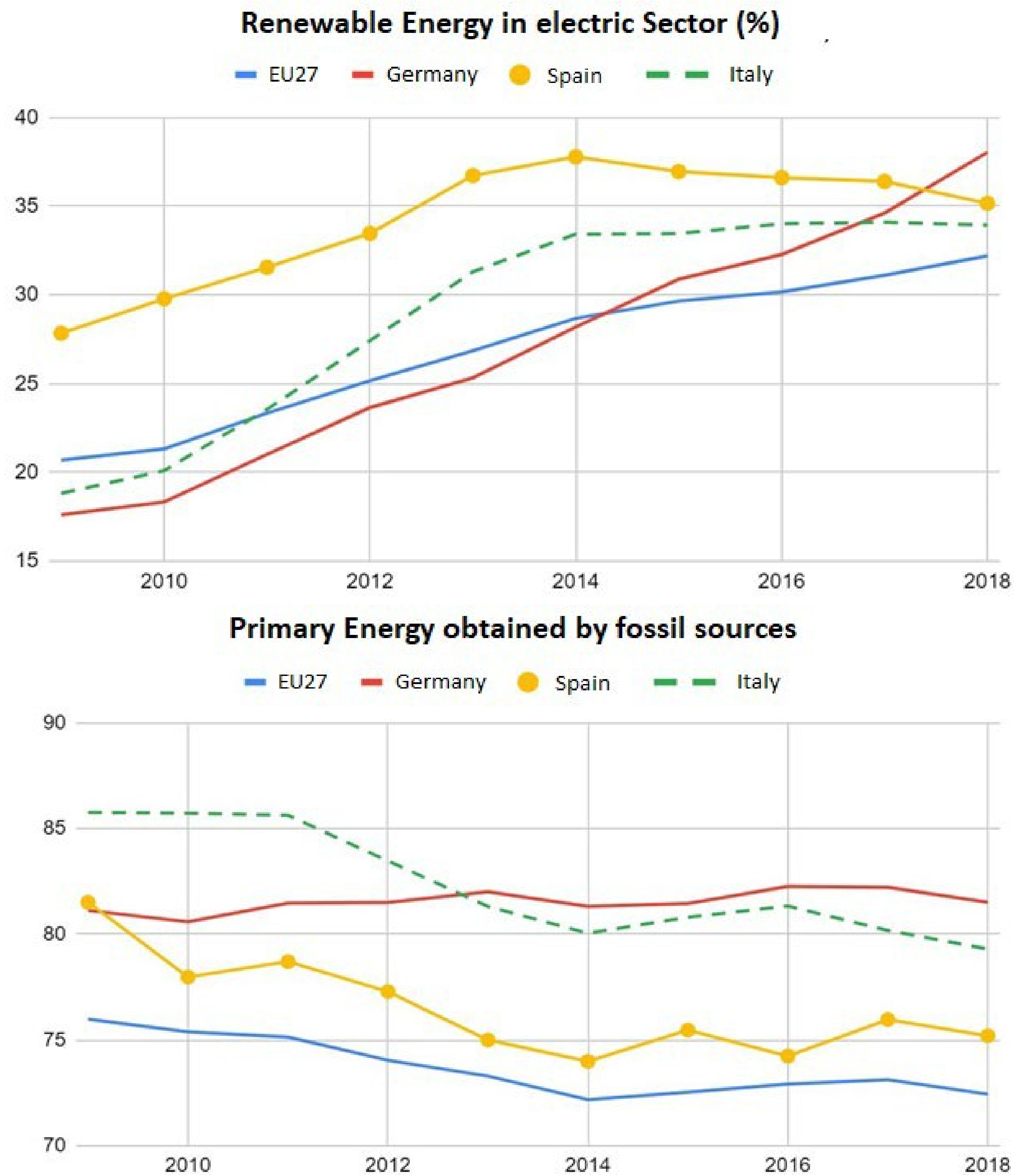


Figure 1.13 - A transition limited to the electricity sector. Source: elaborations on Eurostat data.

At the international level, the decarbonisation process is essentially at a standstill: the carbon intensity of the energy system (tonnes of CO_2 per tonnes of oil equivalent - toe) was 2.39 in 1990 and 2.32 in 2018 (Di Giulio and Migliavacca, 2020).
The situation in Europe and, in particular, in Italy is slightly better. The transformation underway has so far been focused in the electricity sector, which in Italy accounts for 22% of final energy use and 16% of primary energy. Looking at the contribution of fossil fuels to the overall energy demand, it can be seen that the transition process is however limited (in Italy as in other European countries). Figure 1.13 shows two ways of describing the transition: the graph on the left shows the small revolution that has taken place in the electricity sector, where generation from renewable sources has come in a few years to contribute more than a third of total generation; the graph on the right documents, however, that in the overall energy demand (which includes all energy sources and end uses) the dominance of fossil sources appears barely affected by the transition, their contribution having fallen but still remaining between 72 and 82 per cent of the total.
The policies needed to achieve these objectives, such as those changing relative energy prices, influence energy costs and the allocation of production factors within the economic system. This process, if not accompanied by appropriate policies, can affect the competitiveness of businesses and the welfare of households, particularly the most vulnerable. Moreover, all activities linked to the exploitation of resources destined to disappear from the energy system (oil products, gas and coal) would see their economic fundamentals worsen (the market for their products would shrink), with the risk that productive capital (production facilities, transport and distribution infrastructure) would lose its value because it is no longer usable. This is even more evident in the case of extractive industries, whose core business is the extraction and marketing of fossil fuels.

Chapter 2

2 The Economic Effects of Climate

2.1 The Economic Effects of Climate

According to some estimates, between direct and indirect costs, managing the risk of extreme weather events could increase costs for businesses around the world by around 20% by 2040, which is about $100 billion more than the global expenditure on emergency and business risk management caused by extreme weather events such as floods, heat waves and droughts. This is an increase of 20% or more, split between direct business costs and indirect costs. The economic risk of global warming to the commercial sector has been highlighted and calculated by research from the University of Cambridge, which has defined a Cambridge Climate Change Business Risk Index using modelling data both to predict possible scenarios of extreme weather events and to assess their effects on global supply chains (e.g. business interruption).

According to this business risk index, direct costs - which currently average about USD 195 billion per year - could rise to USD 234 billion by 2040, an increase of USD 39 billion. The rest, about $61 billion, would be absorbed by indirect costs, such as those resulting from supply chain disruption. For example, the index shows that, by 2040, Chicago businesses can expect a 50% probability of having an additional 20 days per year where average temperatures will exceed 25°C, with an additional week where temperatures will be above 30°C. Accurate quantification of this type of information, therefore, could help businesses in that area plan for the cost of risks due to their increased exposure to heat waves.

Andrew Coburn, a researcher at the Centre for Risk Studies in Cambridge, said that the battle between business and weather forecasting is currently an unequal one, especially when it comes to predicting long-term extreme events and understanding how they might affect business.

In this chapter the different economic and financial aspects of climate change are analysed.

2.2 Analysis of the economic impact of climate change

Evidence of the impact of climate change on natural and human systems has increased considerably in recent decades. Climate change, in its two components of mean and deviations from mean, is a factor that is and will be of increasing importance in the strategic and risk management of companies.

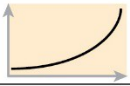
There is a lot of scientific evidence showing the main factors through which climate change and alterations can affect certain sectors such as agribusiness, utilities (energy and water) and insurance.

It is undeniable that, in the long run, the impact of climate change on economic sectors is smaller than that caused by traditional socio-economic factors, such as population growth and ageing, income, relative prices, lifestyles, public policies and regulations. However, many economic sectors will be positively or, more often, negatively affected by permanent changes in temperature, precipitation, sea level and the magnitude and frequency of extreme weather events. For example, in the energy sector, changes in average and extreme temperatures could permanently increase the demand for cooling energy in summer periods and decrease it in winter periods; the final balance will, of course, depend on geographical, socio-economic and technological factors. On the supply side, climate change could adversely affect the energy production infrastructure in some geographical areas and the efficiency of thermal conversion. Regarding resources for agricultural use, water demand may increase as temperatures rise and decrease as higher CO2 concentration enhances agricultural yields; in turn, water supply will depend on rainfall, temperature and infrastructure conditions that may be vulnerable to extreme climate events (Pareglio, FEEM, 2020). With regard to the transport sector, the increased frequency of extreme events may negatively affect the life cycle of some infrastructures, thus increasing the frequency of repairs or replacements. Sudden catastrophic events are undoubtedly unfavourable for tourism, but an increase in the average temperature could make locations that usually have colder climates more hospitable, or lengthen the tourist season in places where tourism is concentrated only when the climate is at higher temperatures.

The insurance sector, in turn, is strongly linked to extreme events, the frequency and intensity of which could increase and thus increase the expected average damage. Finally, the health care system will also be impacted on both the supply and demand sides, as the number of illnesses resulting from climate change may increase or decrease depending on location, time and specific pathology. Figure 2.1 summarises what has just been explained, showing the sign (positive and/or negative) of the impacts of climate change on various sectors on both the demand and the supply side.

The implications of climate change on some particularly exposed industrial sectors are discussed below: the agri-food sector, utilities (water and energy services), the insurance sector and the financial system.

Table 10-10 | Summary of findings.

Sector	Climate change drivers	Sensitivity to climate change	Sign	Other drivers	Relative impact of climate change to other drivers
Winter tourism	• Temperature • Snow		Negative	• Population • Lifestyle • Income • Aging	Much less
Summer tourism	• Temperature • Rainfall • Cloudiness		Negative for suppliers in low altitudes and latitudes Positive for suppliers in high altitudes and latitudes Neutral for tourists	• Population • Income • Lifestyle • Aging	Much less
Cooling demand	• Temperature • Humidity • Hot spells		Positive for suppliers Negative for consumers	• Population • Income • Energy prices • Technology change	Less
Heating demand	• Temperature • Humidity • Cold spells		Negative for suppliers Positive for consumers	• Population • Income • Energy prices • Technology change	Less
Health services	• Temperature • Precipitation		Positive for suppliers Negative for consumers	• Aging • Income • Diet/lifestyle	Less
Water infrastructure and services	• Temperature • Precipitation • Storm Intensity • Seasonal Variability		Negative for water users Positive for suppliers Spatially heterogeneous	• Population • Income • Urbanization • Regulation	Less in developing countries Equal in developed countries
Transportation	• Temperature • Precipitation • Storm intensity • Seasonal variability • Freeze/thaw cycles		Negative for all users Positive for transport construction industry	• Population • Income • Urbanization • Regulation • Mode shifting • Consumer and commuter behavior	Much less in developing countries Less in developed countries
Insurance	• Temperature • Precipitation • Storm intensity • Seasonal variability • Freeze/thaw cycles		Negative for consumers Neutral for suppliers	• Population • Income • Regulation • Product innovation	Less or equal in developing countries Equal or more in developed countries

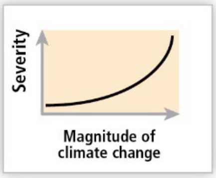


Figure 2.1. Summary of climate change impacts on some industrial sectors. Source: (IPCC, 2014c)

2.2.1 Agri-food sector

The agri-food system is the infrastructure and processes that ensure food security for the population (IPCC, 2014a). Climate and soil are the most important determinants of agricultural yields, so it is unavoidable that their changes will have an impact on the agri-food sector.

Temperature is a key variable in plant physiological processes. With regard to cereals and oilseeds, there is evidence that, close to reaching the optimum temperature for the growth of a crop, an average increase in temperature can speed up ripening, reduce seed production (if it occurs during the flowering period) and increase the water stress to which the plant is subjected.

There is little evidence on the impacts of a prolonged increase in temperature above the optimum level. The literature identifies a temperature of 30°-34°C as a threshold beyond which negative impacts on agricultural production occur (IPCC, 2014a).

The regional component is, however, very important in determining the sign and magnitude of the impact as the balance between several components depends on it: solar irradiation (positive impact), water stress (negative impact) and proximity to the optimum temperature. Maize and wheat yields in tropical areas start to decline with a temperature increase of 1°-2°C, and in temperate areas with a temperature increase of 3°-5°C.

Despite the fact that water is a fundamental element for plant development, the variation in rainfall levels, which manifests itself much more heterogeneously at local level than that of temperatures, does not seem to be decisive on agricultural productivity, unless it occurs in conjunction with an increase in temperature.

Climate change can also affect the agri-food sector in indirect ways. The increasing globalization achieved in the 20th century means that shocks spread from one region to another through price signals. This is also true for climate change-related impacts that lead to higher prices of agricultural products, resulting in difficulties in accessing food - especially by the most vulnerable strata of the population and with tighter budgetary constraints - as well as on the output of the agro-processing and distribution sectors (FAO, 2015). Although agricultural prices have been on a downward trend in the 20th century, some fluctuations have been observed in recent times. Increased demand for biofuels, stimulated by energy policies and rising oil prices, is one of the factors behind these price fluctuations. Lobell et al. (2011) estimate the impact of climate change on the price to be around +19% (+6% considering the CO2 fertilization effect). Increased prices for agricultural products could therefore have strong negative impacts on consumers and producers of final goods globally, and, on the other hand, positive impacts on agricultural producers.

There is growing evidence of the influence of climate change on the intensity and frequency of extreme events (IPCC, 2014a). Extreme events, in particular floods, severe droughts and heat waves, can lead to major losses in the agricultural sector, especially in developing countries and for small farmers. For example, the 2010 flood in Pakistan resulted in an average loss of 50% of households income (Kirsch et al., 2012). The impacts of extreme events are not only limited to the directly affected areas, but propagate into international markets through price changes: the 2010 heat wave in Russia, combined with the export freeze, more than doubled the world price of wheat.

Extreme events can also affect the infrastructure necessary for production and distribution in the agro-food sector, causing damage to processing industries, disrupting the distribution of electricity essential for production, and damaging distribution networks (roads, ports). Extreme events, due to their violence and impromptu nature, also imply a reduction in the incentives to invest in agriculture, in some cases reducing the possible gains from higher crop prices. This phenomenon mainly affects small farmers with little access to credit and insurance.

The increase in the concentration of CO2 in the atmosphere, which has a positive correlation with the increase in temperature, can increase the level of fertilization depending on the type of crop. This factor, which can be counted among the indirect impacts of climate change in the cereal sector, is not very relevant in case of high or low temperatures, but becomes significant in the presence of water stress.

Climate change also affects the proliferation of plant pests and pathogens and the migration of new species of insects and weeds.

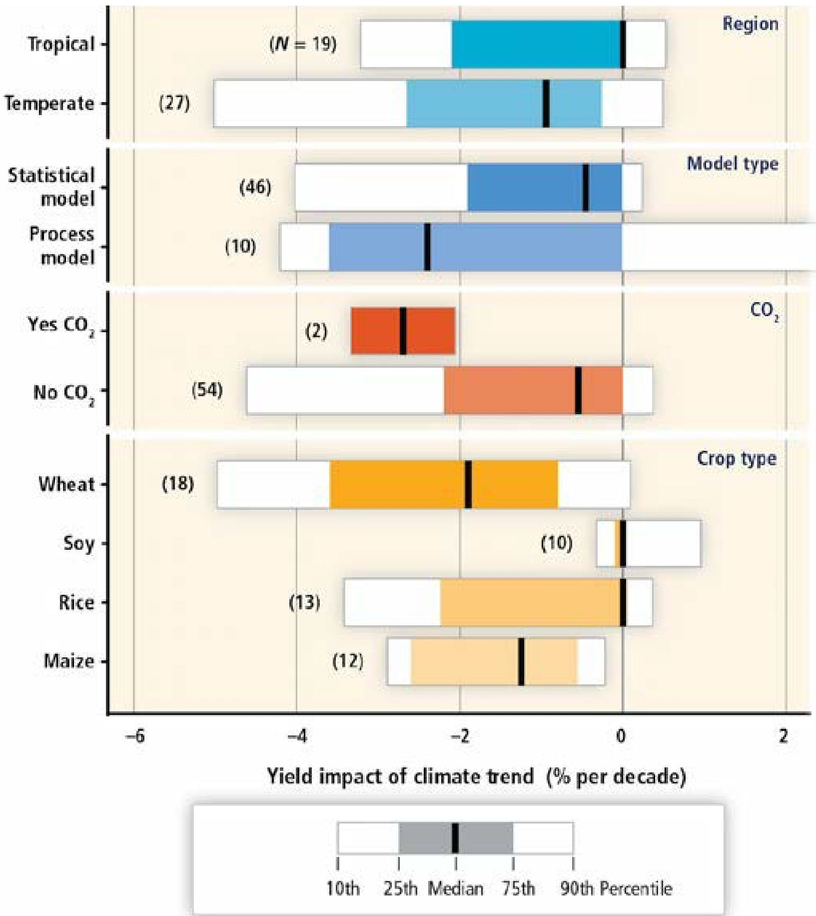


Figure 2.2. Summary of estimated impacts by geographical area, model type, CO2 fertilization and main crops. Source: (IPCC, 2014a)

The literature estimating the magnitude of climate change impacts on agriculture over the last 50 years is extensive. As can be seen in Figure 2.2, wheat and maize crops are most likely to be negatively affected by global climate change (medium confidence), while rice and soybean yield reductions are marginal. Moreover, production losses are more pronounced in temperate areas than in tropical ones (IPCC, 2014a).

One of the most damaging effects of climate change on crops is an increase in the frequency of high night-time temperatures, which has a strong negative effect on rice production and quality in particular. In any case, peaks in daily maximum temperatures can be lethal for many crops.

Despite the uncertainty of climate projections, predictive models are a valuable tool to assess the impact of climate change on agricultural yields and to guide individual and policy choices. According to the IPCC report (2014a), a hypothetical temperature increase of more than 3°C will have negative effects on agricultural production of all crops (in the absence of adaptation, but also considering the fertilization effect of CO2). Negative impacts are expected to start appearing from 2030. Impacts above 5% will be quite likely by 2050 and likely by the end of the century. Lobell et al. (2008), using a statistical model and 20 general circulation models, identify Asia and southern Africa as the regions where the highest agricultural losses will occur. Knox et al. (2012), through a meta-analysis of 52 studies, estimate a production loss in these regions of around 8% by 2050 (wheat, sorghum and millet are more affected than rice, cassava and sugar beet).

According to AgMIP and ISI-MIP studies, in an RCP8.5 scenario by 2100, agricultural yields will decrease by between 20% and 45% for maize, between 5% and 50% for wheat, between 20% and 30% for rice and between 30% and 60% for soybean (Rosenzweig et al., 2013). The fertilization effect of CO2, in the presence of water scarcity, could mitigate these losses by up to 50%.

Figure 2.3 summarizes the impacts of climate change on agriculture. It can be seen that future projections are consistent in sign and magnitude with those observed in the past and with the regional variability of these impacts (which is greater in temperate regions). Climate change will reduce agricultural production by an average of 1% per decade.

Recent peaks in maximum temperature values and reduced rainfall in the European area have generated significant damage to cereal production, especially in southern and central Europe, both in terms of reduced productivity compared to the potential of the agro-climatic zone and in terms of crop losses (IPCC, 2014b).

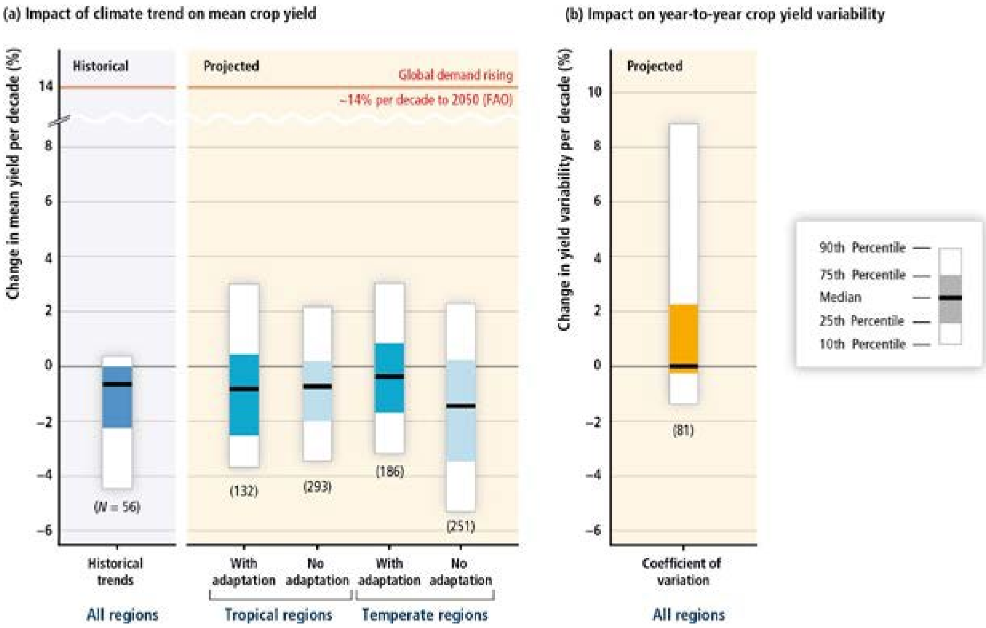


Figure 2.3. Summary of the impacts of climate change on agriculture. Source: (IPCC, 2014a)

Heatwaves in the summers of 2003 and 2010 led to wheat crop losses of 20% and 25-30% respectively in the affected regions in Europe and Russia. Cereal production in the Iberian Peninsula was significantly affected by the 2004-2005 drought (-40%).

An examination of past trends may foreshadow the difficulties the sector will face in the coming decades. Recent studies, combining different emission scenarios, global circulation models (GCM) and assessments of related impacts, predict a small reduction in agricultural productivity in 2080 if the temperature increase remains within 2.5°C; failure to curb GHG emissions, coinciding with a temperature increase of around 5.4°C could instead lead to an average reduction in production of 10% (Ciscar et al., 2011). The fertilization effect linked to the increase in the concentration of CO2 in the atmosphere will bring initial benefits to productivity, but these will fade at the end of the century due to changing climatic conditions.

Southern Europe will be most affected by large productivity losses (-25% in 2080 in a scenario predicting a 5.4°C temperature increase), mainly concentrated in summer and to the detriment of non-irrigated crops (Ciscar et al., 2011).

Climate change will also have an impact on the proliferation of insects, pests and fungi that could damage crops, especially in northern Europe, where low temperatures have so far curbed the spread of these species.

Estimates of the economic damage in a scenario of a strong temperature increase (5.4°C) amount to about 1% of GDP in Southern Europe: Italian agriculture seems to be strongly exposed to the repercussions of climate change (Alpino and Lavecchia, 2020).

Available empirical analyses estimate a general reduction in the quantity and quality of agri-food and livestock production in our country, with a loss that appears high in comparison with other EU and Mediterranean countries, even in the case of moderate emission scenarios (Bozzola et al., 2018).

Considering a high-emissions scenario (RCP 8.5 - see Box 2.3), Italy would experience a reduction in income from the agricultural sector (including livestock) by 2050 of around 10 or 40 per cent depending on the presence (or absence) of the CO2 fertilization effect, with significant heterogeneity at the regional level (Perez Dominguez and Fellmann, 2018). Yields for maize crops in Italy could decrease by up to 25% and wheat cultivation would experience strong declines particularly in the South (-50 %; Hristov et al. 2020). Climate change would also affect tree crops (such as olive groves, vineyards, etc.) which would experience a reduction in their life cycle and relative productivity. In particular, there would be a yield reduction for spring-summer crops such as maize, sunflower and soybean, and a potential positive effect for crops such as wheat, rice and barley. For wine and oil, a qualitative and quantitative reduction is expected in the Southern Italy in favour of moving further north or to higher altitudes (CMCC, 2017). In general, the effects would be more negative in the South, where higher temperatures would also be accompanied by drought situations with the possibility of some crops moving to the relatively cooler northern parts of the country.

Similarly to agriculture, negative effects are expected in fisheries and livestock breeding, where rising temperatures may affect the lives of animals in terms of growth, reproductive possibilities and increased chance of illness. Farmers' mitigation and adaptation activities appear limited, while the benefits associated with rising temperatures would be limited to some areas and crops, with negative impacts largely prevailing (especially in the South).

2.2.2 Tourism sector

Another sector characterized by a high concentration of risks is tourism. A recent work analyses the channels through which climate change may influence the various types of tourism in Italy (Mariani et al., 2020). Climate change could lead to a decrease in the attractiveness of seaside tourism destinations, primarily due to the intensification of erosion phenomena that could cause a loss of space and infrastructure; the increase in temperatures and the greater frequency of heat waves could also make this type of tourism less attractive due to the greater eutrophication of the Mediterranean. Mountain tourism would also be affected by the higher temperatures: the main climate models predict a decrease in snow days in the coming decades, which could lead to a reduction in the presence of natural snow that could fall to 75% of the currently existing ski resorts and, in the event of particularly unfavorable scenarios, to one third of those currently operating (Abegg et al., 2007). With regard to Alpine summer tourism, the impacts of climate change would certainly be less unfavorable. Finally, cultural tourism would also be adversely affected, as the state of cultural heritage could also be jeopardized. In cities, the increase in temperature will be amplified by the scarcity of vegetation, the abundance of reflective surfaces and the density of buildings (heat islands).

2.2.3 Transport Sector

Climate change affects all three dimensions of the transport sector: infrastructure, operations and transport demand. In Italy, at present, there is still no unambiguous, specific and complete reference for assessing the effects of climate change on transport. Therefore, only qualitative considerations on potential future impacts are presented below. Rising temperatures will increase the vulnerability of road (paved roads) and rail (tracks) infrastructure due to the increasing frequency of hot days, but at the same time reduce their vulnerability due to the lower frequency of cold days. In those areas of the country where rainfall increases in intensity and frequency (i.e. especially in the north during the winter period), soil stability will be negatively impacted, particularly in the case of road and rail infrastructure located in the most unstable contexts. In addition, transport infrastructures located near watercourses will be rapidly subject to flood risks. Rising sea levels pose risks for road and rail infrastructure located on coastlines and for port infrastructure.

2.2.4 Utilities sector - Water

Scientists now agree that climate change is having a major impact on freshwater availability. It has been estimated that for every 1°C increase in the earth's temperature, an additional 7% of the world's population would see their water supply reduced by 20%. Scientists also agree that climate change would reduce surface and deep water resources in most arid subtropical and mid-latitude regions and increase them in high latitude regions. However, even in regions where an increase is estimated, there would be short periods of scarcity due mainly to high variability of precipitation and the decreasing seasonal maintenance capacity of snow and ice. Although scientific evidence is limited, it is believed that, in the most affected regions, the decrease in available water resources increases competition between the various sectors that use water (agriculture, industry, energy production, ecosystem, human settlements) and thus generates negative impacts on all sectors involved. Climate change is also expected to reduce water quality, posing serious risks to the potability with traditional treatment methods; this is due to the interaction of several factors:

- increased temperature;
- increased quantities of sediments, nutrients and pollutants from heavy rainfall;
- increased concentration of pollutants during periods of increased drought.

Water is the key element in determining the impact that climate change will have on humans and the environment; it is the primary resource not only for climate change adaptation policies, but also for mitigation policies. This dual function therefore poses major challenges to its present and future use, as its use in one direction inevitably reduces the possibilities of its present and/or future use in the other, which is why it is argued that adaptation and mitigation policies for water are in conflict with each other. For example, the goal of phasing out the use of fossil fuels for clean energy production could limit the availability of water resources for communities and ecosystems, and hinder their use in adaptation strategies to cope with climate change. Specifically, biofuels require large amounts of water for irrigation and bioenergy processing; hydropower plants require the storage of immense amounts of water. In both cases and in the agricultural sector, these processes limit the use of water as an adaptation tool in the - increasingly likely - periods of drought. Another closely related use is the capture and storage of carbon through the use of water.

2.2.5 Utilities sector - Energy

In developed countries, progressive global warming will lead to an increase in energy demand (electricity) for air conditioning at low and medium latitudes; while at higher latitudes demand (electricity, coal, oil and gas) will decrease due to milder temperatures. In developing countries, rising temperatures do not appear to be a key factor in expanding demand, but rather growth in per capita income. This will stimulate demand and mainly consumption of electricity and fuels, which are otherwise constrained by tight budget constraints (IPCC, 2014a). According to the TIMER/IMAGE model (Isaac and Van Vuuren, 2009), energy demand for air conditioning will increase from 300 TWh in 2000 to 4000 TWh in 2050, to 10,000 TWh in 2100. This increase will be 75% due to the increase in per capita income and 25% due to climate change. A similarly

drastic increase in heating demand is not expected because the lowest temperature peaks will be concentrated in developed countries.
The impacts of climate change on energy supply will mainly be indirect, related to the increased frequency of extreme events and affecting especially energy production and transmission infrastructures.
Thermoelectric production will be subject to the constraints of mitigation policies; although the production infrastructure is resilient to climate change, rising temperatures will reduce the efficiency of energy conversion, but this can be compensated for by technological innovations and increased energy efficiency. Altered rainfall may have a strong influence on electricity production by reducing the water available in the cooling process, leading to reduced production and even temporary plant shutdown. If the thermal power plant is equipped with CO_2 capture systems, this will result in an approximately 8-14% reduction in energy efficiency and the plant's water demand will double.
Climate change will have similar, if not more intense, effects on nuclear power plants, given the stricter safety regulations for this activity. The constant availability of water and electricity is a prerequisite not only for the normal operation of the plants, but also for the safety procedures themselves.
Hydropower generation, the main renewable source in the energy mix, is strongly influenced, directly and indirectly, by climatic (average annual and seasonal precipitation, snowfall and glacier water production), demographic (domestic water demand) and economic (irrigation) variables. According to the literature, the impact of climate change on hydropower production in 2050 will be positive in Asia (+0.27%) and negative in Europe (-0.16%).
Solar electricity will be favoured by mitigation policies. The formation and persistence of cloudiness, which decreases the degree of insolation of installations, may lead to reduced efficiency or even temporary cessation of production, and installations will be easily damaged by severe storms.
In addition, the projected increase in the frequency of environmental disasters due to climate change has the effect of further shifting the probability distribution of impacts, which increases the expected loss. This necessarily leads to an increase in the certainty equivalent of the impact, with repercussions on the insurance premium and the future probability of non-insurance by the client.

2.2.6 Insurance sector

Direct and insured damages caused by climate disasters have increased in recent decades both globally and regionally: about USD 1.4 billion per year on average globally in the period 1980-2008. However, the higher number of damages reported is mainly a consequence of economic growth, including higher population and wealth concentration in at-risk areas; thus the literature produces analyses with normalized data, i.e. net of the growth of assets at risk due to these key drivers. Most of the studies available in the literature are conducted at the regional level. The literature (Barthel and Neumayer, 2012) shows that, at a global level, looking at data over the period 1980-2008, there is no positive and statistically significant trend in normalized losses from climate disasters; nevertheless a positive and statistically significant trend has been identified in the United States and Germany for some non-geophysical events such as floods and tornadoes. Climate change will lead to more frequent and more intense environmental disasters in some regions, testing the insurance industry's ability to offer affordable products, especially in low- income regions, which are most exposed to climate impacts. Accessibility to insurance instruments plays a key role and can only be maintained through risk reduction measures. In this respect, another indirect but crucial role played by the insurance sector is to encourage public policies and private adaptation behaviour in order to reduce climate impacts and hence insurance premiums. The main problem with managing insurance products to cover damage from extreme weather events is that the adverse event affects a very large number of policyholders simultaneously. This increases the probability of large losses and leads to an rise not only in the variance of the distribution but also in its tail (Kousky and Cooke, 2012). Restricting ourselves to Europe, it has been observed that damage and economic losses due to natural events derive mainly from a small number of highly destructive episodes. In fact, 70% of the losses were caused by 3% of the events (EEA, 2017a). From an insurance point of view (in the years 1980-2013), the percentage of insured assets out of the total assets damaged by climate events is still low, especially in Eastern Europe, the Mediterranean countries, Portugal and Finland; the states with the highest percentage of insured assets out of the total assets damaged (68%) are the United Kingdom and Ireland (EEA, 2017b).

