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Managing climate change risks

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Contents

Introduction

"Today, the world is set to produce 120% more fossil fuels than is consistent with a 1.5°C pathway (...). But the scientific community is also telling us that the roadmap to stay below 1.5°C is still within reach"

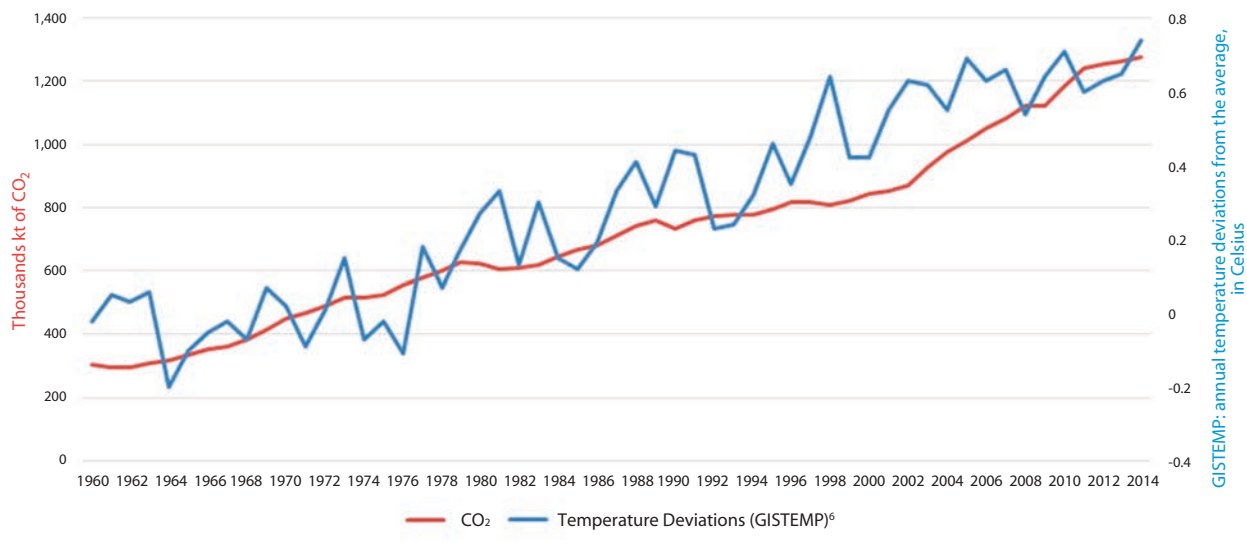
– Antonio Guterres[1]

Over the past two decades, concern for environmental degradation and climate change has gradually increased; as a result, it has been occupying a relevant place in the political agenda. Scientific studies conducted so far have set out to demonstrate the man-made origin of this change, arguing that the continuous emission of greenhouse gases (GHG) is causing an increase in the average temperature of the Earth[2], which will have serious social and economic consequences in the medium term (figure 1).

Initially, the focus was on the impact of economic activity on the environment and, derived from it, the necessary promotion of more respectful environmental practices. This is reflected by the extensive adoption of international standards such as the GRI Sustainability Reporting Standards[3]. However, in recent years, numerous internationally renowned actors in the public and private sectors have strongly emphasized the consequences to which countries, companies, the financial system and the global economy are exposed[4,5]. This has brought the need to understand the risks associated with global warming and the necessary transformation of the current production model to the top of the international political agenda.

1 The United Nations Secretary-General, during his speech at the COP25 in Madrid (2019).
2 IPCC (2014).
3 Global Reporting Initiative (GRI) Standards (2019).
4 Carney, M (2015).
5 This is supported, among others, by William D. Nordhaus, who was awarded the Economics Nobel Prize in 2018 "for integrating climate change into long-run macroeconomic analysis". The Royal Swedish Academy of Sciences (2018).
6 GISTEMP: Goddard NASA global surface temperature analysis (Goddard's Global Surface Temperature Analysis: GISTEMP). Temperatures are shown in degrees Celsius. The anomalies are measured in relation to a base period that, in the case of GISTEMP, is 1951-1980.
7 Datahub (2019).
8 The World Bank (2019).

Figure 1: temperature deviations from the global average and CO_2 emissions



Source: Datahub[7] and the World Bank[8]

The environmental impacts derived from climate change

Together with the rise of sea levels caused by the melting Arctic areas and the acidification of the oceans, various sources point to the increase in the frequency and severity of extreme events such as hurricanes or floods as one of the main consequences of climate change[9]. These phenomena could cause serious damage to the world economy. According to the latest study by the renowned Carbon Disclosure Project, the world's largest 215 companies estimate that their potential loss in asset value due to adverse climate impacts would be around 170 billion dollars, representing about 1% of their market capitalization[10].

An example of this is PG&E, electricity supplier for the state of California, and now considered by many to be the first case of bankruptcy directly caused by the impact of climate change[11]. After the devastating fires that ravaged California in the fall of 2018, the electricity company officially declared itself bankrupt as a consequence of the terrible damages suffered to its infrastructure as well as having to face millions of obligations for its role in the origination of those fires due to its electrical system. It is broadly accepted that extreme drought and heat conditions were decisive in the start, spread and severity of the fires. Another example is that of the insurance sector, known to be one of the industries most exposed to physical risks arising from climate change. Annual insured losses globally have increased 20-fold since the 1970s, reaching an average of 65 billion dollars during that decade. In 2018 alone, this figure increased to 85 billion dollars[12].

Some regions of the world and economic sectors will be particularly exposed to the risks of an increasingly unstable climate and rising water levels. However, in a globalized economy, climate change will affect all countries and industry sectors to some degree and will pose an important challenge to the stability of the global financial system.

Finally, companies will have to face the challenges of adapting to greater social awareness, new regulations and the pressure of financial markets.

Social context

Concern for climate change has taken a leading place in global collective consciousness. Many studies show that a large number of consumers would not only change their habits in order to lessen their impact on the environment, but would also like companies to help them live more sustainably[13]. In the US market, data shows that during the 2014-2017 period the growth in sales of products classified as "sustainable" was superior to conventional products.[14].

This trend is leading to the emergence of new opportunities and business models based on respect for the environment, resource sharing and sustainability criteria. It is also generating risks, such as those derived from society's perception of certain industries as having a negative impact on the environment. This is reflected by the increasingly common social movements demanding that governments and companies take drastic measures to combat global warming.

As a result of the above, over the last few years there has been a wave of judicial processes that have set a new precedent, as they have introduced the concepts of "climate responsibility and climate rights"[15]. This phenomenon is gaining special strength in the United States, and it is not surprising that fossil fuel companies are most affected. According to Michael Gerrard, founder of the Sabin Center on Climate Change Law at Columbia University, more than 1,000 climate lawsuits have been initiated in the US[16].

One of the most controversial recent cases has been the lawsuit against oil giant Exxon Mobil. The company was accused by the states of New York (and recently acquitted by this state) and Massachusetts[17] of misleading its shareholders about the real costs and risks of climate change in the company[18]. Total is another oil company that has also been sued by several cities and NGOs, accused of not making sufficient efforts to mitigate climate change[19]. Also, more than 10 cities in the USA, from New York to San Francisco, have sued large fossil fuel companies for the damages suffered as a result of global warming. In addition, in 2018, a group of fishermen from California and Oregon sued 30 large fossil fuel companies for their role in climate change and the damage caused to their activity[20]. Lastly, in line with this wave of judicial processes, a Filipino human rights commission opened a judicial hearing in New York to study whether large oil companies are violating human rights by being direct contributors to climate change[21].

The public sector has also been impacted by this wave of litigation pertaining to climate change. In recent years,

9 IPCC (2012).
10 CDP (2019b).
11 Forbes (2019).
12 The Economist (2019).
13 Nielsen (2018).
14 Ibíd.
15 Irfan, U. (2019).
16 Schwartz, J. (2019).
17 Associated Press (2019).
18 Ibíd.
19 De Beaupuy, F. (2020).
20 Bland, A. (2018).
21 Malo, S. (2018).

citizens from the US[22], Canada[23], Netherlands[24], Ireland[25] and Pakistan[26], have sued their governments for not acting with sufficient determination to reduce greenhouse gas emissions and failing to drive a transition to a sustainable economy.

This upward trend in litigation from climate change is a huge risk for companies, especially those in industry sectors that cause large-scale GHG emissions.

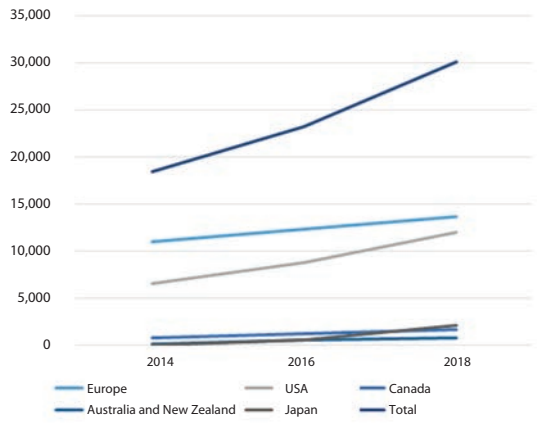
Multilateral and regulatory initiatives

The Paris Agreement[27] established objectives at the international level in order to "keep the global average temperature increase well below 2°C with respect to pre-industrial levels, and continue efforts to limit that temperature increase to 1.5°C." This commitment implies that the signatory countries must establish measures to quickly reduce their greenhouse gas emissions and favor the transition to a decarbonized economic system, which requires a drastic transformation of the economy in all productive sectors.

However, an unanticipated transition to a low-emissions economy could produce major shocks in the global economy. Therefore, in recent years, various regulatory bodies and multinational entities, mainly in the financial sector, have focused on developing recommendations, and subsequently regulations, to favor the consideration and management of risks arising from climate change. Their aim is twofold: on the

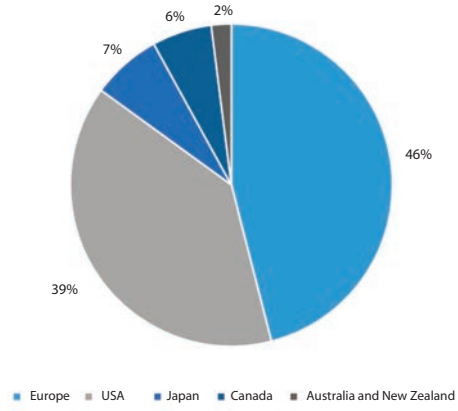
[22] Schwartz, J. (2018).
[23] McKenna, P. (2019).
[24] Apparicio, S. (2018).
[25] Coghlan, O. (2018).
[26] Gill, A. (2015).
[27] UN (2015).

Figure 2: growth of sustainable investments by region (in billions of USD)



Source: Global Sustainable Investment Review 2018[35]

Figure 3: proportion of global sustainable investments by region in 2018



Source: Global Sustainable Investment Review 2018[35]

one hand, to better understand and manage climate risks that the economy is exposed to and, on the other hand, to favor the transition towards a low GHG emission economy through the acknowledgement of these risks. Recommendations and regulations from the TFCD[28], the EU[29,30] and the Bank of England[31], which are being adopted in both the public and private sectors, continue to gain momentum and this trend is expected to continue.

The adaptation of financial markets

The 2008 crisis reflected the importance of recognizing all types of risks to which companies are exposed. Institutional investors and insurance companies have increasingly been asking companies -especially those in more vulnerable industries- , to be more transparent about how climate change impacts them and how they plan to deal with the potential risks[32]. One of the most relevant examples is the recent BlackRock announcement stating that it will stop investing in companies that are not sufficiently transparent in ESG matters[33,34].

On the other hand, the growing demand for "green" financial products by investors[35], (figures 2 and 3), coupled with unclear standards in relation to what is considered a sustainable financial product (including significant methodological differences in how specialist agencies rate SRI issues[36]) have resulted in the growth of the so-called "greenwashing" effect. To address this, security markets regulators from different geographies have taken different measures to make sure criteria are implemented in a more transparent and homogeneous way (e.g. Sustainable Finance Plan for the EU, or the review by the British FCA of the "ethical investments" sector).

A context of new opportunities

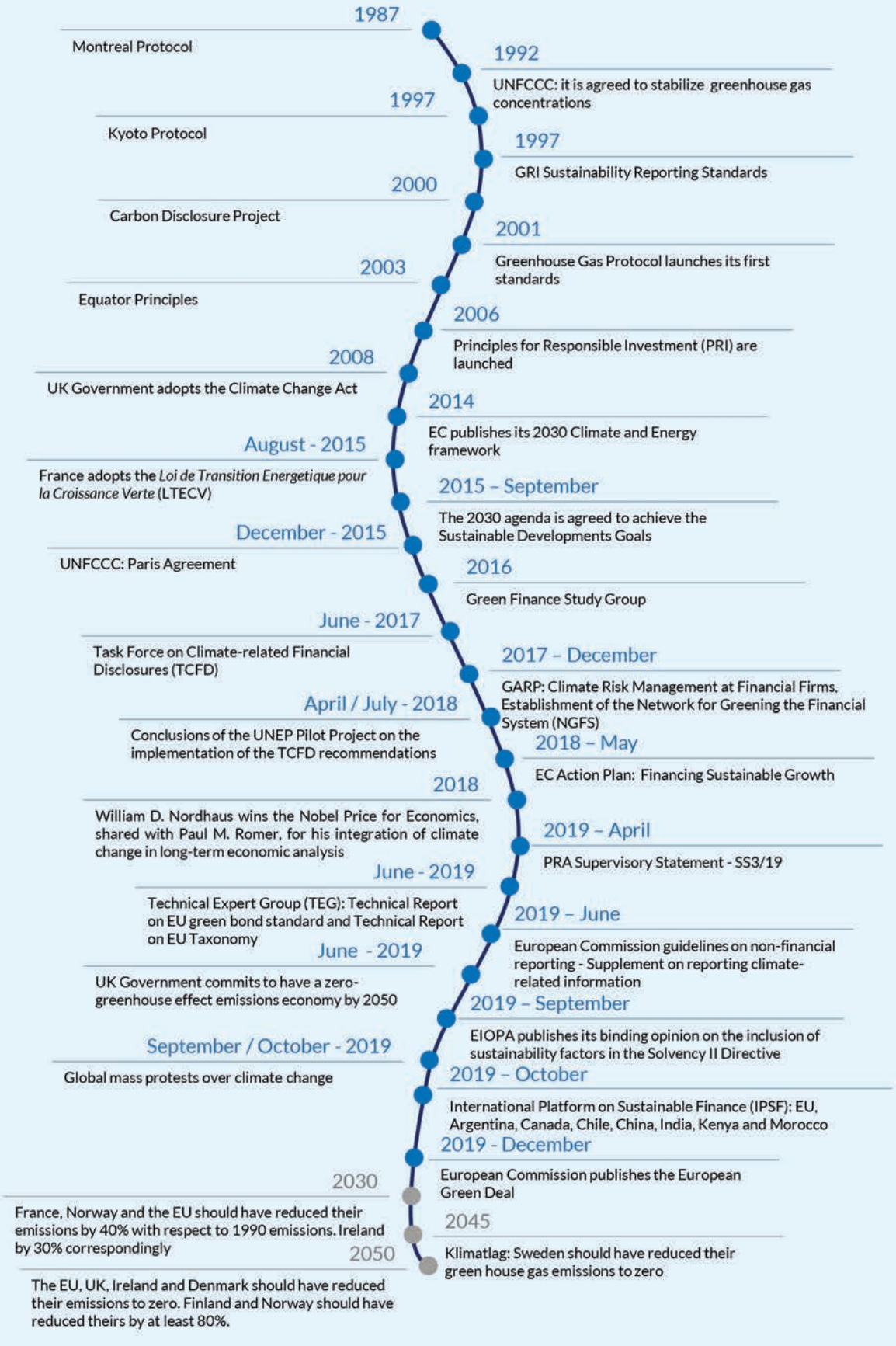
Despite its inherent risks, climate change also brings new business opportunities, mainly in those industries that are emerging as a solution to the problem. Such is the case of low-carbon emission products and services, transportation that does not involve intensive use of fossil fuels (e.g. rail and electric vehicles), alternatives for generating and transporting electricity through renewable or less polluting energy, engineering for the design and construction of plants in which these alternative energies are generated, etc. Additionally, the new focus on sustainability is perceived as an opportunity for companies to improve their positioning and reputation.

An example of these are the strong stock market revaluations experienced by those companies that have opted for green energy, so much so that it caused concerns that valuations that are too high might lead to a "green bubble".

In this context of new investments, the President of the European Commission (EC), Úrsula Von der Leyen, communicated in her opening speech at the UN Climate Change Conference (COP25) in Madrid that the EU would publish a European Sustainable Investment Plan as part of the New Green Deal, which will include an investment of one trillion euros[37] over ten years[38]. She also referred to that plan as the "new growth strategy for Europe". The Governor of the Bank of England (BoE), Mark Carney, who also spoke on the matter at COP25, estimated that an investment of about

[28] TCFD (2017).
[29] EC (2019b).
[30] EIOPA (2019b) y EIOPA (2019c).
[31] PRA (2019).
[32] Knight, Chan & Paun (2016).
[33] Environmental, Social and Governance.
[34] Euromoney (2020).
[35] GSIA (2018).
[36] Socially Responsible Investing.
[37] In this document, monetary quantities are expressed using the short scale.
[38] Von der Leyen, U. (2019).

Historical milestones of climate change



$90 trillion dollars[39] in infrastructure between 2015 and 2030 will be necessary, which would mean great opportunities in different sectors (e.g. energy, transport or food)[40].

The channeling of funds towards these opportunities can be seen in the financial sector with the increased supply of specific financial products such as "green bonds" (fixed income products aimed at financing projects that meet certain environmental criteria, activities identified as sustainable or projects whose aim is to mitigate climate change)[41] (figures 4 and 5).

The financial sector has also developed other products that facilitate investments for climate change mitigation. Some of these new products are green loans and deposits, energy efficiency financing plans, support for innovative start-ups, linking interest rates to sustainable performance or conservation finance[42].

Conclusions

Economic actors will face enormous challenges to adapt to the new social context, growing regulatory pressure and increasing demands from investors as a result of climate change. The starting point is to recognize this risk as an emerging cross-cutting risk which companies need to examine in greater depth to ensure they understand its nature, to properly assess its impact and to embed it into their risk management frameworks. At the same time, they should review their strategies and undertake plans to transform their business models.

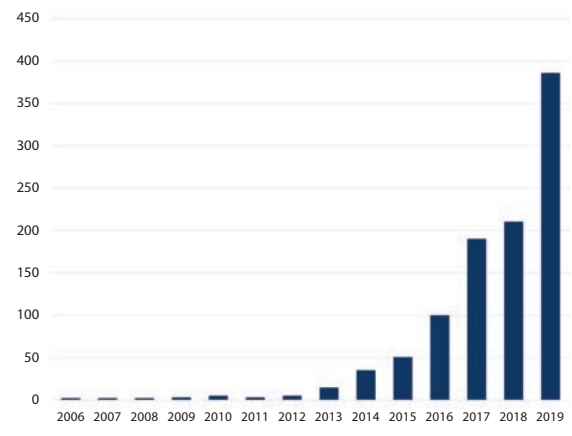
In this context, this document aims to offer a perspective on the present and future of the risks associated with climate change for organizations. The document is structured in the following sections:

- In-depth look into the nature of the risks associated with climate change together with a vision of the associated regulatory framework.
- Review of the risk management principles for these risks applied to different aspects: risk map, governance, evaluation methodologies, embedding into risk management practices and generation of reporting.
- In-depth look into the methodologies for assessing these risks in the financial sector and their different regulatory and management uses.
- Analysis of the incorporation of climate change risks in the valuation of financial assets.

