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***Climate change-related risks for financial
intermediaries.
Management practices, analysis of measurement
models and European monitoring and
comparison.***

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To my family.

Introduction

Climate change represents one of the most significant challenges of our time, with effects that extend far beyond the environmental sphere and increasingly permeate global economic dynamics and financial stability. The European Union's commitments under the 2015 Paris Agreement, together with the evolving framework of sustainable finance, require financial intermediaries not only to limit the negative externalities generated by their activities but also to integrate climate-related considerations into their risk management and strategic decision-making processes. The dual concept of sustainable materiality and financial materiality captures this interplay between the environmental impact of corporate actions and the financial consequences of climate risks. Supervisory authorities such as the European Banking Authority (EBA) and the European Insurance and Occupational Pensions Authority (EIOPA) have progressively incorporated environmental and social risks into their regulatory agendas, promoting greater transparency, harmonized disclosure requirements and the development of robust methodologies to assess both physical and transition risks, as well as emerging forms of climate vulnerability.

Stress tests conducted by the European Central Bank (ECB) and the NGFS seek to respond to the growing need to estimate potential long-term losses along different climate transition pathways and to verify the adequacy of risk management practices. In this sense, the financial sector plays a central role in limiting the propagation of climate-related shocks in the real economy and defining the allocation of capital towards more sustainable and resilient activities.

Against this background, this thesis contributes to the academic and regulatory debate by examining how climate-related risks, ESG indicators and prudential factors interact with the performance and stability of European banks and insurance companies. More specifically, it makes three main contributions. First, it provides a comparative empirical assessment of climate-related and ESG risks for both banks and insurance companies, addressing a gap in the existing literature that remains predominantly bank-focused. Secondly, the analysis with the structured panel data for the period 2017-2024 aims to capture both the pre- and post-COVID-19 dynamics, allowing an assessment of the materialization of climate and transition risks.

Thirdly, the thesis explicitly links ESG indicators to measures of financial performance and solvency, offering insights relevant to prudential supervision and risk management practices.

The thesis is structured as follows. The first chapter outlines the conceptual and regulatory foundations of sustainable finance and its implications for financial stability, while the second chapter analyses nature, transmission mechanisms and measurement of climate risks within the financial system. Building on this framework, the third chapter presents the empirical analysis using panel-data econometric models and investigates the relationship between ESG factors, climate-related risks and the financial performance and solvency of European financial intermediaries over the period 2017–2024, with a specific focus on differences between the banking and insurance sectors.

The fourth chapter explores cybersecurity as an emerging and complementary dimension of sustainability and operational resilience, highlighting its interaction with ESG considerations in the financial sector. The final section concludes by summarizing the main findings, discussing policy implications and outlining directions for future research.

Part I: Climate change in the financial sector.

Chapter 1

Climate change: definition and impacts on the activity of financial intermediaries

CHAPTER OUTLINE

1. CLIMATE CHANGE: PHYSICAL ASPECTS AND ECONOMIC IMPLICATIONS. – 2. THE ROLE OF FINANCIAL INTERMEDIARIES IN MANAGING CLIMATE RISKS IN FINANCIAL MARKETS. – 3. THE NATIONAL AND INTERNATIONAL REGULATORY FRAMEWORK ON CLIMATE CHANGE. – 4. CLIMATE CHANGE FOR FINANCIAL INTERMEDIARIES: EVIDENCE FROM A SYSTEMATIC REVIEW AND BIBLIOMETRIC ANALYSIS.

1. Climate change: physical aspects and economic implications

The following chapter examines the main causes of climate change and potential mitigation strategies, with reference to the irreversible effects on the activities carried out by financial intermediaries considered among the key actors in the transition process.

The damage caused by climate change is progressively compromising ecosystems, due to the increasing intensity and frequency of extreme events (Malhi et al., 2020).

According to the United Nations Framework Convention on Climate Change (UNFCCC), climate change is a phenomenon of global concern that has two main components: on the one hand, natural climate variability –

attributable to oscillations in solar cycles or orbital variations; on the other hand, dangerous human activities conducted by humans that contribute significantly to climate change. In fact, the intensive use of fossil fuels and deforestation have contributed to rising temperatures, changes in climate patterns and a significant increase in greenhouse gas emissions. Recent studies show how the combination of these factors has a structural influence on the long-term climate trend, making it necessary to intervene promptly and in a coordinated way to safeguard biodiversity (França et al., 2020).