With regard to future projections in Europe, general circulation models (GCMs) estimate that the intensity of winter storms will decrease in the Mediterranean regions and increase, with the exception of the eastern regions, in the rest of Europe: the frequency of major damage will increase.

It is therefore clear that the expected increase in the frequency and intensity of adverse events, the low propensity of the population to use insurance solutions and the high public debt in some countries represent a very risky combination for the future of Europe in terms of resilience to climate change. This mix of elements is generating serious concerns among policymakers and has stimulated a heated debate about the use of public-private partnerships (PPPs for short) to hedge risk. PPPs are supposed to encourage the pooling of responsibilities among different actors and distribute risk efficiently, with the intention of increasing insurance coverage and the degree of penetration among the population; they would also be an additional financial guarantee from the state in the event of particularly rare but disastrous events. However, this comes up against several factors. Among the most important are: the difficulty in correctly measuring the probability and damage of an adverse event, the degree of competitiveness of the insurance industry, and the heterogeneity of risk between geographical regions and between potentially affected parties. If all these factors were not considered together and correctly, making it compulsory for the entire population to take out insurance products would certainly have the undesirable effect, contrary to the basic principle of insurance, of shifting a large part of the economic burden onto the subjects least exposed to the adverse event and with the highest value of insured assets and therefore not, as it should be, onto the subjects with the highest degree of exposure and vulnerability. For this reason, new and different PPP modalities are being discussed - especially in the light of the importance of climate change adaptation policies in order to reward those who are less exposed and who actively intervene on their own degree of risk.

2.3 The Impact of Climate Change on financial system

Climate change may be associated with increases in the intensity and frequency of extreme weather events, which may affect economic activity (physical risk). At the same time, the implementation of more ambitious climate policies, such as the EU's goal of zero emissions by 2050, may lead to a significant reduction in the value of real and financial assets related to fossil fuel use (transition risk). Both risks are relevant for the financial system as they may lower the ability of households and businesses to meet their obligations, including through a decrease in the value of assets pledged as collateral for loans.

The previous paragraphs have shown that both the expected effects of climate change and the decarbonization process, particularly if disorderly, can result in losses for our country's economic system. This section describes how these losses can be transmitted to the financial system, i.e. what are the characteristics of climate-related financial risks.

Two types of risk can be identified: the first is the risk associated with the lack of decisive action to reduce emissions (climate change mitigation policies) or to mitigate the effects of climate change (i.e. no investment in climate change adaptation). This type of risk is thus linked to inaction in combating climate change and is classified as a physical risk, which we might call the risk of 'not acting'.

Physical risk is linked to the occurrence, in the short or long term, of those extreme natural phenomena attributed by science to climate change. These phenomena can be chronic, such as the progressive deviation of temperatures and precipitation from their historical trends, or acute, such as the occurrence of natural events that have a low probability of occurring but, when they do, have a significant impact on the affected territories (such as floods or heat waves).

If inaction entails risk, then sudden action against climate change can also be a source of risk for the economic and financial system, particularly if poorly planned and inconsistent. The previous chapter showed how policies promoting transition change the relative prices of energy inputs and can affect activities linked to the exploitation of fossil resources. Since these risks result from a transition of the energy system from fossil sources to a model that reduces its carbon intensity, they are called transition risks.

The financial system, due to its centrality in the economy, is particularly exposed to such risks. Its role as a mediator of savings and investments by businesses and households makes it potentially capable of amplifying the negative consequences of adverse events linked to climate change and the green transition. Physical risks involve financial intermediaries both directly and indirectly. Extreme natural events linked to climate change (e.g. floods, landslides, hurricanes, etc.) can, for example, cause direct damage to the branches of a banking institution, interrupting its operations. In addition to these direct risks, there are also indirect risks. The same natural events can damage a private home, or the fixed assets of businesses (plants, warehouses, machinery). The owners of the damaged assets, faced with the loss of production capacity or unforeseen expenses, may find it difficult to honor their financial commitments, implying possible losses on the banks' balance sheets.

If those affected by the events are covered by insurance, damages from extreme events could weigh on the financial situation of exposed insurance companies, reaching a significant magnitude in the case of particularly large events, such as Hurricane Katrina in 2006 or the California wildfires in 2018 (so-called liability risk). In the absence of such coverage, the effects of natural events take resources away from those who suffer damage and can lead to a significant reduction in the value of any collateral provided to obtain credit. In turn, a reduction in the value of collateral coupled with an increase in the financial vulnerability of affected households and businesses could increase both the probability of default and the amount of losses the bank have to bear should the default materialize; if the affected area is widespread or the event particularly intense, these effects could spread to a large part of the banking system.

Increased risks due to climate change could lead banks to restrict credit to those located in the most at-risk areas, with potential negative repercussions also on the transmission of monetary policy impulses. A study on our country shows that more than 20 per cent of loans to the productive sector are granted in areas at high flood risk and that credit flow is negatively correlated with risk exposure, particularly when borrowers are small and medium-sized enterprises (Faiella and Natoli, 2018). Considering that our country is expected to suffer the greatest damage in Europe from the exacerbation of flooding processes related to river floods (Ciscar et al. 2018), it is important to take this relationship into account when assessing possible future impacts on the credit channel, both from a perspective that concerns the stability of the individual intermediary and from a macroprudential perspective.

In addition to losses related to the credit provided or insurance policies taken out, there are other negative effects on the financial system. In the event of an adverse event, damaged companies may suffer a depreciation of their shares and bonds, leading to losses for intermediaries holding shares in their portfolios. In addition, affected companies may be forced to divert capital from technology and innovation to reconstruction, slowing down their production and innovation processes and reducing their profitability in the medium term.

Looking ahead, an increase in the frequency and intensity of extreme events could affect the financial position of an increasing number of banks and insurers, posing risks to the stability of the financial system as a whole. If intermediaries that are exposed to damaged households and businesses were to stop providing certain services; if the value of their own securities were to fall sharply, the negative effects of climate change could spread to unaffected financial institutions, extending the negative consequences to credit and insurance markets (so-called second-order effects). These phenomena would be all the greater if the frequency and severity of such events were to be underestimated and the situation worsened over time; the growth of temporal and spatial correlation (so-called clustering effects) would make the reinsurance process increasingly difficult.

The transition risk stems directly from the commitments made by the international community to stabilize the atmospheric concentration of greenhouse gases within a level compatible with a temperature increase below 2°C compared to pre-industrial levels. An ungoverned transition to a low-carbon economy could abruptly reduce the value of energy reserves and infrastructure related to the exploitation, processing and use of fossil fuels (coal, oil and gas). Unlike physical risk, transition risk is not persistent but could be disruptive to the stability of the financial system. Indeed, given the importance of the sectors involved and the pervasiveness of energy products, a sudden drop in the value of reserves and related infrastructure could trigger a rush to sell energy company stocks with consequences that could affect the global economic growth path (as happened with financial firms exposed to the sub-prime mortgage sector during the last major financial crisis that led to the Great Recession). A recent study estimates that even if we stopped building energy infrastructure using fossil fuels in 2018, cumulative GHG emissions from normal use of existing plants would not be compatible with the carbon budget needed to keep temperatures rising within 1.5°C (Tong et al., 2019). Thus, if this target were to become stringent, many of these plants would not be able to operate for their entire lifetime, which would depreciate their value.

Moreover, the transition is likely to lead to higher prices, as climate policies require the use of alternative energy sources that are currently more expensive or the introduction of carbon pricing systems that internalize costs currently not borne by businesses and citizens, affecting prices and economic activity. For example, the establishment of a carbon tax, designed to grow over time, is in line with increased ambitions to reduce emissions. As energy demand is inelastic in the short term (Faiella and Lavecchia, 2020b), a sharp increase in energy prices would increase the financial vulnerability of firms and households through increased spending on energy goods.

In this context, it is useful to examine how the fundamentals of the companies most exposed to transition risk are evolving: Bernardini et al. (2019), analyzing the stock returns of European energy companies, find that companies with a more fossil-oriented energy mix have experienced significant asset write-downs, which have weighed on operating results, eroding equity and increasing leverage. Through a simulation exercise also show that, over the period 2012-16, portfolio allocation strategies that took into account the carbon intensity of power generation would have provided a higher risk- return combination.

2.3.1 Stranded assets and the 'Carbon Bubble'.

The market value of shares and bonds is determined on the basis of current and prospective information held by investors, which is considered relevant for making estimates about the future prospects of profitability and financial soundness of issuing companies. The information that the prices of financial instruments today incorporate relates almost exclusively to economic-financial profiles, while that concerning sustainability aspects is more difficult to obtain. In addition, it is difficult to assess the impacts that might result from public policies to mitigate climate risks and, more generally, to cope with environmental risks, as well as from consumers' and investors' changing perception of environmental risks (Caldecott et al., 2016) and finally from the evolution of technology. According to Porter et al. (1995), environmental regulation can have positive effects on innovation and competitiveness, with long-term benefits that may outweigh the short-term costs of transition; however, there is still uncertainty about the balance point between costs and benefits (Albrizio et al., 2014).

If the market value of financial instruments does not fully take into account climate risks, investors would be exposed to the same risks on their investment portfolios (Battiston et al., 2018). News about the possible inability to use productive assets throughout their life cycle (so-called stranded assets) or information about changes in the composition of company costs and revenues can lead to marked revisions in the valuations of listed stocks and bonds. For example, McGlade et al. (2015) estimated that 82% of coal deposits, 49% of gas reserves and 33% of oil reserves would be unusable due to the energy policies required to meet commitments to limit temperature increase to 2°C. According to a recent estimate (Financial Times, 2020), asset write-downs of major oil and gas companies would amount to $900 billion, one third of their market value.

The impairment of corporate assets from 2011 onwards is mainly due to environmental risk factors (Carbon Tracker Initiative, 2011), which are receiving increasing attention. The write-down of corporate investments that have become incompatible with the carbon budget limits dictated by climate targets (Carbon Tracker Initiative, 2013) is a phenomenon whereby the negative externalities of more carbon-intensive sectors are internalized into the company (Ansar et al., 2013).

The destruction of enterprise value is not a new concept and indeed according to Schumpeterian theories (Perez, 1985) is part of the process of innovation and contextual change that underlies economic growth. Examples of past devaluations of infrastructure, plant and machinery and human capital have given rise to new phases of economic progress and growth.

The difference from the past is that destruction does not occur through the entry of new emerging industries ('sunrise') but through the (induced) decline of existing industries ('sunset') (Semieniuk et al. 2020).

Among the sectors most exposed to the risk of impairment of multi-year investments, in addition to the coal- and hydrocarbon-related sectors (where both reserves and the entire production chain from exploration to refining and distribution networks could be affected), are those more focused on energy production or consumption (e.g. utilities, steel and cement production) and those related to transport systems (automotive) (Van der Ploeg et al., 2020). For these sectors, asset values could suffer from premature economic obsolescence and changes in the relative prices of inputs could affect the efficiency of their business models and require changes, even radical ones, to production systems, with profound consequences on the economic and financial equilibrium of the companies involved. The estimation of such effects is complex because it is subject to considerable elements of uncertainty concerning, among other things, the development path of public policies and technology (Monasterolo, 2020).

The effects of write-downs on instruments most exposed to transition risk will mainly be reflected on investors with larger holdings of such instruments, including institutional investors (including pension funds), but also individual savers. Second-order effects can be added due to the interdependencies of financial system actors (e.g. for investments in banks and insurance companies lending funds or insuring companies exposed to climate risks). Some estimates by Battiston et al. (2017) indicate that these effects are significant and even higher than the direct effects. Moreover, the delay in the implementation of climate policies is likely to significantly increase final costs compared to an optimal path of gradual reconversion of plants where possible (Campiglio et al., 2020). Asset impairment can also result from expectations of the impacts of physical climate risks (e.g. flooding or sea level rise) that can lead to destruction or loss of value of properties and buildings. In addition, the effects of climate change may adversely affect companies' inputs, with impacts on facilities, infrastructure, workers, and the entire supply and distribution chain of companies' products and services. Effects on the supply chain can be particularly significant for multinational companies and those operating in certain regions where physical climate risks are more likely or more intense (Cicero, 2017). Some examples of physical climate risks on supply chains refer to the exposure to flood risk of electronic component suppliers in Thailand or refineries located on the US Gulf Coast, as well as the exposure to heat waves or intense rainfall, respectively, of agricultural producers in Africa (Tanzania, Kenya and Ethiopia) and South America (Brazil, Colombia and Costa Rica).

2.4 Climate change and Responsible Investment

As shown in the previous section of the chapter, the consequences that climate change and its effects have on the real economy are relevant and complex, but, alongside them, there are other economic areas in which the climate issue, and more generally the environmental one, are increasingly making their weight felt.

In particular with regard to investments, more specifically responsible investments that seek to strategically combine social and/or environmental benefits with financial returns, thus linking the social, ethical, ecological and economic concerns of investors under the common banner of sustainability.

From benefits inherent in these areas, indicators can be deduced which, under certain conditions, can help to catalyse the interest of investors and attract foreign capital, which seeks to position itself as an international participant in local capital markets.

These factors are commonly encapsulated in the acronym ESG, as short as it is relevant, an acronym that in recent years is undoubtedly increasingly characterising the literature on finance and beyond.

Behind these three letters, there are three macroscopic topics, increasingly known outside the world of finance but also of the mere concept of sustainability, which refer to three different concepts, in fact ESG stands for: Environmental, Social, and Corporate Governance.

Three essential issues to assess, evaluate and advocate the sustainability commitment of a company or organization.

In particular, this thesis work wants to focus on the **E** of **E**nvironmental that deals with the relationship with the environment and promotes initiatives and operations aimed at reducing the impact of climate change and related risks at the level of climate change also with regard to respect for biodiversity, attention to population growth and, in general, the management of primary resources such as water, not neglecting the decisions and interventions on the food chain, agri-food security, land, air, emissions and vegetation.

Attention to ESG parameters is becoming increasingly important and, as some analysts have pointed out, is becoming mainstream. While until recently the environmental and social impact of companies producing goods and services or their social commitment was important, but only marginally inspired consumer choices, i.e. it was listened to by a limited number of customers, in recent years there has been a simultaneous increase in the awareness of citizens and consumers and in the choices of companies regarding environmental impact issues. An attitude and a conviction that are in a position to influence consumers' purchasing choices both now and, above all, in the future.

Moreover, companies are increasingly oriented towards valuing investments and choices made for the environment, for social commitment and for implementing forms of corporate governance that benefit the environment and territories. This attitude is reflected, in an increasingly explicit and evident way, in the communication activities of these companies.

It is now essential to draw attention to the importance of the relationship between the economy and the sphere of environmental, social and governance risks.

Wanting to deepen the link between the economy and the risks just defined, it is first of all possible to state that these have negative effects not only on the resilience and long-term competitiveness of the economy, but also on the financial stability of an economic-financial system; in fact, a wrong exposure to environmental risks, as well as to social risks and errors in corporate governance, inexorably translate into vulnerability of the company.

To summarize, the importance of paying attention also to those risks that do not fall exclusively within the economic-financial perspective, such as market risk (credit, liquidity, country, settlement, etc.) or counterparty risk (inflationary, exchange rate, interest rate, price, etc.), is emphasised; rather, they are part of secondary risks but can easily turn into threats to the survival of the company itself.

These risks, however, can be a source of progress, bringing attention to three fundamental steps: the search for a better relationship between economics and environmental, social and corporate governance risks; the questioning of what has always been the guiding principle of business, i.e. profit maximization as the sole objective; and the increased attention in the economic system to the new concept, a valuation paradigm, of shared value.

The shared-value paradigm stems from the now outdated concept of profit maximization as the guiding criterion for economic action. There has therefore been a real transition from a model in which profit was at the center of everything to one in which, thanks also to external pressure from consumers (especially millennials), companies have had to change their guiding criteria in favor of shared value.
ESG is about representing, measuring and certifying the ability of companies to calibrate and manage their impact in environmental, social and governance terms. The purpose of ESG is to identify fundamental factors to be used to assess the sustainability of a financial transaction and the impact it will have on the environment, society, and governance of the company itself. This aim is not insignificant, as it aims to harmonize the concept according to specific parameters and to establish what are the objective criteria that will be used to select which, among the many possible, is the right investment to make. The responsible investment policy should aim to manage those factors that are important drivers of the fund's investment risks and returns while limiting attention to factors that are not relevant to the financial value of the fund (Croft Thomas and Malhotra Annie, 2017).
These criteria cover a wide range of factors that are not primarily part of financial action, but which may also be relevant from this point of view. The number of transactions using ESG factors has grown rapidly over the past decade, and the outlook is more than optimistic, with prospects for great growth, for the use of factors that help to better determine the future financial performance of companies.
The last few years have therefore seen a transformation: these types of parameters are rapidly turning from a niche in the investment world into a real trend, perhaps a dominant one, certainly an important one to follow.
Making sustainable investments means basing a company's financial operations on a serious assessment of the impact they can have, but above all deriving numerous financial benefits from this. First of all, companies contemplating the implementation of ESG are more attractive to investors; performance will be better from this point of view, and so will financial indicators. Lowering risks, adaptability to the planetary system, and adopting the latest infrastructure and technology. All in the name of sustainability: energy efficiency, innovation, achieving objectives more effectively. Without neglecting the fact that a brand that applies the principles of sustainable finance, and therefore ESG criteria, can have a clear leap forward in terms of brand image.

The term 'sustainability' is widely used to describe and define this path, but in reality a distinction should be made between responsible investments and sustainable investments. Responsible investments aim at mitigating ESG risks and avoiding damage to society, while sustainable investments actively pursue ESG positive outcomes for society. However, the key to both types of investment strategies remains the overriding concern for competitive financial returns. Currently, there are many differences in responsible investment across countries. Overall, across all share classes, Europe ranks first, followed by the US and then Asia Pacific. These regional differences reflect public policy orientation and regulatory responses, as well as cultural differences.

The central thrust of the emerging policy framework is directed towards one overriding goal: addressing the negative externalities arising from those everyday business activities that impose uncompensated costs on society at large. They include environmental damage, governance failures, poor labour practices, stagnant incomes, the hollowing out of the middle class and growing inequality (State Street Global Advisors, 2020). This laudable objective marks a radical change from the traditional way of investing, which has long targeted risk-adjusted returns, assessed primarily on financial criteria.

Markets are seen as the strongest link in a mutually reinforcing chain involving three other groups of partners: governments, through the use of their supportive fiscal and trade policies; technology, which provides innovations in the cost-effectiveness of *green energy*; and consumers, who favor pro-sustainability products.

For individual asset managers, the implied change has huge implications in a number of areas of the value chain: research, the investment process, stock selection, portfolio construction, talent pools, staff incentives, fund pricing, distribution, client engagement and performance reporting.

For climate change, the risks arising from it are reflected in a multitude of equally worrying secondary effects such as an increase in the frequency and intensity of extreme weather events capable of causing significant damage to human life, material/tangible assets and economic activities.

2.5 SRI investments

As has been the case for years in the world of consumption, critical and conscious choices are also influencing the world of finance, where the idea that it is no longer enough to invest for mere profit and that it is also necessary to create added value for the environment and society as a whole is becoming increasingly widespread.

This is shown by the survey "The responsible saver", conducted by the Forum for Sustainable Finance in collaboration with Doxa[4] conducted by the Forum for Sustainable Finance in collaboration with Doxa, which states that investors who consider socially relevant aspects to be very important in the financial sector have risen from 23% in 2013 to 40% in 2017. A response to this growing need is therefore represented by sustainable and responsible funds, which in financial jargon are identified by the acronym SRI (Sustainable and Responsible Investment).[5]

SRI investments are investment funds that combine the search for returns with socially responsible issues and are used in the main financial markets including, albeit for a few years, the Italian market, where they are known as 'ethical funds'.

From the point of view of management and distribution structures, as well as all other financial and regulatory aspects, they are identical to ordinary mutual funds. They are therefore forms of collective investment in which the assets represent an undivided community of assets, of which each participant is co-owner for the amount paid in.

These assets, obtained from the sum of the contributions, are managed by an asset management company (SGR), but are separate from both the assets of the management company and those of the subscribers. The main characteristic of the funds analysed here is therefore the possibility offered to the saver to finance social initiatives or to guarantee him a careful selection of the investment.

In fact, the portfolio includes securities from countries and companies that meet precise requirements, such as respect for human rights, the environment and the absence of involvement in sectors such as gambling, the production of weapons, tobacco or pornographic material. They are therefore instruments designed to satisfy people who pay attention to the social side of their actions. It is also important to remember the split to which the SRI fund category can be

[4] https://www.bva-doxa.com/risparmiatore-responsabile-italia/

[5] SRI funds, making money but with an eye on social and environmental issues, 26/03/2018, https://www.cnppartners.it/blog/i-fondi-sri/

subjected, in fact, these are subdivided according to their type between charitable (so- called devolved) and socially responsible funds.

The the first category includes those funds composed of those that were the first financial instruments of an ethical type to appear on the national market, these immediately offered, and offer, to the consumer, the opportunity to devolve to charitable bodies a part of the capital gains obtained by the fund. In order to do this, the fund directly withholds part of the revenues or directly allocates part of the subscription commissions collected to support charities or other solidarity initiatives.

As above mentioned, the second category contains those socially responsible funds, which unlike the first, in these there is a selection of assets in which the asset manager decides to invest, and this selection of assets must respect ethical canons which will then frame the fund itself. The difference, in this case, lies upstream and not directly in the destination of the profits. This procedure ensures that the companies that will be financed by this collection must all respect stringent parameters relating to sustainability. In this way, it will be possible to avoid financing companies that have heavy impacts in the three spheres of environmental, social and corporate governance.

In order to be able to guarantee this strict selection, specific committees are set up, known as "Ethical Control Committees", and ethical advisors are also appointed.

These two figures will be responsible for verifying and guaranteeing that the work of the fund manager is in line with the ethical objectives declared at the start of the fund, and also for identifying the basic criteria on which the level of ethicality of the investments will be verified.

Some Asset Managers in recent years have developed strategies that combine the principles of charitable and socially responsible funds, resulting in a hybrid product that combines the donation of part of the proceeds to charity with a strict selection of upstream assets.

In general, four strategies are usually identified, which correspond to the different branches along which socially responsible investment is usually developed:

- negative screening.
- positive screening.
- community investing.
- shareholder activism.

There are certain characteristics, in the Asset Management evaluation and selection process, that lead to the exclusion or inclusion of different assets in the fund's asset allocation. The first

two characteristics concern the scope of the assets and the different environmental and social policies.
Although there is no regulation that standardizes the concept of ethicality for all Asset Management Companies, there are certain elements that make this concept uniform, and in complying with it, we choose not to include assets relating to the following sectors: manufacture and/or trade in arms, tobacco, alcohol, pornography, gambling and nuclear energy; respect for privacy, intellectual property, free competition, as well as genetic manipulation.
Positive screening is a process of positive selection, which aims to include in the composition of the fund those securities that are socially conscious; furthermore, the same process aims to encourage both listed companies and the states themselves to behave more ethically.
The third point, community investing, is also called *cause-based* investing, i.e. a type of investment that refers to causes, to purposes. The main causes of such investments are those who would not otherwise receive funding from the usual official channels (banks). It is therefore a reserved and dedicated line of credit, which does not take the form of a non-repayable loan, since compensation for the credit is in any case envisaged, but rather, financing at favorable conditions designed to support local communities or micro-enterprises that intend to support themselves financially in an autonomous manner.
The last of the strategies that can be implemented is shareholder advocacy, or activism, which aims to raise awareness and thus increase the social responsibility of the companies included in the fund's portfolio. This is made possible through a relationship between the fund manager and investors, who, being in effect direct shareholders of the various companies in the fund, have the power to influence the company to make ethical choices.

2.6 ESG Factors and Materiality Maps of SASB

An understanding of ESG factors is a prerequisite for understanding sustainable finance and specifically sustainable investments. The ESG factors, as suggested by the acronym, are subdivided according to specific areas of relevance: Environment, Social and Corporate Governance. Depending on the thematic area concerned, the following specification is possible thanks to the "c" (PRI):

- For the Environmental segment:
  - Climate Change
  - Exploitation of natural resources

- Pollution
- Waste production
- Deforestation

- For the Social segment:
  - Working conditions/exploitation
  - Slavery and Child Labour
  - Health and Safety
  - Labour relations
  - Survival of Local Communities (including indigenous communities)
  - Gender Diversity
- For the Governance segment (Corporate Governance)
  - Management remuneration
  - Bribery and corruption
  - Board composition, structure and diversity
  - Lobby Politics and Conduct/Fiscal Strategy

However, it must be emphasized that this list is only an example and that the PRIs mentioned above are only intended as a guideline for defining minimum conditions.

If the aim is to develop an ESG rating or profile, and thus structure a methodology for choosing which assets to include in one's allocation, a further step is to understand what the material ESG factors are. In other words, there is a need to carry out the so-called Materiality Assessment, which will take care of sanctioning the capacity of that specific ESG issue to impact and influence the financial performance of an asset or its issuer.

The process of identifying those ESG issues that are likely to impact the financial performance of the asset/security and its issuer implies a conscientious assessment of the context in which these entities operate, and should therefore be a consideration of characteristics such as geographic region and industry level.

Considering now that there is a potentially recognizable link between a given ESG factor and the relative value drivers related to the issuing company's core business, which make it possible for this company to translate its actions and choices into risks or opportunities, the Materially Assessment is based on the representation of this link.

Once the meaning of materiality of a certain ESG issue is understood, it is then easy to realize that the number of relevant ESG issues may be different for companies belonging to one industry rather than another and that, even in the presence of a sustainability issue considered material for companies belonging to different industries, the quality of materiality may also be different, i.e. there may be a greater or lesser pervasiveness of the value drivers that are affected.

Materiality analysis, as has already been mentioned, is performed in order to elaborate an ESG profile, an ESG rating of a single company/issuer that may be of interest to several stakeholders; once this is done, it is possible to elaborate a kind of ESG rating, which is called ESG Score.
By applying and developing the ESG Score concept to a variety of assets, it will also be possible to develop the so-called Fund Sustainability Rating (or Fund ESG Rating), which is nothing more than a Sustainability Rating applied to mutual funds and variable capital investment companies.

2.6.1 The Materiality Map of SASB

In describing the best known Materiality Map, that of SASB, it is appropriate to put a face to it. In fact, SASB, which stands for Sustainability Accounting Standards Board is an independent non-profit organization that sets standards to guide the disclosure of financially relevant sustainability information by companies to their investors.
The SASB standards identify the subset of environmental, social and governance (ESG) issues most relevant to financial performance in each of the 77 sectors.
SASB's "mission" and "vision" are respectively: to establish and improve industry-specific disclosure standards on financially relevant environmental, social and governance topics that facilitate communication between companies and investors on decision-useful information; global capital markets where a shared understanding of sustainability performance enables companies and investors to make informed decisions that drive long-term value creation and better outcomes for companies and their shareholders, the global economy and society at large.
The map drawn up by SASB, identifies material issues, i.e. those where there is a high probability of impacting on the financial and operating conditions of a company and which are therefore topics that investors consider very important.
In order to best define and construct the map, SASB has opted to use the investor's perspective, thus reflecting on which ESG factors are likely to have an impact on the conditions of an issuer and which should in no way be overlooked in the process of selecting an investor.
SASB itself, in describing the importance of financial materiality states <<Although there is a great deal of environmental, social, governance (ESG) and sustainability information publicly disclosed, it can often be difficult to identify and assess which information is most useful in making financial decisions. SASB identifies financially material issues, which are the issues that are reasonably likely to affect a company's financial condition or operating performance

and are therefore most important to investors. Ultimately, companies decide what is financially material and what information must be disclosed, taking into account legal requirements. >> 11 This shows how this interactive tool can be ably used both on the corporate side, to check the sustainability strategies in place or that they want to undertake and understand where they can invest their resources; on the investor side to analyze portfolio exposure and specific risks and also to uncover new opportunities. The map includes a list of 26 different possible ESG issues that are then grouped into 5 macro- dimensions of analysis that will then be examined in relation to 11 sectors divided in turn into 77 industries. The 5 above mentioned macro-dimensions are:

1. Environment - this dimension encompasses environmental impacts, either through the use of non-renewable natural resources as inputs to production factors, or through harmful emissions to the environment that may impact on the company's financial condition or operational performance.
2. Social capital - this dimension refers to the expectation that a company will contribute to society in return for a social licence to operate. It deals with managing relationships with key external parties, such as customers, local communities, the public and government. It includes issues related to human rights, protection of vulnerable groups, local economic development, access to and quality of products and services, affordability, responsible business practices in marketing and customer privacy.
3. Human capital - this dimension addresses the management of a company's human resources (employees and individual contractors) as key resources for delivering long-term value. It includes issues that affect employee productivity, the management of labour relations and the management of employee health and safety and the ability to create a safety culture.
4. Business model and innovation - this dimension addresses the integration of environmental, human and social issues into a company's value creation process, including resource recovery and other innovations in the production process, as well as product innovation, including efficiency and responsibility in the design, use and disposal of products.
5. Leadership and Governance - this dimension involves managing issues that are inherent to the business model or common practice in the industry and that potentially conflict with the interest of wider stakeholder groups, and therefore create a potential liability or limitation or removal of a licence to operate. This includes regulatory compliance, risk management, safety management, supply chain and materials procurement, conflicts of interest, anti-competitive behaviour and bribery and corruption.

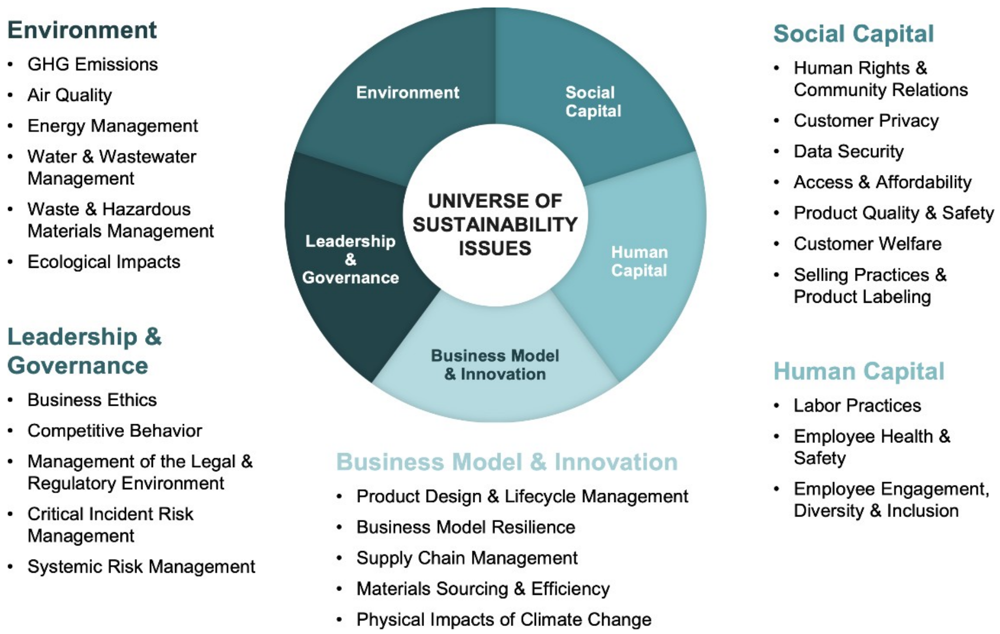


Figure 2.5: SASB Sustainability Framework. Source: SASB.org

Materiality Map takes the form of a table in which, horizontally, at the top of the table, 11 different key sectors are placed as headings: the consumer goods sector, the mining sector, the financial sector, the food & beverage sector, health care, infrastructure, renewable resources and alternative energy, the services sector, the technology and communication sector and finally the transport sector. Vertically in the first column, you can find the 5 macro-dimensions discussed above, which will expand, immediately next to them in the second column, the 26 sustainability issues, already developed and mentioned in Figure 2.5. Going to cross this set of headings, it is possible to find that the cell generated by this intersection, returns a number of important results, starting with the color (which varies from white to grey to dark grey) that is given to that particular cell, SASB will indicate that that specific area, in relation to one of the 26 issues, will be a significantly material issue or not.