Finally, it should be taken into account that, although the correct denomination of these risks is "climate-related risks" based on their cross-cutting and multiple impact nature, variations of this definition, such as climate change risks or simply climate risks, will also be used throughout this document. In the same way, we will refer indistinctly to climate change and global warming and, although CO_2 is not the only gas whose atmospheric accumulation causes this phenomenon - since other GHG such as methane or water vapour are also the cause - we will fundamentally refer to CO_2 as the main inducer.

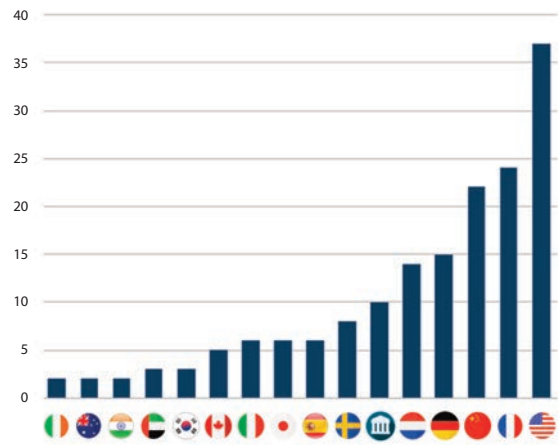
[39] In this document, monetary quantities are expressed using the short scale.
[40] Carney, M. (2019).
[41] ShareAction (2017).
[42] Ibíd.
[43] Environmental Finance Bond Database (2019).
[44] Fatin, L. (2019).

Figure 4: total annual value of the global green bond market (in billions of USD)



Source: Bond Data[43]

Figure 5: 15 largest green bond issuers in 2019 (in billions of USD)



Source: Climate Bonds Initiative[44]

Sustainable financial products

The financial sector has identified important opportunities derived from the large amount of capital and financing necessary for the transition to a decarbonized economy and the mitigation of the impacts of climate change. This has resulted in a significant development of sustainable financial products (at environmental and social level). Some of the most important or innovative are the following:

Asset Products

Sustainable loans	Sustainable loans (purpose of the funds) Sustainability-linked Loans (interest rate)
Sustainable credits	Green Credits Social Credits Social and impact microcredits
Agribusiness	
Green Mortgages	

Investment Funds

- **Green Investment Funds**
- **Social Investment Funds**
- **Mixed or sustainable investment funds (green + social)**

Liability Products

Financing through the issuance of Bonds	Green Bonds (Green Bond Principles) Social Bonds (Social Bond Principles) Sustainable bonds (green + social) Transition Bonds ODS-linked Bonds Sustainability-linked Bonds

Services

- **Bookrunner in the issuance of sustainable bonds by corporate issuers/other banks**
- **Financial Advisory and Private Banking services in sustainable matters**

Source: Management Solutions

Executive Summary

"The globe at century's end will be vastly different from today. The condition of our world will depend on the steps we take now to slow global warming"

– William Nordhaus[45]

This section aims to synthesize the main conclusions reached regarding the definition, governance and management of the risks arising from climate change (which will be discussed in the corresponding sections of this document).

1. Concerns for environmental degradation and climate change, as well as the evidence that has been observed, in this regard, have continue to receive increased attention internationally on the agendas of various public and private sectors. The emphasis being placed on the consequences to which countries, companies, the financial system and the global economy are exposed to. This has led to regulators, governments and companies taking action to address this issue in a coordinated way.

2. The Task Force on Climate-related Financial Disclosures (TCFD)[46], created by the Financial Stability Board (FSB), has established a definition and categorization of the risks arising from climate change that has become the international reference standard. The TCFD divides risks into two main categories: physical risks - derived from the increase in extreme weather events or from the long-term impacts of climate change - and transition risks that economic agents face on their way towards a decarbonized economy. The latter can also be sub-divided into legal, technological, market and reputational risks.

3. In response to the challenges of global warming, international standards and regulations have been developed in various geographies with a focus on three fundamental areas: (i) the promotion of transparency on climate risks to which organizations are exposed; (ii) the transformation of the production model to meet the targets set for reducing GHG emissions; and (iii) specific regulation for the financial sector in order to ensure its resilience against this phenomenon, and also due to its role in funnelling investment into the productive sector.

4. Regarding transparency, the TCFD recommendations on the disclosure of climate information have become the global reference standard. Its eleven main recommendations can be grouped into four areas: (i) climate risk governance; (ii) the definition of the potential financial impact of these risks considering different scenarios; (iii) the management of these risks; and (iv) the establishment of applied metrics for their measurement and objectives setting.

5. With respect to the transformation of the production model, in recent years numerous countries have enacted legislation that establishes the basis for the transition to a low GHG emission economy. This tendency is especially relevant in Europe, where the European Commission has announced its intention to publish the first European Climate Law as part of the European Green Deal, which seeks to make Europe the first continent completely decarbonized by 2050.

6. In recent years, regulations have been developed that seek to guarantee the stability of the financial system in the face of the climate challenge and to favor the channeling of funds to support the transition towards a decarbonized economic model. In particular, the regulation seeks to (i) promote the transparency and homogeneity of sustainable financing criteria to avoid greenwashing; (ii) ensure that financial institutions recognize and properly manage the risks arising from climate change; and (iii) ensure that there is adequate financial sector supervision and resilience. Particularly

[45] Speech at the award ceremony of the Prize in Economic Sciences in Memory of Alfred Nobel (2018) "for integrating climate change into long-run macroeconomic analysis".

[46] TCFD (2017).

noteworthy are the initiatives of the European Union, mainly represented by its Action Plan on Financing Sustainable Growth[47], and those of the United Kingdom.

7. Implementing a global climate change risk management framework involves addressing five main aspects: risk map, governance, measurement, processes and management tools, and disclosure.

8. Climate change materializes through increased exposure to other risks already consolidated in companies' risk maps. However, its relevance and cross-cutting nature determines that, in the case of the most exposed sectors, there is a tendency to include it in risk maps as a differentiated risk.

9. The following trends can be observed in the governance of this risk: (i) increasing involvement of the Board; (ii) establishment of policies that determine the principles and criteria for dealing with climate change and its associated risks, and establish the roles and responsibilities for developing and controlling these policies within the organization; and (iii) in the case of the financial sector, where the origination of indirect risks through portfolios or counterparties is especially relevant, review of the policies regulating all risks affected by climate change, whether these risks are financial or non-financial.

10. Measuring exposure to climate risk involves significant challenges such as uncertainty about what the final temperature increase scenario will be, the long-term horizon associated with the materialization of risks, the lack of knowledge about the actual political measures to restrict emissions that will eventually be implemented or future technological advances in terms of energy efficiency, new energy sources or carbon emission capture. Despite this, measuring the risk of climate change is a first and necessary step to managing it.

11. Climate change risk quantification can be addressed in four basic steps: (i) establishing the probability distribution of the expected temperature increase and the associated climate change scenarios; (ii) estimating the frequency, probability and severity of the physical and transition risks associated with each scenario; (iii) approximating the correlation between the identified risks; and (iv) running correlated simulations of predicted scenarios. The result is a distribution of losses from climate change, with an average loss and a "CVaR" (Climate Value at Risk).

12. Each organization must establish its own management strategy, evaluating alternatives to ensure the protection of assets and the continuity of operations against physical risks (relocation or increased resilience of facilities, assurance, disaster recovery, etc.) as well as the continuity of investments aimed at reducing the level of GHG emissions of their production model (project screening and control model, controls on production process to monitor the level of implementation of the policies adopted, and review of the management process for other pre-existing risks that are impacted by climate change).

13. Recognition of climate change risks through disclosure is a fundamental pillar for subsequent action. International initiatives such as TCFD, the Carbon Disclosure Project (CDP) or the GHG Protocol play a fundamental role in the standardization of the content and criteria to be disclosed.

14. Companies can improve transparency in relation to climate risks by: (i) defining an appropriate reporting and communication strategy; (ii) creating cross-industry working groups in order to unify the criteria used; and (iii) benchmarking their climate change-related disclosure against their peers, as well as the impact of these disclosures on the different stakeholders.

[47] European Commission (2018).

15. The specificity of the financial industry business means that the way in which risks associated with climate change manifest themselves is significantly different, with indirect financial impacts associated with the risks that affect portfolios and counterparties in all sectors taking priority over direct impacts. Measuring these impacts requires specific methodologies.

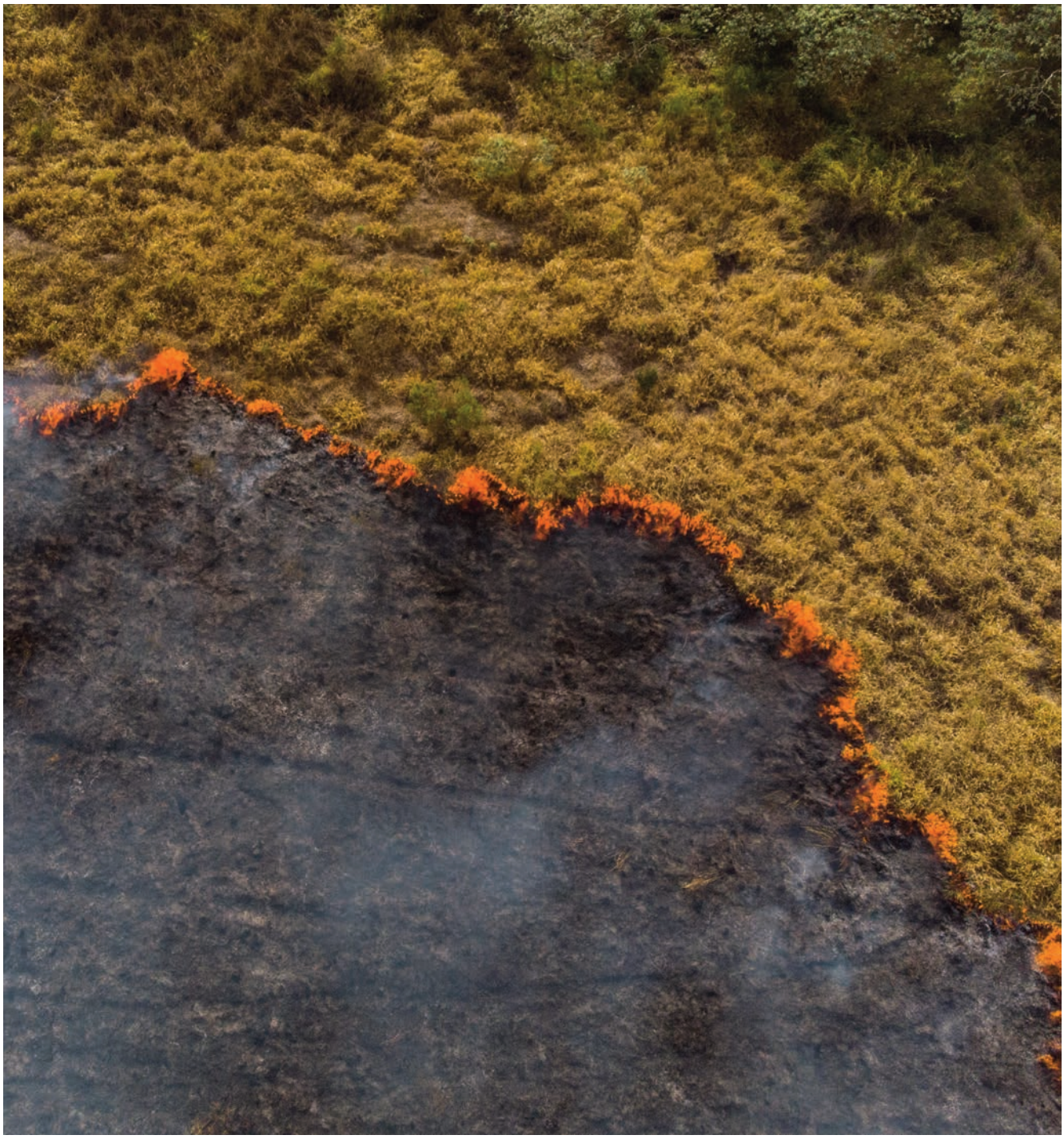
16. The outcome from these methodologies could impact capital (stress test, capital planning and own funds requirements), provisions and market discipline. In any case, it is necessary to incorporate the climate change risk dimension into the risk management process, including risk appetite, as well as into the risk underwriting process (adjustment of rating models, risk-adjusted profitability and pricing) and the risk monitoring process.

17. Finally, as we intend to illustrate through the case study provided in the last section of this document, it is observed that, since the Paris Agreement, green bonds have been listed with a lower issuance premium compared to conventional bonds of similar characteristics, although this impact is different depending on the sector. This allows us to confirm that financial markets are already beginning to consider the risk of climate change in the valuation of assets.

Climate change risks: definition and regulatory context

"We give our best when we are bold and aim high. With the European Green Deal we are aiming high. Europeans are calling on us to drive the change. Now it is up to us, to answer their call"

– Ursula von der Leyen[48]



Definition of climate risks

With the aim of creating a common and consistent global framework for the consideration of economic risks arising from global warming, in 2017 the Task Force on Climate-related Financial Disclosures (TCFD)[49], created by the Financial Stability Board (FSB) and established a definition and categorization of the risks that has become the global reference standard (figure 6).

Climate change risks can be divided into two main categories: those derived from physical impacts and those derived from the transition to a low carbon economy (sometimes called carbon risks).

Physical risks

The physical risks of climate change are defined as those derived from the increasing severity and frequency of extreme weather events or from gradual and long-term changes in the Earth's climate. These risks can directly affect companies through damage to assets or infrastructure, or indirectly by altering their operations or making their activities unfeasible. Physical risks are subdivided into two types:

Acute risks

The risks classified as acute are those caused by extreme weather events whose frequency and intensity would increase due to global warming, such as cyclones, hurricanes, floods or fires.

Chronic risks

Chronic physical risks are those that result from medium or long-term changes in climate behavior, especially due to a general increase in temperatures. Examples of these are the impacts produced by the rise in sea levels, the ocean acidification or the alterations in the level and frequency of rainfall.

Transition risks

The commitments acquired by the signatories of the Paris[50] Agreement and the consequent transition to a decarbonized production system imply a drastic transformation of the global economy as a result of important changes in regulations, markets and technology. These changes carry significant risks for companies. The TCFD distinguishes between the following categories of transition risks:

Regulatory and legal risks

Regulations on climate change are evolving more and more rapidly. These regulations usually seek to limit the activities that contribute to climate change while at the same time promoting measures to adapt to this change. This implies that economic actors must adapt to the new regulations, with a significant impact on their strategy, business and production models. Some examples of policies that carry transition risk are the implementation of CO_2 prices, the promotion and subsidy of renewable and efficient energy sources, or the setting of targets to reduce greenhouse gas emissions.

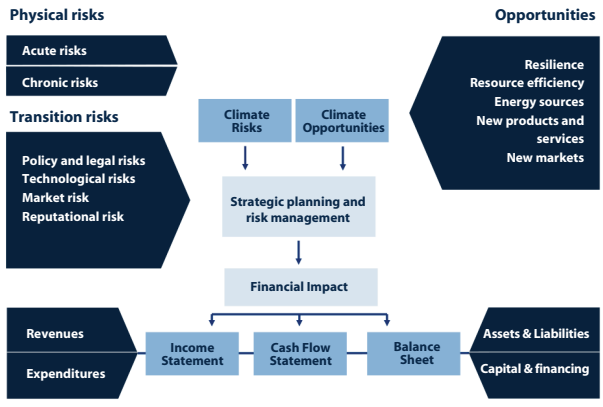
In addition, companies face a growing risk of being sued for their contribution to climate change, for their negligence in establishing measures to mitigate and/or adapt to the effects of climate change, or for a lack of transparency about these risks.

Technological risks

Technological innovations focused on the transition to a low carbon economy can have a very significant impact on companies and entire economic sectors, since they might imply expected value losses on already developed infrastructures, as well as heavy investments in R&D/Innovation and the incorporation of new technologies that are still in the evolutionary phase. Some examples are the technological improvements related to renewable energy, CO_2 capture or energy efficiency.

[48] President of the European Commission, during her speech presenting the European Green Deal to the European Parliament (2019).
[49] TCFD (2017).
[50] UN (2015).

Figure 6: the financial impact of climate risks and opportunities



Source: TCFD[51]

Market risk

Climate change can affect the market in multiple ways, with changes in the supply and demand of products and services or increased production costs being among the most significant. Changes in consumer behavior that increase the demand for products classified as sustainable, or a decrease in the supply of certain resources due to greater scarcity, are examples of this type of risk. This category would include the decrease in the financial valuation of fossil fuel reserves (known as stranded assets) due to the fact that two thirds of these reserves could not be burned under a 2ºC scenario[52].

Reputational risk

Changes in the image and prestige of an entity or an economic activity, due to its positive or negative contribution to the transition to a more sustainable economy, can generate significant risks, as well as opportunities.

It is interesting to point out that physical and transition risks are inversely related: the more powerful and rapid the transition to a green economy, the more significant transition risks will be, whereas physical risks will be less intense and vice versa.

Regulatory context: main initiatives and degree of implementation

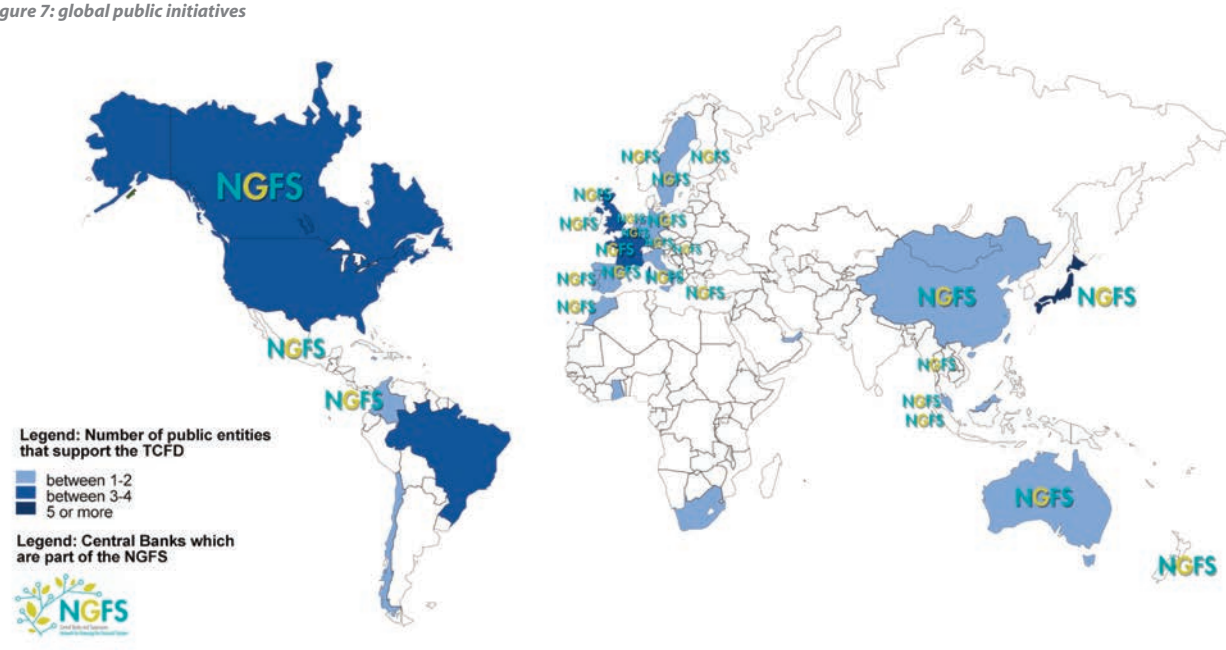
Since the Kyoto Protocol was signed there has been an increase in the number of laws related to climate change by a factor of more than 20[53]. Today, 195 parties have signed the Paris Agreement, 187 have ratified[54] it and each and every one of the signatories have enacted at least one law or regulation on climate change[55].

In particular, several international standards have been developed in recent years, while national and regional regulations have focused on the transition to a low-emissions economy and on the risks arising from climate change.