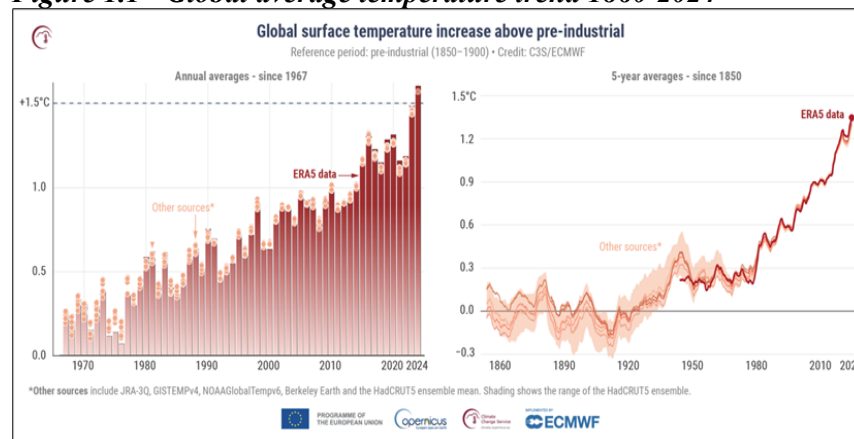
Phenomena such as global warming, melting glaciers and rising sea levels are already generating irreversible effects on the environment also in political and economic terms. Numerous studies confirm that, in the absence of effective measures, global temperatures could rise by about 1.5°C by 2050.

In 2024, a study conducted by the World Meteorological Organization (WMO) announced an increase in average temperatures by one degree compared to pre-industrial levels. This phenomenon was mainly attributed to the anomalous warming of the waters of the Pacific with the spread of long heat waves, acceleration of the melting of glaciers and favored the occurrence of extreme weather events in different areas of the planet, including the area of southern Europe and Italy.

In this context, local and international initiatives aimed at conserving or restoring the functionality of ecosystems become crucial, as it is necessary to preserve the adaptive capacity of communities and territories to climate impacts. In fact, it is necessary that the ecosystems, at the base of the earth system, are managed with a view to sustainability to contribute significantly to the maintenance of the planet's natural balance.

In addition, a solid base of scientific knowledge and the dissemination of knowledge among citizens, institutions and businesses are indispensable tools for the adoption of appropriate measures. In the absence of targeted and coordinated interventions, exceeding the critical threshold of temperature rise could generate irreversible damage.

Figure 1.1 - Global average temperature trend 1860-2024

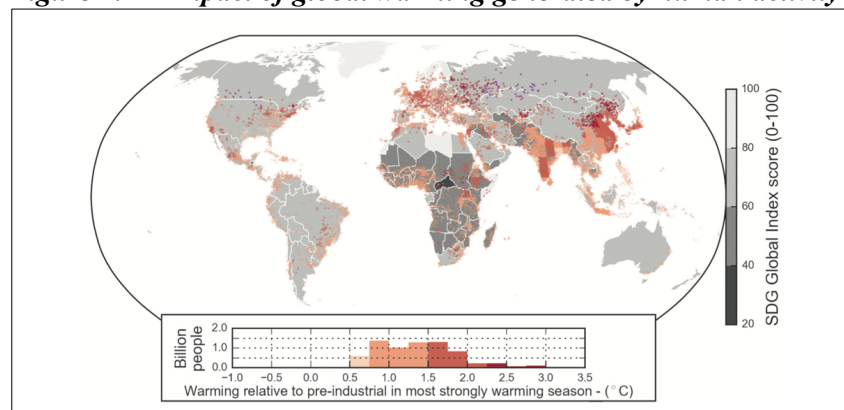


Source: <https://climate.copernicus.eu/climate-indicators/temperature>

At the UNFCCC COP21 conference, held in Paris in 2015, the members of the United Nations signed the Paris Agreement with the aim of keeping the increase in global temperature below the limit threshold of 2°C and fostering the resilience of countries to cope with the impacts of climate change and encourage the use of financial flows for resilient and low-carbon development (Paris Agreement, 2015, Art. 2.1 a–c). In 2015, the United Nations adopted the 2030 Agenda for Sustainable Development, structured around 17 Sustainable Development Goals (SDGs), the European Union, in parallel, established its own climate policy framework, committing to reduce greenhouse gas emissions by at least 40% by 2030 compared to 1990 levels. With the adoption of the measures envisaged by the Paris Agreement, the European Union committed itself to implementing concrete policies to limit the increase in the global average temperature, although progress over time has been uneven and subject to continuous challenges. In a low-carbon economy, financial intermediaries play a central role in reducing negative externalities, assessing their environmental impact through the lens of double materiality, in terms of the impact of their activities on the environment and the financial risk that climate change poses to their performance and stability.