SASB also states that material sustainability issues are capable of exerting a financial impact on the value drivers of a sampled company, in fact these issues are capable of influencing several specificities of companies, starting with revenues, continuing with operating costs, non-operating costs, assets, liabilities and last but not least, the risk profile.

2.7 ESG rating

The ESG Rating (or Sustainability Rating) is a synthetic judgment that certifies the soundness of an issuer, a security or a fund from the point of view of environmental, social and governance aspects. It does not replace the traditional rating but is complementary and its purpose is to increase the information available and thus improve assessments and choices.

The premise of ESG assessment is similar to that of credit ratings: companies interested in communicating their quality through independent analysis sign contracts with agencies that undertake to assess their information and make a judgement on the sustainability of the company according to ESG criteria. According to a 2016 Accenture study, eight out of ten CEOs believe that *"demonstrating a commitment to social purpose is a differentiator in their industry"*.

ESG scores are drawn up on the basis of public data, whether from companies, publications or reports by non-governmental organizations. On the basis of this information, the agencies give a rating in several boxes, which are usually inspired by the 17 themes that make up the United Nations Sustainable Development Goals.

The ESG rating appears to be increasingly important today because it represents an index that allows investors to have a greater and deeper understanding of the sustainability of a company. That is, it extends the '*traditional*' concept of sustainability of a company represented by economic sustainability and the ability to generate new value for investors, to the concept of sustainability towards society and the environment and the ability to generate value for the environment and society. The ESG theme has its origins in the 1990s, when the Global Reporting Initiative (GRI) was created to develop a reporting framework on corporate environmental behaviour. The June 2000 guidelines, which represent an important first step towards a sustainability reporting standard, define an initial approach to ESG issues, which has evolved over the decade.

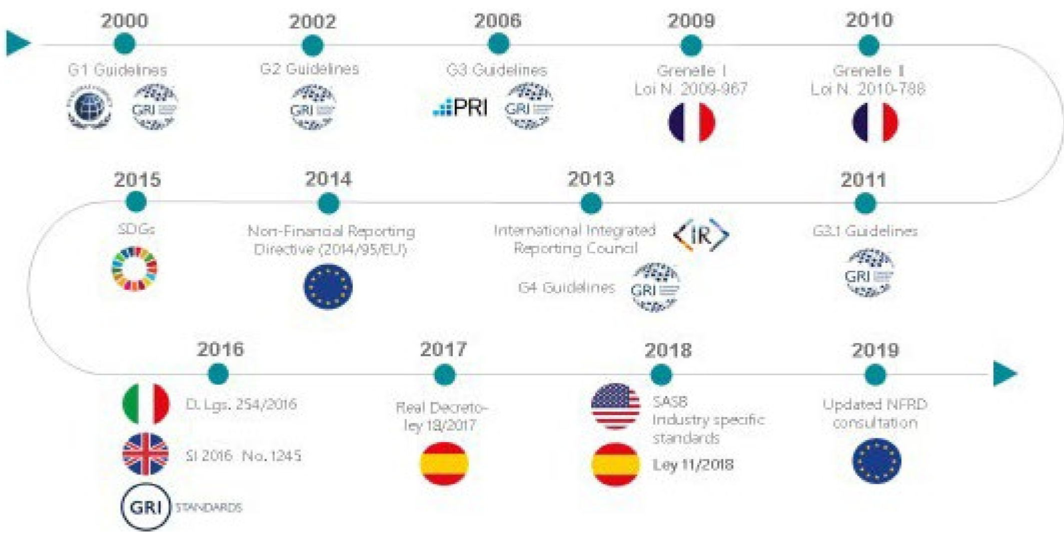


Figure 2.6: SASB Sustainability Framework. Source: SASB.org

A second crucial step is the establishment of the United Nations Sustainable Development Goals in 2015, a list of the aforementioned seventeen goals that aim at global development, the promotion of human well-being and the protection of the environment.
On that occasion, the global community endorsed the 2030 Agenda, the essential elements of which are the 17 Sustainable Development Goals (SDGs) and 169 sub-goals, which aim to end poverty, fight inequality and achieve social and economic development.
They also take up aspects of fundamental importance for sustainable development such as tackling climate change and building peaceful societies by the year 2030.
Just in 2015, at the Paris Climate Conference, 195 countries adopted the first universal and legally binding global climate agreement, setting out a global agreement to avoid dangerous climate change by limiting global warming to well below 2ºC.
On the basis of these agreements, national legislations have introduced non-financial reporting obligations for companies (in Italy for Public Interest Entities) and stricter rules to protect the environment and limit global warming.

2.8 Rating agencies

Sustainability or ESG rating agencies are research centers specialized in collecting and processing information on the environmental, social and governance profile of companies, in order to provide investors with the information they need to make informed investment decisions. The first sustainability rating agency to operate as a credit rating agency was Standard Ethics in London, which was also the first to use the term 'ethical rating'.
In fact, Standard Ethics has introduced a standardized and institutional approach to sustainability ratings that is able to discern between ESG assessments of Corporate Social Responsibility and those of sustainability, which cannot be defined by companies or investors but only by supranational institutions. ESG rating agencies have a great responsibility: it is on the basis of their ratings and the information they collect on companies in the environmental, social and governance spheres that asset managers construct a responsible investment and select companies for inclusion in the so-called investable portfolio.
The main ESG rating agencies are:

Vigeo-EIRIS: Vigeo Eiris is a leading European ESG rating agency. Founded in France as Vigeo SA in 2002, it has quickly established a leading position by acquiring local non- financial rating agencies in several European countries. Thanks to its experience in the field of social responsibility, Vigeo Eiris has more than 300 international clients, including institutional investors, financial managers, banking foundations, NGOs and businesses. The group has 230 qualified analysts specialised by sector, located in its various international subsidiaries. It has an extensive proprietary database of ESG ratings for issuers in the various asset classes (equity and fixed income), and a full range of services and products that enable investors to take a socially responsible approach to their investment processes. On the corporate side, Vigeo Eiris assists companies of all sectors and local authorities with ESG assessments and integration plans, to support them in implementing their sustainability policies. It issues Second Party Opinions in accordance with the Green Bond Principles, to attest to the credibility and transparency in the use of the proceeds of the bond issue, with the aim of promoting projects that generate the greatest environmental and social benefits and demonstrating the company's commitment to sustainability. Vigeo Eiris is present in the main countries of the world, both through offices (France, Belgium, Italy, Morocco, Great Britain, Chile, the United States and Hong Kong) and through partnerships with local operators (Brazil, Germany, Israel). Since April 2019, Vigeo Eiris has become part of the Moody's group.

Morningstar, Inc: an American financial services company based in Chicago, Illinois, USA. It provides a range of research and investment management services.

ECPI: Ethical Capital Partners S.p.A., an Italian company dedicated to research, rating and assigning sustainability indices. It collaborates with FTSE on the FTSE ECPI Italia SRI Index Series. The ECPI family of indices represents one of the broadest ESG offerings on the market, covering major asset classes, geographies and investment themes. Since the launch of its first index in 2001, ECPI has pioneered the world of sustainability investing. ECPI's offering is designed to meet the needs of an ever-growing sustainable investment market. With over 50 indices ranging from global benchmarks to thematic, strategic and hedged indices combined with a proven ability to translate into an investable index.

Oekom-ISS: Evaluates sustainability solutions and provides investors with information on the impact of a company's portfolio of products and services on the United Nations Sustainable Development Goals (SDGs). It contains both an aggregated assessment in the form of a Sustainability Solutions Score, as well as more detailed information and data points regarding specific sustainability goals. It aims to identify companies whose overall activity contributes positively or negatively to the achievement of the SDGs, to identify companies that provide solutions to specific sustainability challenges, such as climate change, water conservation or gender equality. It also has an additional access to 75 individual data points per company, providing detailed information on the percentage of net sales generated with products or services with positive, negative or no impacts (assessed on a 5-point scale), on the achievement of 15 different sustainability goals.

RobecoSAM: is an international investment company and rating agency with a specific focus on sustainability investments. The company was founded in 1995 in Switzerland

and considers economic, environmental and social criteria in its investment strategies. In addition to asset management, the company holds an index and private equity stake in the business. RobecoSAM offers a range of products based on themes such as water, energy, climate, agriculture and healthy living. In 2006, RobecoSAM introduced a division called sustainability services that provides sustainability benchmarking reports to companies. In 2001, RobecoSAM became the first carbon neutral company in Switzerland. RobecoSAM, assigns a rating score ranging from 0 to 100, where 100 corresponds to the score assigned to the best companies from an ESG perspective, while 0 is assigned to the worst.

Inrate: a Swiss rating agency founded in 1990, assigns a rating score ranging from A for the best companies to D for the worst companies. Inrate is owned by Infras AG, the NEST Foundation and various employees and directors.

Refinitiv: Global provider of financial markets data and infrastructure. The company was founded in 2018. It is jointly owned by Blackstone Group LP, which holds a 55% stake, and Thomson Reuters, which holds 45%.

MSCI ESG Research: Established as the analysis arm of Morgan Stanley and subsequently listed on the stock exchange, MSCI is a leading financial analysis company whose ESG department provides research, analysis and produces sustainability indices covering almost all listed companies.

Sustainalytics: a Netherlands-based rating agency founded in 1992 and owned by Morningstar. The rating is divided into five risk levels: 1 negligible; 2 low; 3 medium; 4 high 5 severe; the agency assigns a score from 0 to 100, where 0 is the worst score, thus assigned to the riskiest companies in this respect. Each rating agency analyses data and develops its own analysis according to international indices and indices that they themselves create. Among these, the most important are:

> *Bloomberg gender equality index*: International index measuring corporate performance on gender equality issues and the quality and transparency of their public reporting.
>
> *Dow Jones sustainability index:* the DJSI indices select the companies with the best sustainability performance among those with the largest capitalisation (around the top 300 out of 2,500 worldwide for the World index) on the basis of assessments carried out by the RobecoSAM agency. This index is considered the most reliable by the "Rate the raters" survey conducted by GlobeSCAN SustainAbility on a group of about 700 qualified sustainability experts representing 70 countries. Terna has been included in the DJSI World since 2009.

ECPI: Created by ECPI - an Italian agency founded in 1997 and specialised in ratings, sustainability indices and research to integrate extra-financial information into investment processes - based on its own analyses of the sustainability performance of European companies.

FTSE ECPI: Introduced in 2010, these are the only sustainability indices made up of a selection of only companies listed on the Italian Stock Exchange on the basis of analyses by ECPI. Terna has been included in the FTSE ECPI since 2010.

Ethibel sustainability index: the indices are drawn up on the basis of ratings produced by the Vigeo agency, which takes as its starting universe the approximately 10,000 companies included in the Russell Global Index. Inclusion is subject to the positive opinion of the Ethibel Forum, a panel of independent experts in the various aspects of sustainability.

Euronext Vigeo: Developed by the rating agency Vigeo, these indices are based on a universe of companies listed on the North American, Asian and European markets and included in the STOXX® 1800 basket. Vigeo's ESG indices are based on a methodology with over 330 indicators and 38 sustainability criteria.

FTSE4Good: The FTSE4Good indices group together the best companies for sustainability performance based on analysis conducted by Evalueserve. The index is revised twice a year, in March and September.

MSCI global SRI global Sustainability: MSCI has supplemented the original KLD indices - among the first to track the extra-financial performance of companies and still one of the most trusted references in the US - with other sustainability indices.

Stoxx® ESG: Launched in 2011, these indices are based on assessments by the rating agency Sustainalytics and select the best securities for ESG performance (around 350) from the 1,800 stocks in the STOXX® Global index. To be included in the Global ESG Leaders Index, it is necessary to be included in at least one of the three specialised indices (Global Environmental Leaders, Global Social Leaders and Global Governance Leaders).

Stoxx® low carbon: Launched in February 2016, the STOXX® Low Carbon Indices aim to provide a selection of companies characterised by low CO2 emissions. The selection of companies is based on data collected by CDP (Carbon Disclosure Project). The constituents of the indices are selected from the STOXX® Global 1800 basket based on their carbon intensity data (Scope 1 and Scope 2 of the GHG Protocol) on revenues.

United nations global compact (GC100): Established in 2013 by the United Nations Global Compact in collaboration with research firm Sustainalytics, this index encompasses the 100 companies that have distinguished themselves globally for both their focus on sustainability issues and their performance in the financial sphere, and that adhere to the United Nations' ten core principles on human rights, labour, the environment and anti-corruption.

There are many different choices of ESG criteria on the market. Those who rely on specialist companies do so primarily because they can guarantee independence of judgement on ESG

criteria and can present themselves to investors with the stamp of a body recognised on the market for its reliability in the field. There are those who dispute this approach, however, pointing out the limitation given by the lack of a shared definition on the market of responsible investment: each ESG rating agency applies its own criteria and therefore it can easily happen that a company considered sustainable by one asset manager is not so for another.
The lack of clarity about the methodologies behind these valuation mechanisms does not help investors to effectively compare investments that are defined as sustainable, thus contributing to the risk of greenwashing.
For this reason, ESMA, together with European institutions (especially those in the insurance and banking sectors), is trying to codify the standards that companies will have to adhere to when they claim to market products that claim to have ESG characteristics.
Specifically, these are European standards to ensure the transparency of green investments and bonds in terms of environmental, social and governance aspects.
To this end, ESMA will launch a public consultation by the end of March on specific disclosure requirements.

2.8.1 ESG Score

Now that ESG criteria are considered fundamental tools for selecting securities, funds and mandates, the number of ESG rating and data providers has also grown considerably.
In practice, however, ESG ratings leave open important questions that asset owners and asset managers need to be aware of when assessing the sustainability of securities, funds and mandates.
First of all, ESG ratings often detect a size bias, with larger companies obtaining better ESG scores on average, although this does not imply that they are more ESG-conscious.
This bias is most often caused by the fact that larger companies have more resources to develop and communicate their ESG policies and activities. Size bias seems to suggest that some ESG scoring methodologies still give more importance to policies than to the actual behaviour or products of such companies.
Moreover, almost all methodologies for calculating ESG scores still demonstrate a certain sector neutrality, i.e. they behave as if in each sector there are companies with positive ESG scores and others with negative scores regardless of their field of activity.
This could therefore lead to an obvious conflict with sustainability, since even companies active

in sectors that are certainly not considered sustainable, such as arms, tobacco and traditional energy, can still achieve high ESG scores, above the market average, thanks to their policies and this sector-neutral characteristic. Moreover, there is a low correlation between the ESG scores of different data providers. CSRHub found, as can be seen in Figure 8, that the correlation between the ESG scores of the various rating agencies can fall as low as 0.3[19], a level that shows a clear lack of consistency.

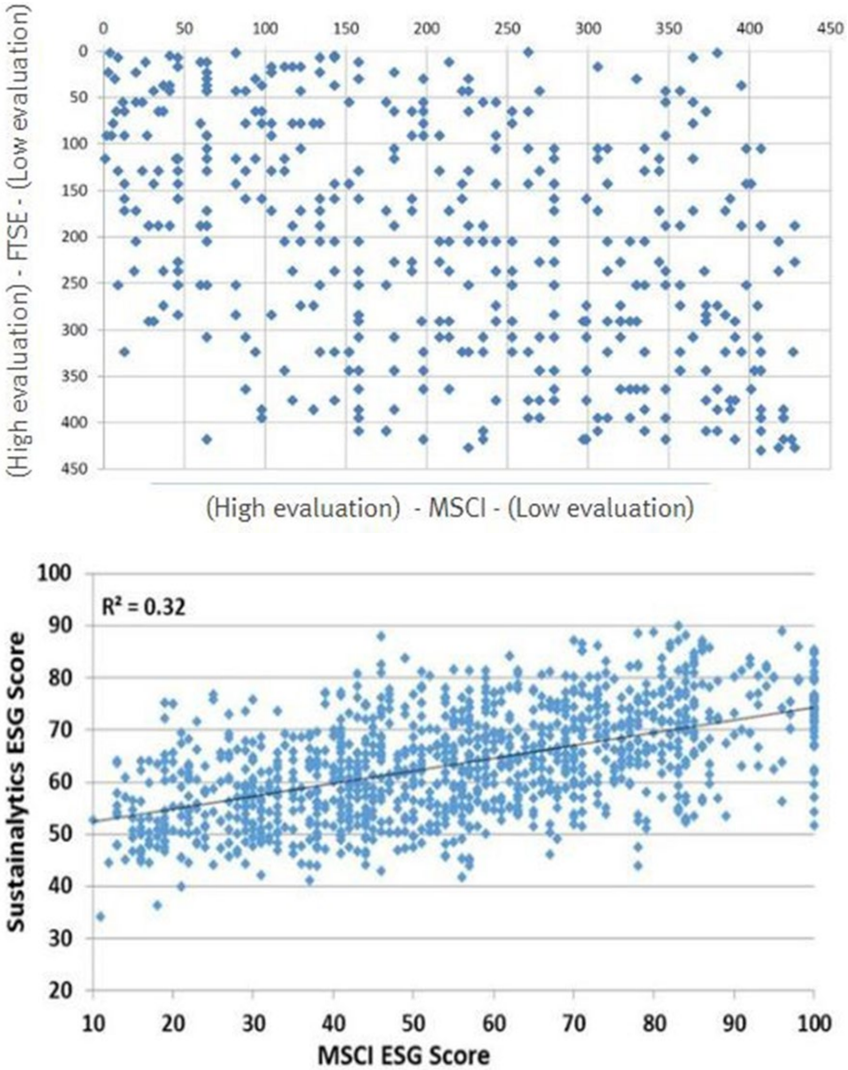


Figure 2.10(a) e (b): Sustainalytics and MSCI - From CSRHub. S&P 1200 equities, January 2015

A recent study conducted by the Massachusetts Institute of Technology (MIT) confirmed this discrepancy by analysing the correlations and dispersion in the ESG ratings given to companies by the main specialist agencies.

The correlations of the ESG scores attributed to companies by the different providers are weak to moderate, ranging from 0.38 to 0.71, with an average correlation of around 0.54 (MIT, 2019).

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For some companies, there was a low degree of dispersion between ratings or scores, and for these, ESG providers largely agreed on the score given. In other cases there is more disagreement.

In fact, it is possible for some companies to receive a negative score from one provider and a positive score from another, implying the exclusion of the same company from a benchmark, even though that company may occupy a place in the top ten of another ESG index using a different rating provider and a different methodology.

It is not uncommon for the various ESG rating providers to conflict with each other, as the assessment process can be complicated and can involve more than 60 rating categories.

Some of the categories used by the Sustainability Accounting Standards Board include data security, employee health and safety, greenhouse gas emissions and waste and hazardous materials management.

If one goes into detail, there are hundreds of different sub-categories that agencies involve in their ratings, which underlines the fact that rating providers and academics have not yet found a common understanding of what should be measured and what should not be measured, how data should be obtained and what relative weight should be assigned to each indicator.

As if that were not enough, within a company ESG data is neither standardised nor mandatory and is largely based on self-assessment; in fact, for companies that do not independently submit ESG reporting, options for rating agencies include assigning a zero rating, using a peer group average or determining a score using a statistical model.

Some rating providers do not even fully explain how a score has been determined; furthermore, ratings are made less clear by the fact that ESG assessors make subjective decisions on the relative merits and thus on the weightings of the E, S and G factors themselves and also in relation to issues such as litigation.

Thus, ESG scores are subjective due to the different methodologies applied, however, such criticism does not change the fact that the insights and arguments behind such scores can still be a valuable input for the investment process. This note only shows that opinions may differ, as is also the case in sell-side research where the same security receives different ratings.

However, the fact remains that, given the inherent subjectivity around ESG ratings and methodologies, forming an aggregate view of a company requires significant judgement and that the variation in ESG index screening methodologies demonstrates how important it is for investors to understand the rules of an ESG index.

Three distinct sources of divergence can be identified:

- *Weight divergence,* which refers to the situation in which several different attributes are used as the basis for forming ratings of different, e.g., attributes such as greenhouse gas emissions, employee turnover, human rights and lobbying activities, etc., which may be included within a rating. One rating agency may include lobbying activities, while another may not, leading to differences in the final overall rating.
- *Aggregation divergence* refers to the situation where rating agencies have different views on the relative importance of attributes and whether the performance of one attribute offsets another. For example, the human rights indicator may enter the final rating with a higher weight than the lobbying indicator. Divergences regarding scope and weight could be assessed as *Aggregation divergence*, since excluding an attribute from the scope of a rating is equivalent to including it with a weight of zero.
- *Measurement divergence* refers to the situation where rating agencies measure the same attribute using different indicators. For example, the labour practices of a company might be rated on the basis of labor turnover or on the number of labour cases against the company. Both assessments capture aspects of labour practices, but are likely to lead to different ratings.

Indicators may focus on processes such as the existence of a code of conduct or outcomes such as the frequency of incidents. Data may come from various sources such as company reports, public data sources, surveys or media reports.

Thus, assuming that rating agencies are trying to measure the same attributes but using different indicators, it is possible to arrive at the conclusion that the final aggregate rating contains all three sources of divergence intertwined in one number.

	SA - VI	SA - KL	SA - RS	SA- A4	VI - KL	VI - RS	VI - A4	KL - RS	KL - A4	RS - A4
ESG	0.73	0.53	0.68	0.67	0.48	0.71	0.71	0.49	0.42	0.64
E	0.70	0.61	0.66	0.65	0.55	0.74	0.66	0.58	0.55	0.70
S	0.61	0.28	0.55	0.58	0.33	0.70	0.68	0.24	0.24	0.66
G	0.55	0.08	0.53	0.51	0.04	0.78	0.77	0.24	-0.01	0.81
Econ	-	-	-	-	-	-	-	-	-	0.43

Correlations between the ratings on the aggregate level (E, S, G, and ESG) from the five different rating agencies are calculated using the common sample. The results are similar using pairwise common samples based on the full sample. SA, RS, VI, A4 and KL are short for Sustainalytics, RobecoSAM, Vigeo-Eiris, Asset4, and KLD, respectively.

Table 2.1: Correlation between aggregate ESG ratings and individual dimensions E, S and G - From: Mit Sloan School of Management Working Paper 5822-19

Table 2.1 shows the Pearson correlations between the aggregate ESG ratings as well as the ratings in the separate environmental, social and governance dimensions. The correlations of ESG ratings are on average 0.61 and range from 0.42 to 0.73.

The correlations of the environmental ratings are slightly higher than the overall correlations with an average of 0.65. Social and governance ratings have the lowest correlations with a mean

of 0.49 and 0.38, respectively. These results are consistent with Semenova and Hassel (2015), Chatterji et al. (2016), Dorfleitner et al. (2015) and Bouten et al. (2017).
KLD clearly shows the lowest correlations with all other raters, both for ESG rating and for individual dimensions. RobecoSAM and Vigeo-Eiris have the highest level of concordance with each other, with a correlation of 0.73 (OECD, 2017) .
Disagreement among ESG ratings is much wider than among credit ratings, as credit rating agencies use different data sources and procedures to assess the ability to pay and willingness to pay of companies, governments and individuals. These procedures and data sources are not free of judgment. However, we find a 98.6% correlation between Moody's and Standard & Poor's credit ratings. Since credit ratings are expressed on an ordinal scale, researchers usually do not report correlations.
The degree of disagreement between the ESG ratings of different providers is therefore much more pronounced. While credit rating agencies sometimes differ in their assessment of a category upwards or downwards, ESG ratings are much more in disagreement.

2.9 The use of ratings in asset allocation

ESG criteria are not an asset class, but a new lens through which investments can be analysed. It allows to understand what is sustainable, what is not. And above all, how to objectively measure all possible intermediate gradations between one extreme and the other. Assessing this matter is an exercise that is based, at least in part, on arbitrary elements. Asset managers are seeing an acceleration in demand for ESG funds, particularly from institutional investors. The popularity of these metrics, on the whole, has grown steadily and remarkably. In fact, considering the number of search results for the term "ESG investments" on Google has increased exponentially in recent years**.**
Multi-asset investors believe it is vital to understand and understand the mechanisms behind this interest and to consider how to maximize returns, whether through a standard diversified portfolio or a comprehensive sustainable investment solution. Strategic asset allocation and the ESG universe are therefore interrelated. The changes taking place in society affect the way capital is allocated to generate long-term returns. It is a reciprocal relationship, as strategic asset allocation can also direct private capital towards a greater focus on the most pressing social and environmental issues.

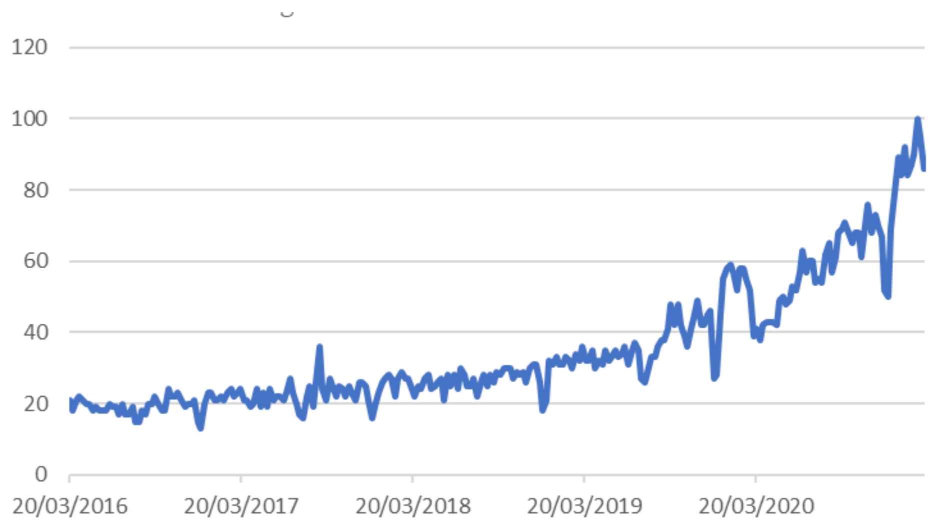

Figure 2.11- Google research trend "ESG Investment" all over the world. Souce: Google.it

Strategic asset allocation has a symbiotic relationship with ESG factors, because while ESG trends influence the investment world, strategic asset allocation can change the society in which we live. Investors are increasingly convinced that ESG-related risks cannot be ignored, as they have a significant impact on the long-term returns of asset classes, and this concept is therefore also transferred to the level of strategic asset allocation.

This is due to the volatility of asset class returns, which are not static and undergo structural changes over time, largely generated by ESG factors. Climate change is a perfect example.

Indeed, meeting the targets set out in the 2015 Paris climate agreement will cost investors an additional USD 1.5 trillion (Mc Collum et al., 2018) a year in energy and low-carbon projects. Climate change is not the only issue that is affected by the scarcity of capital inflows, as the same difficulties can be found in allocating the capital needed to achieve the UN Sustainable Development Goals and to improve the prospects of underdeveloped regions, which often experience low capital flows. Investors will not be able to fill these capital allocation gaps on their own. However, through a strategic asset allocation process that integrates ESG issues, they can enhance the positive impact of their investment portfolio on our society. The main obstacle to strategic asset allocation today is the persistence of low interest rates due to the structural slowdown in growth rates in the global economy. This is affecting yields on long-dated government bonds, especially in Europe and Japan (Oxford Economics, 2018) **.**

In recent years, this situation has led to substantial changes in strategic asset allocation. Interest rates are at low levels due to chronic over-saving, which can be motivated by a number of factors, the most important of which relate to the social sphere, especially population ageing and income inequality. These are the reasons why the long-term yield forecasts for government

bonds and some related asset classes are significantly lower than they were twenty years ago.
Many Western economies are experiencing a major demographic shift, resulting in a shrinking working age population. Japan and some European economies have been able to mitigate the impact of their shrinking working-age populations by adopting policies to attract a larger share of older and female workers.
Thanks to diversity in the workplace, these economies have a higher growth potential than they would otherwise have shown. Other countries, notably the US, have been less successful in encouraging this type of diversity and their participation rate has declined, hampering potential growth.
Governance is also very important for strategic asset allocation, as the event that has had the greatest impact on asset prices over the past 80 years, the 2008 global financial crisis due to reckless subprime selling, is largely attributable to some systemic governance failures in the global banking sector.
These governance failures have had serious consequences for asset allocation and dramatic effects on asset class returns. One of the lessons we have learned from the crisis is the need for long-term investors to pay more attention to systemic governance risks, especially in the financial sector. While not an easy task, it is nevertheless possible to stress test portfolios under different financial shock scenarios.
There are also other reasons for considering governance. In emerging markets, corporate governance standards change from country to country and have developed over time.
Poor protection of minority shareholders' interests often results in high levels of equity issuance, which dilutes returns for investors. This is a key factor behind equity forecasts and a drag on expected returns for emerging market equities.
However, we must be careful not to lean indiscriminately towards this approach. While a SAA process that integrates ESG factors could, if widely adopted, dramatically increase the allocation of capital to energy transition opportunities, it will not be sufficient to close the financing gap associated with climate and social issues.
Investors will only be able to increase the allocation of capital to financing the energy and social transition if there are sufficient projects in which to invest. Otherwise, there is a risk that existing opportunities will become inflated, prices will become over-inflated and expected returns will decline. It is therefore important that growth in opportunities goes hand in hand with growth in capital allocation.

Given the rapidly falling costs of renewable energy and the policy measures taken by governments, it seems that opportunities are set to increase rapidly in the coming years.

By virtue of integrating these issues, it can be said that Strategic Asset Allocation (SAA) is often the most important investment decision that investors have to make because it has a major impact on long-term performance. If investors decide to integrate ESG factors, it is essential that they consider how these factors affect long-term investment returns.

Our work shows that ESG factors are among the main drivers of long-term returns and therefore deserve to be integrated into the strategic asset allocation process.

An SAA that effectively integrates ESG factors should produce better risk-weighted returns.

But there is an even more interesting opportunity to consider. Many of the most complex issues involved in solving climate problems stem from insufficient capital investment.

Through the process of strategic asset allocation it is possible to begin to remedy this situation, so that investors can channel capital to increase its impact on the real world. Strategic asset allocation allows investors to do this using a rigorous method that does not compromise expected returns.

To maximise its effect, this high-impact version of the SAA needs to be coordinated with more ambitious public policy and a commitment to accelerating technological change and stimulating investor ingenuity.

All of this requires a shift in thinking within the investment community: investors must realise that they are not just responding passively to market forces, but are being called upon to play an active role in shaping a more prosperous and sustainable future. This is a paradigm shift, but also a natural evolution of the change that has brought ESG issues to the forefront over the past two decades.

Chapter 3

3 Empirical Analysis on Climate Change Effects

3.1 Event Study on Climate Change Effects

In this chapter the first part of empirical analysis is reported; as highlighted in the previous chapter, the study focused on the impact of extreme climate event on the performance of stocks for companies whose production sites or business interests have been affected by a climate event itself.

3.2 Sample construction

The analysis carried out is based on the hypothesis that extreme weather events, through their effects on productivity and production, can influence the share price trend of Italian companies. The effects associated with extreme weather events are likely to vary along several important dimensions. First, these effects are likely to vary substantially across sectors. For example, extremely hot summer temperatures may affect the production and profitability of firms with key inputs such as food crops and agribusiness in general, but not the profitability of airlines. Conversely, extremely cold winter temperatures, through their effects on overall air traffic and potential weather-related delays, may impact the profitability of airlines, while agriculture-related businesses are unlikely to be affected. It is also possible for the same weather event to be adverse for one business and favourable for another: in this case it would be possible to find, from statistical tests, that the occurrence of an extreme event would generate a positive effect on the stock returns of favoured businesses and a negative effect on the others. For example, if, following an extreme event, a civil structure collapses or is damaged, the company that wins the contract for the reconstruction or maintenance of the damaged structure would certainly be favoured by the event that has occurred, while the companies connected to the activities that took place in the damaged structure would certainly be disadvantaged.