The primary objectives of international regulations and standards can be categorized into three fundamental types:

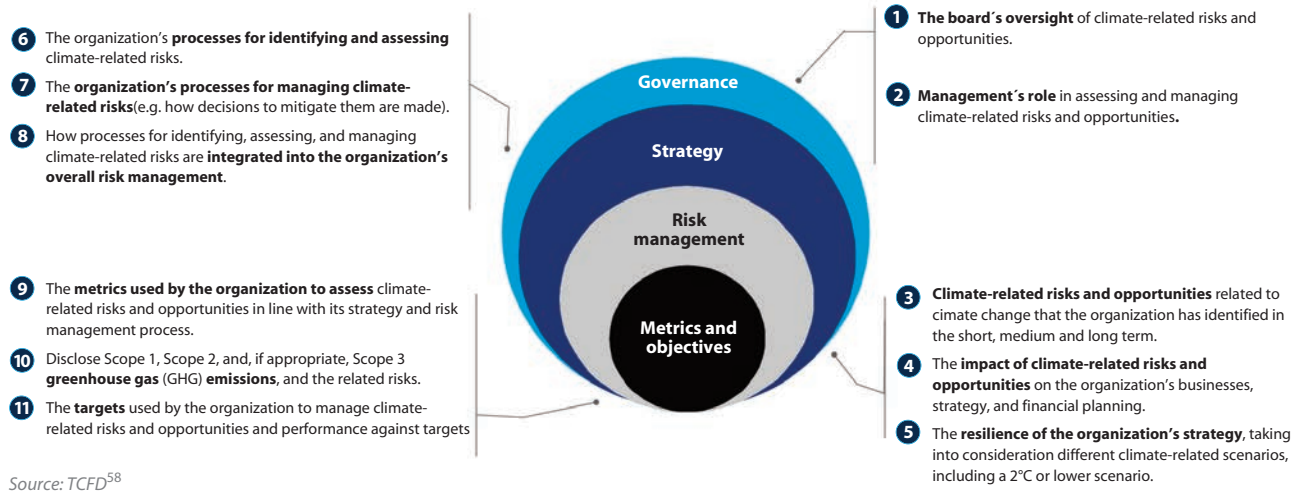
[51] TCFD (2017).
[52] Carbon Tracker Initiative (2013).
[53] Nachmany & Setzer (2018).
[54] United Nations Treaty Collection (2019).
[55] Ibíd.
[56] TCFD (2019).
[57] NGFS (2019).

Figure 7: global public initiatives



Source: TCFD Supporters[56] *and NGFS*[57]

Figure 8: the four main areas and the eleven aspects of information disclosure set by the TCFD



Source: TCFD[58]

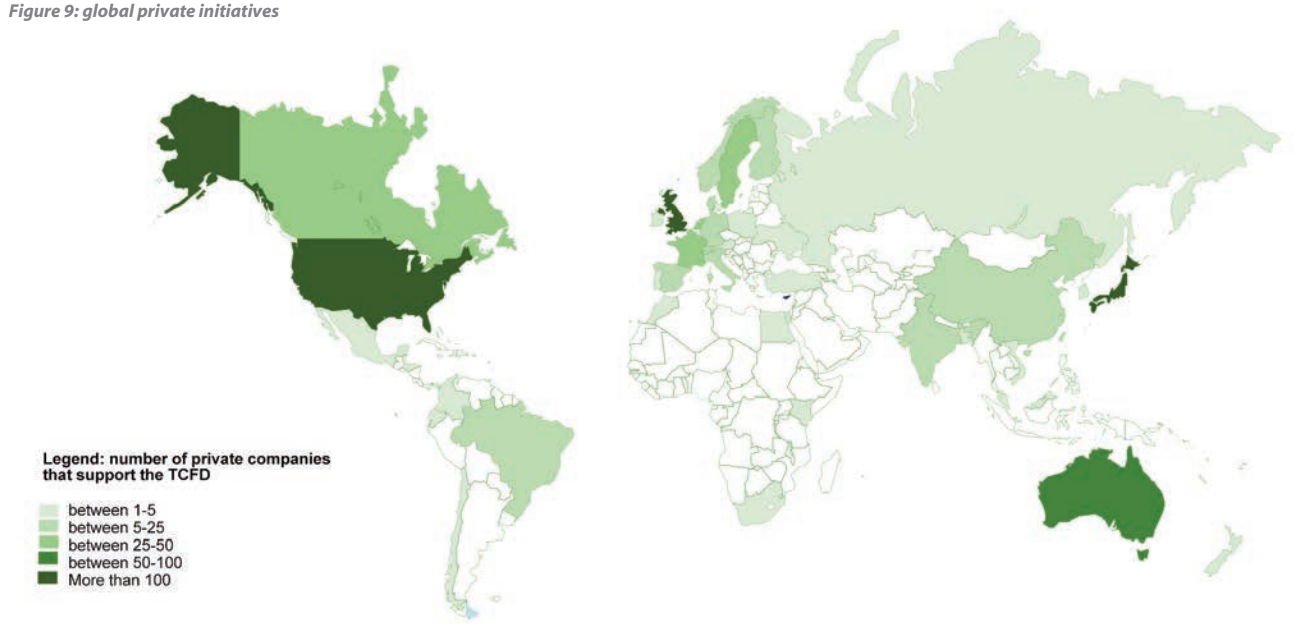
- International standards, sometimes transposed to local regulations, which seek to promote transparency in organizations in relation to how climate change impacts them and how they govern and manage the related risks.
- Regulations that aim to establish actions to reduce CO_2 emissions in line with the objectives of the Paris Agreement[59], as well as to promote an orderly transition of the production model.
- Finally, regulations specifically aimed at the financial sector for its fundamental role in channeling investment into the productive sector, and to ensure the resilience of the financial system.

The global standard on climate risk transparency: the TCFD

The 2017 publication of the recommendations on climate-information disclosure by the Task Force on Climate-related Financial Disclosures (TCFD)[60] established an important milestone by stating that climate risks should be taken into consideration and that an increase in transparency is necessary. Its principles on the disclosure of climate change risks have become the global standard reference for regulators and legislators as well as for the business sector.

[58] TCFD (2017).
[59] UN (2015).
[60] TCFD (2017).

Figure 9: global private initiatives



Source: TCFD Supporters data[56]

Figure 10: framework of climate change laws in the world

Country/Region	Organism	Title	Status	Year of adoption
UK	Government of the UK	Amendment of the 2008 Climate Change Act[61]	Adopted	2008
Mexico	Government of Mexico	Ley General de Cambio Climático[62]	Adopted	2012
Denmark	Ministry of Energy of the Government of Denmark	Lov om Klimaradet[63]	Adopted	2014
France	Ministry for the Ecological and Solidarity Transition of the Government of France	Loi de Transition Énergétique pour la Croissance Verte (LTECV)	Adopted	2015
Ireland	Government of Ireland	Climate Action and Low Carbon Development Act 2015[64]	Adopted	2015
Finland	Ministry of Environment	Kansallinen ilmastolaki[65]	Adopted	2015
Sweden	Government of Sweden	Klimatlag[66]	Adopted	2017
Norway	Government of Norway	Climate Change Act[67]	Adopted	2017
Colombia	National Government of the Republic of Colombia	Ley 1931: Directrices para la Gestión del Cambio Climático[68]	Adopted	2018
Spain	Ministry for the Ecological Transition of the Government of Spain	Anteproyecto de Ley de Cambio Climático y Transición energética[69]	In progress	
Germany	Federal Ministry of Environment, Nature Conservation and Nuclear Safety of the Government of Germany	Entwurf eines Gesetzes zur Einführung eines BundesKlimaschutzgesetzes und zur Änderung weiterer Vorschriften[70]	In progress	
Netherlands	Government of the Netherlands	The Climate Act[71]	In progress	
Chile	Ministry of Environment of the Government of Chile	Anteproyecto de Ley Marco de Cambio Climático[72]	In progress	
New Zealand	Ministry of Environment of the Government of New Zealand	Climate Change Response (Zero Carbon) Amendment Bill[73]	In progress	
European Union	European Commission	European Climate Law	In progress	

Source: Management Solutions

Its recommendations are based on the need to increase transparency on climate risks to which companies are exposed to in relation to different aspects: how these risks are governed, the potential financial impact of climate risks under different scenarios, how climate risks are managed and what metrics are used in order to measure them, as well as the setting of objectives around them (figure 8).

Different regulators and public bodies across the world have expressed their support for the TCFD recommendations or have indicated that they have used them as a basis for developing their own regulations (figure 7).

Multiple organizations within the private sector have declared their official support for the TCFD. Almost half of the companies that support it (49%) belong to the financial sector[74] and, geographically, almost 40% of them are European, followed by Asian (31%) and North American companies (18%) (Figure 9).

Legislation focused on the transiton of the production model

National laws on climate change establish the basis for developing a national strategy to address the challenges of climate change with a stable long-term vision. In general terms, all these laws have a number of elements in common (figure 10):

- They stipulate binding targets for reducing emissions at the national level, following the lines of the Paris Agreement, with targets for 2030 and 2050 in most cases.
- They set objectives for improving energy efficiency.
- They prescribe objectives for the percentage of national energy consumption that should come from renewable energy sources.
- They impose the obligation to present national climate action plans periodically. These plans are aimed at planning the transition of the national economy towards a low carbon emissions model, as well as establishing a national strategy to identify, manage and mitigate climate risks that the country is exposed to.
- They establish mechanisms to monitor progress towards the proposed objectives, as well as processes to correct the course if necessary.
- They establish the need for periodic evaluations of plans and policies by expert and independent bodies.
- Some of these laws, such as the *Loi de Transition Énergétique pour la Croissance Verte* (LTECV)[75] in France establish the obligation for some companies to publish information about climate risks that they are expose to, as well as their strategy to address them.

[61] Department for Business, Energy & Industrial Strategy (2019).
[62] Cámara de Diputados del H. Congreso de la Unión de los Estados Mexicanos (2012).
[63] Danmarks Energistyrelsen (2014).
[64] Government of Ireland (2015).
[65] Finland´s Ministry of the Environment (2015).
[66] Regeringskansliet (2017).
[67] Norway´s Ministry of Climate and Environment (2017).
[68] Congreso de Colombia (2018).
[69] Congreso de los Diputados del Reino de España (2019).
[70] Bundesregierung (2019).
[71] Government of the Netherlands (2019).
[72] Ministerio del Medio Ambiente de Chile (2019).
[73] Ministry for the Environment of New Zealand (2019).
[74] TCFD (2019).
[75] Ministère de la Transition écologique et solidaire (2015).

As shown in Figure 10, a large number of countries have recently adopted or are currently developing framework laws on both climate change and the transition to a decarbonized economy, especially in Europe, where the European Commission announced that the first European Climate Law will be published in 2020[76].

Finally, the European Green Deal presented by the Commission is an ambitious package of measures and policies that seek to make Europe the first decarbonized continent by 2050. This plan aims to mark a new milestone in Europe's environmental transition.

Regulations aimed at the financial sector

Complying with emission reduction objectives requires redirecting financial flows towards the investment needed to enable change in the production model.

Thus, the third objective of the Paris Agreement is to "place financial flows at a level compatible with a trajectory that leads to a climate-resilient development with low greenhouse gas emissions"[77].

For this reason, climate change framework laws tend to be closely followed by regulations focused specifically on the financial sector (including notably the initiatives of the European Union and the United Kingdom).

In the case of the European Union, the regulatory process initiated in 2018, which will continue until 2022, presents the following objectives:

- Avoid "greenwashing", by promoting transparency in financial markets with various initiatives aimed at clarifying what activities are considered sustainable (the taxonomy), establishing a standard for green bonds, expanding the pre-contractual information to investors, also incorporating additional controls on the advertising information, establishing controls over climate transition benchmarks, etc.

- Ensure that financial institutions: i) correctly assess climate change risks (using metrics and scenario analysis); ii) properly disclose these risks (through the incorporation of non-financial disclosures, while their incorporation to Pillar III are in progress); iii) manage these risks; iv) ensure they are resilient in terms of Capital (through the incorporation of the stress test[78] and subsequently in Pillar I Capital); and finally v) that all these elements are subject to appropriate supervision (incorporation in SREP).

Specifically, in 2018 the European Commission approved the Action Plan on Financing Sustainable Growth[79], an ambitious package of measures with three main objectives:

1. Reorient capital flows towards sustainable investments, to achieve sustainable and inclusive growth;

2. Manage financial risks caused by climate change, environmental degradation and social problems;

3. Promote transparency and long-termism in financial and economic activities.

Following approval of the Action Plan, the number of European recommendations, regulations and plans promoting the inclusion of climate risks and sustainability in economic decision-making have increased considerably (see table on European financial climate risk regulations on page 23).

In the United Kingdom, the Bank of England has positioned itself at the head of the group of financial supervisors who are encouraging the consideration of climate risks. In April 2019, the Bank's Prudential Regulation Authority (PRA) was one of the first regulators to publish its expectations about the disclosure and management of climate risks by financial institutions[80]. Inspired by the recommendations of the TCFD, its expectations are structured around four topics: governance, risk management, scenario analysis and information disclosure. Furthermore, in December 2019 the Bank presented a discussion paper on its pioneering 2021 biennial exploratory scenario (BES) exercise[81] which, within their stress testing framework, will focus on

[76] EC (2019c).
[77] United Nations (2015).
[78] Enria, A. (2019).
[79] European Commission (2018).
[80] Prudential Regulation Authority (2019).
[81] Bank of England. Financial Policy Committee & Prudential Regulation Committee (2019).

testing the resilience of banks, insurers and the financial system as a whole to climate related risks. This exercise aims to help develop the analysis of climate scenarios in the British financial system, examine what are the necessary adjustment measures are to ensure the stability of the system in the face of climate change, as well as develop effective risk management strategies. This stress test will observe multiple climate scenarios using a 30-year modeling horizon.

The Network for Greening the Financial System (NGFS)[82] also deserves a special mention as a reference for financial regulators on climate risks. The central banks of most of the world's main economies belong to this association. Its objective is to protect global financial stability from the potential consequences of climate change while promoting the identification and management of such risks, as well as sustainable finance. These central banks officially support and promote the adoption of the TCFD recommendations.

Conclusions

In light of the above, we can conclude that regulation plays a fundamental role in changing the production model to fight the effects of climate change. Although, initially, regulations on climate change focused on analyzing the impact of economic activity on the environment and promoting sustainable practices, regulations currently in progress in those regions most likely to recognize and actively manage this risk are focused on:

- Establishing homogeneous criteria for the definition of climate risks and sustainable activities.
- Improving climate risk recognition transparency for the benefit of investors and the public in general.
- Providing basic legal security to investments needed to adapt the production model and ensuring the financial system's role in channeling capital flows towards these investments.
- Ensuring the stability of the financial system in the face of disruptions to the productive economy as a result of either physical or transition risks materializing.

It is expected that, in the coming years, all kinds of entities, both financial and non-financial, operating in these environments will be progressively forced by regulations to include climate risks in their risk management strategies. The extent to which these regulations are gradually adopted in other geographical areas will depend on the success of multilateral agreements (especially those derived from the Paris Agreement), and on the expansion of social awareness.

[82] Network for Greening the Financial System (2019).

European financial climate risk regulation

Issuing Body	Name	Relevant Dates	Regulation Objectives	Description
European Commission	Action Plan: Financing Sustainable Growth.	Published: March 8, 2018.	Promotion and regulation of sustainable finance. Promote proper management and supervision of ESG risks. Promote transparency.	Ambitious measure package, which has three main objectives: reorient capital flows towards sustainable investment in order to achieve sustainable and inclusive growth; manage financial risks stemming from climate change, resource depletion, environmental degradation and social issues; and foster transparency and long-termism in financial and economic activity.
European Parliament and European Council	Regulation (EU) 2019/876 of the European Parliament and of the Council of 20 May 2019 amending Regulation (EU) No 575/2013 with regards to the leverage ratio, the net stable funding ratio, requirements for own funds and eligible liabilities, counterparty credit risk, market risk, exposures to central counterparties, exposures to collective investment undertakings, large exposures, reporting and disclosure requirements, and Regulation (EU) No 648/2012.	Published: May 2019. Date of effect: June 28, 2021.	Establish requirements for own funds, proper measurement and management of prudential risk.	Includes a 25% reduction to own funds requirements for credit risk for exposures to entities that operate or finance physical structures or facilities, systems and networks that provide or support essential public services, that contribute to environmental objectives and climate change mitigation, among other criteria.
European Commission	Supplement to guidelines on non-financial reporting: Guidelines on reporting climate-related information.	Published: June 2019.	Promote disclosure and transparency.	The guidelines state that entities (financial and non-financial) should disclose information regarding material climate risks. The type of information to be disclosed includes the recommendations of the Financial Stability Board's Taskforce on Climate-related Financial Disclosures (TCFD).
European Banking Authority (EBA)	Consultation Paper: Guidelines on loan origination and monitoring.	Published: June 2019.	Establish standards, reduce credit risk, promote proper credit risk supervision.	Establishes that Institutions should include environmental, social and governance (ESG) factors in their risk management policies, and in particular their credit risk policies and procedures; institutions should develop specific green lending policies and procedures and include climate change risks in their risk management policies.
Technical Expert Group on Sustainable Finance (TEG)	Technical Report on EU Taxonomy.	Published: June 2019. The taxonomy legislation is subject to approval by the European Parliament and Council.	Promote disclosure and transparency, establish standards, avoid greenwashing.	Establishes criteria and methodologies to identify and classify sustainable economic activities.
Technical Expert Group on Sustainable Finance (TEG)	Technical Report on EU Green Bond Standard.	Published: June 2019.	Promote disclosure and transparency, establish standards, avoid greenwashing.	Aims to improve the effectiveness, transparency and credibility of the green bonds market.
European Supervisory Authorities (ESAs)	Technical committees on the inclusion of climate change risks and sustainability factors in the Solvency II, IDD, MiFID II, UCITS and AIFMD directives.	Published: Solvency II and IDD: April 2019. MiFID II: April 2019. UCITS and AIFMD: June 2019. Solvency II: September 2019.	Promote disclosure and transparency.	The European Supervisory Authorities (ESAs) are considering to regulate the inclusion of climate change risks and sustainability factors in these directives.
European Banking Authority (EBA)	EBA Risk Reduction Package Roadmaps.	Published: November 2019. Publication of guidelines for the inclusion of climate risks aligned with Pillar II: 2020. Date of effect: 2022.	Reduce risk, promote disclosure and transparency.	Among other measures, the EBA will publish guidelines for the disclosure of climate risk related information in accordance with the Pillar III Basel CRR.
European Parliament and European Council	Regulation (EU) 2019/2033 of the European Parliament and of the Council of 27 November 2019 on the prudential requirements of investment firms and amending Regulations (EU) No 1093/2010, (EU) No 575/2013, (EU) No 600/2014 and (EU) No 806/2014.	Published: 27th November 2019. Publication of report on assets exposed to ESG activities: December 2021.	Reduce risk, proper risk management and supervision.	Includes a chapter on sustainability, which states that the EBA will assess whether dedicated prudential treatment of assets exposed to activities associated substantially with environmental or social objectives would be justified from a prudential perspective.
European Parliament and European Council	Directive (EU) 2019/2034 of the European Parliament and of the Council of 27 November 2019 on the prudential supervision of investment firms and amending Directives 2002/87/EC, 2009/65/EC, 2011/61/EU, 2013/36/EU, 2014/59/EU and 2014/65/EU.	Published: November 2019. Publication of report on inclusion of criteria related to exposure to ESG factors in SREP: December 2021.	Reduce risk, proper risk management and supervision.	Includes a chapter specifically on sustainability, which states that the EBA will prepare a report on the introduction of technical criteria related to exposure to activities associated substantially with environmental, social, and governance (ESG) objectives for the supervisory review and evaluation process. It also states that in 2024, the European Council will publish a report on the inclusion of ESG factors in the risk governance and management requirements of investment institutions, as well as its consideration in the SREP.
European Insurance and Occupational Pensions Authority (EIOPA)	Results of Occupational Pensions Stress Test 2019.	Published: December 17, 2019.	Reduce risk, proper risk management and supervision.	Presents the results of the 2019 EIOPA Stress Test. For the first time, the European stress test exercise covers the analysis of Environmental, Social, and Governance (ESG) factors for Occupational Retirement Provisions (IORPs).
European Banking Authority (EBA)	Action Plan on Sustainable Finance.	Published: December 2019.	Promotion and regulation of sustainable finance.	Explains the EBA's approach to sustainable finances, from key metrics, risk strategies and management, to scenario analysis and risk weight adjustment analysis.
European Parliament and European Council	Regulation (EU) 2019/2088 of the European Parliament and of the Council of 27 November 2019 on sustainability related disclosures in the financial services sector.	Published: December 2019. Date of effect: 10 March 2021.	Promote disclosure and transparency.	Aims at reducing discrepancies in the disclosure of sustainability-related risks in the financial services sector
European Parliament and European Council	Regulation (EU) 2019/2089 of the European Parliament and of the Council of 27 November 2019 amending Regulation (EU) 2016/1011 as regards EU Climate Transition Benchmarks, EU Paris-aligned Benchmarks and sustainability-related disclosures for benchmarks.	Published: December 2019. Comply by: April 30, 2020.	Promote disclosure and transparency, establish standards.	Establishes that the European Commission (EC) will specify, through delegated acts: the criteria for the choice of underlying assets, including, where applicable, any criteria for excluding assets; the criteria and method for the weighing of underlying assets in the benchmark; the determination of the decarbonization trajectory for EU Climate Transition Benchmarks. In addition, entities will have to report objectives to reduce carbon emission within specific deadlines.
European Securities and Markets Authority (ESMA)	Report on undue short-term pressure on corporations by the financial sector.	Published: December 2019.	Promote a long-term vision within the financial sector.	Study of the undue short-term pressure the financial sector exerts on corporations.
European Banking Authority (EBA)	Consultative document on future changes to the EU stress test.	Published: January 2020. The proposed framework will be included no sooner than in the Stress Test of 2020.	Reduce risk, proper risk supervision, promote disclosure and transparency.	Introduces, among other mandates, the proposal to evaluate additional scenarios and sensitivities by the stress test exercise, which would include climate change risks.
European Securities and Markets Authority (ESMA)	Strategy on Sustainable Finance.	Published: February 6, 2020	Promote proper ESG risk management and supervision, reduce risk.	Considers the inclusion of ESG factors in all its activities, with objectives structured in four main areas: greenwashing, European supervision, sustainability benchmarks and credit rating agencies, and finally risks and opportunities related to sustainable finance.