The transition to a low-carbon economy brings both risks and opportunities not only for the real economy but also for the entire financial system. Therefore, international cooperation has proven essential, as only coordinated efforts can effectively support environmental protection and limit global temperature increases. The first major international step dates to the 1972 United Nations Conference on the Human Environment in Stockholm, which recognized the impact of human activities on ecological balance and laid the foundations for global environmental governance.

Figure 1.2 – Impact of global warming generated by human activity



Source: Intergovernmental Panel on Climate Change

In 1988, growing concerns about global temperature increases led to the establishment of the Intergovernmental Panel on Climate Change (IPCC), jointly created by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO) (IPCC, 2012). Among the initial tasks, as outlined by *United Nations General Assembly Resolution 43/534*, was the task of providing a comprehensive review of the state of climate change with the aim of analyzing the social and economic impact of the phenomenon and suggesting strategies that could reduce the negative effects (United Nations, 1988). In the first report presented in 1990, at the Second World Climate Conference, the IPCC underlined how the uncontrolled spread of greenhouse gas emissions was not only causing a progressive increase in temperatures but was also compromising the ability of natural ecosystems to absorb these emissions, thus generating a profound imbalance in the natural climate regulation mechanism. The report also pointed out that the persistent accumulation of CO₂ in the atmosphere was pushing the planet into a state of instability.

Therefore, climate change began to be considered as a “threat” and, in 1992, the first international climate agreement was drafted, called the “*United Nations Framework Convention on Climate Change*”, in which the goal of reducing emissions was established.

The Convention entered into force in 1994, marking the start of a path of international cooperation aimed at promoting shared strategies for the mitigation of emissions and the protection of climate balance. A further fundamental step came with the Kyoto Protocol, adopted in 1997 by over 160 countries during COP3 and entered into force in 2005.

The Protocol set out a commitment for the signatory States to reduce, through a series of market mechanisms, greenhouse gas emissions by 5% compared to the levels recorded in 1990. Among the tools adopted we have:

- **International emissions trading:** countries that recorded reductions above the set targets could transfer surplus credits to other industrialized countries or with economies in transition, thus encouraging the adoption of technologies with a lower environmental impact;

- **Clean Development Mechanism (CDM):** aimed at encouraging the implementation of projects in developing countries capable of reducing emissions and, at the same time, improving local economic and social conditions. In return, the promoting countries received certified emission reduction credits (CERs), valid for the purposes of compliance with the commitments undertaken;
- **Joint implementation:** it allowed industrialized states to collaborate in the development of emission reduction projects, generating credits that can be used to meet their obligations.

On 8 December 2012, with the adoption of the Doha Amendment, the Protocol was extended until 2020 and introduced a new emission reduction target of 18% compared to 1990 levels and expanding the list of gases subject to regulation.

It should be noted that countries such as China and India, still among the largest emitters of greenhouse gases, were not bound by the obligations of the Kyoto Protocol.

This exclusion highlighted the structural limitations of the agreement and made it necessary to start a new negotiation process. In 2007, the conditions were established for the opening of an alternative path which, two years later, during the COP15 in Copenhagen, laid the foundations for the drafting of the Paris Agreement.

With the adoption of the Agreement, the member countries undertook, among other measures, to allocate about 30 billion dollars to the creation of the Green Climate Fund, an instrument designed to support the adaptation and mitigation programs of developing countries, considered particularly vulnerable but particularly active in the transition process.

The preamble of the Paris Agreement emphasized the need for a coordinated and global response, capable of combining environmental, economic and social dimensions. Among the objectives, there was not only the goal of reducing emissions but also of ensuring food security, the dissemination of innovative technologies and public awareness. Implementation was based on the principle of “common but differentiated responsibilities”, which recognized the different capacities and economic conditions of everyone, emphasizing the importance of greater attention to emerging and developing economies.