Based on these considerations, a sample selection was carried out along two dimensions: the dimension related to the sample of companies to be considered in the study and the dimension

related to the extreme climatic events on which to focus the investigation.
The following paragraphs outline the criteria used to select the two-dimensional sample separately for each of the two dimensions.

3.2.1 Criteria for selecting the sample of companies

In order to identify the sample of companies on which to conduct the study of the relationship between temperature extremes and company stock performance, it was assumed that a cross-analysis would be carried out, taking into account various aspects. In fact, for this purpose, it was necessary to consider several aspects, which can be traced back to the following 3 criteria:

1. as a primary aspect, it was necessary to consider listed Italian companies. This is not an aspect to be overlooked because in Italy the number of listed companies is considerably low in relation to the number of companies actually operating: at the end of 2019, of the 6,091,971 existing companies only 375 were listed[6].
2. Sub-samples had to be identified at sectoral level. Specifically, the 68 six-digit industry classifications of the *Global Industry Classification Standard (GICS)* were used to construct the sub-samples through which to model this relationship. This choice is guided by the evidence of Bhojraj, Lee and Oler (2003), who show that among the various industry classification schemes, the GICS classifications are better at capturing common cross-sectional characteristics of firms and comovement in stock returns.
3. Finally, since climate is location-specific, it was important to take into account the geographical footprint of companies. In order to do so, the problem arose from the fact that in Italy a classification like the one present in other countries was not found, from which it was possible to obtain data at the level of establishment or production activity. For example, Addoum et al. (2018), in studies similar to the one here on a sample of American companies, sampling was conducted using the classification present in the *National Establishment Time Series (NETS)* database, which provides the addresses of establishments owned by every public company in the period from 1990 to 2015 present in the United States. In addition to locations, the database provides information on the

[6] https://www.innovationpost.it/2020/01/28/nel-2019-cresce-il-numero-di-imprese-attive-ma-nel-manifatturiero-il-saldo-e- negativo

portion of a company's annual sales generated in each of its establishments, as well as information on the number of employees working in each location. Unfortunately, for Italy there are no tools like the NETS database; one can only proceed with local analyses, identifying limited areas of land around a reference point and assessing in the area which factories or production areas are present and which companies are located there.

The difficulties linked to the lack of identification of the geographical footprint made it necessary to use a different approach to the problem. In fact, it should not be forgotten that the other central aspect for the construction of the final sample is that companies involved in the extreme climatic events considered are chosen. Therefore, in order to create the sample, a step-by-step approach was taken. Thus, rather than starting by constructing a sample of companies that simultaneously took into account all three of the criteria listed, a sample was constructed by making a selection that crossed the results obtained from the analyses of the first two criteria. Then, once the extreme climatic events had been identified and the regions where they could be geolocated, an event-by-event local analysis of the sites in the selected region was carried out and it was checked which of them fell within the set of companies previously selected.

3.2.2 Criteria for selecting the sample of events

Regarding the choice of event samples, the methodology used is completely original and has no precedent in the literature, at least within the literature research carried out within this thesis work. Some studies have tried to assess the effects of Climate Change (Addoum et al., 2018) but with a completely different methodology than the one that was developed for this study. In particular, Addoum's study did not focus on extreme events caused by climate change but on variations in the operating conditions of production agricultural sites distributed temporally over a rather long and continuous period. Using data on farm location obtained from an American database (*PRISM Climate Group, the official Agricultural Department of USA*), Addoum constructed a panel within which a quarterly variable was specifically created in which the levels of exposure to temperature of the different farm sites were recorded, reporting the measurement of time spent at different temperature levels. Using this measure, it was then tested whether exposure to extreme temperatures affects the company's profitability in a fiscal quarter.

In addition, Addoum examined stock prices and tested whether analysts' earnings forecasts responded to companies' extreme temperature exposures. Specifically, Addoum's study took into account the potential non-linear effects of temperature exposure by using third-order polynomials to measure the relationship between temperature exposure and financial market outcomes of interest.

The methodology, which we detail below, is at the forefront of the climate impact literature (e.g. Schlenker and Roberts, 2009; Blanc and Schlenker, 2017) and does not consider the effect of exposure to prolonged periods of high temperatures, but rather the effect that single extreme events with catastrophic effects had on the share price performance of the company whose production site or application site was fully affected by the consequences of such an event.

The method of approaching the study, therefore, being linked to the date on which the extreme climatic event occurred, was based on an event study and, from the point of view of sample selection, required the selection of events with significant consequences concentrated in rather short time periods.

But, above all, it was necessary to select events involving geographical areas in which sites or headquarters of companies belonging to the selected sample were located, as described in section 3.3.1. For this purpose, the Climate Risk Maps of Italian cities published by Legambiente Onlus[7] were used. These are interactive geographical maps of the Italian territory on which it is possible to find the various extreme climate events that have occurred in the last 10 years.

Once an event has been identified, the map provides information and details on the event and its effects: each type of event is indicated by a different icon, so as to facilitate the choice and allow events of different types to be included in the selection.

Using the interactive maps, it was possible to identify geographical areas of interest in which extreme climatic events occurred and within which several companies fell among those selected in the sample of interest. As far as the temporal location of these events is concerned, it was decided to limit the reference period to the last three years, i.e. from 2018 onwards; this choice was motivated by the fact that, for the companies involved, in addition to the prices of the quotations of their securities, the value of their ISG indicator was also available so that it could be used in further statistical elaborations to extract further information on the data.

Had a larger period been chosen and gone too far back in time, these data would have become scarce.

[7] https://cittaclima.it/mappa/

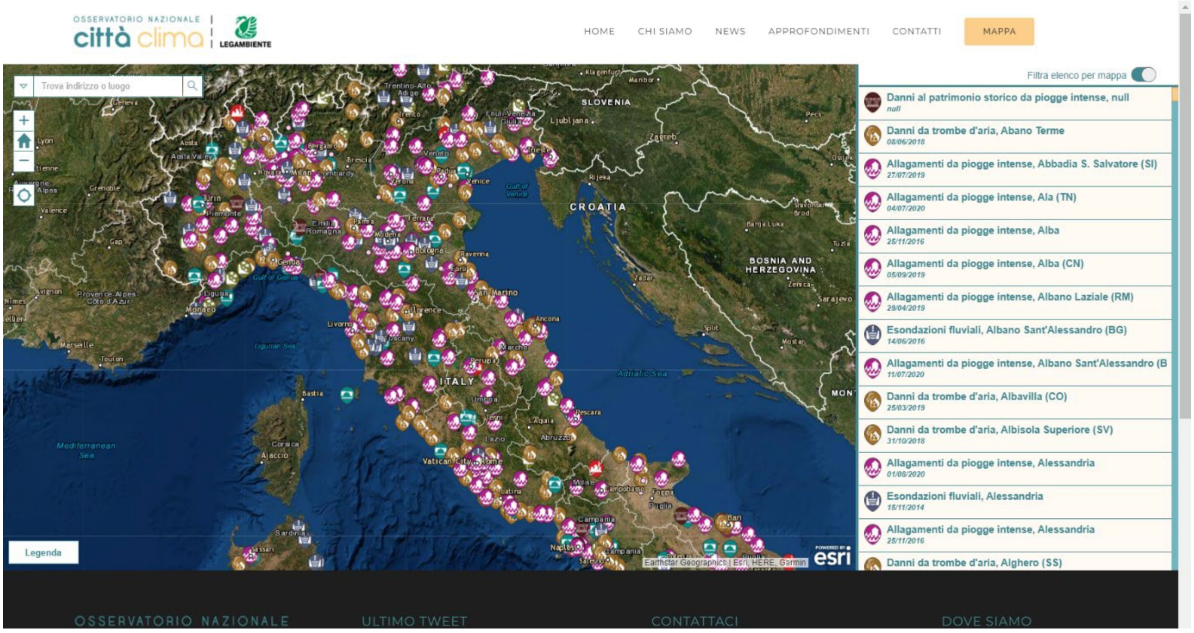

Fig.3.1 - Climate risk map. Source: Legambiente. Cittaclima.it

3.3 Sample description

The selection produced a sample of 8 events located mainly in northern Italy, and to a lesser extent also in the south and on the islands, for a total of 72 companies. The type of event fell into three main categories:

1. Flooding: flooding and inundation as a result of excessive tropical rainfall and abnormal rainfall patterns;
2. Water bomb: storms of excessive intensity with subsequent damage to property, landslides and mudslides;
3. Whirlwind: thunderstorms with extremely strong wind gusts and tornadoes. Some characteristics of the sample are shown in the table below.

EVENT DAY	N. of Companies	Type of event	Geographical location
Friday 8 June 2018	13	Water bomb	Bologna
Monday 29 October 2018	3	Whirlwind	Naples
Sunday 12 May 2019	9	Flooding	Rome
Saturday 25 May 2019	29	Flooding	Milan
Saturday 22 June 2019	7	Whirlwind	Modena
Wednesday 28 August 2019	3	Flooding	Cagliari
Tuesday 15 October 2019	3	Flooding	Genoa
Tuesday 12 November 2019	5	Flooding	Venice
Total	**72**		

Table.3.1 - Results of the selection of events and companies of interest.

Before to explain the empirical analysis and to discuss its results, this section will provide details of the sample used and how it was constructed. Data included in the sample have been provided by Thomson Reuters - EIKON database, matched with Datastream information.
The aim of this work is to analyse the effects that extreme climate events can have on the performance of companies whose production sites or business interests have been affected by a climate event. The final sample has been matched with Datastream results to find the share price and returns of the selected company' stock before and after the date occurrence of the event. The companies examined are attributable to 7 different types of activities, and 46 sub-sectors: the results are shown in the summary table below.

Sectors and Sub-sectors	Numbers of companies	Type of event
Assurance and Financial	**9**	
Asset Management & Custody Banks	3	Flooding
Diversified Banks	1	Whirlwind
Diversified Real Estate Activities	1	Whirlwind
Insurance Brokers	1	Flooding
Investment Banking & Brokerage	1	Flooding
Multi-line Insurance	2	Water bomb
Construction	**5**	
Building Products	1	Whirlwind
Construction & Engineering	2	Flooding
Construction Machinery & Heavy Trucks	2	Flooding
Food Manufactoring	**4**	
Distillers & Vintners	1	Flooding
Food Distributors	1	Flooding
Packaged Foods & Meats	2	Water bomb, Whirlwind
Manufacturing	**19**	
Apparel, Accessories & Luxury Goods	2	Whirlwind
Automobile Manufacturers	1	Whirlwind
Electrical Components & Equipment	2	Water bomb
Electronic Equipment & Instruments	1	Water bomb
Footwear	1	Flooding
Health Care Distributors	1	Flooding
Heavy Electrical Equipment	1	Flooding
Household Appliances	1	Flooding
Industrial Machinery	3	Water bomb, Flooding
Metal & Glass Containers	1	Flooding
Motorcycle Manufacturers	1	Whirlwind
Paper Packaging	1	Flooding
Paper Products	1	Flooding
Personal Products	1	Flooding
Specialty Chemicals	1	Flooding
Services	**26**	

Sectors and Sub-sectors	Numbers of companies	Type of event
Advertising	3	Flooding
Airport Services	2	Flooding
Alternative Carriers	2	Flooding
Application Software	2	Whirlwind, Flooding
Commercial Printing	1	Water bomb
Diversified Support Services	1	Flooding
Internet & Direct Marketing Retail	1	Flooding
Internet Services & Infrastructure	2	Whirlwind, Flooding
Movies & Entertainment	3	Flooding
Publishing	6	Water bomb, Flooding
Research & Consulting Services	2	Flooding
Systems Software	1	Flooding
Transportation	**4**	
Highways & Railtracks	3	Water bomb, Whirlwind
Railroads	1	Flooding
Utilities	**5**	
GICS Sub-Industry Name	1	Flooding
Independent Power Producers & Energy Traders	1	Flooding
Multi-Utilities	1	Water bomb
Oil & Gas Refining & Marketing	1	Flooding
Renewable Electricity	1	Flooding
Total	**72**	

Table.3.2 - Results of the selection of events and companies of interest.

3.4 Empirical Methodology for the Event Study

However, on the surface, measuring the impact of Extreme Climate Events (ECE) on the financial trend of a company seems to be a difficult task, and *Event Study* can be used to easily construct metrics. An *Event study* uses financial market data to measure the impact of specific events on company value. The usefulness of this research is that, given the rationality of the market, the impact of the event will be immediately reflected in the price of securities. Therefore, the security price observed in a relatively short period of time can be used to construct a measure of the economic impact of the event.

An *Event Study* (*ES*) begins by assuming that a particular event affects the value of a company under consideration by modifying it, and that this results in an observable anomalous return in the value of the company. Together with the idea that information is immediately incorporated into prices, the concept of anomalous (or performance) returns is the key to this methodology. The question to be answered is therefore: how does a particular climate event the value of a company?

It is necessary to pay close attention because in every moment there is a mix of market factors and other corporate events, capable of impacting on the value of the same. To measure the impact of a particular event there is therefore a need to control these unrelated factors. The selection of the benchmark to be used, or a model that allows normal returns to be measured, is therefore essential for conducting a successful event study.

The empirical model can be summarized as follows: when an event occurs, market participants will be prompted to revise their expectations (beliefs) causing a change in the company's returns.

The methodology of the Event Study is based on the hypothesis of the efficiency of the markets in the semi-strong form and on the hypothesis that the price of a security traded in an efficient market is equal to the present value of the company's expected cash flows.

The validity of an event study strongly depends on compliance with the assumptions about the efficiency of efficient markets. In the event that these hypotheses are not respected, the empirical results deriving from them could be distorted and inaccurate and consequently lead to incorrect conclusions.

Furthermore, as argued by McWilliams and Sigel (1997), the way in which the research is set up can influence the results obtained: it is therefore possible that some theories have been unjustifiably supported due to inappropriate techniques. Therefore, the confidence in the results provided by an event study search is conditional on the verification of the efficiency hypotheses.

On the basis of these hypotheses, therefore, the results produced by an event on the price of a financial instrument can reveal the results of the event on the company's future cash flows.

This is most effective when:

- the information event is well defined;
- the moment in which the information event arrives on the market is well known;
- there are no reasons to believe that the market has anticipated the news;
- It is feasible to separate the effects of the information event from market, sector or company-specific factors that may affect the performance of the stock.

An event study is a statistical method invented by Ball and Brown (1968) to assess the impact of an event on the value of a firm; the basic idea is to find the abnormal return attributable to the event being studied by adjusting for the return that stems from the price fluctuation of the market as a whole.

The event methodology is very versatile, it can be used to elicit the effects of any type of event on the direction and magnitude of stock price changes; in particular it is used to investigate the stock market responses to corporate events, such as mergers and acquisitions, earnings announcements, debt or equity issues, corporate re-organizations, investment decisions and corporate social responsibility (MacKinlay 1997; McWilliams & Siegel, 1997).

The first step for conducting an ES, concerns the choice of one or possibly more events of interest to be analyzed, of a group of securities on which to narrow the investigation (and therefore the selection of the sample), and the choice of the time window. in which to study its effects ("event window" or "observation period"). Generally, the event window is chosen in a time frame that begins immediately before the event and ends shortly after it, depending on whether the market anticipates the information or whether the effects of the price do not end in a single market session.

For the event study methodology, we refer to standard methodology (MacKinlay 1997) (Brown, Warner 1985): a diagram of this methodology is shown in Figure 3.2.

The length of the windows could be arbitrarily chosen based on the event examined. We defined as event of interest the announcement date of the acquisition, where the event date is 0.

In particular, in the case examined, given the unpredictability of the climatic event, the observation window was set to begin on the day the event occurred, while the extension of the period was extended to n_{op} days following the date of the event itself.

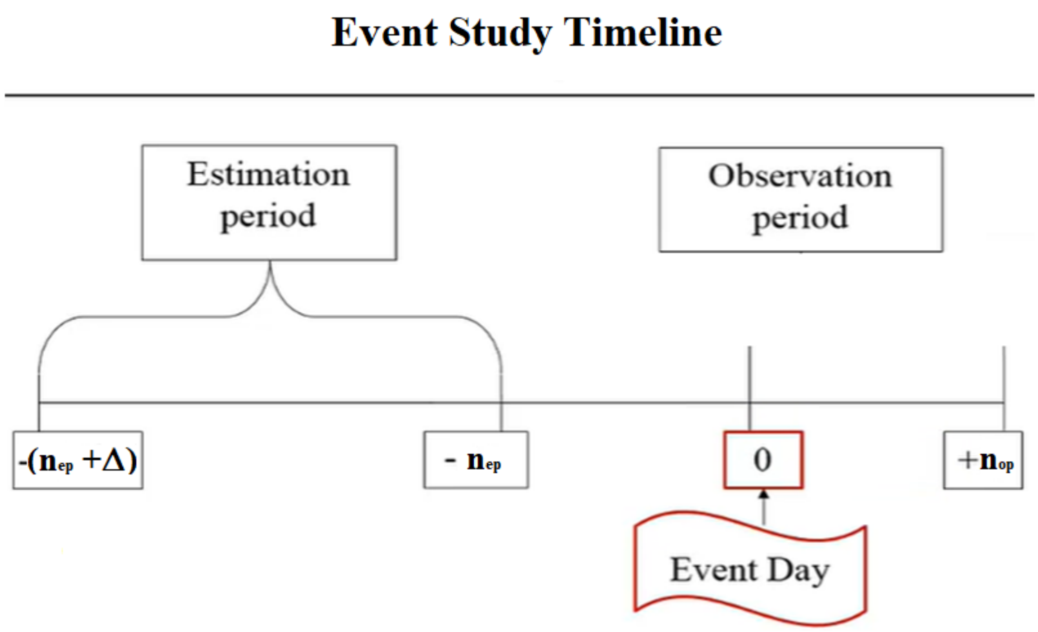

Figure 3.2:Time-period scheme for an ES

We proceed by defining a time period, the estimation window, which precedes the event window, in which to measure the correlation between the yield of the security and the yield of the market. In the case examined, the estimation window was set to end n_{ep} days before the occurrence of the event and its duration was extended within Δ days.

In order to verify the existence of the necessary hypotheses for the application of the event study, it was verified, event by event, that it was an isolated case in time, at least 1 year away from the extreme climatic event that preceded it.

Furthermore, in the sample considered, it was verified company by company, that there were no economic, financial or other events that could hypothetically influence the performance of the individual company's stock and therefore distort the results of the event study.

This relationship is measured with the regression of the market model which allows to quantify the expected returns of the stock. Abnormal Returns (AR) are calculated in the event window as the difference between the actual returns of the stock and the expected returns, in such a way as to purify the performance of the stock from the effects of the market trend.

In addition to the calculation of ARs, the ES also includes that of CARs (Cumulative abnormal returns) and in some cases also those of AARs (Average abnormal returns), and CAARs (Cumulative average abnormal returns), and also the verification of their statistical significance to better understand whether the deviation between the anomalous returns and the expected returns is due to case or has an economic significance, through the use of Statistical Tests such as the t test.

On the dates in which the relevant information has reached the market, the ARs quantify the impact this has caused on the price of a stock, that is, how much the yield of a stock has moved away from its expected return, net of the effects of the market.

The figure 3.3 outlines the logical steps to follow in an analysis of this type.

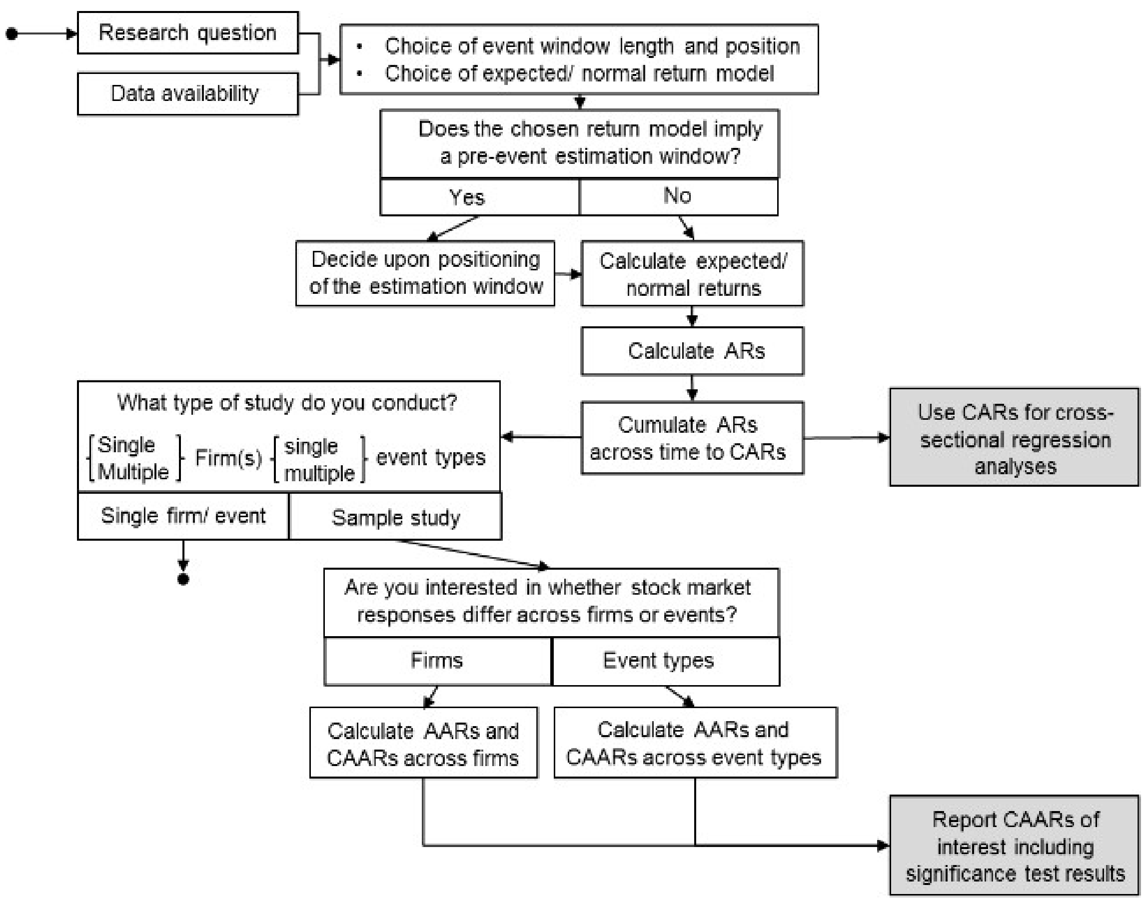

Figure 3.3: Flow chart of Event study choices and analysis steps. Source: http://www.eventstudytools.com/event-study-blueprint

If, following the analysis, no particular statistical significance is noted, it is possible to conclude that AR is not relevant from an economic point of view; if, on the other hand, the resulting AR is statistically significant, it can be stated that the difference between the actual yield of the security and the expected yield has an economic significance and therefore the information disclosed on the

market is "material" information, that is significant for the market.
In general, the higher the AR value, the more "material" the information is.
Theoretically, an event study analyses the difference between the Expected Returns in absence of the event and the returns that were verified – Abnormal Returns.
Abnormal returns are returns earned that are not merely explainable by general market movements. An abnormal return can be either positive or negative; it is merely a summary of how the actual returns differ from the predicted yield.
For example, earning 30% in a mutual fund which is expected to average 10% per year would create a positive abnormal return of 20%. To get the predicted (i.e. ordinary) return, it is necessary to consider the firm' recent performance track record (i.e. its intercept coefficient α), and its sensitivity to general market movements (i.e. its slopeβ).
To obtain this, it is possible to apply a procedure that can be divided in five steps:

1. First, obtain the intercept α and the slope β by running a single index regression of the firm's returns onto the market during a prevent period, called estimation period, i.e. a trading period before the takeover announcement, ending say few days before the announcement itself:
$$r_{i,t} = \alpha + \beta \cdot r_{market,t} + \varepsilon_{i,t}$$
2. Second, take that coefficients, α and β, and apply it to the data from during the event period:
$$\hat{r}_{i,t} = \hat{\alpha} + \hat{\beta} \cdot r_{market,t}$$
3. Third, the abnormal return are obtained as difference between the actual return and the expected return of a given day;
4. Fourth, this step consists in the to calculation of the *CARs* (*Cumulative Abnormal Returns*) by making the sum of these abnormal returns obtained during the event period, i.e. from two days before to two days after the takeover announcement.
5. Fifth, it is necessary to verify the significance of abnormal returns in the event date by making a t test on abnormal returns: it's a two tails test and the significance level could be chosen as we want.

3.5 Empirical Evidence for the Event Study

As explained in par. 3.3, the focus of this study is on the impact of extreme weather events on the share prices of companies affected by the effects of the event.
In this respect, a key step of the study was to identify an adequate sample of events and companies that would allow for credible and relevant results, and for which sufficient data were available to conduct robust analyses.
This phase was long and delicate, since the selection algorithm was devised without having examples

to support it, given the originality of the study itself, both for the subject, which presents an attempt at a novel approach compared to those already present in the literature, and for the scope of application, since, referring to Italy, it has to deal with a system of data acquisition and dissemination, less structured than that of other realities such as the United States.
However, once the sample had been obtained, an event study was carried out following the methodology explained in the previous paragraph.
The hypothesis that the present study aims to verify is:
H_{sin}: *An Extreme Climate Event have a concrete impact on the performance of stocks for companies whose production sites or business interests have been affected by a climate event itself.*
For the determination of the Abnormal Returns we used this formula:

$$AR_t = R_t - R_m$$

Where AR_t is the abnormal return at time t , Rt is the daily return of the companies included in the sample during the considered time and R_m is the Expected Return estimate.
The first problem addressed was that relating to the definition of an appropriate estimation and observation period.
We defined as event of interest the extreme climate event; therefore, the sample was divided into 8 subsamples, as many as the number of climatic events considered.
For each subgroup, day 0 was set with the day of the event: in particular, regarding the observation window, for the case examined, given the unpredictability of the climatic event, the observation window was set to begin on the day the event occurred, while the extension of the period was extended to twelve days following the date of the event itself.
We proceed by defining the estimation window, i.e. a time period which precedes the event window, in which to measure the correlation between the yield of the security and the yield of the market. In the case examined, the estimation window was set to end 5 days before the occurrence of the event and its duration was extended within 70 days.
Following the methodology previously described, we searched for the intercept α and the slope β for each deal of the sample by running a single index regression of the specific firm's returns onto the market during the estimation period.
As reference market, it was decided to use the FTSE Mib 40 of the Milan Stock Exchange: for the companies of each subgroup, the performance of the respective stock was compared with the performance of the market index referring to the period corresponding to the estimation period itself considered, as previously described.
So we obtained a first list of 72 + 72 parameters, α_i and β_i respectively, for the sample, divided in nine sub-lists of parameter, one for each climatic event considered.

$$r_{i,t,sin} = \alpha_{i,sin} + \beta_{i,sin} \cdot r_{market,t} + \varepsilon_{i,t} \text{ for } i = 1,2,\ldots, 72$$

The following tables shows some statistics relating to the most relevant parameters of the regressions performed: as we can see, the α_i values are very small, as expected, and both the intercepts and the slopes take on both positive and negative values.

Parameter	Symbol	Mean	Minimum	Maximum
Intercept	$\alpha_{i,sin}$	1.15347E-05	-0.006877756	0.013794894
Slope	$\beta_{i,sin}$	-0.511764921	-1.257414843	0.361949003
R^2		0.110816249	2.61619E-06	0.642764934
Standard Error		0.019734741	0.007795	0.0569984

Table 3.3 – Main Statistics about parameter for sin acquisitions

Then, starting by that coefficients, we calculated the fitted excess returns $\hat{r}_{i,t}$ during the event period for each firm by the equation:

$$\hat{r}_{i,t} = \hat{\alpha}_i + \hat{\beta}_i \cdot r_{market,t}$$

These were our expected values, so we compared them with the actual values in order to obtain the abnormal returns as their difference. In this way the abnormal return trends were obtained of share stock price for each deal considered in the samples; we reported their behaviour in fig. 3.4.

The graphs show a very marked variability of excess returns in correspondence with the time window of interest, with a clear change in behavior compared to the previous period, even if the aforementioned variation does not show a clear orientation nor does it provide sufficient elements to make the above choice.

The analysis was then continued, focusing attention on the comparison of the abnormal return graphs relating to the two windows considered.

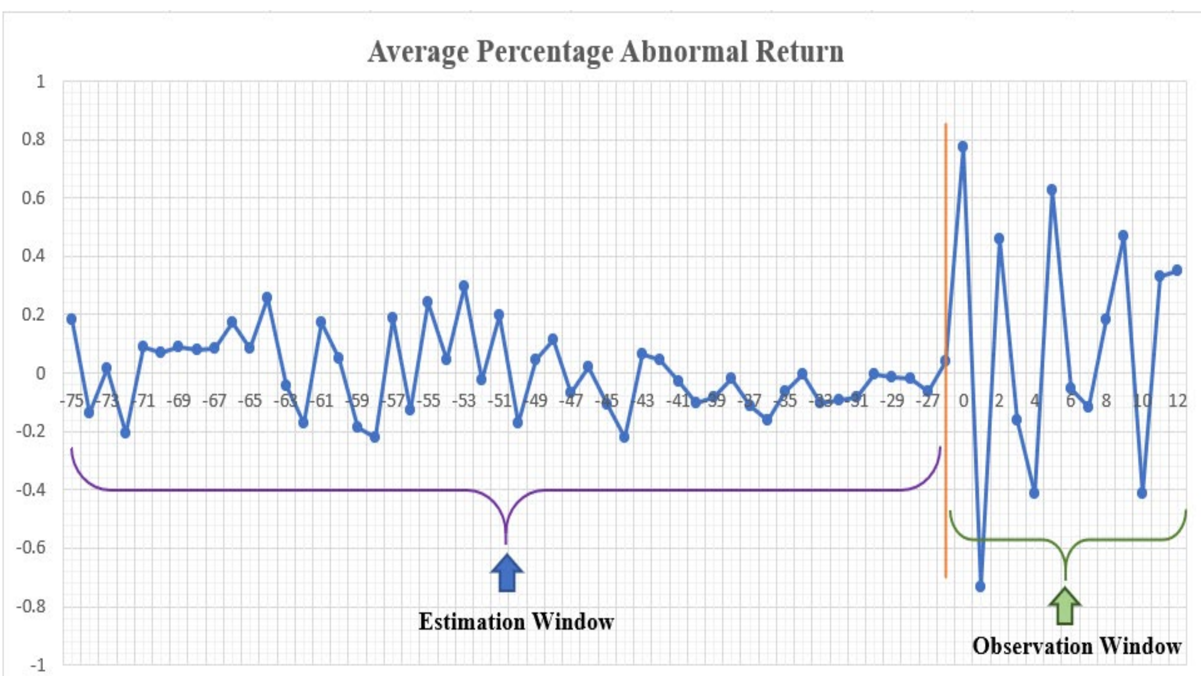

Figure 3.4: Average trend of the Abnormal returns

Nevertheless, what arouses more attention is the practically antithetical behavior that two sub-samples show on average: while the trend in the share price of buyers relating to sin acquisitions, which has shown to decrease practically during the entire estimation window, during the event window undergoes a surge upwards, for non-sin acquisitions the exact opposite occurs, and the positive trend held during the estimation window, undergoes an evident fall in the period between of the date of the announcement. This behavior is even more evident from the graphs representing the Cumulative Abnormal Returns for both samples below.