Source: Management Solutions

Key international initiatives, agreements and standards on climate change

Carbon Disclosure Project

The Carbon Disclosure Project (CDP) is a not-for-profit organization that currently runs the most globally widespread disclosure system on environmental impact information, incorporating one of the most complete databases in the world. Founded in 2000, its objective is to promote the transition to a more sustainable economy by helping investors, businesses, cities and regions to measure and understand the impact of their operations on climate change, water security and deforestation, as well as the related risks and opportunities[83].

Greenhouse Gas Protocol

The Greenhouse Gas (GHG) Protocol is the global reference standard for measuring and managing greenhouse gas emissions generated by public and private sector operations, their value chains and mitigation actions[84]. It was set up in the late 1990s by initiative of the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) with the aim to improve the information available on emissions that generate climate change.

Equator Principles

The Equator Principles provide a risk management framework that can be adopted by any financial entity to identify, evaluate and manage the environmental and social impact risk of the projects it finances[85]. Their main objective is to establish a minimum set of due diligence standards to promote the consideration of these factors in investment decision-making.

The Principles were originally published in 2003, based on International Finance Corporation (IFC) and World Bank standards, and have evolved over time. Currently, 99 financial institutions in 37 countries have officially adopted them, covering most of the international debt for the financing of projects in developed and emerging countries.

The Principles of Responsible Investment

The Principles of Responsible Investment (PRI) is an international and independent investor organization that was created in 2006 by the UN[86]. Its mission is to promote and establish responsible investment criteria. As of today, it is the international standard of reference. It is based on six basic principles and currently has more than 2000 signatories.

Sustainable Development Goals

The United Nations 2030 Agenda on Sustainable Development was agreed at the UN Summit that took place in September 2015 in New York. This agreement consists of 17 main objectives and 169 goals[87] to be achieved in the next 15 years by all members of the United Nations.

The SDGs are a call to action to end poverty and inequality, promote economic development and improve education and health globally while at the same time, as its objective number 13 clearly states, fighting climate change, one of the greatest challenges of our time. The SDGs also emphasize the need to build a sustainable and environmentally friendly development model, as also mentioned in objectives 12, 14 and 15.

Paris Agreement

Following the signing of the SDGs, the historic Paris Agreement was reached in December 2015 during the United Nations Summit on Climate Change. This agreement marks a new direction in the global effort against climate change, allowing nations to set concrete and ambitious goals, through emission-reduction contributions at the national level, which should be reviewed periodically. As of today, 187 of the 195 parties to the Convention have ratified the agreement[88]. Despite the large number of countries that signed, there are some large emissions producers such as Iran, Irak or Turkey that have not ratified it. Additionally, in November 2019, the United States announced their intention to withdraw from the Paris Agreement[89].

The signatories of the agreement pledge to "keep the global average temperature increase well below 2°C with respect to pre-industrial levels, and continue efforts to limit that temperature increase to 1.5°C"[90].

Alongside this main objective, the parties added two more:

- "Increase the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development; and"
- "Making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development."

Task Force on Climate-related Financial Disclosures (TCFD)

In April 2015, the G20 finance ministers and central bank governors called on the Financial Stability Board (FSB) to study, alongside the public and the private sectors, the best way for the financial sector to consider the potential impacts derived from climate change[91]. As a response, in December of the same year the FSB established the Task Force on Climate-related Financial Disclosures (TCFD), a special working committee with two essential tasks[92]:

- Identify and determine the necessary information regarding climate risks and opportunities, as well as their financial impacts.
- Establish an international standard for the development and publication of such information.

Essentially, the TCFD was established with the objective of increasing transparency in relation to the risks and opportunities arising from climate change, as well as its potential impact on the economy.

As a result of these efforts, in 2017 the TCFD published its official recommendations[93], establishing a global standard for the identification, analysis and disclosure of financial information related to climate change. In particular, these recommendations provide a basis for the inclusion of risks and opportunities arising from climate change in the financial statements and the strategy of both financial and non-financial companies.

The response to the TCFD recommendations has been quick and positive, as they are now being adopted by key public and private sector entities. Among these entities are the European Commission, the central banks of England and France, FEBRABAN in Brazil, and multiple business groups from different sectors.

Network for Greening the Financial System

The Network for Greening the Financial System (NGFS) is an association of central banks and financial supervisors established in December 2017 due to their concern about the potential effects of climate change on global financial and economic stability. Its objectives are to promote sustainable finance and the identification and management of risks arising from climate change by the financial sector[94]. The NGFS currently has 34 members and 5 observers around the world, including the central banks of France, England, China and Spain, as well as the Basel Bank for International Settlements. In addition, the NGFS promotes and relies on the recommendations of the TCFD.

[83] Carbon Disclosure Project (2019).
[84] Greenhouse Gas Protocol (2019).
[85] The Equator Principles (2019).
[86] Principles for Responsible Investment (2019).
[87] United Nations General Assembly (2015).
[88] United Nations Treaty Collection (2019).
[89] Pompeo, Michael R. (2019).
[90] United Nations (2015).
[91] G20 Finance Ministers and Central Bank Governors Meeting (2015).
[92] Financial Stability Board (2015).
[93] Task Force on Climate-Related Financial Disclosures (2017).
[94] Network for Greening the Financial System (2019).

Climate Change Risk Management

"Dealing with climate change requires not only mitigating damage, but also adapting for the future, (…) which is mostly about pricing risk and providing incentives for investment, including in new technologies"

– Kristalina Georgieva[95]

In order to address the risks arising from climate change in a timely manner, organizations need to understand these risks in depth in order integrate them into their global risk management framework[96]. For this, organizations need to approach climate change risks from the following key perspectives (figure 11).

Risk map

In a business context, " climate change risk", is perceived as a new reality, an "emerging risk" that was not analyzed in depth until five years ago, at best.

However, the reality is that these risks, if materialized, will increase exposure to other risks already in the risk maps of organizations. There have always been adverse natural phenomena, technological disruptions, regulatory modifications or changes in business models that companies assesed and protected themselves from. The main difference is that, in this case, multiple risks are increased by the same cause: climate change. And, as a result, they are highly correlated.

Therefore, one could say that "climate change risk" triggers a set of other risks that in most cases are already included in companies' risk maps but which, in this context, take on special significance.

In light of the above, climate change risks should be viewed and assessed separately for various reasons, such as the following:

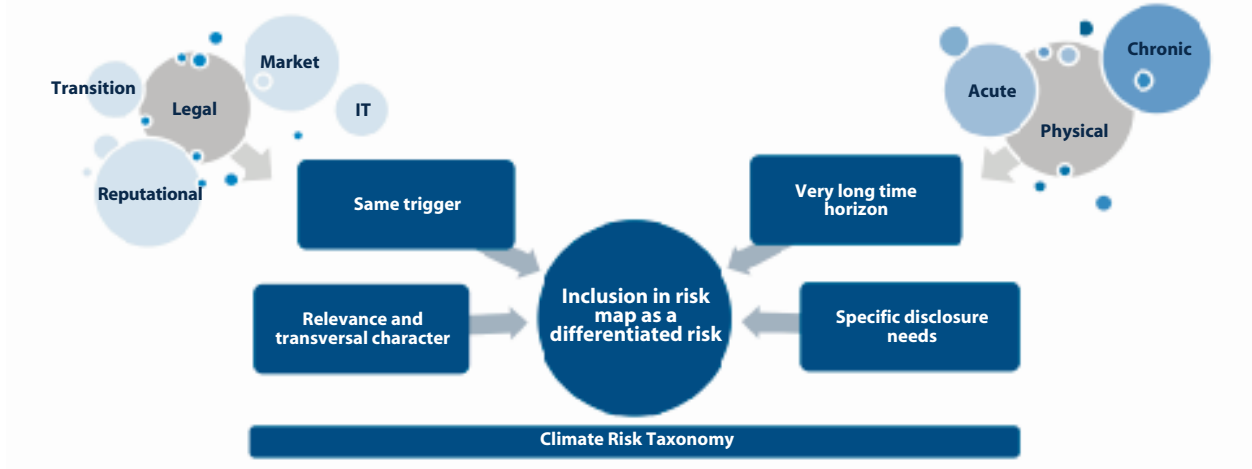
- Their relevance and transversal nature, mainly in the most affected industries[97], which is expected to increase considerably due to regulatory, market, social context and environmental changes.
- The existence of a common factor that significantly affects the frequency and severity of risks, and additionally causes a high correlation between them.

[95] President and Managing Director of the International Monetary Fund (2019).
[96] TCFD (2017).
[97] Ibíd.

Figure 11: climate risk management framework

Source: Management Solutions

Figure 12: climate risk map



Source: Management Solutions

- The specific treatment and assessment they require, considering for example the particularly long-term horizon over which they materialize.

- The disclosure needs required by this particular type of risks.

The moment in time when a risk associated with climate change is incorporated into an organization's risk map is determined by how important that risk is for the organization based on its type of activity. According to the TCFD[98], in the industries most exposed to these risks (financial services, energy, transport, materials and construction, agriculture, food and forest products) there is a tendency to include climate risk as a differentiated risk within their risk map (figure 12).

In the case of non-financial companies, it is worth highlighting the approach of the energy, construction and transport industries.

- In the energy sector, some companies[99] include climate change risk as part of their main risks. Others[100] consider the risk derived from climate changes, and the growing social awareness as an operational risk, since it may involve regulatory changes or new legal requirements that may have an impact on ongoing projects (delays/cancellations), the demand for fossil fuels, potential litigations and additional compliance obligations.

- In the construction sector, some companies[101] include climate change risk as part of their operational risk. Other companies[102] also consider it an operational risk, but include it under a generic environmental risk category.

- In the air transport sector, it is worth mentioning that some companies[103] consider climate change as one of their main risks, and even identify subcategories of this risk, such as carbon credit risk.

The fact that climate change risk is a cross-cutting risk is especially important in the case of the financial sector, because of its widespread impact on other financial[104,105] and non-financial risks. More specifically, climate risk is considered to mainly impact credit risk (since both physical and transition risks can affect the viability and therefore the solvency of borrowers) and liquidity risk, as well as operational risk (due to physical impacts on the assets and operations themselves), regulatory risk (including judicial contingencies), custody and investment risk (due to greater transparency requirements for the financial products offered), business model risk (caused by the need to move portfolios towards more sustainable sectors, and the potential increase in concentration risks that this could entail), and market risk (due to changes in the valuation of financial assets)[106].

Of all of those impacts the one on credit risk measurement and management[107] is possibly among the first financial institutions tackle, as reflected in the annual reports of numerous international financial groups[108].

In the case of the insurance sector, it should be noted that, together with the physical and transition risks, those derived from their subsidiary civil responsibility are considered at the same level, as they can potentially be sued for their insured

[98] Task Force on Climate-Related Financial Disclosures (2017).
[99] For example, please refer to BP Annual Report and Form 2018.
[100] For example, please refer to Shell Annual Report 2018.
[101] For example, please refer to Ferrovial Annual Report 2018.
[102] For example, please refer to ACS Group Annual Report 2018.
[103] For example, please refer to Air France Annual Report 2018.
[104] Carney, M. (2019).
[105] Pereira da Silva, L. (2019).
[106] As it is indicated by the Committee on Payments and Market Infrastructures (CPMI) of the Basel Bank for International Settlements (BIS), among others (Ayuso, J, 2019).
[107] Nykänen (2019).
[108] For example, refer to BNP Paribas: Registration Document and Annual Financial Report 2018; Barclays PLC Annual Report 2018; HSBC Holdings plc Annual Report and Accounts 2018; Lloyds Banking Group Annual Report and Accounts 2018; Santander Annual Report 2018; BBVA Annual Report 2018.

companies having inappropriate or non-existent policies in place.

On the other hand, similar to the banking sector, climate change impacts two of the main risks associated with the insurance sector: firstly, underwriting risk, due to the pricing difficulties arising from changes in the risk profile of insured assets (non-life) or in mortality profiles and demographic trends (life), and even due to the fact that it may not be possible to insure certain industries or geographical areas in the future. Secondly, investment risk, due to the impact of climate risks on the valuation of financial assets[109].

The different nature of the risks derived from climate change in the financial industry, for which the indirect financial impacts through their counterparties or portfolios are clearly superior to the direct impacts (e.g. impacts derived from extreme physical events affecting their own assets), result in substantially different methodological approaches to identification and measurement, as well as to subsequent management. Later in this document we will address both the methodological and management approaches for a non-financial company and for a financial entity.

Climate Risk Governance

From the moment that companies recognize climate change as a relevant risk for the future of their operations and businesses, there is a need to resolve the way in which risk is going to be governed. In other words, the roles that Senior Management will have in fixing appetite and oversight, the areas responsible for leading the action plan and defining and implementing the associated measurement methodologies and how the relationship model with other impacted areas will be defined.

An organization's governance framework can include climate change as an aspect within its existing committees, policies and areas or create committees, policies and specific areas to address this challenge.

Similarly, a company needs to consider adapting its regulatory framework so that both its internal policies and other regulations follow the guidelines for managing this risk.

This section will address the different approaches adopted by companies in relation to the governance and organization of climate change risks.

Governance Model

Company boards are increasingly becoming involved in ESG issues, specifically climate change.

International standards on transparency (mainly the TCFD principles), as well as other regulations in different geographies, highlight the need to communicate to the market which is the Board of Directors' role in the management of climate risk is within each company.

In companies that have expressed their commitment with ESG matters at the highest level, it is the Board (assisted by the corresponding committees), that has the responsibility for approving and supervising the company's sustainability framework, ESG strategy and appetite for climate risk, in addition to monitoring exposures.

[109] Cleary, Harding, McDaniels, Svoronos & Yong (2019).

Some groups explicitly indicate that the Board should directly supervise sustainability and ESG initiatives on a biannual basis, making them ultimately responsible for compliance[110].

Finally, it is worth noting that some national financial sector supervisors (such as the Bank of Spain), have expressed the need for experts to sit on the boards of banks in order to assess the risks of climate change in their business models[111].

In relation to the decision structure, two trends are observed today:

- The creation of specific committees, normally focused on sustainability in a broad sense (environmental, social and governance aspects). This trend is mainly observed in companies in industries most impacted by climate change and, within these, those that seek to develop a leading position in this area.

- Other companies choose to include issues about the impact of climate change and their strategy for dealing with those climate related risks in the agenda of already existing committees.

"Specific" committees appear to have some common characteristics in terms of the topics discussed, their composition, the frequency of meetings and their responsibilities or reporting lines.

In relation to the functions or topics discussed in these committees, they usually include:

- Analysis of the impact of climate change on the entity and generation of specific policies and strategies on the matter and their subsequent revision.

- Follow-up on compliance and reporting to the Board of Directors. In some cases, they are also responsible for implementing the climate strategy.

- Ensuring that risks related to sustainability are identified, measured correctly and have the necessary controls. In some cases, they also set limits or appetite for this type of risk for subsequent approval by the Board.

- Collaboration/coordination with other committees on responsible/sustainable practices and stakeholder groups.

Generally, these committees meet once a quarter and their composition usually includes the participation of independent and external directors.

In relation to how they fit in the organization's overall structure, these are usually treated as subcommittees of the Board of Directors[112]. In other cases, these are treated as components of the investment or responsible investment committees[113].

Control framework

Developing a climate change risk control framework starts with defining policies that will determine the scope of action through principles and criteria, as well as by describing roles and responsibilities within the organization.

[110] For example, HSBC Holdings plc (2018).
[111] Sampedro, 2019.
[112] Such as the Responsible Finance, Sustainability and Culture Committee of Santander Bank (Santander, 2018)and the Sustainable Development and Compliance Committee of Air France (Air France KLM Group, 2018).
[113] Such as BNP Paribas Sustainability Committee (BNP Paribas Annual Report, 2018).

As a result, different organizations have decided to publish specific environmental policies, while, in other cases, these policies are part of a broader sustainability framework (respect for human rights, health and safety, efficient use of resources, fiscal responsibility, prevention of illegal conduct, etc.). Finally, in some cases the decision has been to review and expand the existing Corporate Social Responsibility policies.

In most cases, the fundamental content of these policies largely depends on the industry of the firm, but usually includes at least the following:

- Commitments in the fight against climate change and in caring for the environment. The main commitments included by companies in their policies are: avoiding or minimizing pollutant gas emissions, contributing to the transition to a decarbonized economy, contributing to social awareness (including that of their stakeholders) and providing transparency to the market about their environmental performance.

- Scope of application: these policies usually extend to all the companies in the group.

- Best practices/international standards on which they are based, international initiatives the company has joined and international organizations with which they collaborate.

- Relationship with other policies: in most cases, the overall Corporate Social Responsibility is mentioned, while in other cases organizations mention the relationship with their Risk and Conduct policies.

- Responsibility for policy approval, supervision and updating: in general, responsibility for approval is assigned to the Board of Directors, while oversight or compliance monitoring is usually the responsibility of audit or compliance committees. Responsibility for policy updating depends largely on whether the company has created a specific area or department, in which case this area will be responsible for updating the policy, or if this is done by general departments such as Corporate Social Responsibility or Sustainability.

Additionally, in the case of the financial sector, where indirect risks (e.g. from their counterparties or portfolios) are far more significant than direct risks, it is necessary to review the policies that regulate both financial and non-financial risks currently affected by climate change.