The main objectives set by the Agreement can be summarized as follows:

- Limit the increase in the global average temperature to 2°C compared to pre-industrial levels, with a commitment to continue further efforts to limit it to 1.5°C;
- strengthening the adaptive capacity of states to climate impacts, to foster resilient and low carbon development;
- making financial flows consistent with a sustainable and climate-resilient growth model.

In 2021, the Glasgow Climate Pact was adopted at COP26, which defined a series of strategic actions to support the climate for the following decade. The main results to be achieved are highlighted below:

- a) Mitigation: the commitment to limit the increase in global temperature to 1.5°C was reaffirmed, but it was recognized that the policies implemented up to that point were not sufficient to achieve the goal;
- b) Adaptation: an increase in the share of international funds was envisaged to support the most vulnerable countries, promote the protection of communities and introduce tools (so-called indicators) capable of measuring the progress achieved;

- c) Climate finance: the commitment to mobilize 100 billion dollars by international financial institutions was confirmed. This goal was achieved in 2022.
- d) Transparency: the obligation to report was introduced, as established by the Enhanced Transparency Framework (ETF) of the Paris Agreement starting from 2024 for the reporting of greenhouse gas emissions and removals to the UNFCCC bodies;
- e) Agreements on mechanisms: the objective of creating an international carbon market was confirmed, which would have allowed the reduction of the costs of abatement on emissions through a mechanism for trading CO₂ allowances between the different emitters.

To ensure continuity of action, the 2030 Agenda for Sustainable Development, adopted in 2015 following the Paris Agreement, defined a universal framework divided into 17 Sustainable Development Goals (SDGs), to promote environmental protection and eliminate economic and social inequalities and to place sustainability as a cross-cutting pillar of global policies.

The active involvement of citizens, businesses and governments is key to effectively addressing global challenges, which are strongly interconnected between environmental, economic and social dimensions. The use of solid scientific studies becomes a necessary condition for directing political and financial decisions towards sustainability goals.

The Paris Agreement represented a turning point in the intensification of European climate policies, as highlighted in the 2024 OECD study which underlined how climate change represents an increasingly important threat to international financial stability as an unordered transition to a low-carbon economy carries numerous risks (UNFCCC, Glasgow Pact 2021). Therefore, financial intermediaries are called upon to manage and assess climate risk, which has now taken on a systemic nature.

The main components of this risk can be traced back to three dimensions: hazard, exposure and vulnerability.

Each of them contributes to determining the intensity and probability of the economic and financial impacts deriving from the phenomenon.

In this regard, the European Central Bank (ECB) pointed out in 2020 that “climate change and environmental degradation, considered structural shock, affect both economic activity and the banking system, affecting the real economy and financial stability through the credit channel. In addition, new climate regulations introduced by governments often require significant investment in innovative technologies. As a result, the rapid adaptation that companies must sustain to the changing environment has a negative impact on the profitability and competitiveness of the markets.”

The worsening of weather phenomena related to climate change and the transition to a resilient economy require the adoption of mitigation strategies linked to two types of climate risk, the *intense physical risk* in terms of the probability that a financial loss, resulting from extreme weather events and gradual environmental changes, could impact the assets, operations and solvency of the companies involved; and the *transition risk* arising from significant financial losses incurred directly or indirectly by an institution, as a result of the process of adapting to a sustainable and low-carbon economy, with direct

influences investor sentiment and direct fluctuations in asset prices ((NGFS, 2019; Bolton et al., 2020; Pastor et al., 2021).

The components of climate risk are distinguished by hazard, exposure and vulnerability.

In 2020, the ECB stated that “climate change and environmental degradation”, recognized as structural shocks, affect not only economic activity but also the financial system. The European Central Bank (ECB) recognized the importance of climate change and environmental degradation, emphasizing their structural impact on economic activity and the financial system of Member States.

Physical risk can be “acute” if caused by events such as drought or floods, “chronic” if caused by progressive changes such as the loss of biodiversity, the scarcity of resources and the destruction of ecosystems, up to causing material damage of an economic nature such as the interruption of production chains and loss of productivity.