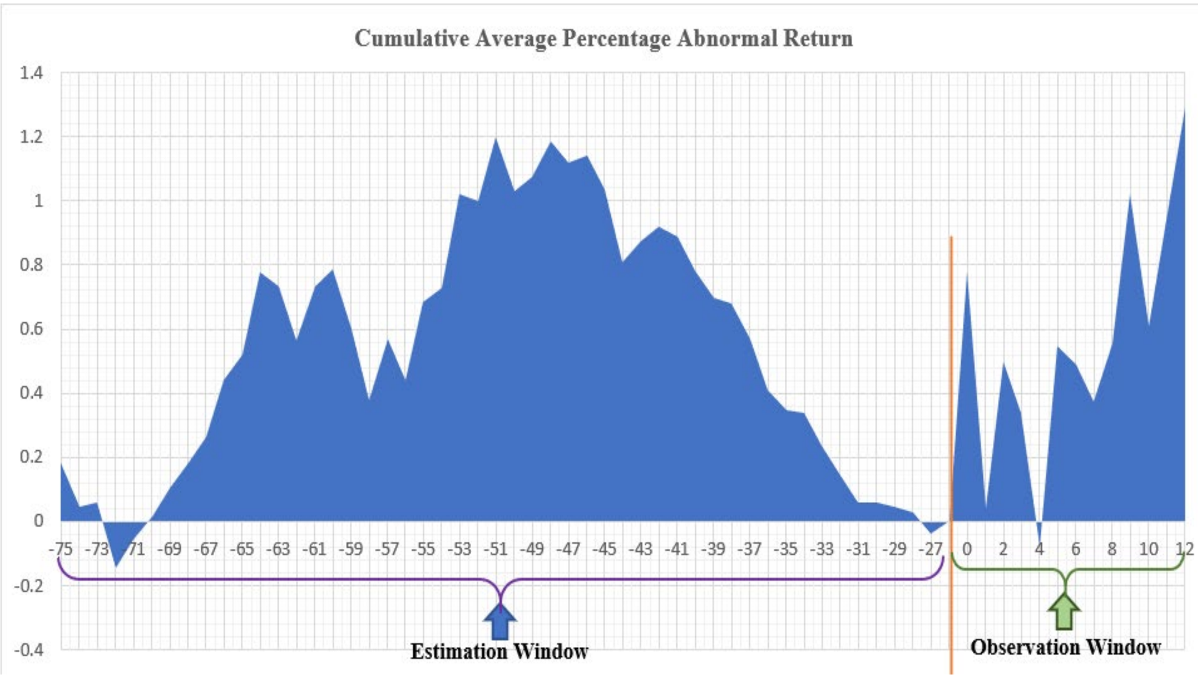

Figure 3.5: Average Cumulative Abnormal returns

In fact, if the hypothesis H_{sin} were verified, we could assume that the value of the abnormal returns calculated is significantly different from zero.

The abnormal and cumulative abnormal returns from event studies are typically used in two ways: either they are deployed as dependent variables in subsequent regression analyses or they are interpreted as-such. This latter direct interpretation seeks to answer the question if the cumulative average abnormal returns of samples of events are significantly different from zero and thus not the result of pure chance.

In this section we try to conduct both the analysis.

As regards CAAR interpretation, for each abnormal return we evaluated the stochastic variable t student in order to conduct a t Test; this test was useful to confirm the hypothesis H_1 of this study.

The answer about statistical significance is given by means of hypothesis testing, where the *null hypothesis,* H_0, claims that there are no abnormal returns within the event window and the *alternative hypothesis,* H_1, suggests the opposite.

Formally, the testing framework reads as follows:

$$H_0: \quad \mu_{CAAR}=0$$

$$H_1: \quad \mu_{CAAR} \neq 0$$

μ_{CAAR}, however, represent the average of *Cumulative Average Abnormal Returns* (CAARs) of our cross-sectional study.

Therefore the hypothesis of the study could be usefully translated into the null hypothesis that follows:

H_0 - The Cumulative Average Abnormal Returns (CAARs) *on the event window are null.*

In the event that the null hypothesis is accepted, then, we can affirm that *the extreme climate events have a concrete impact on the performance of stocks for companies whose production sites or business interests have been affected by a climate event itself.*

We have chosen to use a two-tailed test and as a significance level the value 0.05, which corresponds to a critical value of the variable t equal to t_{crit}=2.27.

The student's t value obtained at the event date was compared with the t_{crit} value to assess the effective significance of the cumulative abnormal returns.

Then, we calculated the CAARs by making the sum of the abnormal returns obtained during the event periods from the event day to twelve days that follow it.

The test revealed that in many cases there was indeed an abnormal return other than zero; in particular, significance was found in 80.5% of the acquisitions tested, equally distributed between the two samples, as shown in the following table.

Hypothesis	**t value**	**Number of stocks**	**Percentage**
H_0 refused	$t > t_{critic}$	58	80.5%
H_0 accepted	$t < t_{critic}$	14	19.5%
	Total Number of stocks examined	**72**	

Table 3.4 – t test results for event study analysis

These results comfort us that the acquisitions in general have had an impact on the trend in the share price of the buyers but they still do not tell us if there has been a different impact depending on particular type of business considered, or if these results depend on other variables. To obtain information in this regard, it is necessary to conduct further analyzes by focusing on the CAARs relating to each acquisition within the event window.

The following table shows some statistics relating to the results obtained. However, as we can see in this table, both 2 days CAR and 5 days CAR shows average returns climbing to the positive side.

	Mean	**Minimum**	**Maximum**
Positive CAARs	9.08 %	2.32%	41.00%
Negative CAARs	-7.90%	-2.38%	-20.56%

Table 3.5 – Main Statistics about CARs for acquisitions during event window

However, as we can see in this table, while CARs show average positive returns for some companies, negative values for others. This is symptomatic of a substantial difference in behavior among companies with different types of business, but from a statistical point of view, there is a need for further analysis to investigate these differences in order to make correct considerations.
To verify the effective validity of the result, other analyzes were carried out: in particular a multivariate linear regression, as illustrated in the following paragraph.

3.5.1 Analysis of CAARs for companies affected by an extreme weather event

The analyses conducted on CAARs took into consideration various aspects, but were mainly focused on the sector to which each company belonged, and therefore on the type of business, the type of event that occurred, and the ESG score relative to the security considered.
As regards the analysis of economic sectors, the results are shown in Table 3.6.
It is evident from the table that, while for some sectors the CAARs were markedly positive, for others they were negative: in particular, the sectors that were negatively affected by the effect of the extreme climatic event were those linked to the manufacturing sector in general and, more specifically, those linked to agro-food products.

Sector	Number of companies involved	CAARs
Assurance and Financial	12	11.10343957
Construction	9	4.964146901
Food Manufactoring	4	-8.087350851
Manufacturing	34	-2.421608782
Services	34	-1.564953151
Transportation	6	-4.139830322
Utilities	7	10.80539275
Total	**106**	

Table 3.6 – Main Statistics about CAARs grouped by Sectors

The effect on the services and transport sectors is also negative.
These sectors are objectively the most affected by the disruption caused by adverse weather events. Sectors such as construction, utilities and insurance/finance, on the other hand, benefit from extreme climate events. This can be interpreted by thinking of the fact that these sectors probably "speculate" on the consequences of a climate event as they are involved in the process of reconstruction and restoration of functionality following the event itself, and therefore the event is transformed into an opportunity to increase their earnings.
To the variables represented by the CAARs in the observation window and the sectors, other information regarding the nature of the event, the size of the company and the values of the *ESG* and

Environmental pillar scores were added in order to obtain a complete dataset for analysis.
The dataset is shown in Table 3.7 and refers to the 58 companies for which the CAARs analysis in the event study was significant.
The empirical models assumed are as follows:

$$lnCAARs_i = \beta_0 + \beta_1 \cdot ESG_i + \beta_3 \cdot Sector_i + \beta_4 \cdot EventType_i + \beta_5 \cdot Size_i + \varepsilon_i$$

$$lnCAARs_i = \gamma_0 + \gamma_2 \cdot Environment_i + \gamma_3 \cdot Sector_i + \gamma_4 \cdot EventType_i + \gamma_5 \cdot Size_i + u_i$$

where:

- $lnCAARs_i$= Neperian logarithm of CAARs value for each company from Event study;
- ESG_i = ESG score from Datastream;
- $Environnment_i$= Environment Pillar score from Datastream;
- $Sector_i$= a factor variable relating to the Company's economic sector;
- $EventType_i$ = a factor variable relating to the type of Extreme Climate Event;
- $Size_i$= Full-time Employer as Size proxy for each company from Datastream.
- *Size##EventType*= Interaction between Size and EventType

The results obtained for our model are shown in table 3.8

	(1) *lnCCARs*	(2) *lnCCARs*
Sector	-0.165	-0.0682
	(0.118)	*(0.111)*
ESG	0.0329**	
	(0.0132)	
Size	0.0000485	0.0000450
	(0.0000279)	*(0.0000295)*
EventType	0.430*	0.459*
	(0.234)	*(0.241)*
Size##EventType	-1.628882	0.5000124
	(1.373706)	*(1.340026)*
Environment		0.0165*
		(0.00867)
constant	0.457	0.924
	(0.879)	*(0.855)*
N	19	20
adj. R^2	0.330	0.233

- Standard errors in parentheses
- * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Name	ISN	Event Type	Event Day	CAARS	Sector	ESG_score	Environment	Size
ACEA	IT0001207098	Flooding	2019-05-12	-3.789629872	Utilities	76.86440177	88.47132847	
AMBROMOBILIARE	IT0004779515	Flooding	2019-05-25	-4.398148591	Ass.& Fin.			14241
AS ROMA	IT0001008876	Flooding	2019-05-12	2.812932191	Services			11342
ASSITECA	IT0001012639	Flooding	2019-05-25	6.50121019	Ass.& Fin.			29
ASTALDI	IT0003261069	Flooding	2019-05-12	6.418790793	Construction			
ATLANTIA	IT0003506190	WaterBomb	2018-06-08	-8.39940727	Transp.	78.72986985	82.98406028	132
AUTOSTRADE	IT0000084043	Whirlwind	2018-10-29	-6.925882579	Transp.			25
BEGHELLI	IT0001223277	WaterBomb	2018-06-08	-15.70540949	Manufact.			10896
BPER	IT0000066123	Whirlwind	2019-06-22	4.53581668	Ass.& Fin.	50.75772002	80.50816626	19274
CALTAGIRONE EDIT	IT0001472171	Flooding	2019-05-12	-3.237628941	Services			3266
CARRARO	IT0001046553	Flooding	2019-11-12	3.835618773	Construction			155
CASTA DIVA G.	IT0005003782	Flooding	2019-05-25	-9.221718025	Services			1461
COSTAMP GROUP	IT0005068249	Flooding	2019-05-25	-15.1868121	Manufact.			1436
DATALOGIC .	IT0004053440	WaterBomb	2018-06-08	-20.55985623	Manufact.	25.07368278	25.49107143	3157
DE'LONGHI	IT0003115950	Flooding	2019-11-12	6.647621572	Manufact.	58.01938727	48.05002821	5613
DIGITAL 360	IT0005254252	Flooding	2019-05-25	-2.918437576	Services		0.412371134	723
ENERGICA	IT0005143547	Whirlwind	2019-06-22	9.388480397	Manufact.			10765
ERG	IT0001157020	Flooding	2019-10-15	2.321700465	Utilities	77.46301461	85.07243403	
EXPERT SYSTEM	IT0004496029	Whirlwind	2019-06-22	-5.57388428	Services			
FIERA MILANO	IT0003365613	Flooding	2019-05-25	-3.508027707	Services			80
FNM	IT0000060886	Flooding	2019-05-25	2.905798884	Transp.			27
GAMBERO ROSSO	IT0005122392	Flooding	2019-05-12	4.231599167	Services			367
GEOX	IT0003697080	Flooding	2019-11-12	-7.240164073	Manufact.	52.81767742	50.80390815	3851
GRIFAL	IT0005332595	Flooding	2019-05-25	8.90628207	Manufact.			8409
HERA	IT0001250932	WaterBomb	2018-06-08	33.88410767	Utilities	77.41440751	88.41698842	5246
I.M.A.	IT0001049623	WaterBomb	2018-06-08	-15.69115581	Manufact.	51.82222147	40.28256397	6594
INNOVATEC	IT0005412298	Flooding	2019-05-25	2.557381793	Manufact.			1713
INTRED	IT0005337818	Flooding	2019-05-25	4.694883165	Services			833
IRCE	IT0001077780	WaterBomb	2018-06-08	-15.99045405	Manufact.			100
KOLINPHARMA	IT0005322950	Flooding	2019-05-25	3.746864062	Manufact.			364
MONRIF	IT0000066016	WaterBomb	2018-06-08	-11.17834318	Services			4181
NOEDECORTECH	IT0005275778	Flooding	2019-05-25	-2.380465825	Manufact.			
ORSEO	IT0005138703	Flooding	2019-05-25	-7.139051573	Food Man.			111
PIQUADRO	IT0004240443	WaterBomb	2018-06-08	9.141626851	Manufact.			188
PITECO	IT0004997984	Flooding	2019-05-25	-2.866605893	Services			696
POLIG.PRINTING	IT0004587470	WaterBomb	2018-06-08	6.928084789	Services			184
PORT. SARDEGNA	IT0005305443	Flooding	2019-08-28	3.224654551	Services			
RISANAMENTO	IT0001402269	Whirlwind	2018-10-29	-4.038924457	Ass.& Fin.			150
SAFILO	IT0004604762	Flooding	2019-11-12	10.19810483	Manufact.			
SALINI IMPREGILO	IT0003865570	Flooding	2019-05-12	4.638031137	Construction	64.5933427	77.92968773	642
TISCALI	IT0004513666	Flooding	2019-08-28	-3.731899226	Services	13.86414584		30903
UNIPOL .	IT0004810054	WaterBomb	2018-06-08	41.00402642	Ass.& Fin.	65.30421715	73.96109173	307
UNIPOLSAI	IT0004827447	WaterBomb	2018-06-08	23.01665719	Ass.& Fin.	50.93352022	56.84498102	30903
VALSOIA	IT0001018362	WaterBomb	2018-06-08	-9.035650129	Food Man.			8622
ZIGNAGO VETRO	IT0004171440	Flooding	2019-11-12	5.843824267	Manufact.	26.04483894	37.74873039	1946

The analysis shows that in both models, the logarithms of the CAARs are significantly dependent on the type of event that occurred and on the ESG and Environment Pillar scores, while they are independent of the type of Sector to which the companies belong and of their size.
In particular, the dependence on ESG and Environment scores is of a direct type, since the value of the regression coefficient is positive in both cases: this means that as these scores increase, the logarithms of the CAARs increase linearly.
Therefore, translating the linear dependence of the logarithm of the variable into a power dependence of the variable on a decimal scale, it can be said that if the CAARs are negative, a high value of the ESG and Environment scores makes them more positive and therefore reduces the negative effects of the event, while if the CAARs are positive, the scores exalt the effect.

Chapter 4

4 EMPIRICAL ANALYSIS ON "*ENVIRONMENT*" SCORE

4.1 Analysis of the effect of ESG score on Excess Return

In Chapter 2 it was discussed how to incorporate environmental concerns, alongside social or governance (ESG) concerns, into investment practices in an increasingly popular instrument (SIF, 2007), so- called socially responsible investing.

Undoubtedly, behind the causes of this success, made evident by the growing demand from both institutional and individual investors, is the growing awareness of the risk inherent in such issues (SIF, 2007).

In this section we want to analyse the trade-off between ESG performance, in particular environmental performance, and investment returns; such an analysis is difficult, both theoretically and empirically, mainly because of the multidimensionality of the ESG concept. On the one hand, most empirical evidence suggests that "good" stocks, i.e. with high ESG scores, earn positive abnormal returns (Derwall et al., 2005; Statman and Glushkov, 2009), thus confirming the results obtained in Chapter 3. It is argued that this is because investors underestimate the benefits of ESG or overestimate its costs, i.e. they misjudge the value relevance of ESG concerns, or risk compensation (Derwall et al., 2005). In parallel, some studies, though not many in reality, show that some good stocks earn negative abnormal returns, explaining them as due to mispricing or risk compensation (Derwall and Verwijmeren, 2007).

On the other hand, it is also true that there is strong evidence in the literature that stocks of "sin companies", i.e., in the alcohol, gambling, tobacco, firearms, military and nuclear sectors, also show positive abnormal returns (Statman and Glushkov, 2009; Hong and Kacperczyk, 2009). This is explained as the effect of social norms, as investors with regulatory constraints discriminate against these firms, thus producing a "negligence" premium in their risk-adjusted returns (Hong and Kacperczyk, 2009).

Focusing on the environmental issue, some studies, drawing on a theoretical model developed by Heinkel et al. (2001), argue that under conditions where there is a sufficient number of investors bound by regulations, the lack of opportunities to share risk in the market could lead to an increase in the cost of equity capital, and thus higher expected returns, for the shares of polluting companies, and a lower cost of equity capital for the shares of non-polluting companies.

The controversy about what relative risk-adjusted returns one should expect from ESG investments arises because of the non-exclusivity of the two equity universes: environmentally sustainable companies are generally those with an outstanding score compared to those that are not, at least with regard to the ESG E-factor. At the same time, 'non-virtuous' companies are not necessarily those with the lowest ESG score, but are rather unscored, i.e. ignored by green investors, often simply because of the sector in which they operate, i.e. because of ethical convictions, as may be the case for companies operating in oil & gas, or in energy production from non-renewable sources.

This study aims to understand the link between the excess returns earned by Italian companies, whether positive or negative, and their ESG scores, particularly with regard to environmental aspects.

We will first assess whether there is an association between these ESG scores and the cross-section of stock returns, while controlling for other factors known to explain stock returns, such as beta, size, value and momentum.

The ESG scores used here are based on Thomson Reuters' assessments of Italian companies over a 10-year period, from 2011 to 2020. As large companies are assumed to disclose more ESG information, which is then readily available for investor decision-making, the focus here has been on members of the FTSE MIB 40 and FTSE Italia All-Share indices. Using the members of these two indices also minimised the presence in the dataset of companies for which a score of zero is likely to indicate a lack of rating rather than a neutral ESG performance.

In the remainder of the chapter, after describing how the dataset was constructed, we introduce the empirical model used, based on Fama and MacBeth's (1973) month-by-month cross-sectional regressions of monthly stock returns on the risk factors beta, size, book-to-market and momentum, and report the results of the empirical analyses performed.

Comments on the results are given in the final section of the thesis, which is reserved for conclusions, together with the commentary on the results in the previous chapter.

4.1.1 Criteria for selecting Environment and ESG score data

Measuring ESG concerns is not easy, and measuring them over a long period as required for risk factor analysis is particularly difficult. Therefore, a literature review was conducted to understand which data sources are commonly considered to be the most reliable and functionally useful for analyses of the type conducted in this section.

Some authors (Manescu, 2010) consider the experience of the investment research firm Kinder, Lydenberg and Domini (KLD) Research & Analytics, considered the leading authority on social research and indices for institutional investors (their database is preferred in many empirical analyses of SRI), to be crucial in this respect. Their database includes data collected since 1991 covering seven ESG dimensions (community relations, corporate governance, diversity, employee relations, environment, human rights and product safety). The data come from media articles, corporate documents and direct communications with company officials, as well as government and NGO information and the research process is proprietary: however, the dataset mostly concerns US listed companies and members of the S&P 500 or DS400 index and includes very few Italian companies (for a thorough description of the data see Becchetti and Ciciretti, 2006; Derwall and Verwijmeren, 2007).

The previous year's annual ESG dataset is available for purchase at the end of each January or beginning of February, and is well designed because each ESG dimension is assessed annually on the basis of a set of positive and negative indicators, i.e. strengths and weaknesses, which are given a score of 1 if present, 0 otherwise.

As the KLD dataset could not be used, Thomson Reuters' Refinitiv dataset was chosen.

Thomson Reuters has been expanding its ESG-rated financial data offering since 2009 with the acquisition of Swiss provider Asset4, which focuses on environmental, social and governance data. Since the acquisition, Asset4's ESG rating methodology has been revised and improved. Reuters' ESG team of 165 analysts covers about 1,700 companies in Europe (Lanza et al., 2020), and its time series of ESG scores starts in 2002.

For each company, two scores are compiled, the 'ESG score' and the 'ESG pillar score': for the former a numerical score is provided, for the latter a literal rating. According to Refinitiv, the ESG score measures the performance, commitment and effectiveness demonstrated by companies in relation to the environmental, social and governance dimensions. The ESG Pillar Score is a combined index that integrates the ESG score with an assessment of companies' controversies on ESG issues. The adopted framework divides the three E-S-G pillars into 10 categories, each of which is measured through a variable number of indicators according to the sector they belong to, selected from a set of 178 indicators (Lanza et al., 2020). For this purpose, the 54 'industry groups' of the Thomson Reuters Business Classification (TRBC) are taken as reference. In the study, we made an initial selection of 25 distinct ESG variables focused mainly on environmental data (such as the level of carbon emissions, energy efficiency and more cross-cutting circular economy issues) available for our investment universe of 100 stocks.

Of these, many were eliminated due to the high number of missing data (NaN) while the remaining variables, after further data cleaning, were merged into a single variable called "*E* score" which was used as a proxy for the Environment factor score.
In order to carry out the analyses correctly, the problem of how to deal with the missing data has been raised: there are various approaches to this in the literature, but the unanimous indication that is given is to arrive at a matrix containing only reported values, and therefore without NaN. Some authors (Lanza et al., 2020) suggest achieving this by deleting rows (observations) and columns (ESG variables) containing NaN until the remaining submatrix for the regression is devoid of it. Others (Peters, 2003) pose the problem of excluding as few correctly reported values as possible, however, following this route is not trivial.
In dealing with missing values, care has been taken to try and understand what caused the absence of the data: usually, data is missing either because the variable relating to it is not applicable to the sector being considered or because the company does not report relevant information or because of anomalies in the data download.
Generally it is easy to distinguish between the 3 cases because, in the case of variables not applicable to the type of company considered, the absence of the data occurs also for the other companies belonging to the same sector and, therefore, it is possible to proceed to the removal of the columns related to them in block; while in the case in which the data is missing due to the absence of information provided by the company, the value that is missing is not reported for entire blocks of columns of the only security considered while it is present for companies of the same sector. In this case the reason for the absence could be that the company does not have the resources to report a value even if the value is a good sign of sustainability, or that the company prefers not to report a figure rather than provide bad news. Because of the uncertainty between these diametrically opposed extreme alternatives, in cases such as these the choice was made to eliminate missing information rather than populate NaNs with potentially incorrect values. In the third case, that of download anomalies, the data is presented as an isolated lack surrounded by cells populated with data; a frequent case, for example, is when it was found that a value was not reported for a variable at a certain time but the information was nevertheless reported some time before and/or some time after. In such cases, it was assumed that there was a problem with the way the raw data was handled; in this case, the information was completed by calculating it through linear interpolation with adjacent data. In cases like these, the solutions adopted are different (use an average per sector or an overall average). In this regard, an interesting analysis aimed at finding the ESG "exposure" for a company in order to extrapolate the unreported ESG information is done by Roy Henriksson et al. , (2019) however the methodology was found to be

difficult to apply at a granular level.

After repopulating the dataset where possible, the first step was to include rows and columns without NaNs and then to add the others, excluding the rows or columns with the highest ratio of NaNs to size. Analysis of the robustness of the data confirmed that this approach produced a fairly good result.

The observations of each farm were also grouped and subdivided according to sectors, resulting in another factor matrix that could eventually be used for further linear regression.

The dataset was then completed by adding some economic variables of interest, and in particular Size, understood as full-time employees, the book-to-market ratio, and momentum defined as a simple average of 10 past monthly returns, in order to have four factors known to explain stock returns.

The Refinitiv dataset from Thomson and Reuters was also used for these financial variables.

The data obtained from Refinitiv contains observations of the year of the company, identified from 2010 onwards by their ISIN code. The missing ISINs were obtained by referring to the identification of the company name and ticker with the companies in 2010. Based on these ISINs, associations to the Fields TAGs within the Categories of interest were then obtained.

To ensure that the accounting variables in the financial statements matched the stock returns that were used to explain them, the stock values for all stocks from July in calendar year t-1 (2010-2019) to July in calendar year t (2011-2020) were matched to the returns between the end of the fiscal year of year t-1 (2010-2019) and the end of the fiscal year of year t (2011-2020). The 6-month (minimum) gap between the end of the fiscal year and the return period is conservative, similar to that used by Fama and French (1992).

For ESG variables, the gap between the data collection period and the return period was conservatively set equal to one year as done by most of the literature reviewed; thus ESG values for all securities from the end of the fiscal year of year t - 2 (2009-2018) to the end of the fiscal year of year t -1(2010-2019) were matched with returns between the end of the fiscal year of year t-1 (2010-2019) and the end of the fiscal year of year t (2011-2020).

Market shares at the end of December of year t-1 were used to calculate book-to-market ratios, while the number of full-time employees of the firms in year t gave the firm size. Both variables were updated for each month. Therefore, in order to be included in the performance tests, a company had to have the book value as of 31 December of year t-1 and the market value of the shares as of 30 June of year t available. In addition, to obtain pre-ranking beta estimates, monthly returns for at least 24 months prior to July of year t also had to be available.

Monthly equity returns were obtained on the basis of the Refinitiv Database and the equity excess

return series used in the empirical tests was obtained by subtracting the risk-free rate from the equity return. A proxy for the monthly risk-free rate was obtained from the Germany long term government bond with 10 year maturity taken from K. French's website.
The most sensitive variable in the empirical tests is the estimate of firm β, which was obtained by applying the portfolio grouping technique as in Fama and French (1992).

4.1.2 Criteria for selecting the sample of companies

As mentioned in the previous paragraph, the selection of companies to be included in the sample was based on the assumption that large companies are usually more willing to make themselves available for investor decision-making and therefore disclose more ESG information.
Assuming a sample size of at least 100 companies, additional companies from the FTSE Italia All-Share Index were added to the set of stocks initially selected from the FTSE MIB 40, taking into account their availability in terms of ESG data predicted in Refinitiv.
The selection resulted in a sample of companies belonging to different sectors according to the distribution shown in Table 4.1.

Row Labels	Number of companies
Accommodation and Food Services	**1**
Restaurants	1
Arts, Entertainment, and Recreation	**1**
Movies & Entertainment	1
Construction	**4**
Construction & Engineering	3
Electric Utilities	1
Finance and Insurance	**27**
Asset Management & Custody Banks	5
Consumer Finance	1
Data Processing & Outsourced Services	1
Diversified Banks	11
Life & Health Insurance	2
Multi-line Insurance	3
Other Diversified Financial Services	1
Specialized Finance	3
Information	**7**
Alternative Carriers	1
Broadcasting	2
Integrated Telecommunication Services	2
Publishing	1
Specialized Finance	1

Manufacturing	**40**
Aerospace & Defense	1
Agricultural & Farm Machinery	1
Apparel, Accessories & Luxury Goods	4
Auto Parts & Equipment	2
Automobile Manufacturers	2
Building Products	1
Construction Machinery, Materials & Heavy Trucks	4
Distillers & Vintners	1
Electrical Components & Equipment	1
Electronic Equipment & Instruments	1
Footwear	2
Health Care Equipment	2
Household Appliances	1
Industrial Conglomerates and Machinery	4
Leisure Products	1
Metal & Glass Containers	1
Motorcycle Manufacturers	1
Multi-Sector Holdings	1
Office Services & Supplies	1
Oil & Gas Equipment & Services	2
Oil & Gas Refining & Marketing	1
Packaged Foods & Meats	1
Pharmaceuticals	1
Semiconductors	1
Textiles	1
Tires & Rubber	1
Professional, Scientific, and Technical Services	**1**
IT Consulting & Other Services	1
Real Estate and Rental and Leasing	**1**
Retail REITs	1
Retail Trade and Wholesale Trade	**3**
Health Care Distributors	1
Food Distributors	1
Technology Distributors	1
Transportation and Warehousing	**5**
Airport Services	3
Highways & Railtracks	2
Utilities	**10**
Electric Utilities	1
Gas Utilities	2
Independent Power Producers & Energy Traders	1
Integrated Oil & Gas	1
Multi-Utilities	4
Renewable Electricity	1
Total	**100**

Table 4.1 - Distribution of the sample in the different economic sectors

The classification shown in Table 4.1 uses the Primary North American Industry Classification System (NAICS) Sector Description for classification into sectors and the Primary Global Industry Classification Standard (GICS) Sub-Industry Description for classification into sub-sectors.

4.2 Empirical Methodology

As illustrated in the previous pages, the central objective of this section is to analyze the explanatory power that Environment scores within ESG concerns have for equity returns for Italian companies.

Explanatory power is assessed using cross-sectional regressions of excess stock returns on Environment scores and four factors known to explain stock returns: beta, size, value, and momentum (Manesku, 2010). This model can be understood as an augmented Fama-French three-factor model (Fama and French, 1992) to which the momentum factor identified by Jegadeesh and Titman (1993) is added. The cross-sectional approach could be equivalently replaced by the portfolio approach which analyses only the return differential between high and low-ESG stock portfolios; some authors prefer the former approach to the latter because of interest in the monotonic effect of ESG concerns on stock returns (Manesku, 2010). Furthermore, the use of ex-post returns should complement Derwall and Verwijmeren (2007), who used ex- ante measures of returns, i.e. the implied cost of equity.

As a null hypothesis for the test on the effect of the environment score, the following is set as the four-factor model:

H0: The estimated effect that the Environment Score, or more generally the ESG factor, has on excess stock returns is statistically indistinguishable from zero.

The alternative hypothesis is therefore that:

H1: The estimated effect that the Environment score, or more generally the ESG factor, has on excess stock returns is statistically significant.

The test is therefore a two-tailed test in that it is not possible to hypothesize what the sign of this influence is and therefore whether it is a direct or reverse influence.

The central economic question that cross-sectional regressions can answer is why average returns vary across assets (Cochrane, 2005).

The expected return on an asset should be high if it has a large exposure to factors that carry risk premiums, i.e. market risk or beta, size, book-to-market ratio, or momentum expressed as a simple average of 10 past returns.

The four-factor model with the aggregate Environment variable estimated here is extended as follows.

Model(1):

$$R_{j\,t+1} = \alpha_0^{t+1} + \alpha_1^{t+1} \cdot \hat{\beta}_{j\,t} + \alpha_2^{t+1} \cdot Size_{j\,t} + \alpha_3^{t+1} \cdot BtoM_{j\,t} + \alpha_4^{t+1} \cdot Mom_{j\,t} + \alpha_5^{t+1} \cdot Env_{j\,t} + u_{j\,t+1}$$

where:

- R_{jt+1}= excess stock return for firm *j* in month *t+1;*
- β_{jt}= estimated market risk (beta) of firm j-th;
- $Size_{jt}$ = log of the number of full-time employees in the company;
- $BtoM_{jt}$= book-to-market ratio;
- Mom_{jt} = average return over the previous 10 returns, i.e. over the period from months *t* - 2 and *t* – 12;
- Env_{jt} = aggregate variable Environment
- u_{jt} = i.i.d. error term, with zero mean and constant variance.

In this model Size, the Env variable and the book-to-market ratio are updated monthly (as Galema et al., 2008), while the estimated beta is updated annually and for each asset *j* (*j* = 1...*N*) through a time series regression up to time *t* of the asset returns and the market index return.

The empirical evidence frequently verified in the literature also led to the verification of the significance of the alternative model below.

Model(2):

$$R_{j\,t+1} = \delta_0^{t+1} + \delta_1^{t+1} \cdot \hat{\beta}_{j\,t} + \delta_2^{t+1} \cdot Size_{j\,t} + \delta_3^{t+1} \cdot BtoM_{j\,t} + \delta_4^{t+1} \cdot Mom_{j\,t} + \delta_5^{t+1} \cdot ESG_{j\,t} + \varepsilon_{j\,t+1}$$

where all the terms that appear are the same as in the previous model except that:

- ESG_{jt}= excess stock return for firm *j* in month *t+1;*
- u_{jt} = i.i.d. error term, with zero mean and constant variance.