For example, in the case of banking, most financial institutions consider the risk of climate change within their loan analysis and granting policies, assigning the Chief Risk Officer or Credit Risk Officer responsibility for embedding environmental risk impact criteria in credit granting decisions, establishing exclusion policies for certain industries (e.g. coal industry[114]) and modifying their exposure limits in the industries most exposed to physical and transition risks.

In some entities, loan and credit managers are responsible for taking into consideration the impact of environmental risks on credit risk or any other relevant risks when making lending decisions[115].

Furthermore, some companies are already considering climate/environmental criteria in their remuneration policy, or are studying how to incorporate them. In some organizations, managerial compensation and incentive policies include CSR and environmental objectives such as reducing the company's GHG emissions[116]; in other cases, companies indicate that they are considering how sustainability can be incorporated into their remuneration policies[117].

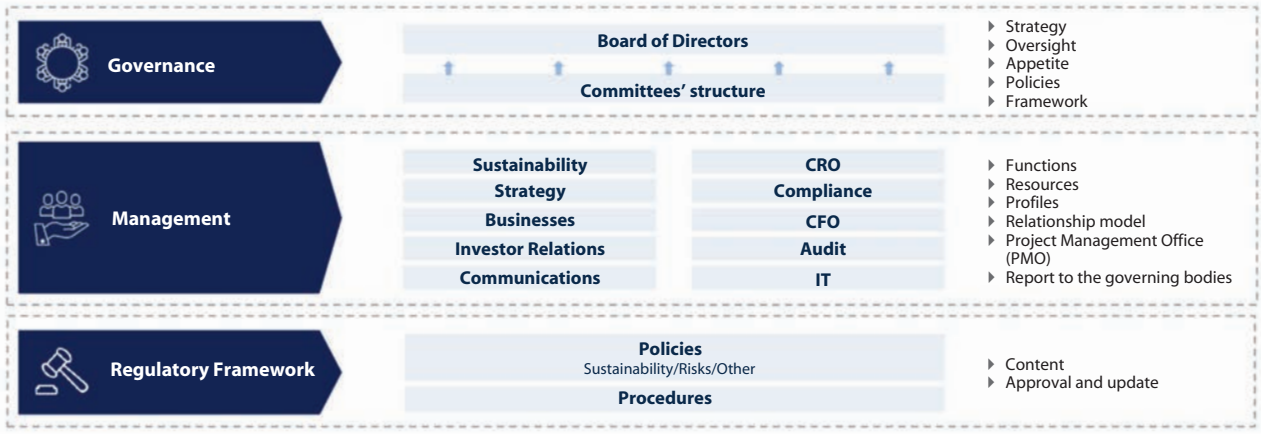
Organizational model

To address the challenges of climate change in a coherent way within the organization, numerous companies have created new areas, work centers or forums, as well as specific roles.

Some organizations have created research centers for sustainability with a particular focus on combating the

[114] BNP Paribas, Deutsche Bank, ING, Lloyds Bank and Santander Bank, among others. BankTrack (2019).
[115] For example Barclays (Barclays Annual Report 2018) and HSBC (HSBC Annual Report 2018).
[116] Air France (2018) and HSBC Holdings plc (2018).
[117] Lloyds Banking Group (2018).

Figure 13: climate change risk governance



Source: Management Solutions

impacts of climate change[118], or committees whose aim is to expand the consideration of sustainability and climate issues by the organization's main governing bodies[119].

Finally, organizations are setting up specific units responsible for leading and coordinating strategic and multi-year action plans for climate change adaptation[120].

The specific location of these units within the organizational structure varies. The initial trend is locating them within the Sustainability area, with a clear focus on managing the reputational risk associated. However, there is a slight trend towards relocating these units within the Risk areas, in line with the increasing sophistication required in measuring the financial impact of these risks (figure 13).

Methodological framework for measuring climate change risk

Climate risk assessment is a crucial component that, generally speaking, is not sufficiently developed in companies. Difficulties associated with uncertainty levels due to the time spans involved, the already mentioned cross-cutting nature of impacts, or the lack of clear references, means that risk assessment in this area is still evolving.

The way climate change may negatively affect businesses, demonstrates the importance of applying the highest rigour in the evaluation of the resulting impacts of the materialization of the aforementioned risks.

Despite the difficult quantitative challenges, the desire to overcome purely qualitative exercises, with the conviction that only the risks that are measured can be adequately managed, requires the development of a methodological framework for measuring the risk of climate change. That comprises two stages: the first includes the identification of risks and the second stage includes their measurement and treatment.

Identification of risks associated with climate change risk taxonomy

As it is the case with the global risk map, a risk taxonomy is required in order to quantify climate change risks. When defining a risk taxonomy, it is important to ensure that there are no overlaps between risks, or risks that are the cause of others.

A good starting point is the definition of risks contained in the TCFD recommendations, as this has become the market standard.

Based on this, organizations should reflect on which risks identified in the company's risk map are affected by climate change and which are not, in order to come up with an initial list of potential threats to consider.

There have been some industry initiatives to define the specific risks for their respective industry, especially in those industries most impacted by climate change. For example, in its Sustainable Finance Action Plan, the EBA[121] has announced its intention to develop a uniform definition of ESG risks for the banking sector, as well as an impact assessment, emphasizing physical and transition climate change risks. On the other hand, the TCFD has given indications on the most relevant climate risk typologies for the following non-

[118] BNP Paribas has created a Sustainability Center and a specific department for sustainable development, with a group of experts whose role includes fighting against climate change (BNP Paribas, 2018). Barclays has created a Sustainable and Thematic Research team that includes a specific section for climate change issues (Barclays PLC, 2018).

[119] Lloyds Bank has established a TCFD Forum senior executive group whose objective is to spread the consideration of climate and sustainability issues within the entity´s main governance bodies (Lloyds Banking Group, 2018).

[120] At Repsol, the Sustainability Director coordinates goals and monitors the action plans of all business units involved in the development of a climate change strategy (Repsol Group, 2018); in Telefonica there is a Climate Change and Energy Efficiency Corporate Office which identifies emission reduction opportunities, among other duties(Telefónica S.A. y sociedades dependientes, 2018).

[121] European Banking Authority (2019b).

Taxonomy of climate risks for the energy industry

Energy is one of the most exposed industries to the risks arising from climate change. Correctly identifying and classifying the most relevant risks for the industry is a key first step for their subsequent evaluation and management. The following is a potential taxonomy classification of climate risks for the energy sector:

Transition risks

Regulatory and legal risks

- Establishment and modification of prices for GHG emissions.
- Establishment of additional taxes and regulatory measures that penalize energies with high GHG emissions.
- Setting of limits to operations based on environmental criteria, such as emissions, water use, waste production or air quality.
- Increased exposure to judicial processes and incurring fees derived from climate change and the company's environmental impact.
- Increased reporting and transparency obligations regarding GHG emissions, environmental indicators, risks arising from climate change and related management strategies.

Market risks

- Increase in the price of GHG emissions listed on secondary markets.
- Consumer behavior changes that increase the demand for less polluting and more sustainable sources of energy.
- Changes in end uses for energy, for example, the promotion of electric cars as opposed to conventional vehicles.
- Market entry of new competitors and forms of energy production derived from, for example, the promotion of sustainability, decentralization, and digitalization.
- Increased cost and price volatility of natural resources and raw materials.
- Increased difficulty of raising funds for products with high GHG emissions, resulting in an increase in the cost of associated financing.
- Stricter investor requirements for transparency and standards in relation to ESG criteria and risks arising from climate change.

Technological risks

- Transformation of assets into "stranded assets", defined as assets that have suffered write-downs in value, devaluations or even conversion to liabilities unexpectedly or prematurely due to the transition to a decarbonized economy. An example would be oil, gas or coal reserves that could not be put to use if the Paris Agreement is fulfilled[122].
- Late or failed design and establishment of a low emissions GHG energy mix.
- Increase in investment spending on technologies necessary for the transition to a low emissions GHG energy mix, such as electric batteries.
- Late or failed adoption of energy efficiency and productivity technologies.
- Late or failed adoption of technology to capture GHG emissions.
- Early obsolescence of high GHG emission energy technologies.

Reputational risks

- Potential reputational impact due to lack of action or late action towards a low GHG emissions model.
- Stigmatization of the energy sector for its contribution to climate change.
- Growing concern of shareholders and other stakeholders regarding the contribution to climate change and environmental impact.

Physical risks

Chronic risks

- Increase in premiums payable to insurers, and increase in exposure to losses due to the refusal of the insurance sector to cover certain events, conditions and geographical areas or liability policies.
- Increase in repair and maintenance costs due to the recurrence of extreme weather conditions.
- Increase in costs due to the increasing unavailability of natural resources and raw materials, as well as their possible price increase.
- Transformation of the energy demand structure. For example, changes in energy demand peaks due to increased frequency of cold or heat waves.
- Need to relocate operations and facilities due to climate and environmental changes in certain geographical areas, e.g. sea level rise.

Acute risks

- Damage to physical assets due to extreme weather events (e.g. hurricanes or floods).
- Interruption and delay in operations due to extreme weather events.
- Transformation of the energy market due to extreme weather events, e.g. the rise in the cost of energy production due to droughts.

[122] Matikainen, S. (2018).

financial sectors: energy, transport, materials and construction, agriculture, and food and forestry products[123].

Risk identification

Creating an inventory of climate change risks for further evaluation requires identifying a sufficiently large number of risks to capture the different realities (e.g. no less than 10), but not too many in order for the quantification exercise to be feasible (e.g. no more than 25-30).

The risks identified in a company will be considered differently depending mainly on the industry sector to which the company belongs to and the region where it operates or has assets located.

In this section we will be providing an example of a risk inventory for a company in the energy sector.

Measurement of climate risk

The way in which climate risk quantification has been approached by both industry and academia has been very diverse, partly due to the fact that there is no consensus on which risks should be quantified (e.g. transition, litigation, reputational, credit, business, etc.), the reliability of the different sources of information used, or the objectives to be pursued.

The relevance of quantifying

The risk assessment of climate change impacts presents a special complexity, caused by different factors:

- The foreseeable impacts would materialize in the long run, although some of them could begin to manifest gradually. However, in many cases companies have not yet planned a 15-20 year business strategy, nor is it known what the level of technological development will be by at that point.
- There is uncertainty concerning what the final temperature scenario will be, the level of intensity of regulatory changes adopted, which will result in each scenario, and the way in which scenarios would affect the company itself.
- There are no similar cases in history to rely on for reference.

However, the commitment already made by many companies to disclose to the market the financial impacts resulting from climate change risk requires a quantitative estimate that, although based on hypotheses, is as sound as possible. Naturally, this will require a robust internal exercise that will involve the entire organization.

This section will present elements to keep in mind when facing this exercise, as well as possible steps that should be taken in order to achieve a robust evaluation.

Approaches prior to the evaluation

- Qualitative approaches. In recent years, companies have shown their environmental sensitivity through different publications such as social responsibility reports, led by sustainability areas, or through specific reports on non-financial risks driven by local regulations[124]. In these reports, companies with a strong environmental protection profile included their lines of action, policies and principles, and even some indicators. The risk of climate change was as a rule, in the best case scenario, to reduced to residual sections on the risk map.
- Quantitative approaches. Some recent approaches offer more sophisticated techniques for the quantitative calculation of climate change risk impacts, as well as the associated opportunities[125]. These approaches estimate the transition impact as the price of CO_2 for each climate scenario multiplied by the estimated reduction in GHG emissions for both that sector and the specific company, taking into account its market share. On the other hand, physical risk is calculated by estimating the severity and probability of extreme weather events in the case of medium and aggressive physical climate scenarios, and their economic impact is compared with that of a base year (for example, the current year). Finally, the potential financial impact of climate opportunities is also taken into account by estimating the potential green patents (associated with sustainable products) that each entity could obtain.
- Sectoral and individual quantitative approaches. Given the need for companies to have more precise estimates over the short term (no more than 3-4 years), increasingly sophisticated exercises have started to be developed internally. These exercises still use simplifications such as making global estimates of scenario impacts, without a breakdown by risk, or without considering the randomness arising from temperature uncertainty. The absence of a common methodology between "peers" across a large number of sectors is also contributing to the fact that steps taken to improve sophistication are still developing.

Methodological principles for quantitative assessment

As already mentioned, the quantification of climate risk is a topic of increasing importance that must be able to combine the necessary methodological robustness, which lends reliability to results, with a practical approach that enables companies to apply it in real situations. Therefore, an approach based on quantification methodologies already

[123] Task Force on Climate-related Financial Disclosures (2017b).
[124] European Parliament and Council (2014).
[125] UNEP Finance Initiative (2019).

consolidated in financial institutions and other corporations is proposed, however adapted and adjusted to collect the specificities of climate risk. The principles of this methodology would be the following:

- Capturing a double uncertainty: temperature and risk materialization. A thorough exercise, which reasonably models the uncertainty associated with this type of risk, requires capturing two uncertain components: the temperature rise at the end of this century, and how that temperature rise will affect the specific company.

- Strategic roadmap projection. To analyze the impacts on the company itself and based on the fact that strategic plans do not usually cover time spans over five years, it is advisable to conduct a prior exercise that helps to frame what the company will look like in a time horizon of 10 to 15 years. This establishes the "base case" for comparison in order to estimate the possible impact.

- Dual perspective on risks and opportunities. A full impact analysis would reflect both the negative impacts from climate change and the potential opportunities that may arise as a result of the transformation process faced by companies. If the company has adopted a long-term strategic position, the main opportunities derived from this change will have been planned, otherwise it will be necessary to estimate them (even if roughly) in order to carry out the exercise.

- Estimation of risk correlation. The fact that climate risks all stem from the same source means they are more likely to materialize simultaneously. In addition, both the correlation, frequency and severity relate to the temperature scenarios, and an increase or decrease in the temperature scenario can create substantial differences.

Steps to quantify climate risk

The steps followed to quantify climate risk are outlined in this section (figure 14):

1. Temperature probability distribution

Capturing the uncertainty derived from the temperature rise in this century requires a specific probability distribution. This probability distribution has already been calculated from analyses and studies of climate experts, based on the probabilities associated with different scenarios of Earth's average temperature rise by 2100 compared to pre-industrial levels. The four most widely used temperature scenarios[126] are:

- 1.5°C scenario: consistent with the most ambitious objective of the Paris Agreement[127]. It has gained relevance after the publication of the IPCC's October 2018 report[128].
- 2°C scenario: consistent with the objective of the Paris Agreement. This scenario, at least, should be disclosed according to the TCFD principles.
- 3°C scenario: corresponding to the commitments made so far in accordance with the Nationally Determined Contributions (NDCs) for the achievement of the Paris Agreement.
- 4°C scenario or Business as Usual scenario, the scenario where no action is taken to reduce greenhouse gas emissions.

It is possible to obtain a reference probability distribution of the different temperature scenarios, based on the reports made periodically by the IPCC[129]. These reports make predictions of the increase in the average temperature of the Earth's surface by 2100 and assign a probability to each increase. Some expert exercises have[130] produced multiple probability distribution functions that fit the probabilities assigned by the IPCC to each scenario, from which an average probability distribution can be calculated and used as a reference.

The reference probability distribution provides a baseline scenario for all types of risks: chronic, acute and transition. For example, a forecast for a high temperature at the end of the century would lead to chronic and acute risks being significantly higher, but the impact on transition risks would be expected to be lower. Conversely, a more moderate increase in temperature would be expected to have a strong impact on transition risk, however lower than chronic and acute risks (figure 15).

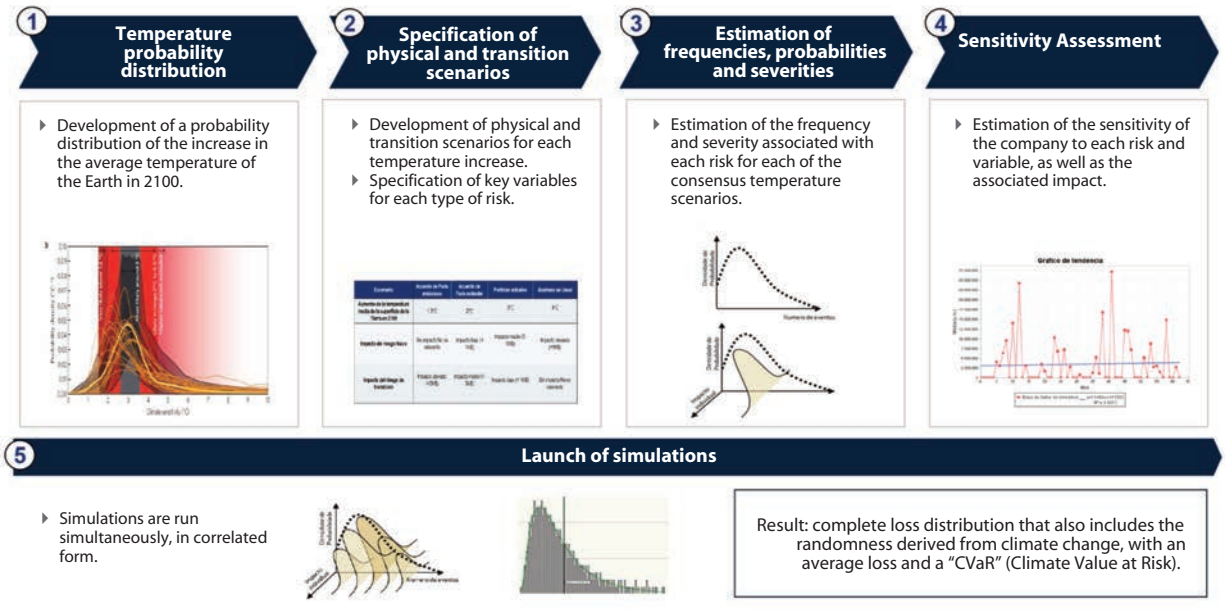
2. Specification of physical and transition scenarios based on temperature probabilities

Scenarios can be specified based on whether there is physical risk, transition risk, or both:

- In the case of physical risks, the variables that drive the different scenarios are usually: global and regional temperature paths, the frequency and severity of climate

[126] UNEP Finance Initiative (2019).
[127] United Nations (2015).
[128] Intergovernmental Panel on Climate Change (2018).
[129] IPCC (2007).
[130] Rogelj, Meinshausen & Knutti (2012).

Figure 14: steps to quantify climate risk



Source: Management Solutions

related events in specific regions (floods, subsidence and freezing), changes in population longevity or changes in agricultural production.

- In the case of transition risks, these can be specified through variables that represent emission limits or price changes, such as the carbon price path, the emission limit path, the price of commodities and energy, or the mix of energy production used.

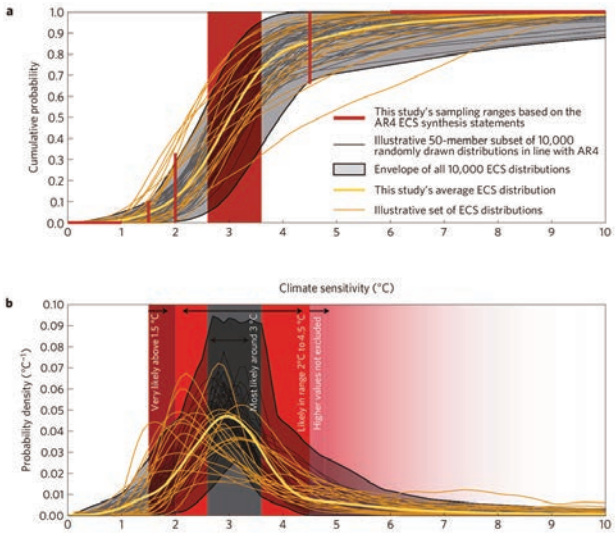
Also, it is often necessary to specify macroeconomic and financial variables that are coherent with the climate scenarios to be able to consistently apply the methodologies, e.g. with the aim of correctly discounting cash flows. Therefore, it is common to use models that link climate scenarios with macroeconomic variables such as GDP, unemployment or inflation, or financial variables such as the return on sovereign bonds, interest rates or exchange rates.

3. Estimating frequencies, probabilities and severities

This step is possibly the most complex, since it implies a transversal knowledge of the company itself and its strategy. This includes the sensitivity to be able to determine the extent to which a specific temperature increase would affect physical risks, and how GHG emission reduction efforts associated with certain temperature scenarios can affect transition risks. All of this requires that the estimation of impacts should be a cross-cutting exercise that brings all types of experts throughout the company: areas of strategy, operations, legal, financial markets, technology, etc.

The first estimation exercises will likely be less accurate, but successive iterations and updates will refine the assessment as the company develops further insights.

Figure 15: probability distribution of the different climate scenarios



Source: Global Warming under Old and New Scenarios Using IPCC Climate Sensitivity Range Estimates[131]

The objective of this step is to estimate the frequency or probability and the severity of each risk for each of the temperature scenarios. For this, considerations such as the following must be taken into account:

- Some of the risks only have a downside, that is, they can only have negative impacts for the company (e.g. adverse atmospheric phenomena). On the other hand, some risks can have an upside (e.g. commodity price variations, or opportunities from technological change). In some other cases, there could even be an upside in the short term and a downside in the long term. For example, an initial increase in the demand for natural gas instead of other fossil fuels and a subsequent replacement by other alternative energy sources in the medium term, or an increase in farm productivity under a lower temperature increase (e.g. under 1ºC) and a subsequent decline in productivity for higher temperature increases. It is necessary, therefore, to select the most appropriate distributions depending on the type of risk.

- Given the foreseeable absence of historical data to characterize climate risks, it will be necessary to make an estimate using expert judgement, led in each case by the people within the company with greater knowledge and sensitivity. In any case, this estimate should be objective and explain the base assumptions and, if possible, should also be based on clear studies or drivers.

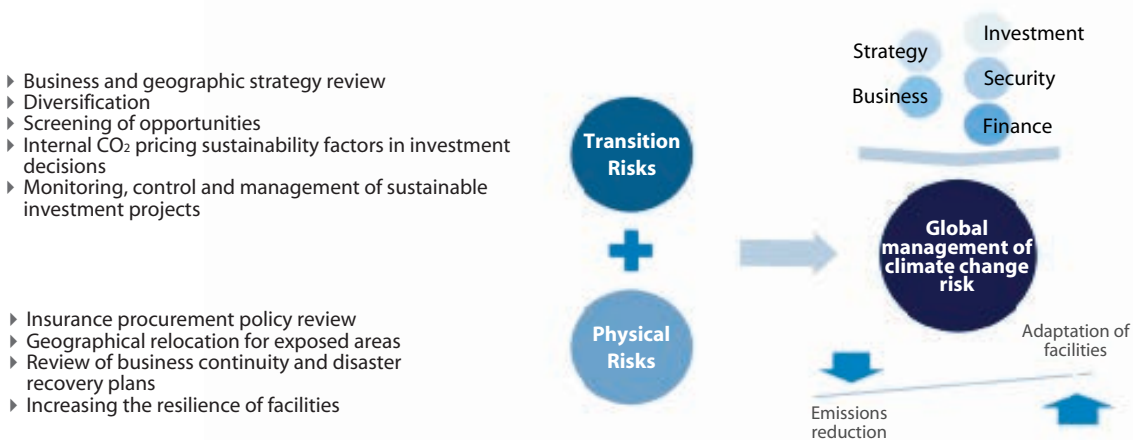
- The variables to be estimated will depend on the type of risk: the frequency or probability on the one hand, and the severity of the impact itself on the other, for at least two scenarios (e.g. medium and worst-case). This information would be sufficient to be able to model each of the risks for each of the four-temperature rise scenarios considered.

- In estimating the key elements of risk, it will be important to differentiate between acute risks (e.g. floods, storms, droughts, etc.) where the critical element for estimation will be the frequency, from transition risks, where it is good practice to estimate a specific market scenario in business terms and derive from there the associated impacts.

- In all cases, estimates will need to be adapted to the specific geography, since acute risks will not affect all places with an equal severity, just as transition impacts are likely to vary depending on the speed with which each country incorporates the principles agreed to globally into its own regulation.

[131] Rogelj, Meinshausen & Knutti (2012).

Figure 16: climate risk management processes and tools



Source: Management Solutions

4. Sensitivity estimation

Once the frequencies, probabilities and severities are obtained, it is necessary to link these elements to some variable (or variable vector) that represents the losses or changes in value of assets or value of activities. There are different methodologies to determine both the relationship between these factors and the losses and the possible relationship between risk factors.

- Statistical models: some methodologies are based on statistical regressions linking the scenarios to macroeconomic, sectoral or company performance-related variables. Other methodologies along these lines are based on the calculation of losses, linking a climate variable to its impacts on socioeconomic aspects or on specific companies or assets. This group of models also includes techniques based on environmental economics used to quantify capital losses.

- Financial modeling: impacts are included in cash flows or collateral valuations through techniques typically used for in financial valuations. The impact of the climate factor on the model is taken into consideration by altering factors such as the cash flows or the risk premium in the discount factors.

- Through correlations: these methodologies are based on generating correlations between risks and types of impacts. Since there is a clear common factor to these types of risks, their correlation is likely to be high. It is therefore necessary to consider this when adding risk measures. To carry out this estimation, a matrix can be used in which, assuming symmetry, the correlation between the risks is entered. Normally, this estimate is more qualitative, between 0 and 1 depending on whether the risks are independent or totally dependent on each other. These approaches are adequate to reduce data dependencies and prioritize those risks with the greatest impact.

5. Simulation runs

The last step is running simulations simultaneously. This is done at two levels:

- Simulations are run for each of the four scenarios in isolation. In this case the simulations are generated for each of the risks identified, applying correlations according to the relationships indicated in the correlations matrix or, if the definition is an equation (in the case of statistical methods and financial models), considering the interaction of variables in the model developed.

- Simulations are run for all scenarios, combining the temperature and risk distributions, or weighing the results of statistical or financial models, adding the randomization of the temperature rise scenarios to those of the company's own risk materialization.

The result is a complete loss distribution from which different metrics can be obtained: from an average loss to the "CVaR" (Climate Value at Risk) at any percentile required.

Management processes and tools

As indicated previously, the risk of climate change is a common factor that triggers a disruptive increase in certain risks of diverse nature. These risks manifest differently depending on the type of industry and geographical environment in which the company operates. Consequently, management processes and tools must be adapted to the specific way in which these risks impact the organization's business or assets.

Thus, different management mechanisms for physical and transition risks need to be identified.

In connection with the physical risks, it is necessary to consider those that affect the organization's productive assets and human resources, along with the indirect impact that the materialization of those risks can have on the business model:

- Different strategies can be used to cover the risks associated with the organization's physical assets. These include reviewing the current insurance policy (including insurance provided by specialized companies, or insurance through financial markets), and relocation to geographical areas where the impact of physical risks is expected to be lower. Further strategies include: reviewing business continuity and disaster recovery plans to adapt them to the new circumstances, or the installation of preventive mechanisms to protect assets against certain risks.

  In the latter case, the scale of these types of solutions (such as building containment dams where the sea level is

The key measure: the carbon price

A carbon price is a cost assigned to greenhouse gas emissions, generally for each ton emitted, i.e. it is a cost applied to pollution to encourage agents to reduce their emissions.

There are different carbon pricing schemes established by agencies. The main CO_2 prices currently at the heart of the international debate are those established by governments and legislators. However, a private company could also set an internal price on carbon in order to inform their decision-making on investments. Some companies, such as BP[132], Repsol[133] or Air France[134] already do this.

In general, there are two main ways to set carbon prices[135]:

1. Set a direct tax on CO_2 emissions, their sale, distribution or use.
2. Establish an emissions quota or budget for a specific country or economic sector (cap and trade model). These emission rights are auctioned to companies or given free of charge in exceptional cases, such as in strategic sectors.

Today, 46 national and 28 subnational jurisdictions have established a carbon price[136]. A particularly relevant example is the EU Emissions Trading System (EU ETS)[137], a cap and trade model with the following characteristics:

- Applies to all EU countries plus Iceland, Liechtenstein and Norway.
- It covers companies that:
  - Produce CO_2 due to energy and heat generation, industrial production (for example, oil refineries or iron producers) and commercial aviation.
  - Release N_2O due to the production of certain chemical elements.
  - Produce perfluorocarbons (PFCs) due to the production of aluminium.

Under this scheme, each year companies receive free emission rights or are able to buy them. By the end of each year companies need to indicate their level of emissions; if companies exceed their limits, they have to pay substantial fines.

Carbon prices are considered by many to be one of the key measures for effective, efficient and fair reduction of GHG emissions and for achieving the objectives of the Paris Agreement[138]. The establishment of a global carbon market is one of the most controversial issues in the international negotiations that take place during the United Nations Climate Change Summits.

[132] BP (2018).
[133] Grupo Repsol (2018).
[134] Air France KLM Group (2018).
[135] The World Bank (2019).
[136] Carbon Pricing Leadership Coalition (2019).
[137] European Commission website (2019).
[138] The World Bank (2019).

expected to rise, transporting water to areas in danger of desertification, etc.) requires that they are undertaken in coordination with the Government (for example, through strategic investment policies and plans or tax policies that encourage such investments, and by bidding for coordinated development projects). An example of this is the strategy launched by New York City to combat climate change through developing specific urban and construction projects[139] as a way of dealing with floods.

- The indirect impact of physical risks through customers or counterparties requires organizations to review their business risk management processes. For example, insurance and reinsurance companies must adjust the models to assess subscription risk, reinsurance policies or the impact on mathematical provisions. In the case of the banking sector, there is a need to review collateral valuations in vulnerable areas or exposure to adverse climate risks because of the geographical location of customers.

On the other hand, transition risks, as described previously, can be classified into different risk subtypes (regulatory and legal, technological, market and reputational risks). Each of these will be managed according to its characteristics:

1. In especially affected sectors (e.g. energy industry, automotive or construction) reviewing the current business model to include new diversification opportunities or substantial changes to the production model will be key to managing these risks. This requires a coherent definition of the control model for both project execution and business processes.

2. Specific risk monitoring and control indicators will need to be developed in order to properly monitor the level of implementation of adopted policies.

3. Current processes to manage the risks affected by climate change (e.g. compliance, reputational, etc.) should be reviewed to ensure that the potential impact is being considered.

4. Finally, the "screening" of investment projects and opportunities to improve should be reviewed and optimized, making sure climate change risk is factored in.

Disclosure and Reporting

The practice of disclosing information to the market, by which economic actors are required to make public all relevant investment decision-making information, is based on the principle that all market players must have equal access to this information.

As mentioned in the first section of this document, investors' requirements for transparency in relation to climate change risks have been rapidly increasing. An example of this is the Climate Action 100+ initiative, whereby investors having more than 35 trillion dollars (USD) in managed assets have pledged to try and influence the world' largest emitters of greenhouse gases to strengthen their disclosure practices in relation to these risks in accordance with the TCFD principles[140].

It is also worth highlighting the relevance of the environmental impact and GHG emission disclosure practices for the identification and evaluation of climate risks. To assist with this, the Carbon Disclosure Project (CDP) runs the most globally widespread system for disclosing environmental impact information, and has been joined by countless organizations. The CDP promotes the publication of climate change impact, water security and deforestation metrics, among others.

On the other hand, the Greenhouse Gas Protocol (GHG Protocol) is the global standard for measuring and managing GHG emissions generated by public and private sector operations and their value chains, as well as for measuring and managing their mitigation actions[141]. One of the TCFD recommendations most widely followed by organizations is the publication of information on their own scope 1, 2 and 3 GHG emissions in accordance with the principles of the GHG Protocol.

Implementation status of TCFD recommendations

According to the latest annual study published by the TCFD on the degree of implementation of its recommendations[142], the disclosure of climate change-related financial information by companies has grown in recent years, but it is still insufficient. Some aspects emphasized by the TCFD are the need for greater clarity in relation to the potential financial impact of these risks, the lack of information published about organizational strategy resilience where organizations conduct scenario analysis and the need for organizations to publish detailed information about how they embed climate change risks into their risk management strategy.

It should be noted that European companies maintain leadership in climate transparency and that the banking, energy and materials and construction sectors are the ones that disclose the most information under the TCFD principles.

Current disclosure practices: metrics and objectives

Despite the existence of a strong demand for the standardization of the information reported, it is possible to observe multiple metrics and information related to the risks arising from climate change whose publication and disclosure has been extending. The majority of large

[139] See https://onenyc.cityofnewyork.us
[140] Climate Action 100+ (2019).
[141] Greenhouse Gas Protocol (2019).
[142] Task Force on Climate-Related Financial Disclosures (2019).

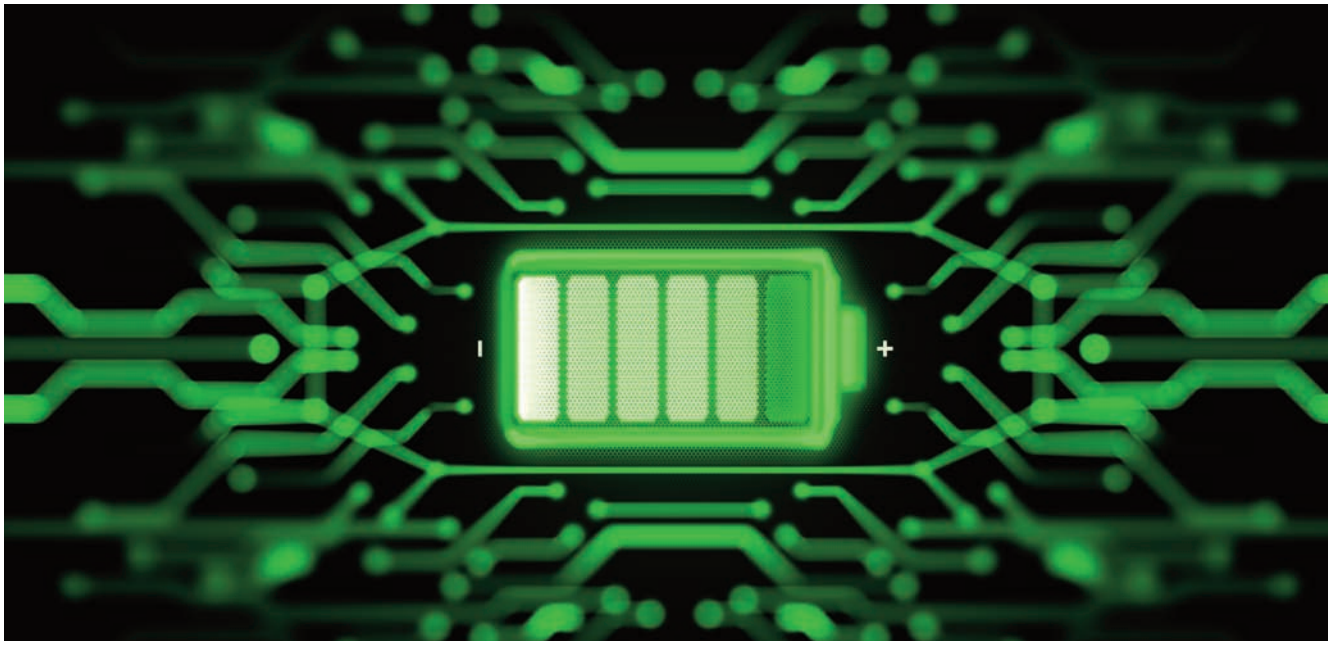
companies in the industries most exposed to these risks currently publish the following:

- Their own scope 1, 2 and 3 GH emissions in accordance with the Greenhouse Gas Protocol principles, as recommended by the TCFD.
- Their water and electricity usage, as well as their waste production.
- Most companies publish specific targets for reducing their greenhouse gas emissions. A substantial number of large companies, leaders in their respective sectors, have recently declared their intention to become carbon neutral in the future[143,144,145].
- Specific objectives for energy consumption from renewable sources.
- Objectives for energy efficiency and use of resources such as water.

Additionally, each sector discloses information in line with its activities. For their part, financial institutions set metrics and targets on portfolio emissions and sustainable project funding. For example, some banks publish the following indicators and metrics:

- Information about their portfolio carbon emissions, objectives to reduce financed emissions and the percentage of green bonds issued[146].

[143] Expansión (2019).
[144] Patiño, M.A. (2019).
[145] Green, M. (2019).
[146] For example, please see BNP Paribas: Registration Document and Annual Financial Report 2018.



- Total assets linked to CO_2 emissions and their proportion to total credit exposure. They also disclose metrics on transactions made in support of public policies, the objective of which is to mitigate climate change, and on the proportion of shareholder votes in support of climate actions[147].

- Their strategy and methodology for aligning both their credit and emissions portfolios with the 2°C objective of the Paris Agreement[148]. They also publish information about their funding of projects considered sustainable, and about non-funded sectors and projects. Finally, some firms publish a portfolio breakdown by economic sector.

- Goals on funding renewable energy and companies whose main task is to solve environmental challenges, as well as to reduce the carbon footprint of both transactions and the distribution chain[149].

- Within the insurance sector, some companies publish their objectives to reach a certain percentage of sustainable investments[150], and to favor energy efficiency and renewable energy consumption.

Other examples in relation to non-financial companies are the following:

- In the transport sector, some companies publish information about their hedging of carbon credit risk, i.e. the risk arising from the need to purchase CO_2 quotas on the European carbon market[151].

- In the Oil and Gas sector, some companies[152] publish their net water consumption and the volume of hydrocarbons released into water or land. In other cases[153], companies disclose the amount of biofuels used for fuel generation.

- Finally, in the transport infraestructure sector[154], some companies publish the amount of land reused for construction, the demolition and construction waste produced, and the material reused on site.

Main challenges of disclosure

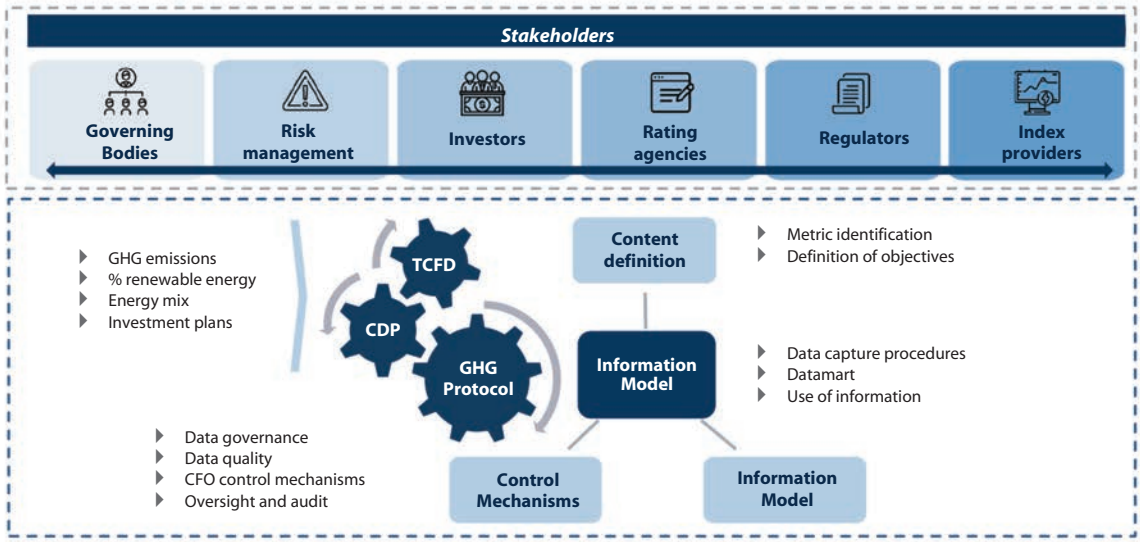
The recognition of climate change risks through disclosure is a fundamental pillar for subsequent action. However, this poses several challenges:

- The first challenge lies in the difficulty of measuring these risks. This difficulty comes from the transversal, complex and long-term nature of these risks, along with the lack of a historical pattern.