In both of these models, the coefficients were estimated using the Fama-MacBeth procedure, which allows the calculation of coefficients $\hat{\alpha}_k^{t+1}$ e $\hat{\delta}_k^{t+1}$ con k = 1, 2, 3, 4 time-varying. This procedure is known as *two-step* Fama-MacBeth estimation, because first a time-series regression of individual stock returns on the market index return is estimated to obtain beta estimates, and then these estimates are used as explanatory variables in the cross-sectional regression.

The procedure is explained in detail in the sub-section below.

Some authors (Manesku, 2010) point out that estimation error can be a problem when using this procedure, due to a possible measurement error (sampling variance) in $\hat{\beta}_j$, i.e. the problem of *Errors In Variables* (*EIV*) (Black et al., 1972). The estimation of $\hat{\beta}_j$ in Models (1) and (2) is equal to the sum of the true value, which is unobservable, and a measurement error equal to the sampling variance, denoted v_j, which is assumed to be a random variable i.i.d. with zero mean and variance σ^2. Black et al. (1972) suggest the use of solving methodologies such as the "clustering technique", developed by themselves, which provides consistent N-estimates of $\hat{\alpha}_k^{t+1}$ and $\hat{\delta}_k^{t+1}$was therefore used in what follows.

Most empirical studies on ESG emphasize that the ESG factor is sector-specific and that a comparison between different ESGs can only be made by considering companies in the same sector: for example, companies in one sector might have both high ESG scores and high stock returns, while those in another sector might have low ESG scores and low returns. Without controlling for these sector effects, a false positive association between ESG and returnsmight appear. Conversely, any ESG concerns that might have different effects across sectors would obscure their overall effect. Therefore, equation (1) was also estimated augmented with 9 *Economic Sector* dummies, to control for any confounding effects, as in the main estimation model.

Model(1'):

$$R_{j\,t+1} = \alpha_0^{t+1} + \alpha_1^{t+1} \cdot \hat{\beta}_{j\,t} + \alpha_2^{t+1} \cdot Size_{j\,t} + \alpha_3^{t+1} \cdot BtoM_{j\,t} + \alpha_4^{t+1} \cdot Mom_{j\,t} + \alpha_5^{t+1} \cdot Env_{j\,t} + \sum_{i=1}^{9} \vartheta_i^{t+1} \cdot Sector_{j\,t} + u_{j\,t+1}$$

Model(2'):

$$R_{j\,t+1} = \delta_0^{t+1} + \delta_1^{t+1} \cdot \hat{\beta}_{j\,t} + \delta_2^{t+1} \cdot Size_{j\,t} + \delta_3^{t+1} \cdot BtoM_{j\,t} + \delta_4^{t+1} \cdot Mom_{j\,t} + \delta_5^{t+1} \cdot ESG_{j\,t} + \sum_{i=1}^{9} \gamma_i^{t+1} \cdot Sector_{j\,t} + \varepsilon_{j\,t+1}$$

4.2.1 Fama-MacBeth methodology

Through the Fama-MacBeth methodology, it is possible to estimate the risk premiums associated with the factors to which a particular asset is exposed. Under the assumptions of various pricing models, it is possible to measure the excess returns of a particular asset with respect to a risk factor in the following formulation:

$$R = \beta \cdot \lambda$$

The required excess return R is equal to the product of the reaction coefficient β to the risk factor and the risk premium λ recognised for the exposure to that factor.

Two steps are therefore identified in the Fama-MacBeth procedure:

1. estimation of betas;
2. estimated risk premiums.

The first step is based on the assumption that it is possible to explain the historical returns of a particular asset through a linear relationship with risk factors.

Let m be the number of factors taken into consideration, so that $F_{1,t}$, $F_{2,t}$,...,$F_{m,t}$ indicates the risk factor k at time t. Given n assets, with $i=1,2,...n$, such that $R_{1,t}$,$R_{2,t}$,..., $R_{n,t}$ indicate the historical returns of the n assets at time t, we proceed to estimate the betas for each factor through n Rolling-Window Time Series regressions covering the period t considered:

$$\begin{cases} R_{1\,t} = \alpha_{1\,t} + \beta_{1\,F1} \cdot F_{1\,t} + \beta_{1\,F2} \cdot F_{2\,t} + \ldots + \beta_{1\,Fm} \cdot F_{m\,t} + \varepsilon_{1\,t} \\ R_{2\,t} = \alpha_{2\,t} + \beta_{2\,F1} \cdot F_{1\,t} + \beta_{2\,F2} \cdot F_{2\,t} + \ldots + \beta_{2\,Fm} \cdot F_{m\,t} + \varepsilon_{2\,t} \\ \quad \ldots \\ \quad \ldots \\ R_{n\,t} = \alpha_{nt} + \beta_{n\,F1} \cdot F_{1\,t} + \beta_{n\,F2} \cdot F_{2\,t} + \ldots + \beta_{n\,Fm} \cdot F_{m\,t} + \varepsilon_{m\,t} \end{cases}$$

In matrix form, we express the set of regressions in the following form:

$$R_n = \|F\|\, \beta_n + \varepsilon_n$$

where R_n is a row vector of returns of dimension t $x1$, $\|F\|$ is a matrix of factors t x $(i+1)$, with the elements in the first column equal to 1 as they are associated with the coefficient αn, and β_n a row vector $(i+1)$ x 1, with the elements in the first column equal to the coefficient αn and εn a vector of disturbance terms t x 1.

Through the set of regressions we obtain the estimates of the coefficients $\hat{\beta_i}$, F_k of reaction of the i-th asset to the factor k.

In the second step of the Fama-MacBeth methodology, the risk premiums associated with each factor are estimated *by* carrying out T cross-sectional regressions with cross-sectional units, as follows:

$$\begin{cases} R_{i\,1} = \alpha_1 + \lambda_{1\,1}\beta_{i\,F1} + \lambda_{2\,1}\beta_{i\,F2} + \ldots + \lambda_{m\,1}\beta_{i\,Fm} + o_{1\,t} \\ R_{i\,2} = \alpha_2 + \lambda_{1\,2}\beta_{i\,F1} + \lambda_{2\,2}\beta_{i\,F2} + \ldots + \lambda_{m\,2}\beta_{i\,Fm} + o_{2\,t} \\ \ldots \\ \ldots \\ R_{iT} = \alpha_2 + \lambda_{1\,T}\beta_{i\,F1} + \lambda_{2\,T}\beta_{i\,F2} + \ldots + \lambda_{m\,T}\beta_{i\,Fm} + o_{T\,t} \end{cases}$$

In matrix form, we express the set of regressions in the following form:

$$R_t = \|\beta\|' \lambda_t$$

where R_t is an $n \times 1$ vector of average asset returns at time t, $\|\beta\|'$ is an $n \times (m+1)$ vector of estimated reaction coefficients, with the elements in the first column equal to 1, and λ_t is an $(m+1) \times 1$ vector of risk premia, with the elements in the first column equal to α.

The outcomes of the cross sectional regressions shall generate a number of λ equal T for the m risk factors. The premium λ_k associated with factor k shall be equal to the average of the premiums associated with that factor, calculated over the T periods:

$$\lambda_j = \frac{1}{T} \cdot \sum_{t=1}^{T} \lambda_{j\,t}$$

The significance test on the estimated coefficient can be carried out by considering the test statistic calculated as follows:

$$\lambda_j = \frac{\lambda_{j\,t}}{SQM_j \frac{1}{\sqrt{T}}}$$

4.3 Empirical Evidence for the Regressions

Taking into account what was obtained through the definition of the sample in terms of Environment and ESG score values, the following time-averaged values are obtained for each specific sector of the 9 identified:

Sector	Environment	Social	Governance	ESG Score
Accommodation and Food Services	65.56	78.70	61.94	70.30
Construction	66.45	74.28	50.69	65.01
Finance and Insurance	34.10	46.27	37.13	41.18
Information	30.96	53.72	53.97	50.04
Manufacturing	55.46	62.47	51.77	57.40
Retail & Wholesale Trade	25.38	39.55	44.76	38.22
Services	21.43	34.33	37.44	33.55
Transportation and Warehousing	78.11	76.72	65.97	74.10
Utilities	76.42	70.31	60.28	70.55
Average Value	**48.93**	**57.60**	**48.33**	**53.26**

Table 4.2 - Average values of individual and aggregated ESG factors for different economic sectors

From Table 4.2 it is clear that the sectors with the highest environment factor values are Transport & Warehousing, together with utilities, which have a significant gap between them and the Construction sector, while Retail and Services in general have values of just over 20.

The situation changes slightly when the aggregate ESG factor is considered, as the position occupied by the Accommodation and Food Services sector in the ranking rises sharply, mainly due to the effect of the Social factor, which sees this sector as the one with the highest score. If we want to examine the evolution of the factors considered over time, we can analyze what is shown in figure 4.1 for the Environment factor and 4.2 for the aggregate ESG factor.

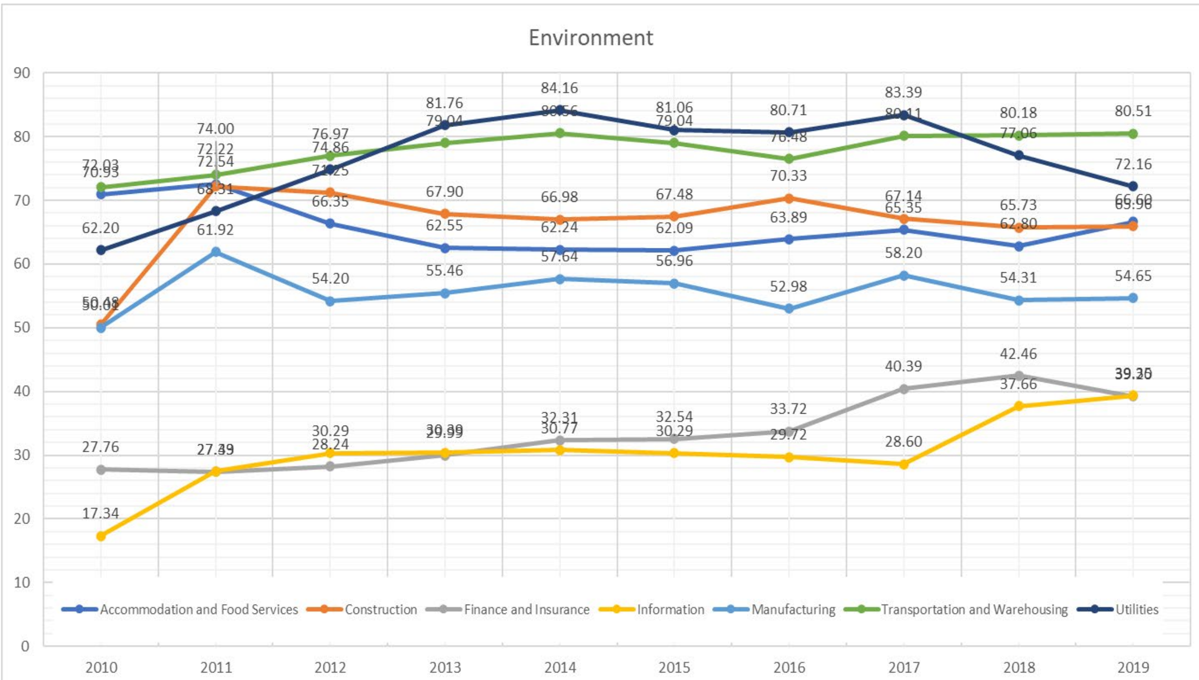

Figure 4.1 – Time series average values of Environment factors for different economic sectors

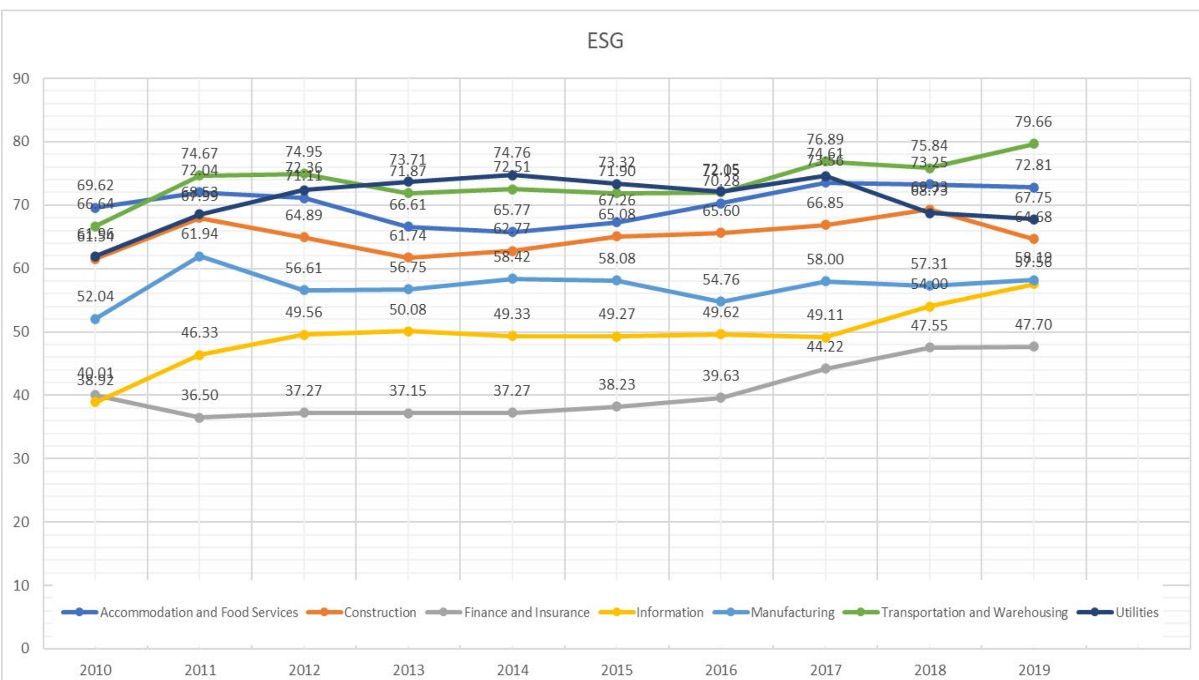

Figure 4.2 – Time series average values of ESG aggregate factors for different economic sectors

From the diagrams, it can be seen that there has been a slow but progressive increase in the values of ESG scores for almost all sectors over the years, with the exception of Utilities, which peaked between 2014 and 2017 and then slightly decreased in value. However, for all sectors, the variation ranges do not exceed 35% over the 10 years considered, and there are moderate, never sharp and discontinuous progressive changes.

Focusing on Models (1') and (2') were estimated using Fama-MacBeth cross-sectional regressions month by month, and while for Model (1') the *Environment score* obtained as reported in paragraph 4.1.1 was used for Model (2') two types of values were used for the ESG variables: one obtained from the Refinivit database as an aggregate ESG Score index directly present in the database and processed by Refinitiv itself, and the other obtained starting from the selected sample by merging the single variables of type "E", "S" and "G" selected from those available in Refinitiv and merged according to the *Principal Component Analysis (PCA)* methodology, so as to have a parameter for comparison with the factor processed by the experts of Thomson and Reuters.

Therefore, three regressions were run: one with Model (1') and two with Model (2').

The first results obtained show full independence from the dummies variables related to economic sectors and the results are difficult to interpret. The explanation for this result is probably to be found in the fact that, as is evident from Table 4.1, the sectors, when exploded, are very heterogeneous within themselves.

This element certainly made it less important to belong to a specific sector. However, following these results it was decided to return to the simplicity of Models (1) and (2), in which the dependence on belonging or not belonging to a specific sector was neglected.

To recapitulate: for the first stage of the Fama-McBeth method, time series rolling regressions were carried out based on a time span of 15 months and from these the time series of market betas for each company analysed was obtained.

Once obtained the latter, we moved on to perform the second stage of the method adding, for each date and for each stock in the portfolio, the data on Book to Market Size and Momentum as previously discussed. With the dataset thus obtained I performed cross-sectional regressions of the returns on the ESG variable, and the other covariates for each date.

Finally, I extrapolated the mean values for the coefficients, and thus for the ESG risk premium; the t-statistics of the coefficients as the standard deviation of each coefficient of the cross-sectional regressions divided by the square root of the number of dates.

The analyses were repeated three times using a different ESG variable each time:

1) for the first cycle of analysis, the Environmental variable obtained from the Refinitiv

data was used as described above;

2) for the second cycle of analysis an ESG variable was used, obtained by conducting a PCA on the three variables Environmental Pillar Score, Social Pillar Score and Governance Pillar Score of Refinitiv;
3) for the third cycle of analysis, the aggregate ESG Score provided by Refinitiv was used.

The results of the regressions are shown in the tables below.

	(1) exReturn	(2) exReturn	(3) exReturn
β	0.527378801***	0.66048525**	0.630830834**
	(0.0000041533)	(0.0000033325)	(0.0000034716)
BtoM	0.013040685***	0.010432226***	0.009120316***
	(0.002908488)	(0.00284172)	(0.002860407)
Size	0.0001265***	0.000123899***	0.000124719***
	(1.27681e-05)	(0.000012838)	(1.29283E-05)
Momentum	-0.0162144933***	-0.019038123***	-0.019434714***
	(3.64012e+09)	(0.002500743)	(0.0025005)
Environment	0.059206752***		
	(0.020728475)		
ESG		0.2352627784***	
		(0.07820592759)	
ESG_Score			2.375391947***
			(0.1195760739)
_cons	1.889678***	-0.4976358	4.423567***
	(0.17923498)	(0.3980913)	(0.1681368)
N	44166	44166	44166
adj. R^2	0.122	0.182	0.178

Standard errors in parentheses
* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Table 4.3 - Average values of individual and aggregated ESG factors for different economic sectors

Over the period 2011-2020, beta, size, book-to-market and momentum explained the cross-section of returns, regardless of the type of ESG factors used.

While Momentum provided a negative coefficient value, the book-to-market and size coefficients were positive, although very low (especially for size.

Regarding ESG variables, in all three cases they seem to have had an effect on equity returns, which was particularly strong when the ESG score provided by Refinitiv was analysed as an aggregate. In all three cases they had a positive effect on equity returns,

Based on what was obtained for the ESG variables, it is therefore possible to reject the null hypothesis of independence of the excess return of Italian equities as a function of the ESG score and confirm a positive effect of this factor on risk.

Conclusions

Researchers have formulated various hypotheses to explain the link between the expected returns of high ESG companies compared to those of conventional companies, relying mainly on two arguments, one purely economic and one based on discriminant taste theory (Statman, 2006). The economic argument shows that having a high ESG score involves both costs and benefits; what is not well defined and what can make the difference is which of the two factors outweighs the other. Furthermore, for costs and benefits to be efficiently reflected in share prices, ESG performance needs to be sufficiently supported by information and this information needs to be made available to the market to be efficiently incorporated.

According to the discriminatory taste argument, on the other hand, the relationship between ESG costs and benefits is of secondary importance, whereas what might affect an investor's propensity to opt for a high ESG security is beyond purely financial factors.

In this case, there might be enough investors who would invest in high ESG securities deriving non-financial utility from them to influence prices regardless of whether ESG is a net cost or a benefit.

In addition, there is a third argument that has attracted less attention, an argument of non-sustainability risk. ESG performance could in fact influence the risk profile of companies by adding a component of non-sustainability risk in addition to market, size, book-to-market and other theoretically and empirically documented systemic risks.

Putting these arguments and their implications for equity returns together, we arrive at three mutually exclusive scenarios for the risk-adjusted returns of high ESG versus low ESG companies, which are briefly discussed below.

Renneboog et al. (2008) provide a critical review of the literature on SRI and discuss in depth the causes and impacts of ESG on shareholder value, among other related issues.

The "*no-effects scenario*" is that there is no difference in the returns, adjusted for common risk factors, of high ESG companies compared to low ESG companies. This is entirely consistent with the efficient markets hypothesis if the ESG performance of firms does not provide relevant pricing information (Statman and Glushkov, 2009). Even if ESG performance does provide relevant pricing information, if this information is publicly available and fully incorporated into asset prices, then there should be no difference in the risk-adjusted returns of ESG and non-ESG firms (Wall, 1995). In this case we cannot distinguish whether ESG costs are higher or

lower than ESG benefits by looking only at stock returns. When controlling for common risk factors in studies of socially responsible (SR) fund performance versus non-SR fund performance, this scenario has generally been confirmed (Bauer et al., 2005).
The "*Mispricing scenario*" predicts that ESG performance has a real impact on companies' cash flows but that this is not efficiently reflected in share prices due to the lack of sufficient information available. This results in higher or lower risk-adjusted returns for high ESG companies, depending on the net benefit of ESG as predicted by the economic argument, which would therefore become the predominant argument in this scenario. In this case then, if the benefits of ESG exceed their costs, but investors, on average, due to lack of adequate information, do not have the perception of this and consistently underestimate the benefits or overestimate the costs, then the risk-adjusted returns of high ESG firms would be higher than those of low ESG firms (Statman, 2006). Thus, in this case, underestimating the benefits of ESG would be reflected in positive earnings surprises (Edmans, 2008) or reduced earnings volatility (Derwall and Verwijmeren, 2007), both of which could lead to mispricing. In a study by Derwall et al. (2005) it was found that high performance relative to the environment during 1995-2003 provided positive abnormal returns, which the scholars interpreted as mispricing. In a sample of multinational corporations, Dowell et al. (2000) also found that companies with high environmental standards had a higher corporate value than the others, as measured by Tobin's Q.
It has also been shown that portfolios built on specific ESG dimensions have positive abnormal returns over long periods (Kempf and Osthoff, 2007).
On the other hand, a completely opposite condition might arise in the case where the benefits from high ESG values are lower than its costs and investors, due to lack of sufficient available information, end up overestimating the benefits or underestimating the costs. In this case, the same economic argument, assuming it becomes the predominant component, would cause the risk-adjusted returns of high ESG companies to be lower. In a study by Barnea and Rubin (2006) it is shown that ESG performance can be a source of agency costs because company managers, in order to gain reputational advantages, receive an incentive to promote ESG investments at the expense of shareholder benefits. In the study cited here the hypothesis is empirically supported by demonstrating the existence of a negative link between insider ownership and the social rating of companies.
The third and last scenario is the *"Risk Factor scenario"*, which interprets the link between expected returns and ESG score by assuming that low ESG companies have higher expected

returns mainly because they are characterised by a non-sustainability risk premium. The ESG rating of a company could indicate its exposure to a non-sustainability risk factor.
In particular, focusing on aspects, this risk factor could include product and business practice risks related to extreme weather events that may have more or less negative influences on them, or the risk associated with changing climatic conditions such as higher temperatures (Dufresne and Savaria, 2004). Apart from weather phenomenology, issues related to decarbonisation policies, energy transition strategies, energy efficiency and CO_2 emission policies might be important. But in addition to climatic aspects, broader environmental factors such as those related to waste, pollution, circular management of natural resources and general environmental impact could be influential. Not to mention the possibility of indirect effects that may also relate to the risk of litigation, investor confidence and other intangible benefits (Becchetti and Ciciretti, 2006; Derwall and Verwijmeren, 2007) that could significantly influence the future financial performance of companies. Taking into account investors' growing awareness of sustainability risk in the most recent period, it is expected that the premium for non-sustainability has increased in recent years.
A systematic distortion of market prices that results in higher expected returns for low ESG (or non-SR) firms may also occur under the discriminatory tastes argument that divestment from certain stocks is done exclusively for moral or ethical reasons (Hong and Kacperczyk, 2009; Derwall and Verwijmeren, 2007). The existence of investors who derive a non-financial benefit from investing in high ESG (i.e., value-based SRI) companies could decrease the demand for the shares of low ESG companies and thus increase their cost of equity capital. Heinkel et al. (2001) developed an equilibrium model in which there is an impact on firms' cost of capital as soon as there is a substantial share of SR investors. Hong and Kacperczyk (2009) showed that higher institutional disinvestment from sin stocks leads to a higher cost of capital for these firms than for others, confirming this alternative argument.
Alternatively, in the risk factor scenario, it may also be that the expected returns of high ESG firms are higher because they may have a premium for some missing risk factors other than the common beta, size, value and momentum factors. This argument has usually been used as an alternative explanation to mispricing for the higher risk-adjusted returns observed for high ESG firms, such as the eco-efficiency premium puzzle (Derwall et al., 2005).
Due to ethical beliefs (values) or a (non) sustainability risk factor, ESG performance could therefore influence expected stock returns, if two conditions are met: ESG performance information must be available to investors, and there must be enough investors who care. As

both of these conditions may change, the effect of ESG performance on equity returns may vary over time.

Regarding the availability of ESG information, the UK Companies Act 2006 holds company directors responsible for disclosing environmental and social information regarding the long-term prospects of companies (Clark and Knight, 2009). According to CorporateRegister.com, a private company specialising in corporate social responsibility monitoring/ESG disclosure, since the mid-1990s more and more companies have started to disclose ESG information (Dhaliwal et al., 2009). Dhaliwal et al. argue that the increase in voluntary ESG disclosures may have to do with increased scrutiny of corporate impact on society following the loss of trust after the series of corporate scandals in the early 2000s. Finally, KPMG (2008) reports that 80% of the world's 2200 largest companies published an ESG report in 2008 or integrated ESG information into their annual reports.

Regarding the number of socially responsible investors, Haigh and Hazelton (2004) question the existence of a high number, while Hong and Kacperczyk (2009) argue the opposite. Epstein and Freedman (1994) interviewed a random sample of average individual investors and found that they too wanted ESG information, not just institutional investors. Respondents mainly wanted information on environmental performance and product quality. Empirical studies also show the market reaction to the disclosure of such information (Patten, 1990), confirming that investors care.

In the light of these few pages, it is perhaps easier to interpret the results obtained in Chapters 3 and 4 in which the empirical analyses of interest for the purpose of this paper were conducted. The analysis carried out in Chapter 3 was aimed at testing the existence of an effect of extreme weather events on the stock returns of companies affected by the consequences of such events and was conducted through a carefully prepared event study.

The analysis revealed that the CAARs were significant at a significance level of 5% in 58 out of 72 cases: thus a significant effect of the event was detected in a rather large portion of the cases. The raw data obtained in this way, although interesting, did not make it possible to obtain more accurate indications on how and why this dependence is actually expressed.

It was therefore decided to deepen the analysis by creating a dataset in which the value of the CAARs obtained was associated with each company and other information was added in the form of additional variables of another type:

1) variables linked to the event and the context in which it takes place, which would allow the data to be differentiated on the basis of the type of event and industry concerned

2) variables that would give me indications on how the specific company interfaces with environmental and ESG aspects in general, introducing the Environment score and the aggregate ESG score and obtaining with each of them a different model to test.

The multilinear regression analysis carried out on this dataset showed that in both models obtained, the logarithms of the CAARs are significantly dependent on the type of event that occurred and on the scores of the ESG and Environment pillars, while they are independent of the type of Sector they belong to, the size of the companies and the interaction between Sector and type of event.

It can therefore be said that, when the response is differentiated according to the type of event and the specificity of the company, especially according to how the company interfaces with environmental and sustainability issues in general, the market proves to be rather sensitive to such events and ready to price their effects.

And the behaviour of the market seems to be in line with what one would expect: the value of the regression coefficient is positive both for the ESG score and for the Environment, therefore, the dependence is of a direct type in both cases: this means that as these scores increase, the logarithms of the CAARs increase linearly and therefore there is a power type dependence between the variables on a decimal scale.

For companies, having high ESG and Environment scores concretely means reducing the negative effects of risk from adverse climate events and increasing the gain in case the event turns into a favourable event for the company itself, since a higher Environment score enhances the positive effect on CAARs.

This, from a strategic perspective, would mean using the focus on environmental issues to competitive advantage: Aware of this result, companies that want to extend their assets and invest in new plants can elaborate positioning strategies for their production realities that take into account these aspects, while in the case of already positioned plants, investing in policies to increase the ESG score, among other achievable advantages, could allow them to absorb the impact of events whose frequency, with the passing of time, will probably tend to increase, or even gain a competitive advantage over companies with low ESG.

As for the survey conducted in Chapter 4, the results show that, during the period 2011-2020, there was a positive association between candidate ESG variables and risk-adjusted stock returns.

The elements to be considered in reality appear multiple: thinking of the scenarios illustrated at the beginning of the paragraph it would seem to be in the case of a Mispricing Scenario; in particular it seems to occur in the case where the benefits of ESG exceed their costs, but investors, on average, due to lack of adequate information, do not have the perception of this and consistently underestimate the benefits or overestimate the costs, then the risk-adjusted returns of high ESG firms would be higher than those of low ESG firms.

This explanation is well suited to the Italian situation in which ESG has only recently come to the fore and is a factor that takes on strategic importance above all for large companies in an international context, a scenario that is quite far removed from the Italian one made up of small and medium-sized enterprises and few really large companies.

The composition of the Italian productive and industrial fabric, made up of small and medium-sized companies, could also make companies with high ESG more risky in the eyes of investors because they are seen as more cyclical, i.e. more positively correlated with GDP growth or other indicators linked to national or local macroeconomic variables.

Moreover, these results could be partly due to the systematic distortion of market prices highlighted above and attributed to the discriminatory tastes argument that results in divestment from certain stocks is done exclusively for moral or ethical reasons. Thus the recent widespread attention to environmental and circular issues may have led to the spread of investors who derive a non-financial benefit from investing in high ESG companies and a decrease in the demand for the shares of low ESG.

It would certainly be advisable to investigate the empirical elements underlying each of these lines of enquiry with appropriate analyses: in particular, it would be necessary to understand whether the dependencies observed are dynamic and have evolved over time, and whether it is therefore possible to subdivide the time span analysed, which extends over 10 years, into shorter sub-periods for which different behaviours are observed.

It could be possible to verify whether the mispricing hypothesis is indeed confirmed using methodologies such as the test of Charoenrook and Conrad (2005) through the technique of simulated portfolios. But all these may represent useful hints for further future research developments.

Bibliography

Abraham Lioui – Is ESG Risk Priced? 2018

Abramson, L., & Chung, D. (2000). Socially responsible investing: Viable for value investors? Journal of Investing, 9(3), 73–80.

Aggarwal, P. (2013). Sustainability reporting and its impact on corporate financial performance: A literature review. Indian Journal of Commerce & Management Studies, 4(3).51-59.

Aggarwal, R., Erel. I., Stulz, R., & Williamson.R. (2007). Do US Firms Have the Best Corporate Governance? A Cross-Country Examination of the Relation between Corporate Governance and Shareholders Wealth. Finance Working Paper #145/2007 of the European Corporate Governance Institute.

Addoum Jawad M., David T. Ng and Ariel Ortiz-Bobea – Temperature Shocks and Earnings News, 2018

Ahn DH, Conrad J, Dittmar RF. 2005. Basis assets. Review of Financial Studies 22: 5133–5174.

Amihud Y, Christensen BJ, Mendelson H. 1992. Further evidence on the risk-return relationship. Research Paper, Stanford University 1248: [Accessed 19.04.2010].

Arbel A, Carvell S, Strebel P. 1983. Giraffes, institutions and neglected firms. Financial Analysts Journal 39: 2–8.

Aktas, N., De Bodt, E., & Cousin, J. G. (2011). Do financial markets care about SRI? Evidence from mergers and acquisitions. Journal of Banking & Finance,35(7), 1753- 1761.

Al-Najjar, B., & Anfimiadou, A. (2012). 'Environmental Policies and Firm Value', Business Strategy and the Environment, vol.21, 49-59

Angel, J.J., Rivoli, P., 1997. Does ethical investing impose a cost upon the firm? A... Journal of Investing 6, 57.

Arellano, M. (2003). Panel Data Econometrics, Oxford University Press: Advanced Texts in Econometrics, Oxford.

Aupperle, K., Carroll, A. & Hatfield, J. (1985). An Empirical Examination of The Relationship Between Corporate Social Responsibility and Profitability. Academy of Management Journal, Vol. 28, pp. 446–63.