- Another significant challenge is the fact that the information published can include fundamental aspects related to the business strategy of organizations. In their latest report on the implementation status of their recommendations, the TCFD observed that 46% of the companies surveyed stated that disclosing information about the methodology used to assess the climate risks to which they are exposed to would involve disclosing confidential information about their businesses[155].

[147] For example, please refer to UBS: Our Climate Strategy (2018).
[148] For example, please see ING Terra Approach.
[149] For example, please see Barclays Annual Report 2018.
[150] For example, please see AXA Registration Document 2018 and Allianz Annual Report 2018.
[151] For example, please see Air France Registration Document 2018.
[152] For example, please see Exxon Mobil Sustainability Report 2017 and Shell Sustainability Report 2018.
[153] For example, please see Galp Integrated Report (2018).
[154] For example, please see Ferrovial – Sostenibilidad (2019).
[155] Task Force on Climate-Related Financial Disclosures (2019).

Figure 17: disclosure and reporting strategy



Source: Management Solutions

- Another relevant challenge is the lack of standardized sector-specific disclosure criteria adapted to the individual characteristics of each industry. It is, therefore, necessary to define and standardize metrics, data, and information by type of industry, something that is already underway in regulated sectors such as banking.

- A major obstacle so far has been determining what is considered "sustainable" or beneficial in the transition to a decarbonized economy, as well as establishing a classification of activities under this criterion. For this reason, the upcoming inclusion in the European legislation of a definitive taxonomy of sustainable activities is possibly one of the most anticipated measures in this area[156].

Required lines of action

Disclosure strategy

As mentioned in the previous section, the difficulties companies are encountering to keep strategy-related information confidential in the face of current transparency requirements may require that they take the following steps (figure 17):

- Define a reporting and communication strategy to ensure the information provided to different forums and different stakeholders is consistent.

- Create or participate in cross-industry working groups in order to unify the reporting criteria used.

- Monitor the disclosures of peers, as well as the impact of disclosures on the different stakeholder groups.

Report generation

After defining both the reporting strategy and the related management objectives and drivers, companies should take the following steps:

1. Definition of content to be included (under TCFD principles or, where appropriate, industry guidelines or regulations) and definition of metrics to develop content.

2. Definition of the information model required to support such content and implementation of the data collection process to ensure the organization collects from the source (customers/operations) the information required for disclosure and, at the same time, the information required for data risk management and internal reporting, as well as the information requested by investors, rating agencies and index providers.

3. Establishment of adequate information governance and quality control mechanisms, as well as models for CFO control and Internal Audit oversight over published information, similar to the models in place for other financial information.

[156] EU Technical Expert Group on Sustainable Finance (2019a).

Climate change risks in the financial sector

"A new, sustainable financial system is being built (…), but the task is large, the window of opportunity is short, and the risks are existential"

– Mark Carney[157]

As mentioned previously, the specificity of the financial industry means that the risks associated with climate change are markedly different, with indirect financial impacts on portfolios and counterparties being more prominent than direct impacts on assets or operations. For this reason, the measurement methodologies used also differ significantly.

Being a regulated industry, these measurements are used for other purposes in addition to climate risk control and management, including compliance with regulations whose primary aim is to ensure the solvency of financial institutions and the protection of the financial system as a whole.

This section deals with measurement methodologies in the financial industry and details the different uses that can be derived from those methodologies.

Segmentation and measurement mechanisms in the financial industry

In the case of the financial sector, the methodology for measuring climate change risk must be extended and adapted to allow for the measurement and quantification of this risk on securities and credit investment portfolios. These portfolios in the financial business include operations with counterparties from all industries. This adds another layer of difficulty respect to companies in other industry sectors, and means more sophisticated measurement methods are required in order for the impact measurement to reflect the specific characteristics of multiple sectors.

The 2º Investing Initiative (2ºii) think tank provides climate risk metrics for financial markets. In particular, it has developed a portfolio analysis tool, now being implemented in close to 200 financial institutions, to measure the alignment of financial portfolios with long-term climate and economic goals[158]. This portfolio analysis tool, known as the Paris Agreement Capital Transition Assessment tool (PACTA), is a free software that analyzes the exposure of equity and fixed income portfolios to climate change-related risks under multiple scenarios. In 2019, the scope of the PACTA software was extended to include corporate credit investment portfolios. It offers portfolio-based analysis that can be used in risk management processes.

The methodology can also be further developed to measure the potential losses from wholesale credit investment portfolios. Since financial institutions estimate these losses through the use of credit risk parameters ("probability of default" or PD, and "loss given default" or LGD), this measurement can be done by identifying how those parameters can be transformed to incorporate climate change-related risks. In order to do this, a structured method is proposed, involving two steps: identification and categorization of exposures, and measurement.

For retail portfolios, a similar methodology based on the Vasicek model can be used to modify the PD or LGD making certain assumptions about credit quality, although it requires some modifications. There are also other approaches for retail portfolios based on the assessment of physical or transition risks affecting collaterals, using the expected average loss under different scenarios, or Value at Risk methodologies for their quantification.

Exposure identification and categorization

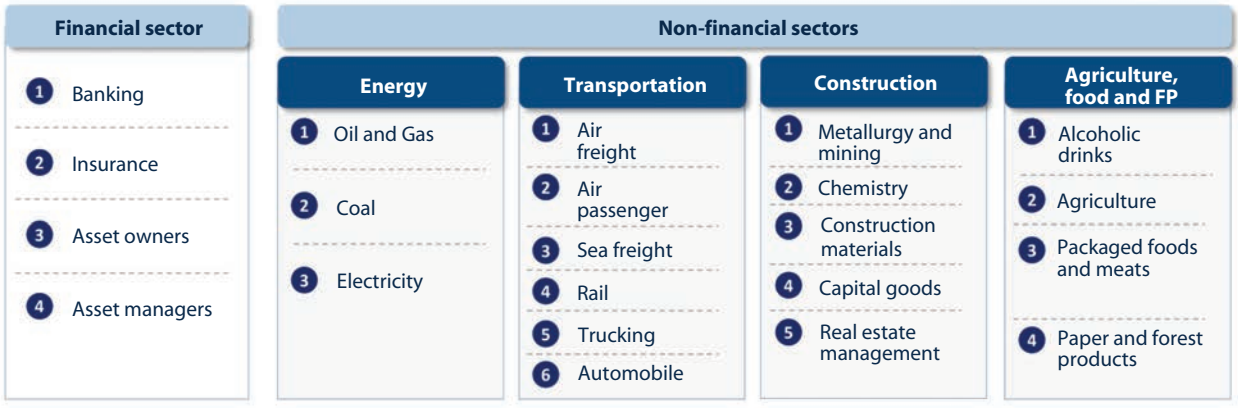
A classification of exposures is carried out based on different factors (industry sector, internal classification, etc.) and regions, to identify and classify clients/exposures according to their business model and level of emissions, or vulnerability to physical risks. The starting point for this classification can be the industry groups included in the TCFD recommendations (figure 18).

Although an analysis of each individual counterparty would be much more precise, it could initially be much more costly, depending on its size and the information required. However,

[157] Current Governor of the Bank of England; it has been announced that he will leave this role in March 2020 to become the United Nations Special Envoy for Climate Action and Finance. Former Governor of the Bank of Canada, former President of the FSB. Speech at the United Nations Climate Action Summit (2019).

[158] See https://2degrees-investing.org

Figure 18: sectors most exposed to climate risks



*Source: TCFD[159]; *FP = Forest Products*

it is possible to conduct an individual analysis of the most significant counterparties, covering all sectors, and then extrapolate the outcome of that analysis, assuming that the counterparties being analyzed represent the general behavior in each sector. A materiality filter can be used prior to conducting the analysis in order to select the most significant counterparties. The identification of exposures follows a four stage process (figure 19).

This analysis could also incorporate the measurement methodology developed in the PACTA project.

Measurement

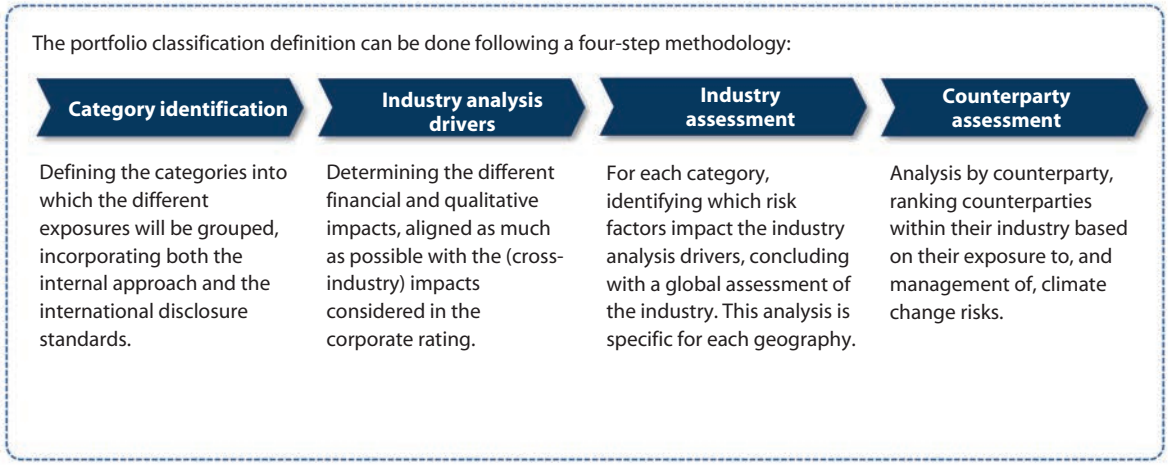
Scenario analysis begins after counterparties are categorized. The aim is to estimate the potential impact on portfolios of hypothetical transition scenarios to a decarbonized economy. Consideration is given to each of the selected temperature scenarios (which include political assumptions, geographies, technologies, and market impact, as well as the relevant variables: energy prices, coal, emissions, energy mix demanded, etc.).

Each scenario analysis involves two steps:

- Calculating the impact on the risk and financial drivers identified in the previous point, on two levels:
  - Analysis of the relative sensitivity, for each of the segments (industries /homogeneous groups of counterparties), for each of the potential quantitative impact on the analysis drivers.
  - Impact at the counterparty level on the credit risk rating input factors (analysis drivers), which in the absence of data can be based on expert analysis.

[159] TCFD (2017).

Figure 19: processes for the identification and categorization of exposures



Source: Management Solutions

- Measuring the impact on expected losses by analyzing and adjusting the associated risk parameters (PD, EAD, LGD). This can be assessed, for example, by simulating either the rating distribution (which affects the PD), or the potential impact on the collateral value and associated recovery rates (which affects the LGD).

Uses of climate risk measurement in the finance industry

As stated in previous paragraphs, financial firms can embed impact measurements associated with climate change in their risk management processes and, at the same time, respond to the growing regulatory pressure in this area. The following section describes the different purposes for which climate-related risk measurement can be used:

- Regulatory purposes, with a special focus on capital (internal capital adequacy assessment and capital planning, and regulatory capital requirements), provisions and transparency.

- Strategic and risk management purposes, with a focus on risk appetite, and risk origination and monitoring.

The following section will look at the climate-related risk analysis implications for each of these purposes.

Regulatory impacts of climate change risk quantification

Regulatory Capital

Financial firms are required to meet minimum capital requirements to cover the potential unexpected losses originating from the materialization of different risks. In particular, Pillar I of the Basel framework[160] covers credit, market and operational risks, whereas Pillar II covers other risks.

In some countries, this framework has been or is being adapted to their legal system. In the case of the EU, the Basel framework has been adopted via the prudential supervision directive 2013/36/UE and the EU prudential requirements regulation nº 575/213.

Within the EU, an incentive has already been incorporated in order to reduce the Pillar I capital requirements for some sustainable portfolios.

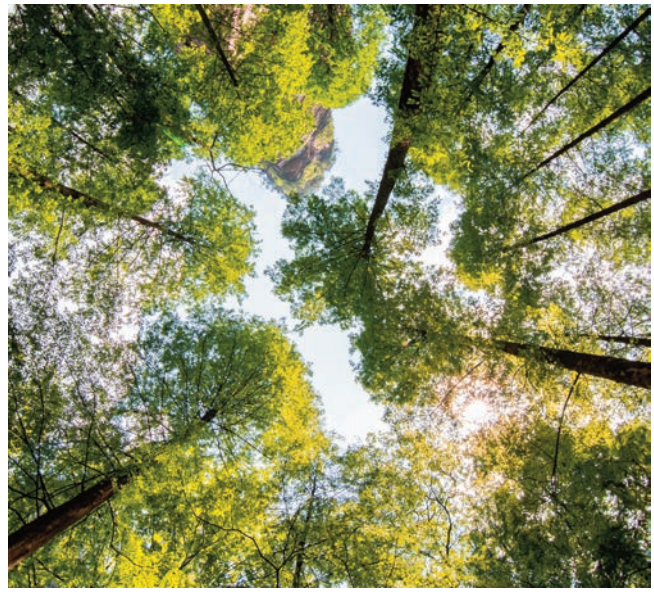
- Firstly, Article 501a of the May 2019 amendment[161] to the prudential requirements regulation includes a reduction in credit risk capital requirements. This is through the application of a 0.75 factor over risk-weighted assets on loans to enterprises or specialist finance companies not in default whose aim is to support the funding of public service structures. This is provided that they comply with a number of requirements such as having to provide regulators with a study that verifies the contribution of such structures to environmental objectives, including climate change mitigation and adaptation, sustainable use of natural resources, pollution control and prevention, and the protection of healthy ecosystems.

  Due to this, it would be necessary to establish mechanisms to identify and classify these exposures under the taxonomy provided by the European Commission's EU Technical Expert Group (TEG) on Sustainable Finance[162], as well as to certify compliance with the designated requirements.

  Penalties are expected to be imposed globally, which would increase capital requirements for banks with a higher exposure to sectors harmed by climate change risk[163].

- Secondly, firms that have corporate portfolios under the internal models-based approach for capital requirements calculation use probabilities of default estimated internally, which are used to quantify risk weighted assets. The inclusion of climate change-related risks in the measurement of the credit quality of counterparties could potentially impact these requirements. To address this in Europe, the EBA intends to launch a process (to be explored in a discussion paper before June 2025) to assess the need for the prudential framework to cover exposures on assets especially affected by social or environmental objectives.

[160] BCBS (2011).
[161] Modified through the EU/2019/876 regulation.
[162] EU Technical Expert Group on Sustainable Finance (2019a).
[163] Bolton, Despres, Pereira da Silva, Samama & Svartzman (2020).



Internal capital adequacy assessment and capital planning exercises

In addition to the Pillar I capital requirements, financial firms conduct an internal exercise to analyze their capital adequacy (ICAAP). This exercise is used in the capital planning process, where all the material risks a firm is exposed to are included, independently of their consideration under Pillar I.

In this capital self-assessment exercise, climate change can be included in the measurement and management of credit and market risks (using the previously mentioned methodologies). Climate change can also be factored in the estimation of other risks, such as operational risk (by reviewing the potential impact and probability of extreme climate events) or compliance risk (by analyzing current sustainability regulations and monitoring specific projects to assess their compliance). Additionally, it can be factored in the estimation of reputational risk and business model risk, in order to consider a roadmap that will ensure adequate portfolio transition, etc. In fact, the absence of these elements could lead to increased capital requirements, as supervisors could prescribe additional regulatory capital if, for instance, a financial firm does not adequately monitor or manage climate change-related risks[164].

Finally, it is possible to include the impact of transition and physical risks in the scenario analysis and stress tests methodological framework[165]. The TCFD highlights scenario analysis as the key climate risk evaluation method, and regulators and supervisors are launching initiatives to include those climate risks in these regulatory exercises. The IMF has expressed its intention to include climate risk in its FSAP[166] stress testing exercises.

Within the EU, the Action Plan on Sustainable Finance, published by the EBA, mentions the inclusion of climate risks in the ICAAP and in scenario analysis and stress testing exercises. Specifically, they recommend the incorporation of ESG risks in the ICAAP (through qualitative information supported by metrics and targets), and will conduct an exercise to assess financial sector sensitivity to climate risks in 2020, which firms may voluntarily join[167].

Moreover, the Bank of England indicated in its supervisory statement for banks and insurers on managing financial risk arising from climate change that they have to use scenario analysis (as part of the stress test exercise). The Bank of England's annual stress testing exercise will also use exploratory scenarios to test the resilience of the financial system to transition and physical risks[168].

Estimating credit risk provisions

The information above raises the issue of whether climate change-related risk and its impact on credit risk measurement should also be taken into account to estimate provisions. In those jurisdictions where estimates are based on the probability of default it might be possible to transfer

[164] Bolton, Despres, Pereira da Silva, Samama & Svartzman (2020).
[165] Likewise, the discussion paper EBA/DP/2020/01 analyzes the option of including in the stress test the so-called exploratory scenarios, which would include long-term environmental changes.
[166] Financial Sector Assessment Program.
[167] Emphasis is also placed on the credit origination process.
[168] Bank of England. Financial Policy Committee & Prudential Regulation Committee (2019).

to the provisions model the criteria added both to the risk parameters used for measuring regulatory capital as well as to the stress test. That is the case for example in countries and regions under IFRS 9, like Europe, or countries that implement the CECL accounting standards, like the US. In the case of IFRS 9, the change in the measurement of credit quality would be incorporated in provisions, with a greater impact on stage 2 and 3 portfolios due to the impact of the forward-looking and lifetime perspective, since the credit quality would reflect the potential impact of climate change on the solvency of the counterparty in the long term. These elements could also be included in models with a single loss bucket, as in the case of CECL in the US.

In the case of company portfolios where provisions are estimated through an individualized analysis, the investment analysis process would include climate criteria, in alignment with the portfolio identification and segmentation process used for other purposes.

Transparency and market discipline

Current standards and regulation focus on governing and increasing transparency on climate change-related risk exposure and management. This trend can be seen clearly in, for example, the creation of the NGFS[169], the EBA's intention to issue guidance and technical standards for ESG risk and climate change-related information to be included in the Pillar III[170] disclosure requirements for financial institutions (expected to be published in 2021[171]), or the expectations of the UK's PRA[172] concerning the disclosure and management of climate risks by financial institutions, among other initiatives.

Likewise, it is necessary to review that the marketing of products is aligned with the new (upcoming) regulations in order to ensure the information provided to customers is transparent, accurate and complete.

Strategy and Risk Management

The ultimate purpose of any risk measurement methodology is to provide financial firms with sufficient information that, embedded in their business as usual, will allow them to make decisions consistent with their risk appetite expectations and the criteria set by management, which are regulated internally through the relevant policies[173].

Risk appetite and reporting to Management

Climate change risk may be incorporated into risk appetite via setting limits and thresholds, which will evolve in line with the availability of information. Some examples of metrics that

[169] Network for Greening the Financial System (2019).
[170] EBA (2019b).
[171] Although these regulatory standards will be applicable from June 2021 onwards, the requirement to disclose ESG information is postponed until June 2022.
[172] PRA (2019)
[173] In this sense, the EBA establishes that entities should include ESG criteria, risks and opportunities in their risk management policies, specifically in their credit policies and proceedings (please refer to *Guidelines on loan origination and monitoring* published by the EBA in June 2019, whose application date is expected to be the 30th of June 2020). Additionally, the EBA has the objective of publishing a guide about including ESG criteria in risk management practices (and its incorporation to the supervisory process –SREP–), as a draft in 2020 and as a final version in June 2021. Please see Action Plan on Sustainable Finance, published by this institution the 6th of December 2019.

may be incorporated into risk appetite are the carbon footprint (or financed emissions), which links a portfolio's level of CO_2 emissions with its size, the carbon intensity, which links the level of emissions with the income from funding that position or counterparty, or the Green/Brown Share approach, which aims to differentiate positions based on their contribution to the transition to a low-carbon economy[174].