Aust, D. N. (2013).Enhancing Shareholder Value by Improving Sustainability Performance.Corporate Finance Review, 17, 6; 11-15.

Barnea A, Rubin A. 2006. Corporate social responsibility as a conflict between shareholders. EFA 2006 Zurich Meetings

Bauer R, Koedijk K, Otten R. 2005. International evidence on ethical mutual fund performance and investment style. Journal of Banking and Finance 29: 1751–1767.

Becchetti L, Ciciretti R. 2006. Corporate social responsibility and stock market performance.

CEIS Working Paper 79

Black F, Jensen M, Scholes M. 1972. The capital asset pricing model: Some empirical tests. In Jensen M (ed.) Studies in the Theory of Capital Markets. Praeger Publishers, 72–194.

Blanc, Elodie, and Wolfram Schlenker, The use of panel models in assessments of climate impacts on agriculture, Review of Environmental Economics and Policy 11, 258-279, 2017.

Banz, R.W., 1981. The relationship between return and market value of common stocks. Journal of Financial Economics 9, 3–18.

Bassen, A., & Kovàcs, M. (2008). 'Environmental, Social and Governance Key Performance Indicators from a Capital Market Perspective', ZeitschriftfürWirtschafts- und Unternehmensethik, vol.9, no.2, 182-192

Bassen, A., Meyer, K., & Schlange, J. (2006). The influence of corporate responsibility on the cost of capital. Available at SSRN 984406.

Bauer, R., & Hann, D. (2010).Corporate Environmental Management and Credit Risk.ECCE Working Paper. University Maastricht, the European Centre for Corporate Engagement.

Bauer, R., Gunster, N. & Otten, R. (2004). Empirical Evidence on Corporate Governance in Europe: The Effect on Stock Returns, Firm Value and Performance. Journal of Asset Management, Vol. 5, August, 91-104.

Bebchuk, L., Cohen, A., & Ferrell, A. (2010). 'What Matters in Corporate Governance?',The Review of Financial Studies, vol.22, no.2, 783-827

Bhojraj, S., & Sengupta, P. (2003). Effect of Corporate Governance on bond ratings and yields: The role of institutional investors and outside directors. Journal of Business, 76(3), 455-475.

Bradley, M., Dallas, G. S., Snyderwine, E., & Chen, D. (2008). The effects of corporate governance attributes on credit ratings and bond yields. Available at SSRN 1327070.

Brammer, S., C. Brooks & S. Pavelin (2006). Corporate social performance and stock returns: UK evidence from disaggregate measures, Financial Management 35, 97–116.

Bursa Malaysia (2007).Corporate social responsibility (CSR) framework for Malaysian public listed companies. Retrieved from http://www.csr-weltweit.de/uploads/tx_jpdownloads/Bursa_Malaysia_01.pdf

Caplan, L., Griswold, J.S., & Jarvis, W.F. (2013).From SRI to ESG: The Changing World of Responsible Investing. Retrieved from https://www.commonfund.org /InvestorResources/publications/White%20Papers/Whitepaper_SRI%20to%20ESG%202013 %200901.pdf

Carhart, M.M., 1997. On Persistence in Mutual Fund Performance. The Journal of Finance 52, 57–82.

Cheung, A. W. K. (2011). Do stock investors value corporate sustainability? Evidence from an event study. Journal of Business Ethics, 99(2), 145-165.

Cho, C. H., Roberts, R. W., & Patten, D. M. (2010).The language of US corporate environmental disclosure. Accounting, Organizations and Society,35(4), 431-443.

Clark, G. L., Feiner, A., & Viehs, M. (2014). From the Stockholder to the Stakeholder: How

Sustainability Can Drive Financial Outperformance. Available at SSRN 2508281.

Clarkson, L. Richardson, & Vasvari (2008) Clarkson, PM, Li, Y., Richardson, GD, & Vasvari, FP (2008).Revisiting the relation between environmental performance and environmental disclosure: An empirical analysis. Accounting, Organizations and Society, 33(4), 303-327.

Cormier, D., & Magnan, M. (2003). Environmental reporting management: a continental European perspective. Journal of Accounting and public Policy, 22(1), 43-62.

Cox, P., Brammer, S., & Millington, A. (2007).Pension fund manager tournaments and attitudes towards corporate characteristics.Journal of Business Finance and Accounting, 34(7), 1307–1326.

Cremers, K. J. M., & . B. Nair (2005). Governance mechanisms and equity prices, Journal of Finance 60, 2859-2894.

Crisóstomo, V. L., Freire, F.S. & Vasconcellos, F.C, (2011), "Corporate social responsibility, firm value and financial performance in Brazil", Social Responsibility Journal, 7 (2). 295 – 309

Charoenrook A, Conrad J. 2005. Identifying risk-based factors. AFA 2006 Boston Meetings Paper

Chatterji A, Brooks C, Pavelin S. 2008. How well do social ratings actually measure corporatesocial responsibility? Journal of Economics and Management Strategy 18: 125–169.

Clark G, Knight E. 2009. Institutional investors, the political economy of corporate disclosure, and the market for corporate environmental and social responsibility: Implications from the uk companies act. U. of Pennsylvania Journal of Business Law 11: 259–296.

Cochrane J. 2005. Asset Pricing. Princeton University Press.

Derwall J, Gunster N, Bauer R, Koedijk K. 2005. The ecoefficiency premium puzzle. Financial Analysts Journal 61: 61–63.

Derwall J, Verwijmeren P. 2007. Csr and the cost of equity capital. In Derwall J (ed.) The Economic Virtues of SRI and CSR. Haveka, 193–213.

Dhaliwal D, Li OZ, Tsang A, Yang YG. 2009. Voluntary non-financial disclosure and the cost of equity capital: the case of corporate social responsibility reporting. Working Paper

Dowell G, Hart S, Yeung B. 2000. Do corporate global environmental standards create or destroy market value? Management Science 46: 1059–1074.

Dufresne F, Savaria P. 2004. Corporate social responsibility and financial risk. Journal of Investing 13: 57–66.

Dell, Melissa, Benjamin F Jones, and Benjamin A Olken, Temperature shocks and economic growth: Evidence from the last half century, American Economic Journal: Macroeconomics 4, 2012, 66-95.

Dembinski, P., Bonvin, J.-M., Dommen, E., & Monnet, F. (2003).The ethical foundations of responsible investment.Journal of Business Ethics, 48(2), 203–213.

Derwall, J., N. Guenster, R. Bauer, & K.C.G. Koedijk (2005).The eco-efficiency premium *puzzle, Financial Analysts Journal 61, 51–63.*

Dunfee, T. W. (2003). Social investing: Mainstream or backwater? Journal of Business Ethics, 43(3), 247–252.

Easley, D. & O'Hara, M. (2004).Information and the cost of capital.Journal of Finance, 59: 1553–1583.

Eccles, N. S., & Viviers, S. (2011). The origins and meanings of names describing investment practices that integrate a consideration of ESG issues in the academic literature.Journal of Business Ethics, 104: 389–402.

Eccles, R. G., Ioannou, I., & Serafeim, G. (2014).The impact of corporate sustainability on organizational processes and performance. Management Science, 60(11), 2835-2857.

Edmans, A., 2011. Does the stock market fully value intangibles? Employee satisfaction and equity prices. Journal of Financial Economics 101, 621–640.

Eccles, R.G., Ioannou, I., Serafeim, G., 2012. The Impact of a Corporate Culture of Sustainability on Corporate Behavior and Performance. National Bureau of Economic Research Working Paper Series No. 17950.

El Ghoul, S., Guedhami, O., Kwok, C.C.Y., Mishra, D.R., 2011. Does corporate social responsibility affect the cost of capital? Journal of Banking & Finance 35, 2388–2406.

Edmans A. 2008. Does the stock market fully value intangibles? employee satisfaction and equity prices. Working paper Series at the R.L. White Center for Financial Research 16-07

Epstein M, Freedman M. 1994. Social disclosure and the individual investor. Accounting, Auditing and Accountability Journal 7: 94–109.

Fama E, French K. 1992. The cross-section of expected returns. Journal of Finance 47: 426–465.

Fama E, French K. 1993. Common risk factors in the returns of stocks and bonds. Journal of Financial Economics 33: 3–56.

Fama E, MacBeth J. 1973. Risk, return and equilibrium: Empirical tests. Journal of Political Economy 81: 607–636.

Friend I, Blume M. 1970. Measurement of portfolio performance under uncertainty. American Economic Review 60: 561–575.

Fisher-Vanden, K., & Thorburn, K. S. (2011).Voluntary corporate environmental initiatives and shareholder wealth. Journal of Environmental Economics and management, 62(3), 430-445.

Flammer, C. (2013a). Corporate social responsibility and shareholder reaction: The environmental awareness of investors. Academy of Management Journal, 56(3), 758- 781.

Flammer, C. (2013b). Does Corporate Social Responsibility Lead to Superior Financial Performance? Working Paper. University of Western Ontario.

Francesco, A. J., & Levy, D. (2008).The impact of sustainability on the investment environment. Journal of European Real Estate Research, 1(1), 72-87.

Francis, J., Nanda, D. & Olsson, P. (2008).Voluntary disclosure, earnings quality, and cost of capital.Journal of Accounting Research, Vol. 46 No. 1, 53-88.

Freeman, R.E., 1984. Strategic management: A stakeholder approach. Cambridge University Press, Cambridge.

Friedman, M., 1970. The Social Responsibility of Business is to Increase its Profits. New York Times Magazine.

Galema R, Plantinga A, Scholens B. 2008. The stocks at stake: return and risk in socially responsible investment. Journal of Banking and Finance 32: 2646–2654.

Garriga, E., Melé, D., 2004. Corporate Social Responsibility Theories: Mapping the Territory. Journal of Business Ethics 53, 51–71.

Gentry, R. J., & Shen, W. (2010). The relationship between accounting and market measures of firm financial performance: How strong is it? Journal of managerial issues, 514-530.

Giannarakis, G. (2013). Determinants of corporate social responsibility disclosures: the case of the US companies. International Journal of Information Systems and Change Management, 6(3), 205-221.

Godfrey, P. C., Merrill, C. B., & Hansen, J. M. (2009). The relationship between corporate social responsibility and shareholder value: An empirical test of the risk management hypothesis. Strategic Management Journal, 30(4), 425-445.

Gompers, P. A., J. L. Ishii, & A. Metrick, (2003).Corporate governance and equity prices, Quarterly Journal of Economics 118, 107-155.

Goss, A., & Roberts, G. S. (2011).The impact of Corporate Social Responsibility on the cost of bank loans.Journal of Banking and Finance, 35, 1794-1810.

Gompers, P., Ishii, J., Metrick, A., 2003. Corporate Governance and Equity Prices. Quarterly Journal of Economics 118, 107.

Ghassane Benmir, Ivan Jaccard, Gauthier Vermandel – Green Asset Pricing, ECB Working Paper Series N°2477, 2020.

Graff Zivin, J., Small, A., 2005. A Modigliani-Miller Theory of Altruistic Corporate Social Responsibility. B.E. Journal of Economic Analysis & Policy: Topics in Economic Analysis & Policy 5, 1–21.

Graham, J.R., Harvey, C.R., & Rajgopal, S. (2005). The economic implications of corporate financial reporting.Journal of Accounting and Economics, 40: 3–37.

Gregory Birth, Laura Illia, Francesco Lurati, Alessandra Zamparini, 2008. Communicating CSR: practices among Switzerland's top 300 companies. Corporate Communications: An International Journal 13, 182–196.

Griffin, J.J. & Mahon, J.F. (1997). The corporate social performance and corporate financial performance debate: twenty-five years of incomparable research, Business and Society, Vol. 36 No. 1, 5-31.

Haigh M, Hazelton J. 2004. Financial markets: A tool for social responsibility? Journal of Business Ethics 52: 59–71.

Heinkel, Kraus A, Zechner J. 2001. The effect of green investment on corporate behavior. Journal of Financial and Qantitative Analysis 36: 431–449.

Hong H, Kacperczyk M. 2009. The price of sin: the effects of social norms on markets. Journal *of Financial Economics 93: 15–36.*

Hirshleifer, David, and Tyler Shumway, Good day sunshine: Stock returns and the weather, Journal of Finance 58, 2003, 1009-1032.

Hong, Harrison G, Frank Weikai Li, and Jiangmin Xu, Climate risks and market efficiency, Journal of Econometrics (forthcoming).

Hsiang, Solomon, et al., 2017, Estimating economic damage from climate change in the United States, Science 356, 2017, 1362-1369.

Hsiang, Solomon M, Temperatures and cyclones strongly associated with economic production in the Caribbean and Central America, Proceedings of the National Academy of sciences 107, 2010, 15367-15372.

Hamilton, J. 1995. Pollution as news: Media and stock market reactions to the toxic release inventory data. Journal of Environmental Economics and Management. 28:98-113.

Hong, H., Kacperczyk, M., 2009. The price of sin: The effects of social norms on markets. Journal of Financial Economics 93, 15–36.

Horváthová, E., 2010. Does environmental performance affect financial performance? A meta-analysis. Ecological Economics 70, 52–59.

Harjoto, M.A. & Jo, H. (2014). Legal vs. Normative CSR: Differential Impact on Analyst Dispersion, Stock Return Volatility, Cost of Capital, and Firm Value. Journal of Business Ethics. 128, 1–20.

Haryono, U., Iskandar,R. (2015) Corporate Social Performance and Firm Value, International Journal of Business and Management Invention, ISSN (Online): 2319 – 8028, ISSN (Print): 2319 – 801X www.ijbmi.org || Volume 4 Issue 11 || November. 2015 || PP-69-75 www.ijbmi.org 69 .

Healy, P.M. & Palepu, K.G. (2001). Information asymmetry, corporate disclosure, and the capital markets: a review of the empirical disclosure literature. Journal of Accounting and Economics, Vol. 31 Nos 1-3, 405-40.

Ingram, R. & Frazier, K. (1980). Environmental Performance and Corporate Disclosure. Journal of Accounting Research, Vol. 18 No. 2, pp. 614–621.

Jang, J. I., Lee, K., & Choi, H. S. (2013). The relation between corporate social responsibility and financial performance: Evidence from Korean firms. Pan - Pacific Journal of Business Research, 4(2), 3-17.

Kang, K.H., Lee, S., Huh, C., 2010. Impacts of positive and negative corporate social responsibility activities on company performance in the hospitality industry. International Journal of Hospitality Management 29, 72–82.

Jensen, M.C., Meckling, W.H., 1976. Theory of the firm: Managerial behavior, agency costs and ownership structure. Journal of Financial Economics 3, 305–360.

Jensen, M.C., 1986. Agency Costs of Free Cash Flow, Corporate Finance, and Takeovers. American Economic Review 76, 323.

Kent D. Daniel, Robert B. Litterman, Gernot Wagner – Applying asset pricing theory to calibrate the price of climate risk, working paper 22795, National Bereau of economic research, Noveber 2016, 2018.

Karydas, Christos; Xepapadeas, Anastasios: Pricing climate change risks: CAPM with rare disasters and stochastic probabilities, Economics Working Paper Series, No. 19/311, ETH Zurich, CER-ETH - Center of Economic Research, Zurich, 2019.

Leila Bennani, Théo Le Guenedal, Frederic Lepetit, Lai Ly, Vincent Mortier, Thierry Roncalli, Takaya Sekine – How ESG investing has impacted the asset pricing in the equity market, Discussion Paper – 36 2018 Amundi research team, CROSS ASSET Investment Strategy.

Mohamed Ben Slimane, Dany Da Fonseca, Vivek Mahtani – Facts and Fantasies about Green Bond Premium, Working Paper 102 2020, Amundi Asset Management.

Christina E. Bannier Yannik Bofinger Björn Rock – Doing safe by doing good : Risk and Return of ESG Investing in the US and Europe. CFS Working Paper Series No. 621 2019.

Julia L. Pollard, Matthew W. Sherwood and Ryan Grad Klobus – Establishing ESG as Risk Premia, The Journal Of Investment Management · January 2018

Edvin Berg and Karl Wilhelm Lange - Enhancing ESG-Risk Modelling A study of the dependence structure of sustainable investing.

Théo Roncalli, Théo Le Guenedal, Frédéric Lepetit, Thierry Roncalli and Takaya Sekine , Measuring and Managing Carbon Risk in Investment Portfolios, 2020

Thierry Roncalli – The Alpha and Beta of ESG Investing – Amundi Asset Management RIA Conference, Montréal , 2019.

Robert F. Engle Iii Stefano Giglio Bryan T. Kelly Heebum Lee Johannes Stroebel- Hedging Climate Change News, Working Paper 25734, National Bureau Of Economic, 2019

Jegadeesh N, Titman S. 1993. Returns to buying winners and selling losers: Implications for stock market efficiency. The Journal of Finance 48: 65–91.

Jensen M. 1969. Risk, the pricing of capital assets, and the evaluation of investment portfolios. Journal of Business 42: 167–247.

Kempf A, Osthoff P. 2007. The effect of socially responsible investing on portfolio performance. European Financial Management 13: 908–922.

Kinder P. 2005. Socially responsible investing: an evolving concept in a changing world

MacKinley A. 1995. Multifactor models do not explain deviations from the capm. Journal of Financial Economics 38: 3–28.

Merton R. 1987. A simple model of capital market equilibrium with incomplete information. Journal of Finance 42: 483–510.

Patten D. 1990. The market reaction to social responsibility disclosures: The case of the Sullivan principles signing. Accounting Organisations and Society 15: 515–87.

Renneboog L, Horst JT, Zhang C. 2008. Socially responsible investments: institutional aspects, performance, and investor behavior. Journal of Banking and Finance 32: 1723–1742. SIF. 2007. 2007

Statman M. 2006. Socially responsible indexes. Journal of Portfolio Management 32: 100–109.

Statman M, Glushkov D. 2009. The wages of social responsibility. Financial Analysts Journal 65: 33–46.

Wall L. 1995. Some lessons from basic finance for effective socially responsible investing. Economic Review - Federal Reserve Bank of Atlanta 80: 1–12.

Kim, J., Chung, S., & Park, C. (2013).Corporate Social Responsibility and Financial Performance: The impact of the MSCI ESG Ratings on Korean Firms. Journal of the Korea Academia-Industrial Cooperation Society. Vol. 14, No. 11, 5586-5593

Koellner, T., Sangwon, S., Weber, O., Moser, C., & Scholz, R. W. (2007). Environmental impacts of conventional and sustainable investment funds compared using input output life-cycle assessment. Journal of Industrial Ecology, 11(3), 41–60.

Kurtz, L., 2005. Answers to Four Questions. Journal of Investing 14, 125–139.

Lanis, R. & Richardson, G. (2013). Corporate social responsibility and tax aggressiveness: a test of legitimacy theory. Accounting, Auditing & Accountability Journal. Vol. 26 No. 1, 2013, 75-100.

Lemmon, M. L., & Lins, K. V. (2003). Ownership structure, corporate governance, and firm value: Evidence from the East Asian financial crisis. The Journal of Finance, 58(4), 1445-1468.

Mackenzie, C., & Lewis, A. (1999). Morals and markets: The case of ethical investing.Business Ethics Quarterly, 9(3), 439–452.

Mackey, A., Mackey, T.B., Barney, J.B., 2007. Corporate social responsibility and firm performance: investor preferences and corporate strategies. Academy of Management Review 32, 817–835.

Margolis, J., Elfenbein, H., Walsh, J., 2007. Does it pay to be good ? A meta-analysis and redirection of research on the relationship between corporate social and financial performance, Working Paper Harvard University

McWilliams, A., Siegel, D., 1997. Event studies in management research: theoretical and empirical issues. Academy of Management Journal 40, 626–657.

Ming, L. W., Zhi, Y.F., & Hua, W.H. (2013).Corporate Social Responsibility and Cost of Equity Capital: A Global Perspective, https://business.illinois.edu/zimmerman/wp-content/uploads/sites/ 56/2015/08/046-Feng.pdf

Mishra, S., & Suar, D. (2010). Does corporate social responsibility influence firm performance of Indian companies?. Journal of Business Ethics, 95(4), 571-601.

Myers, S.C., 1977. Determinants of Corporate borrowing. Journal of Financial Economics 5, 147–175.

Ohlson, J.A., 1995. Earnings, Book Values, and Dividends in Equity Valuation. Contemporary Accounting Research 11, 661–687.

Orlitzky, M., Schmidt, F.L., Rynes, S.L., 2003. Corporate Social and Financial Performance: A Meta-Analysis. Organization Studies 24, 403–441.

Porter, M.E., 1991. America's green strategy. Scientific American 264, 168.

Porter, E.M., & Kramer, R.K. (2011). 'Creating Shared Value', Harvard business review, January 2011, 62-77

Prior, D., Surroca, J., & Tribó, J. A. (2008). Are socially responsible managers really ethical?

Exploring the relationship between earnings management and corporate social responsibility. Corporate Governance: An International Review,16(3), 160-177.

Saleh, M., Zulkifli, N & Muhamad, R. (2011).Looking for evidence of the relationship between corporate social responsibility and corporate financial performance in an emerging market.Asia-Pacific Journal of Business Administration, Vol. 3 No. 2, 2011, pp.165-190.

Schauten, M. B. J., & van Dijk, D. (2011). Corporate Governance and the Cost of Debt of large European firms.Working Paper.RSM Erasmus University and Erasmus School of Economics.

Schwartz, M. S. (2003). The ''ethics'' of ethical investing.Journal of Business Ethics, 43(3), 195–231.

Scott, D. L. (2003). Wall Street Words: An A to Z Guide to Investment Terms for Today's Investor. Boston: Houghton Mifflin Company.

Securities Commision (2004).Speeches by Other Dignitaries at SC Events. Retrieved from http://www.sc.com.my/post_archive/special-address-by-ybhg-tan-sri-nor-mohamed- yakcop-second-finance-minister-of-malaysia-at-the-corporate-social-responsibility- conference-csr-creating-greater-competitive-advantage-csr-sri/

Sekaran, U. & Bougie, R. (2009).Research Method for Business, a Skill Building Approach.Wiley, Singapore.

Servaes, H. and Tamayo, A. (2013) The impact of corporate social responsibility on firm value: the role of customer awareness. Management Science, 59(5), 2013, 1045-1061.

Siagian, F., Siregar, S. V., & Rahadian, Y. (2013). Corporate governance, reporting quality, and firm value: evidence from Indonesia. Journal of Accounting in Emerging Economies, 3(1), 4-20.

Simpson, W. G., & Kohers, T. (2002). The link between corporate social and financial performance: evidence from the banking industry. Journal of Business Ethics, 35(2), 97-109.

Statman, M. (2008). Quiet conversations: The expressive nature of socially responsible investors. Journal of Financial Planning, 21(2), 40–46.

Thamotheram, R., & Wildsmith, H. (2007). Increasing long-term market returns: Realising the potential of collective pension fund action. Corporate Governance: An International Review, 15(3), 438–454.

The Star (2014).Bursa to introduce Environmental, Social and Governance Index. Retrieved from http://www.thestar.com.my/Business/Business-News/2014/06/ 10/Bursa-to-introduce-more-products-The-sophisticated-products-include-Environmental -Social- and/?style=biz

The Star (2015).ValueCap's RM1b ESG fund to be launched by June, says Najib. Retrieved from http://www.thestar.com.my/Business/Business-News/2015/04/23/ ValueCaps- RM1b-ESG-fund-to-be-launched-by-June-says-Najib/?style=biz

UN PRI (2015a). About the PRI Initiatives. Retrieved from http://www.unpri.org/about-pri/about-pri/

UN PRI (2015b). Signatories to the Principles for Responsible Investment. Retrieved from http://www.unpri.org/signatories/signatories/

Van der Laan, G., Van Ees, H., & Van Witteloostuijn, A. (2008). Corporate social and *financial performance: An extended stakeholder theory, and empirical test with accounting measures. Journal of Business Ethics, 79(3), 299-310.*

Viviers, S., Bosch, J. K., Smit, E. V. M., & Buijs, A. (2009). Responsible investing in South Africa. Investment Analysts Journal, (69), 3-16.

Waddock, S., & Graves, S. (1997). The corporate social performance-financial performance link.Strategic Management Journal 18, 303-319.

Weber, O. (2005). Sustainability benchmarking of European banks and financial serviceorganizations. Corporate Social Responsibility and Environmental Management, 12(2), 73–87.

Witmer, J., & Zorn, L. (2007). Estimating and comparing the implied cost of equity for Canadian and U.S. firms. Working Paper of the Bank of Canada.Albuquerque, R., Durnev, A., Koskinen, Y., 2012. Corporate Social Responsibility and Asset Pricing in Industry Equilibrium. Working paper.

Revelli, C., Viviani, J, 2013. Performance financière de l'investissement socialement responsable (ISR) : une méta-analyse. Finance Contrôle Stratégie [Online], 15-4 |2013, Online since 18 March 2013,.URL : http://fcs.revues.org/1222

Russo, M.V., Fouts, P.A., 1997. A resource-based perspective on corporate environmental performance and profitability. Academy of Management Journal 40, 534–559.

Sharfman, M.P., Fernando, C.S., 2008. Environmental risk management and the cost of capital. Strategic Management Journal 29, 569–592.

Statman, M., Glushkov, D., 2009. The Wages of Social Responsibility. Financial Analysts Journal 65, 33–46.

Teoh, S.H., Welch, I., Wazzan, C.P., 1999. The Effect of Socially Activist Investment Policies on the Financial Markets: Evidence from the South African Boycott. Journal of Business 72, 35–89.

Waddock, S.A., Graves, S.B., 1997. Finding the link between stakeholder relations and quality... Journal of Investing 6, 20.

Berg F., Koelbel F. J., Rigobon R. (2019), "Aggregate Confusion: The Divergence of ESG Ratings", MIT Sloan School Working Paper 5822-19, 15/08/2019

Berg F., Koelbel F. J., Rigobon R., (2019), "Aggregate Confusion: The divergence of ESG Ratings" su basi Truvalue Labs, MIT Sloan School of Management.

Clarence Tolliver, Alexander Ryota Keeley, Shunsuke Managi, (2019) "Drivers of green bond market growth: The importance of NationallyDetermined Contributions to the Paris Agreement and implications forsustainability", Journal of Cleaner Production, Volume 244.

D'Angerio V. (2019), "Risparmio, la sostenibilità in portafoglio migliora le performance", Il Sole 24ore, 17/09/2019

David K., (2017), senior analyst in Morningstar.

Decreto legislativo 147/2018, Attuazione della Direttiva (UE) 2016/2341 relativa alle attività e alla vigilanza degli enti pensionistici aziendali o professionali (EPAP), 13/12/2018.

Deloitte, (2019), "The Deloitte Global Millennial Survey 2019 Societal discord and *technological transformation create a generation disrupted." – disponibile a: https://www2.deloitte.com/content/dam/Deloitte/global/Documents/About-Deloitte/deloitte-2019-millennial-survey.pdf*

Dipartimento per la Pubblica Informazione Nazioni Unite (2015), "Trasformare il nostro mondo: Agenda 2030 per lo Sviluppo Sostenibile" disponibile a: https://unric.org/it/agenda-2030/

Direttiva 2014/95, 22 ottobre 2014.

Direttiva UE 2013/34, 26 giugno 2013.

Direttiva UE 2016/2341, 14 dicembre 2016.

Direttiva UE 2017/828, 17 maggio 2017.

European Commision (2018), "Action Plan on Financing Sustainable Development", 08/03/18, disponibile a: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018DC0097

European Commision (November 2020), "Study on Sustainability - Related Ratings, Data and Research" – disponibile a: https://op.europa.eu/en

Friedman M. (1970), "The Social Responsibility of Business is to Increase its Profits.", The New York Times, Section SM, page 17.

Global Sustainable Investment Alliance (GSIA) (2018), "Global Sustainable Investment Review 2018" – disponibile a: http://www.gsi-alliance.org/

HLEG (2018), "Financing a sustainable European economy", cit., pp. 15-19.

Integrate ESG Rating & Research.

International Capital Market Association – ICMA (2018) "Social Bond Principles Voluntary Process Guidelines for Issuing Social Bonds" disponibile a: https://www.icmagroup.org/assets/documents/Regulatory/Green-Bonds/June-2020/Social-Bond-PrinciplesJune-2020-090620.pdf

International Capital Market Association – ICMA (2018) "The Green Bond Principles (GBP)" disponibile a: https://www.icmagroup.org/sustainable-finance/the-principles-guidelines-and-handbooks/green-bond-principles-gbp/

International Organization of Securities Commissions - OICV-IOSCO (2013), "Principles for Financial Benchmarks, Final Report."

Konqui M. H., Millet F., Darolles S., (2019), "Why using ESG helps you build better portfolios", Lyxor Dauphine Research Academy

Loi de Transition Énergétique pour la Croissance Verte (2016), art. 173, 13/12/2016.

McCollum D. L., Zhou W., Rihai K. et al (2018), "Energy Investment Needs for Fulfilling the Paris Agreement and Achieving the Sustainable Development Goals. Nature Energy." 18/06/2018, disponibile a: https:/www.nature.com/articles/s41560-018-0179-z#change-history

Michael E. Porter and Mark R. Kramer (2011), "Creating Shared Value How to reinvent capitalism - and unleash a wave of innovation and growth."

Morningstar data, 31/12/2018.

Morningstar research data, 31/12/2019.

Morningstart research data, 31/03/2020.

Organizzazione per la cooperazione e lo sviluppo economico OCSE (2017) "Rapporto economico italia 2017 - Sintesi della Presentazione del Dip. Economico"

Oxford Economics, agosto 2018.

Parlamento Europeo (2019), "Indici di riferimento di basse emissioni di carbonio e gli indici di riferimento di impatto positivo in termini di carbonio" 26/03/2019.

Regolamento UE 2016/1011 recante modifica delle Direttive 2008/48/CE e 2014/17/UE e del Regolamento UE 596/2014 dell'8 giugno 2016.