These first level indicators would be integrated and developed in reports to Management and Governance Bodies, as described previously in the Climate Risk Governance section.

On the other hand, the setting of limits and thresholds, as well as of risk reduction objectives, implies the need to set business objectives that target emerging sustainable industries and/or products (green finance or green lending), identifying market niches and developing an appropriate commercial strategy (e.g. in terms of product catalogue).

Integration in the risk measurement and risk management process

The impact on risk models, including the estimation of credit risk parameters (PD and LGD) as mentioned earlier in this section, means that these parameters need to be embedded in credit risk management, both in the origination and follow-up processes:

Risk origination process

The following are some of the most common credit risk management processes to be undertaken at origination:

- Setting of limits for projects that are financed and exclusion of specially affected sectors.
- Inclusion of climate change risk factors in the internal rating, for example through industry-based qualitative modules, that impact the company's overall rating[175] .This implies the need for information related to the management of climate change and environmental elements (e.g. GHG emission projects).
- Development of eligibility criteria for sustainable projects (green lending) and implementation of a workflow for the approval of such projects, which will ensure their traceability and auditability[176].
- Risk-adjusted return analysis and inclusion in transaction pricing[177].

Risk monitoring processes

In addition to monitoring compliance with risk appetite policies and limits, it will be necessary to develop specific procedures for monitoring the evolution of each sustainable financing project. This could be done, for example, compiling and periodically analyzing the information related to compliance with the ESG criteria initially established for the project, and adapting the measurement to its specific characteristics (e.g. according to the type of project financed: vehicles, real estate, rural investment and electricity).

[174] Swiss Sustainable Finance (2019).
[175] This can be done, for example, by modifying the final score up to a certain proportion, or by notches movement in an individual rating scale.
[176] Please see section 4.3.4 of the *Guidelines on loan origination and monitoring* published by the EBA the 19th of June 2019.
[177] For example, Natixis published in November 2019 that it demands a higher profitability from projects that have a higher environmental impact.

Incorporation of climate change in the financial sector stress test

The main aim of a climate stress testing exercise is to translate different temperature scenarios into impacts on banks' credit and market risk portfolios at industry sector or company level.

Specification at the company level is necessary to distinguish between the different impacts on firms in the same industry, as a result of both their different levels of exposure and ability to adapt to different scenarios.

To reflect this, a stress testing exercise would need to incorporate three elements of analysis: i) the level of exposure at the industry or company level; ii) the sensitivity to climate change-related impacts, based on some metric (e.g. carbon emissions); and iii) the ability to adapt, which can mitigate the exposure of different industries or companies (figure 20).

- In relation to the exposure, companies can be affected at different points in their value chain. It is therefore necessary to consider the direct impacts (substantial for industries such as mining, aviation or the chemical industry), the indirect impacts (linked to the use of energy), and the impacts related to other indirect emissions (associated with the value chain)[178].
- In relation to sensitivity, macroeconomic scenarios already used in other stress testing exercises are often applied. These models make it possible to incorporate the impact on the economy by applying the different shocks identified in the scenario design phase.

  Some methodologies translate the impact obtained at the national level into industry-specific objectives, which can be then be taken to the company level through metrics such as carbon emissions. Some of these methodologies include the Carbon Delta method[179] or the Stress Test by Vermeulen et al.[180]. Other approaches calculate the sensitivity to climate change-related impacts directly at the company level, such as the PACTA stress testing model[181].
- Different granularity levels are obtained depending on how adaptability is treated. As a result, some approaches use an industry-specific analysis to later analyze subgroups based on emissions[182], or incorporate information about carbon emission-related patents through a qualitative analysis[183].

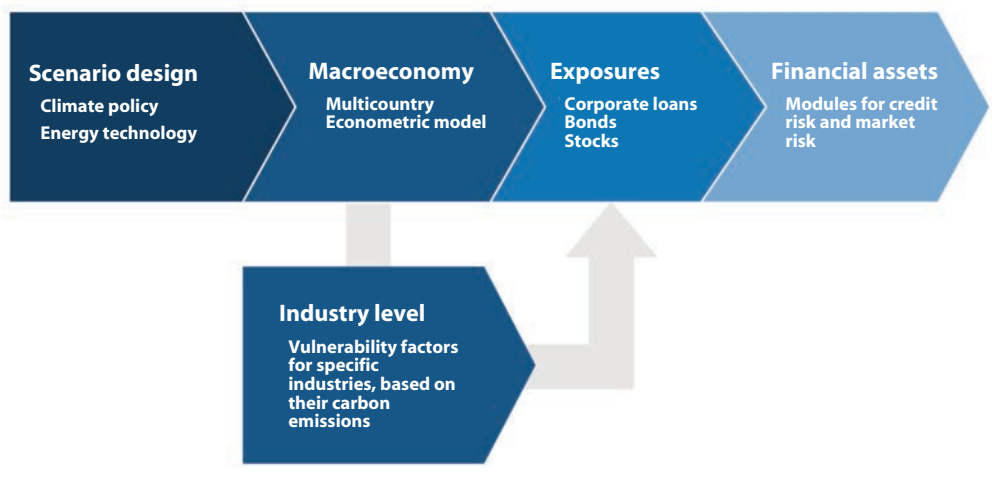
Other exercises require the calculation and individual analysis of exposure, sensitivity and adaptability to climate change through cash flow discounting or collateral valuation methods, using the collected TFCD disclosures as the input.

Finally, the final phase is based on measuring market and credit risk from climate change. This quantification can be done using top-down and bottom-up models, similar to the ones used in regular stress tests.

A notable example of a climate risk stress test was conducted in the Netherlands[184], consisting of an exercise based on the imposition of a 100 USD carbon tax, as well as a technological shock that would result in the elimination of capital stocks. The results showed that losses could amount to 11% of the value of insurance companies' assets and 3% of banks' assets, with a 4 basis point decrease in the CET1 ratio for Dutch banks.

[178] According to the classifications of ambit 1, 2 and 3 of the GHG Protocol.
[179] UNEP Finance Initiative (2019).
[180] Vermeulen et al. (2019).
[181] 2 Degrees Investment Initiative (2019).
[182] Battiston et al. (2017).
[183] UNEP Finance Initiative (2019).
[184] Vermeulen et al. (2019).

Figure 20: measuring market and credit risk from climate change



Source: Vermeulen et al. (2019)

Quantitative analysis: climate change risk in the valuation of financial assets

"We will be increasingly disposed to vote against Management when companies are not making sufficient progress on sustainability-related disclosures and the business practices and plans underlying them"

– Larry Fink[185]

A key step in the evaluation of climate change risks associated with a financial asset is analyzing the asset's price components in order to verify that it already incorporates climate related expectations. The aim of this review would be to avoid duplicating the effect of measuring climate risk through the two components where this risk can materialize: the acquisition price and a possible subsequent valuation adjustment.

In this sense, there is extensive empirical literature proposing methods to incorporate climate change into the pricing process, as well as approaches to measure the climate risk of a given asset, portfolio, company, sector or country, which can be applied in the subsequent valuation adjustment.

This section reviews the different approaches currently being used, and provides a practical exercise that looks at the differences between specific bond prices to see if their market valuations include expectations of climate risk.

Climate risk measurement: a fragmented picture

Although climate risk has been successfully included in weather derivatives[186], academic literature indicates that there are reasons to discard the use of traditional financial models to incorporate climate change aspects, since these models do not make it possible to integrate the deep uncertainty involved in the measurement of potential losses arising from climate change scenarios[187]. As a result, different approaches have been proposed which seek to include variables that reflect climate change risks in the valuation of assets, as well as to relax the assumptions underlying the current valuation models so that these risks can be correctly reflected[188].

Examples of these proposed approaches are valuation models that use carbon emissions as a proxy for climate risk in determining the cost of capital[189], the CAPM or Fama-French models[190], in which carbon intensity is found to be an indicator of worsened valuation expectations that is not included in multifactor models, or the sovereign bond valuation model[191], which includes the notion of sovereign climate spread and proves that it is sensitive to the different transition risk scenarios.

Although the previous methodologies have been developed to some extent in the academic literature, it appears that they have seldom been used in risk management, at least in the financial sector.

In the case of credit risk, there is evidence that, until the signing of the Paris Agreement in 2015, banks did not consider climate risks in their credit spreads. After that date, although it seems that banks started to consider them, the spread for companies with a high exposure to climate risk compared to others with reduced exposure to this risk was small[192]. However, credit rating agencies are beginning to incorporate climate related criteria into their ratings. An illustrative example is that of S&P, which has modified 106 out of 717 (preliminary) ratings assigned in 2015-2017, either because the final rating has changed or because S&P's Outlook for those ratings has changed or the ratings have been placed on Creditwatch[193].

In the case of market risk, there is evidence of investor reaction to two events of a markedly climatic nature: both Trump's presidential election and the nomination of Scott Pruitt to lead the Environmental Protection Agency led to short-term improvements in the profitability of companies with higher emissions. However, there is also evidence of investors rewarding companies that have more responsible climate strategies[194]. In the same way, Monasterolo and de Angelis[195] identify different betas for stocks based on the company's emission levels, but in a particular way that suggests investors have begun to consider low carbon assets as a more attractive opportunity while not yet penalizing carbon-intensive assets.

[185] President and CEO of BlackRock. Letter to CEOs (2020).
[186] Campbell & Diebold (2005).
[187] Solomon et al. (2009); Weitzman (2009); Ackerman (2017); Steffen et al. (2018).
[188] Morana & Sbrana (2018); Glen & Gostlow (2019).
[189] Chen & Gao (2011).
[190] Choi, Jo & Park (2018).
[191] Battiston & Monasterolo (2019).
[192] De Greiff et al. (2018).
[193] S&P Ratings (2017).
[194] Ramelli et al. (2018); Wagner et al. (2018).
[195] Monasterolo & De Angelis (2018).

Finally, in the case of the real estate sector, Baldauf, Garlappi and Yannelis, in an article published in 2019 and remarkably called "Does Climate Change Affect Real Estate Prices? Only If You Believe in It", they conclude that there is a statistically significant negative relationship between the prices of homes that are projected to be under water due to sea level rise and other homes, but only in geographical areas where more people are aware of climate change. The authors found that homes located in areas where the economic agents were more concerned about climate change sold at a discount of 7%.

To summarize, it can be concluded that the pricing of stocks and other assets is undergoing a transition. For some assets, especially carbon-intensive ones, the climate change magnitude is beginning to be factored into the price, but this also depends on the beliefs of economic agents, as well as on the measurement tools used.

Analysis of the spread and rating of green and conventional bonds

Based on what is below, this practical exercise aims to compare the spreads of hypothetical green bonds and conventional bonds in order to determine whether there are negative spreads for green bonds, as this would reveal a preference by investors for this type of investment provided that all other elements defining the investment are identical.

For this, a sample containing both green and conventional bonds was used. The bonds in this portfolio were matched in pairs following the methodologies described in Zerbib (2016) and Bachelet & Becchetti & Manfredonia (2019), so bonds with the following characteristics will be analyzed together:

Bond characteristics	Matching criteria
Amount issued	±400%
Interest Rate	±0.25%
Maturity date	±2 years
Currency	Same
Country	Same
Sector	Same
Coupon Type	Same

The method used for determining the differences is based on the calculation of the Yield to Maturity spread:

$$\text{YTM Spread}_i = \text{Bond Yield to Maturity}_i - \text{Benchmark Bond Yield to Maturity}_i$$

The Yield to Maturity is calculated by solving the following equation:

$$P_0 = \frac{Par\ Value}{(1+YTM)^t} + \sum_{t=1}^{T} \frac{Coupon\ Payment}{(1+YTM)^t}$$

Where:

- P_0 represents the bond price at the time of issue
- YTM represents the estimated yield to maturity
- T represents the maturity of the bond

After performing this analysis, 1,582 bond pairs were found to meet the previously described matching criteria. By conducting a t-test on both populations, we observed that, although green bonds are less profitable, suggesting that there is a negative issuance premium on them due to these bonds being perceived as less risky, the differences are not significant enough to reject the null hypothesis that the mean values for both groups are not significantly different .

However, when evaluating within each industry whether or not the bonds are green, and including a variable that represents whether the bonds were issued after the Paris Agreement, the variable related to the green bond becomes statistically significant.

This also affects the sector estimators, so the impact of the Paris Agreement has affected the different sectors asymmetrically. This impact, which can be observed through the analysis of the differences of standardized betas, is greater in government bonds, the energy and financial sectors.

	After	Before	Difference	Rel. Difference
Energy	0.053103	0.045886	0.007217	13.59%
Financial	-0.292991	-0.261670	-0.031320	10.69%
Government	-0.113989	-0.081370	-0.032610	28.62%
Industrial	0.168864	0.161096	0.007768	4.60%
Utilities	0.295933	0.323682	-0.027750	-9.38%

In short, this indicates that, although the issuance of green loans and other investment products carries higher costs in terms of certification and regular audits, the fact that the market has a greater appetite for these products would be reflected in a negative premium[197].

[196] The same result is obtained if couples are eliminated from the samples where some of the bonds have a return equal to -1, which corresponds entirely to issues made by the Kreditanstalt fuer Wiederaufau on October 27, 2015.

[197] See similar reflection in the Speech of the Governor of the Bank of Spain for the Spanish Energy Club, entitled "Economic and financial policy in the face of climate goals".

Conclusions

Some conclusions can be drawn from the above analysis:

- There is little evidence that markets and agents have factored in the different types of climate risk in their pricing of financial assets so far.

- Where this evaluation is carried out, it either does not fully incorporate climate risks or is subject to a high level of uncertainty. The fact that an abrupt change in climate policy may occur (e.g. derived from the impact of an extreme physical event on society's perception) that could lead to a disorderly restructuring of the economy, might change the baseline scenario in the short term and therefore result in price volatility.

- As such, two things are necessary: the subsequent evaluation of assets in order to fully consider climate change risks, and the development of scenarios that make it possible to evaluate abrupt changes against the expectations of economic agents.

- In the particular case of the practical exercise, although there are differences in the profitability of the bonds, these have only occurred since the Paris Agreement. One possible interpretation is that investors tend to incorporate climate change risk into their expectations when there is some consensus on the need to take action, but it is clear that the assets of companies that issue green bonds are priced differently compared to those of companies that do not.

- Finally, the impact of climate risk on the price of financial assets is not symmetrical for all industry sectors.

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Glossary

Paris Agreement: an agreement within the United Nations Framework Convention on Climate Change (UNFCCC) that marks a new direction in the global effort against climate change, with nations setting concrete and ambitious goals through individual contributions at the national level, which should be reviewed periodically. As of today, 187 of the 195 signatories have ratified the agreement. The signatories of the agreement pledge to "keep the global average temperature increase well below 2°C with respect to pre-industrial levels, and continue efforts to limit that temperature increase to 1.5°C."

BCBS (Basel Committee on Banking Supervision): supranational body for the prudential regulation of banks. Its objective is to improve the quality of capital and promote the homogenization of financial system supervision.

Carbon Disclosure Project (CDP): a non-profit organization that currently manages the most widespread global environmental impact information disclosure system, as well as one of the most comprehensive databases in the world on this topic. Its objective is to promote the transition to a more sustainable economy by helping investors, companies, cities and regions to measure and understand the impact of their operations on climate change.

EBA (European Banking Authority): independent authority of the European Union, whose main objective is to maintain financial stability within the Union and safeguard the integrity, efficiency and orderly functioning of the banking sector. It was set up on January 1, 2011 as part of the European System for Financial Supervision (ESFS), taking over the previous Committee of European Banking Supervisors (CEBS).

FCA (Financial Conduct Authority): responsible for regulating the conduct of entities that provide financial services in the United Kingdom. Its aim is to promote effective competition among financial services providers, ensure that markets operate properly and protect consumers.

Greenhouse Gas Protocol (GHG Protocol): global standard for the measurement and management of greenhouse gas emissions originated by both public and private sector operations and their value chains, as well as for measuring and managing their mitigation actions.

Financial Stability Board (FSB): supranational body that aims to increase the stability of the global financial system through greater coordination between national financial authorities.

ICAAP (Internal Capital Adequacy Assessment Process): internal process of self-assessment of capital adequacy in the banking sector.

NGFS (Network for Greening the Financial System): association of central banks and financial supervisors whose aim is to promote sustainable finance, as well as to encourage the identification and management of risks arising from climate change by the financial sector.

SDG (Sustainable Development Goals): 17 key objectives and 169 goals to be achieved by all United Nations members over the next 15 years, as agreed at the United Nations Summit that took place in New York in September 2015. SDGs are a call to action to end poverty and inequality, promote economic development and improve education and health at the global level, while, as explicitly stated in objective number 13, fight against climate change.

PRA (Prudential Regulation Authority): responsible for the prudential regulation and supervision of a number of banking entities in the United Kingdom, construction companies, credit unions, insurance companies and large investment companies. Its aims include promoting the security and soundness of firms, protecting policyholders and facilitating effective competition.

Equator Principles: risk management framework, open to all financial firms, for determining, assessing and managing environmental and social risk in project finance. Its main aim is to establish a minimum standard for due diligence and monitoring to support the consideration of environmental and social risks in investment decision making.

PRI (Principles for Responsible Investment): established by an international and independent investor organization that was born in 2006, supported by the UN. Its six basic principles seek to promote and establish responsible investment criteria.

Stress test: simulation technique used to determine firms' resilience to an adverse financial situation. In a broader sense, it

refers to any technique used to assess the ability to withstand extreme conditions, and is applicable to firms, portfolios, models, etc.

Task Force on Climate-related Financial Disclosures (TCFD): special working committee established by the FSB with the aim of increasing transparency in relation to the risks and opportunities arising from climate change, as well as in relation to the potential impact these risks might have on the economy. In 2017, the TCFD published its official recommendations, which set a global standard for the identification, analysis and dissemination of climate change-related financial information.

List of acronyms

BES: Biennial Exploratory Scenario.
BoE: Bank of England.
BOE: Spain's Boletín Oficial del Estado.
CDP: Carbon Disclosure Project.
CIO: Chief Information Officer.
COP: Conference of the Parties.
CPLC: Carbon Pricing Leadership Coalition.
CVaR: Climate Value at Risk.
EBA: European Banking Authority.
EC: European Commission.
ECB: European Central Bank.
EIOPA: European Insurance and Occupational Pensions Authority.
ESAs: European Supervisory Authorities.
ESG: Environmental, Social and Governance.
EU: European Union.
EU ETS: EU Emissions Trading System.
FSB: Financial Stability Board.
GARP: Global Association of Risk Professionals.
GHG: Greenhouse gases.
GHG Protocol: Greenhouse Gas Protocol.
GRI: Global Reporting Initiative.
IFC: International Finance Corporation.
IMF: International Monetary Fund.
IPCC: The Intergovernmental Panel on Climate Change.
IPSF: International Platform on Sustainable Finance.
LTECV: Loi de Transition Énergétique pour la Croissance Verte.
NDCs: Nationally Determined Contributions.
NGFS: Network for Greening the Financial System.
PACTA: Paris Agreement Capital Transition Assessment.
PRA: Prudential Regulation Authority.
PRI: Principles for Responsible Investment.
SDG: Sustainable Development Goals.
SRI: Socially Responsible Investment.
TCFD: Task Force on Climate-related Financial Disclosures.
TEG: EU´s Technical Expert Group on Sustainable Finance.
UNEP: United Nations Environment Programme.
UNEP-FI: United Nations Environment Programme Finance Initiative.
UNFCCC: United Nations Framework Convention on Climate Change.
USD: United States Dollar.
WBCSD: World Business Council for Sustainable Development.
WRI: World Resources Institute.

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