Report of the World Commission on Environment and Development (1987), "Note by the Secretary-General", 04/08/1987, A/42/427, disponibile a: https://sustainabledevelopment.un.org/milestones/wced

The Global Sustainable Investment Alliance (2018), "2018 Global Sustainable Investment Review"

Web links

- *Aberdeen Standard Investments: www.aberdeenstandard.com/.../article-page/the-elements-of-esg*
- *Accredia: www.accredia.it/.../finanza-verde-lacc...investimenti-green*
- *Agenzia Italiana per la cooperazione e lo sviluppo: www.aics.gov.it/.../obiettivi-di-svilu...o-sostenibile-sdgs*
- *Alma Laboris Business School: www.almalaboris.com/.../2453-cosa-signific...a-sostenibile.html*
- *Alza Rating: www.alzarating.com/.../rating-esg-come-va...nibilita-delle-pmi*
- *Anasf – Associazione nazionale consulenti finanziari: www.anasf.it/.../corso-in-tema-di-f...imenti-sostenibili*
- *Athena Financial Advisory: www.athenafinancialadvisory.com/.../consulenza-bancaria/rating-esg-rating-di-sostenibilita*
- *Blackrock: www.blackrock.com/.../approfondimenti/investimenti-sostenibili*
- *Blackrock: www.blackrock.com/.../esg-multi-asset-fu...-it-individual.pdf*
- *Blue planet heart: www.blueplanetheart.it/.../20-aprile-2010-die...-deepwater-horizon*
- *Bluerating: www.bluerating.com/.../fitzgerald-vanguar...le-metodologie-esg*
- *Bluerating: www.bluerating.com/.../investimenti-quatt...lereranno-nel-2021*
- *BNP Paribas: www.bnpparibas.it/.../category/sostenibilita*
- *Borsa Italiana: www.borsaitaliana.it/.../forum/gsiareport.htm*
- *Borsa Italiana: www.borsaitaliana.it/.../glossario/agenzie-rating-sostenibilita.html*
- *Borsa Italiana: www.borsaitaliana.it/.../sotto-la-lente/green-bond-definizione.htm*
- *Business Community: www.businesscommunity.it/.../gli-investimenti-e...dei-portafogli.php*
- *Business People: www.businesspeople.it/.../Rating-Esg-istruzi...sostenibile-113483*
- *Bva Doxa: https://www.bva-doxa.com/risparmiatore-responsabile-italia/*
- *Ceros: www.view.ceros.com/.../citywire/esg-supplement-ita*
- *Cerved: www.know.cerved.com/.../cose-il-rating-esg...g-di-sostenibilita*
- *CNN Partners: www.cnppartners.it/.../blog/i-fondi-sri*
- *Cobat: www.cobat.it/comunicazione/press-room/news/covid-19-nonostante-la-crisi-crescono-gli-investimenti-in-sostenibilita*
- *Commissione Europea: www.ec.europa.eu/.../negotiations/paris_it*
- *Commissione Europea: www.ec.europa.eu/.../negotiations/paris_it*
- *Consob: www.consob.it/.../1278f006-0f95-4709...-82e7-cbd1ba2b504a*
- *Council of the European Union: www.consilium.europa.eu/.../climate-change/paris-agreement*
- *Digital4: www.digital4.biz/.../finance/esg*
- *Doga Dores: www.dogadores.it/.../cosa-sono-gli-investimenti-esg*
- *Ecomill: www.ecomill.it/.../news/banca-etica-greenarms-2*
- *Economist: https://www.economist.com/briefing/2020/07/25/the-covid-19-pandemic-is-forcing-a-rethink-in-macroeconomics*
- *Erg Europa: www.erg.eu/.../responsabilita-economica/rating-di-sostenibilita*
- *Esg 360: www.esg360.it/.../esg-tutto-quello-c...-social-governance*
- *Esg Amundi: www.esg-amundi.com/.../p/9*

- *Eur-Lex: www.eur-lex.europa.eu/.../IT/TXT*
- *Eur-Lex: www.eur-lex.europa.eu/.../resource.html*
- *Eur-Lex: www.eur-lex.europa.eu/.../TXT/PDF*
- *Eur-Lex: www.eur-lex.europa.eu/.../TXT/PDF*
- *Fideuram: www.fideuram.it/.../indici-fideuram/indici-del-giorno*
- *Finanza Alternativa: www.finanzalternativa.it/.../2020-01-13-aberdee...di-craig-mackenzie*
- *Finanza Operativa: www.finanzaoperativa.com/.../fitzgerald-vanguar...le-metodologie-esg*
- *Focus Risparmio: www.focusrisparmio.com/.../quanto-rendono-str...ie-sri-criteri-esg*
- *Focus Risparmio: www.focusrisparmio.com/.../rating-esg-5-regol...cadere-in-trappola*
- *Fondazione Cariplo: www.fondazionecariplo.it/.../pietro-negri---sdg...za-sostenibile.pdf*
- *Fondo Pegaso: www.fondopegaso.it/.../page_category/esg*
- *Forum Per la Finanza Sostenibile: www.finanzasostenibile.it/.../09/140227_Glossario.pdf*
- *Forum Per la Finanza Sostenibile: www.finanzasostenibile.it/.../11/manuale-Europa-IT-WEB.pdf*
- *Forum Per la Finanza Sostenibile: www.finanzasostenibile.it/.../11/SettimanaSRI2018_Europa.pdf*
- *Forum Per la Finanza Sostenibile: www.finanzasostenibile.it/.../Ecoscienza_Dicembr...017_f.bicciato.pdf*
- *Forum Per la Finanza Sostenibile: www.finanzasostenibile.it/soci/vigeo-italia/*
- *Gam: www.gam.com/.../investment-opinions/easy-as-esg*
- *Il sole 24ore: www.econopoly.ilsole24ore.com/.../12/esg-azienda-dati*
- *Il sole 24ore: www.econopoly.ilsole24ore.com/.../23/finanza-sostenibile-esg*
- *Il sole 24ore: www.st.ilsole24ore.com/art/finanza-e-mercati/2019-03-07/il-futuro-investimenti-e-sostenibile-175912.shtml*
- *Investire Mag: www.investiremag.it/.../https---www-invest...ell-esg-9471--9471*
- *Investire Responsabilmente: www.investiresponsabilmente.it/.../glossario/rating-esg*
- *Investire Responsabilmente: www.investiresponsabilmente.it/.../la-performance-fin...otti-e-servizi-sri*
- *Investire Responsabilmente: www.investiresponsabilmente.it/2014/07/14/la-performance-finanziaria-dei-prodotti-e-servizi-sri/*
- *I-Shares: www.ishares.com/.../investimenti-sostenibili/cosa-significa*
- *La mia finanza: www.lamiafinanza.it/.../01/la-nuova-frontiera-dellesg*
- *Lyxor etf: www.lyxoretf.it/.../range/esg-trend-leaders*
- *Milano Finanza: www.milanofinanza.it/.../gli-investimenti-e...201909171623164010*
- *Milano Finanza: www.milanofinanza.it/.../rating-esg-5-istru...202002031343236070*
- *Morningfuture:www.morningfuture.com/.../business-roundtable-documentosostenibilita/721*
- *Morningstar: www.morningstar.it/.../come-investire-in-...o-sostenibile.aspx*
- *Morningstar: www.morningstar.it/.../fondi-sostenibili-...e-performance.*
- *Morningstar: www.morningstar.it/.../fondi-sri-il-bilan...8-è-positivo.aspx*
- *Morningstar: www.morningstar.it/mobile/Article.aspx?Site=it&articleid=203396*
- *Network Digital 360 – Agrifood: www.agrifood.tech/sostenibilita/esg-che-cose-e-perche-sta-influenzando-economia-e-finanza/*
- *Notiziario Finanziario: www.notiziariofinanziario.com/.../cosa-significa-esg...inanza-*

sostenibile
- *Pandslegal: www.pandslegal.it/.../finanza-sostenibil...-normativo-europeofonte*
- *Parlamento Europeo: https://www.europarl.europa.eu/news/it/headlines/society/20200429STO78172/il-green-deal-europeo-al-centro-del-piano-di-ripresa-post-covid-19*
- *Parlamento Europeo: www.europarl.europa.eu/.../il-green-dealeurop...resa-post-covid-19*
- *Politecnico di Milano: https://www.som.polimi.it/banor-sim-presenta-il-nuovo-studio-in-ambito-esg-sul-mercato-obbligazionario/*
- *Quello che conta: www.quellocheconta.gov.it/.../glossario/index.html*
- *Repubblica: www.repubblica.it/.../esg_scelte_differe...i_filtri-253979114*
- *Reuters: https://www.reuters.com/article/us-bp-contracts-idUSBRE8AR0M120121128*
- *Schroders: www.schroders.com/.../covid-19-e-investi...li-cosa-e-cambiato*
- *Senato della Repubblica: www.senato.it/.../BGT/01089395.pdf*
- *Sitografia*
- *Skuola: www.skuola.net/.../appunti/finanza-etica-petracci*
- *Snam: www.snam.it/.../reporting_e_performance/indici_di_sostenibilita.html*
- *Snam: www.snam.it/.../sosten-indicizzati-2016/04-Snam-indici-sostenibilita.pdf*
- *Symbola: www.symbola.net/.../approfondimento/politiche-internazionali-green*
- *The New York Times: www.nytimes.com/.../letters/milton-friedman-capitalism.html*
- *Think Tank: www.empoweryourlifethinktank.com*
- *Umich: www.umich.edu/.../doc/Friedman.pdf*
- *Valori: www.valori.it/.../investimenti-esg-3...ni-occhio-ai-falsi*
- *Valori: www.valori.it/.../investimenti-respo...-dietro-le-pagelle*
- *Valori: www.valori.it/investimenti-esg-31-trilioni-occhio-ai-falsi/*
- *Wall Street Italia: www.wallstreetitalia.com/.../esg-usa-2019*
- *Wall Street Italia: www.wallstreetitalia.com/.../rating-esg-cos-e-come-si-calcola*
- *Wall Street Italia: www.wallstreetitalia.com/.../trend/esg*
- *Wall Street Italia: www.wallstreetitalia.com/rating-esg-cos-e-come-si-calcola/*
- *We-Wealth: www.we-wealth.com/.../esg-la-ricetta-ide...nce-dei-portafogli*
- *We-Wealth: www.we-wealth.com/.../i-fondi-sostenibil...con-i-*
- *We-Wealth: www.we-wealth.com/.../sri-impact-investing/fondi-esg-record*
- *Wikipedia: www.it.wikipedia.org/.../wiki/Finanza_sostenibile*
- *Wikipedia: www.it.wikipedia.org/.../wiki/Protocollo_di_Kyoto*
- *Wikipedia: www.it.wikipedia.org/.../wiki/Rapporto_Brundtland*
- *Wikipedia: www.it.wikipedia.org/.../wiki/Sviluppo_sostenibile*
- *Wired: www.wired.it/.../21/dieci-anni-deepwater-horizon*

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Executive Summary

In recent years, ongoing climate change and the transition to a model of sustainable economic development have taken on central importance for the financial system, calling into question the various players involved - central banks, companies, national and international government bodies - who are taking up the challenges posed by these phenomena in their institutional and investment activities. Consequently, recent years have seen the growth and development of an environmental conscience among human beings, a conscience that is progressively changing the way human beings act. This renewed awareness is triggering virtuous mechanisms whereby everything does not have to be done only for the sake of maximum economic profit; in fact, choices can also be made to make man's coexistence in the environmental ecosystem more sustainable and to preserve the habitat in which he lives.

International climate agreements, national carbon pricing systems, and the growing competitiveness of alternative energy sources, such as wind and photovoltaics, compared to fossil fuels, are the prominent trends that could change the current energy paradigm, shifting the structure of the current production, industrial, building or manufacturing landscape towards a more environmentally friendly target.

The body of scientific evidence supporting climate change and its anthropogenic causes is overwhelming. First, mean temperatures are rising. Temperatures in each of the previous three decades have been warmer than the last. Collectively, the 30- year period from 1983 to 2012 was likely the warmest in the Northern Hemisphere over the last 1,400 years. Second, extreme weather events are becoming more prevalent. On a global scale, the prevalence of cold and warm temperature extremes has increased. Further, climate scientists find that in some locations, the frequency of heat waves has more than doubled and is expected to increase by a factor of almost five over the next 50 years (Lau and Nath, 2012). The Fifth Assessment Report on Climate Change (AR5), published in 2013 by the Intergovernmental Panel on Climate Change (IPCC) and sponsored by the United Nations, required countries around the world to come to an international agreement to take action to limit the maximum temperature increase to 2°C by the end of the century. The annual greenhouse gas emissions must be reduced (between 50% and 60% by 2050) and then reduced to zero (between 2080 and 2100) over the century to have a good chance of achieving the target. Since 65% of annual greenhouse gas emissions are carbon dioxide, mainly emitted by the combustion of fossil fuels, plans must be devised to reduce CO2 concentrations by replacing fossil fuels with renewable sources, increasing energy efficiency and capturing the CO2 generated.

Irrespective of international agreements, 39 nation-states and 23 federal states have already implemented a system that puts a price on emitted carbon dioxide (carbon pricing), thereby disadvantaging fossil fuels.

Currently, the system covers 12% of total world emissions, but in the coming years, this percentage, the number of countries adopting carbon pricing and the unit price (currently USD 7 per tonne of CO2) look set to rise. Nevertheless, the real news is narrowing the competitive gap between renewable sources such as wind and photovoltaics and traditional fossil fuels: in the most favourable conditions, the generation costs of these technologies are now close to those of gas and coal plants. In the United States, over the period 2009-2014, the cost of a kilowatt-hour fell by 78% for PV and 58% for onshore wind, approaching wholesale electricity market prices. By 2040, both technologies' cost could fall further (-40% or more in the case of PV, where increased efficiencies, currently just over 20% at best, could play a decisive role). Installed capacity has also improved at a high annual rate (+49% photovoltaic and +21% wind in 2007-2015), reaching levels well above the most optimistic past scenarios' expectations.

However, their impact on the world's energy supply remains marginal: in 2013, wind and solar accounted for only 0.7% of the world's total primary consumption (3.496 of electricity generation). Evolving and rising to the challenge does not imply an immediate and sudden change, of course, but requires immediate preparation to tackle partly unknown issues and develop new models.

The link between human activity and climate change highlights the need to refound the model of development in a sustainable direction, starting with the gradual abandonment of fossil fuels, which have so far guaranteed unprecedented prosperity.

Economic activity is both the cause and the victim of climate change. It causes it through the use of fossil energy: three quarters of greenhouse gas emissions are generated by the combustion of energy. At the same time, climate change is affecting human activities: higher average temperatures and greater fluctuations are increasingly affecting all activities, starting with those that are most exposed to natural events, such as agriculture; more frequent and intense hydrogeological phenomena and heat waves can cause significant economic damage; and rising sea levels are threatening coastal communities around the world.

Climate change and the policies designed to contain its effects significantly affect the real economy and the financial system. They give rise to new risks - so-called climate risks - which public institutions and all companies, financial and non-financial, must understand and monitor. The aim of this thesis work is to investigate the effects that the focus on issues related to climate change and climate change may have on stock markets and stock returns for Italian companies. The strands of analysis on which the contents of the thesis are developed are mainly two:

1) the first one is aimed at assessing or what are the effects on the markets caused by extreme climate events and their consequences in Italy;
2) the second concerns the ESG theme and, in particular, aims to analyse the link between risk and the climate-environmental component within the ESG factor attributed to specific Italian companies.

The increasingly widespread attention to climate-related issues has led many companies to adopt environmentally virtuous corporate policies, which have enabled them to achieve high scores in terms of the *"E" = Environment* component of the ESG factor.

The study conducted in this thesis is aimed at assessing whether this high score translates into something economically and financially tangible when an uncommon climate event occurs or in terms of investor attractiveness and risk variation in equity markets.

The thesis is divided into five chapters, of which the first two introductory ones are the necessary premise for a complete and explicative understanding of the topic on which the analyses conducted in the following sections are based. The third and fourth chapters, on the other hand, present the empirical analyses carried out to verify each of the two study hypotheses on which the work focuses, while the third and last section is the shortest and corresponds to the conclusions, where the results are interpreted and possible subsequent lines of research are mentioned.

In particular, Chapter One introduces the issue of climate change by giving a brief and concise introduction on the origins of the topic and explaining why in the last period this issue has become of primary importance both for the global macroeconomic scenario and for individual companies, especially those operating in markets where environmental and climate aspects play a critical role, such as the oil and gas sector.

In the second chapter, the economic effects of climate change are discussed, differentiating the impact of these changes according to the particular economic sector considered and applying the analysis to the Italian economic context. Evidence of the impact of climate change on natural

and human systems has increased considerably in recent decades. Climate change, in its two components of mean and deviations from mean, is a factor that is and will be of increasing importance in the strategic and risk management of companies.
There is a lot of scientific evidence showing the main factors through which climate change and alterations can affect certain sectors such as agribusiness, utilities (energy and water) and insurance.
It is undeniable that, in the long run, the impact of climate change on economic sectors is smaller than that caused by traditional socio-economic factors, such as population growth and ageing, income, relative prices, lifestyles, public policies and regulations. However, many economic sectors will be positively or, more often, negatively affected by permanent changes in temperature, precipitation, sea level and the magnitude and frequency of extreme weather events. For example, in the energy sector, changes in average and extreme temperatures could permanently increase the demand for cooling energy in summer periods and decrease it in winter periods; the final balance will, of course, depend on geographical, socio-economic and technological factors. On the supply side, climate change could adversely affect the energy production infrastructure in some geographical areas and the efficiency of thermal conversion. Regarding resources for agricultural use, water demand may increase as temperatures rise and decrease as higher CO_2 concentration enhances agricultural yields; in turn, water supply will depend on rainfall, temperature and infrastructure conditions that may be vulnerable to extreme climate events (Pareglio, FEEM, 2020). With regard to the transport sector, the increased frequency of extreme events may negatively affect the life cycle of some infrastructures, thus increasing the frequency of repairs or replacements. Sudden catastrophic events are undoubtedly unfavourable for tourism, but an increase in the average temperature could make locations that usually have colder climates more hospitable, or lengthen the tourist season in places where tourism is concentrated only when the climate is at higher temperatures.
The insurance sector, in turn, is strongly linked to extreme events, the frequency and intensity of which could increase and thus increase the expected average damage. Finally, the health care system will also be impacted on both the supply and demand sides, as the number of illnesses resulting from climate change may increase or decrease depending on location, time and specific pathology.The Second Chapter also introduces the ESG theme and discusses the methodologies for calculating the components linked to these factors and the main databases that deal with the calculation and dissemination of these indicators. As has been the case for

years in the world of consumption, critical and conscious choices are also influencing the world of finance, where the idea that it is no longer enough to invest for mere profit and that it is also necessary to create added value for the environment and society as a whole is becoming increasingly widespread.

An understanding of ESG factors is a prerequisite for understanding sustainable finance and specifically sustainable investments. The ESG factors, as suggested by the acronym, are subdivided according to specific areas of relevance: Environment, Social and Corporate Governance.

If the aim is to develop an ESG rating or profile, and thus structure a methodology for choosing which assets to include in one's allocation, a further step is to understand what the material ESG factors are. In other words, there is a need to carry out the so-called Materiality Assessment, which will take care of sanctioning the capacity of that specific ESG issue to impact and influence the financial performance of an asset or its issuer.

The process of identifying those ESG issues that are likely to impact the financial performance of the asset/security and its issuer implies a conscientious assessment of the context in which these entities operate, and should therefore be a consideration of characteristics such as geographic region and industry level.

The third chapter, on the other hand, focuses on an Event Study carried out to determine whether there is an effective impact of extreme climate events on the performance of the shares of companies affected by such events. A new and original study is carried out that, by combining information obtained from different types of sources, manages to create a sample of events that have occurred in recent years in Italy involving the production sites of listed companies in order to assess whether the occurrence of such events has had tangible repercussions on the market performance of these companies, and if so, what elements may have determined it.

The analysis carried out is based on the hypothesis that extreme weather events, through their effects on productivity and production, can influence the share price trend of Italian companies. The effects associated with extreme weather events are likely to vary along several important dimensions. First, these effects are likely to vary substantially across sectors. For example, extremely hot summer temperatures may affect the production and profitability of firms with key inputs such as food crops and agribusiness in general, but not the profitability of airlines. Conversely, extremely cold winter temperatures, through their effects on overall air traffic and potential weather-related delays, may impact the profitability of airlines, while agriculture-related businesses are unlikely to be affected. It is also possible for the same weather event to be adverse for one business and favourable for another: in this case it would be possible to find, from statistical tests, that the occurrence of an extreme event would generate a positive effect on the stock returns of favoured businesses and a negative effect on the others. For example, if, following an extreme event, a civil structure collapses or is damaged, the company that wins the contract for the reconstruction or maintenance of the damaged structure would certainly be favoured by the event that has occurred, while the companies connected to the activities that took place in the damaged structure would certainly be disadvantaged.

Based on these considerations, a sample selection was carried out along two dimensions: the dimension related to the sample of companies to be considered in the study and the dimension related to the extreme climatic events on which to focus the investigation.

The selection produced a sample of 8 events located mainly in northern Italy, and to a lesser extent also in the south and on the islands, for a total of 72 companies. The type of event fell into three main categories:

1. Flooding: flooding and inundation as a result of excessive tropical rainfall and abnormal rainfall patterns;
2. Water bomb: storms of excessive intensity with subsequent damage to property, landslides and mudslides;
3. Whirlwind: thunderstorms with extremely strong wind gusts and tornadoes.

However, on the surface, measuring the impact of Extreme Climate Events (ECE) on the financial trend of a company seems to be a difficult task, and *Event Study* can be used to easily construct metrics. An *Event study* uses financial market data to measure the impact of specific events on company value. The usefulness of this research is that, given the rationality of the market, the impact of the event will be immediately reflected in the price of securities. Therefore, the security price observed in a relatively short period of time can be used to construct a measure of the economic impact of the event.

An *Event Study* (*ES*) begins by assuming that a particular event affects the value of a company under consideration by modifying it, and that this results in an observable anomalous return in the value of the company. Together with the idea that information is immediately incorporated into prices, the concept of anomalous (or performance) returns is the key to this methodology. The question to be answered is therefore: how does a particular climate event the value of a company?

However, once the sample had been obtained, an event study was carried out following the methodology explained in the previous paragraph.

The hypothesis that the present study aims to verify is:

H_{sin}: *An Extreme Climate Event have a concrete impact on the performance of stocks for companies whose production sites or business interests have been affected by a climate event itself.*

Therefore the hypothesis of the study could be usefully translated into the null hypothesis that follows:

H_0 - The Cumulative Average Abnormal Returns (CAARs) *on the event window are null.*

In the event that the null hypothesis is accepted, then, we can affirm that *the extreme climate events have a concrete impact on the performance of stocks for companies whose production sites or business interests have been affected by a climate event itself.*

The obtained results comfort us that the acquisitions in general have had an impact on the trend in the share price of the buyers but they still do not tell us if there has been a different impact depending on particular type of business considered, or if these results depend on other variables. But, while CAARs show average positive returns for some companies, negative values for others. This is symptomatic of a substantial difference in behavior among companies with different types of business, but from a statistical point of view, there is a need for further analysis to investigate these differences in order to make correct considerations.

To verify the effective validity of the result, other analyzes were carried out: in particular a multivariate linear regression. The empirical models assumed are as follows:

$$lnCAARs_i = \beta_0 + \beta_1 \cdot ESG_i + \beta_3 \cdot Sector_i + \beta_4 \cdot EventType_i + \beta_5 \cdot Size_i + \varepsilon_i$$

$$lnCAARs_i = \gamma_0 + \gamma_2 \cdot Environment_i + \gamma_3 \cdot Sector_i + \gamma_4 \cdot EventType_i + \gamma_5 \cdot Size_i + u_i$$

where:

- $lnCAARs_i$= Neperian logarithm of CAARs value for each company from Event study;
- ESG_i = ESG score from Datastream;
- $Environnment_i$= Environment Pillar score from Datastream;
- $Sector_i$= a factor variable relating to the Company’s economic sector;
- $EventType_i$ = a factor variable relating to the type of Extreme Climate Event;
- $Size_i$= Full-time Employer as Size proxy for each company from Datastream.
- *Size##EventType*= Interaction between Size and EventType

The analysis shows that in both models, the logarithms of the CAARs are significantly dependent on the type of event that occurred and on the ESG and Environment Pillar scores, while they are independent of the type of Sector to which the companies belong and of their size.
In particular, the dependence on ESG and Environment scores is of a direct type, since the value of the regression coefficient is positive in both cases: this means that as these scores increase, the logarithms of the CAARs increase linearly.
The fourth chapter instead investigates the effect that having a high value of the Environment ("E") component of the ESG factor for Italian companies can have in terms of Risk Premium: the extent and nature of this effect has already been widely debated in the international scenario, but the originality of the analysis conducted concerns the fact that it focuses on the climate-environmental factor rather than on the aggregate ESG factor, and is focused on the Italian stock market.
The ESG scores used here are based on Thomson Reuters' assessments of Italian companies over a 10-year period, from 2011 to 2020. As large companies are assumed to disclose more ESG information, which is then readily available for investor decision-making, the focus here has been on members of the FTSE MIB 40 and FTSE Italia All-Share indices. Using the members of these two indices also minimised the presence in the dataset of companies for which a score of zero is likely to indicate a lack of rating rather than a neutral ESG performance.

Explanatory power is assessed using cross-sectional regressions of excess stock returns on Environment scores and four factors known to explain stock returns: beta, size, value, and momentum (Manesku, 2010). This model can be understood as an augmented Fama-French three-factor model (Fama and French, 1992) to which the momentum factor identified by Jegadeesh and Titman (1993) is added. The cross-sectional approach could be equivalently replaced by the portfolio approach which analyses only the return differential between high and low-ESG stock portfolios; some authors prefer the former approach to the latter because of interest in the monotonic effect of ESG concerns on stock returns (Manesku, 2010). Furthermore, the use of ex-post returns should complement Derwall and Verwijmeren (2007), who used ex- ante measures of returns, i.e. the implied cost of equity.
As a null hypothesis for the test on the effect of the environment score, the following is set as the four-factor model:

H0: The estimated effect that the Environment Score, or more generally the ESG factor, has on excess stock returns is statistically indistinguishable from zero.

The alternative hypothesis is therefore that:

H1: The estimated effect that the Environment score, or more generally the ESG factor, has on excess stock returns is statistically significant.

The test is therefore a two-tailed test in that it is not possible to hypothesize what the sign of this influence is and therefore whether it is a direct or reverse influence.

The four-factor model with the aggregate Environment variable estimated here is extended as follows.

Model(1):

$$R_{j\,t+1} = \alpha_0^{t+1} + \alpha_1^{t+1} \cdot \hat{\beta}_{j\,t} + \alpha_2^{t+1} \cdot Size_{j\,t} + \alpha_3^{t+1} \cdot BtoM_{j\,t} + \alpha_4^{t+1} \cdot Mom_{j\,t} + \alpha_5^{t+1} \cdot Env_{j\,t} + u_{j\,t+1}$$

where:

- R_{jt+1}= excess stock return for firm *j* in month *t+1;*
- β_{jt}= estimated market risk (beta) of firm j-th;
- $Size_{jt}$ = log of the number of full-time employees in the company;
- $BtoM_{jt}$= book-to-market ratio;
- Mom_{jt} = average return over the previous 10 returns, i.e. over the period from months *t* - 2 and *t* – 12;
- Env_{jt} = aggregate variable Environment
- u_{jt} = i.i.d. error term, with zero mean and constant variance.

In this model Size, the Env variable and the book-to-market ratio are updated monthly (as Galema et al., 2008), while the estimated beta is updated annually and for each asset *j* (*j* = 1...*N*) through a time series regression up to time *t* of the asset returns and the market index return.

The empirical evidence frequently verified in the literature also led to the verification of the significance of the alternative model below.

Model(2):

$$R_{j\,t+1} = \delta_0^{t+1} + \delta_1^{t+1} \cdot \hat{\beta}_{j\,t} + \delta_2^{t+1} \cdot Size_{j\,t} + \delta_3^{t+1} \cdot BtoM_{j\,t} + \delta_4^{t+1} \cdot Mom_{j\,t} + \delta_5^{t+1} \cdot ESG_{j\,t} + \varepsilon_{j\,t+1}$$

where all the terms that appear are the same as in the previous model except that:

- ESG_{jt}= excess stock return for firm *j* in month *t+1;*
- u_{jt} = i.i.d. error term, with zero mean and constant variance.

In both of these models, the coefficients were estimated using the Fama-MacBeth procedure, which allows the calculation of coefficients $\hat{\alpha}_k^{t+1}$ e $\hat{\delta}_k^{t+1}$ con k = 1, 2, 3, 4 time-varying. This procedure is known as *two-step* Fama-MacBeth estimation, because first a time-series regression of individual stock returns on the market index return is estimated to obtain beta estimates, and then these estimates are used as explanatory variables in the cross-sectional regression.

Over the period 2011-2020, beta, size, book-to-market and momentum explained the cross-section of returns, regardless of the type of ESG factors used.

While Momentum provided a negative coefficient value, the book-to-market and size coefficients were positive, although very low (especially for size.

Regarding ESG variables, in all three cases they seem to have had an effect on equity returns, which was particularly strong when the ESG score provided by Refinitiv was analysed as an aggregate. In all three cases they had a positive effect on equity returns,

Based on what was obtained for the ESG variables, it is therefore possible to reject the null hypothesis of independence of the excess return of Italian equities as a function of the ESG score and confirm a positive effect of this factor on risk.

The results of the analysis of the last two chapters are commented on in the final chapter, in which an attempt is made to argue some interesting points for reflection: In the light of these few pages, it is perhaps easier to interpret the results obtained in Chapters 3 and 4 in which the empirical analyses of interest for the purpose of this paper were conducted.

The analysis carried out in Chapter 3 was aimed at testing the existence of an effect of extreme weather events on the stock returns of companies affected by the consequences of such events and was conducted through a carefully prepared event study.

The analysis revealed that the *Cumulative Average Abnormal Returns (CAARs)* were significant at a significance level of 5% in 58 out of 72 cases: thus a significant effect of the event was detected in a rather large portion of the cases. The raw data obtained in this way, although interesting, did not make it possible to obtain more accurate indications on how and why this dependence is actually expressed.

It was therefore decided to deepen the analysis by creating a dataset in which the value of the CAARs obtained was associated with each company and other information was added in the form of additional variables of another type:

1) variables linked to the event and the context in which it takes place, which would allow the data to be differentiated on the basis of the type of event and industry concerned

2) variables that would give me indications on how the specific company interfaces with environmental and ESG aspects in general, introducing the Environment score and the aggregate ESG score and obtaining with each of them a different model to test.

The multilinear regression analysis carried out on this dataset showed that in both models obtained, the logarithms of the CAARs are significantly dependent on the type of event that occurred and on the scores of the ESG and Environment pillars, while they are independent of the type of Sector they belong to, the size of the companies and the interaction between Sector and type of event.

It can therefore be said that, when the response is differentiated according to the type of event and the specificity of the company, especially according to how the company interfaces with environmental and sustainability issues in general, the market proves to be rather sensitive to such events and ready to price their effects.

And the behaviour of the market seems to be in line with what one would expect: the value of the regression coefficient is positive both for the ESG score and for the Environment, therefore, the dependence is of a direct type in both cases: this means that as these scores increase, the logarithms of the CAARs increase linearly and therefore there is a power type dependence between the variables on a decimal scale.

For companies, having high ESG and Environment scores concretely means reducing the negative effects of risk from adverse climate events and increasing the gain in case the event turns into a favourable event for the company itself, since a higher Environment score enhances the positive effect on CAARs.

This, from a strategic perspective, would mean using the focus on environmental issues to competitive advantage: Aware of this result, companies that want to extend their assets and invest in new plants can elaborate positioning strategies for their production realities that take into account these aspects, while in the case of already positioned plants, investing in policies to increase the ESG score, among other achievable advantages, could allow them to absorb the impact of events whose frequency, with the passing of time, will probably tend to increase, or even gain a competitive advantage over companies with low ESG.

As for the survey conducted in Chapter 4, the results show that, during the period 2011-2020, there was a positive association between candidate ESG variables and risk-adjusted stock returns.

The elements to be considered in reality appear multiple: thinking of the scenarios illustrated at the beginning of the paragraph it would seem to be in the case of a Mispricing Scenario; in particular it seems to occur in the case where the benefits of ESG exceed their costs, but investors, on average, due to lack of adequate information, do not have the perception of this and consistently underestimate the benefits or overestimate the costs, then the risk-adjusted returns of high ESG firms would be higher than those of low ESG firms.

This explanation is well suited to the Italian situation in which ESG has only recently come to the fore and is a factor that takes on strategic importance above all for large companies in an international context, a scenario that is quite far removed from the Italian one made up of small and medium-sized enterprises and few really large companies.

The composition of the Italian productive and industrial fabric, made up of small and medium-sized companies, could also make companies with high ESG more risky in the eyes of investors because they are seen as more cyclical, i.e. more positively correlated with GDP growth or other indicators linked to national or local macroeconomic variables.

Moreover, these results could be partly due to the systematic distortion of market prices highlighted above and attributed to the discriminatory tastes argument that results in divestment from certain stocks is done exclusively for moral or ethical reasons. Thus the recent widespread attention to environmental and circular issues may have led to the spread of investors who derive a non-financial benefit from investing in high ESG companies and a decrease in the demand for the shares of low ESG.

It would certainly be advisable to investigate the empirical elements underlying each of these lines of enquiry with appropriate analyses: in particular, it would be necessary to understand whether the dependencies observed are dynamic and have evolved over time, and whether it is therefore possible to subdivide the time span analysed, which extends over 10 years, into shorter sub-periods for which different behaviours are observed.