Many scholars and analysts argue that the introduction of a “price” on carbon, to ensure a reduction in emissions, would represent an incentive to reduce polluting emissions,

while recognizing that such an instrument alone would not be sufficient to contain the costs of the transition and reduce social inequalities. In addition, several economists and institutions argue that a combination of market mechanisms, public investment in infrastructure, green technologies and targeted social policies would be the most effective way to achieve an orderly transition. It is therefore essential to understand the extent to which the uncertainty arising from different climate policies affects financial markets and the possibility of new growth opportunities where, the magnitude of estimated losses, in terms of physical and transition risk, together with the speed at which they could materialize, represent a factor of vulnerability both for banks and for the financial system as a whole.

Consequently, the implementation of a climate governance model is therefore necessary to balance investment strategies with social protection strategies, to ensure a fair and sustainable transition, which aims at the coordination between economic and environmental policies with financial policies (Monasterolo et al., 2020).

Therefore, considering what has been said, there is a growing consensus among scholars and experts on the opportunity to introduce climate policies that include tools such as carbon pricing or an “emissions tax”, to reduce the production of CO₂ and other greenhouse gases and to internalize the negative externalities related to global warming (Stern et al., 2017).

2. The role of financial intermediaries in managing climate risks in financial markets.

The growing attention paid to environmental sustainability has highlighted the role played by financial intermediaries in promoting economic models oriented towards growth and social well-being. The financial system, in fact, plays a central role in achieving sustainability objectives, as it intervenes decisively in the processes of credit allocation, investment choices and asset protection.

As highlighted by the Bank of Italy (2021), the growing interest in sustainable finance has led banks to integrate climate-related risks into their investment and risk management frameworks.

In the same vein, the EIOPA (2023) report highlights that climate change poses significant risks to the insurance sector, particularly in relation to increasing protection gaps and exposure to extreme events.

The Brundtland Report of 1987 (Our Common Future) remains one of the main references for the definition of sustainable development, understood as the ability to meet the needs of the present without compromising the needs of future generations.

In this context, sustainable finance can confirm that it focuses on the quality of economic growth, on the production of income and on the creation and employment opportunities according to environmental and social needs. This new approach aims to ensure the achievement of a sustainable and resilient economy that guarantees collective well-being. The growing attention to sustainability is fueled by the awareness that the new emerging risks and the traditional ones, in terms of probability and impact, mostly have an environmental matrix. Critical scenarios, banks and insurance companies could record a significant increase in credit losses, due both to the potential depreciation of securities on the market and to the obligation to cover claims more than premiums collected with the occurrence of extreme weather events.

Among the functions of the financial system, intermediation plays a central role: it allows the transfer of monetary resources from surplus to deficit entities, making use of various direct and indirect financing instruments according to a mechanism for allocating economic resources towards investments that have characteristics related to sustainability.

As highlighted by Alogoskoufis et al. (2021), climate change represents an important source of systemic risk for banks, particularly for investment portfolios concentrated in vulnerable sectors and geographical areas. In line with this view, the Intergovernmental Panel on Climate Change (IPCC) defines climate risk as the result of the interaction between climate-related hazards, exposure and vulnerability, which together determine the magnitude and likelihood of potential impacts on natural and human systems (IPCC, 2014).

Biodiversity loss is also a significant risk factor: the health of ecosystems and biodiversity accounts for more than 50% of market value for listed companies. In fact, according to Johnson et al. (2020), in some countries the costs associated with biodiversity decline could reach a share of 4% of annual GDP by 2050.

The concept of systemic risk has attracted increasing attention especially since 2008, with the outbreak of the global financial crisis triggered by the collapse of Lehman Brothers and aggravated by the subsequent sovereign debt crisis in the Eurozone. The set of events has highlighted the fragility of the international financial system and has contributed to a significant evolution of its literary definition.

De Bandt et al. (2000) argue that the concept of systemic risk basically refers to episodes of stress, in particular contagion, affecting banking, financial and payment systems, due to the lack of a unified theoretical framework. According to the European Central Bank (2009), systemic risk occurs when financial institutions fail to meet their obligations, generating far-reaching repercussions on the entire system to the point of compromising stability.

In 2005, Lehar interpreted systemic risk as "the probability that a single event will cause multiple financial institutions to fail simultaneously."

Acharya et al. (2009), on the other hand, associated it with the joint collapse of institutions and capital markets, with negative effects on the supply of capital destined for the real economy.

Finally, Patro et al. (2013) described systemic risk as a condition of stress that inevitably affects financial markets and the real economy, reducing the supply of capital and amplifying economic losses.

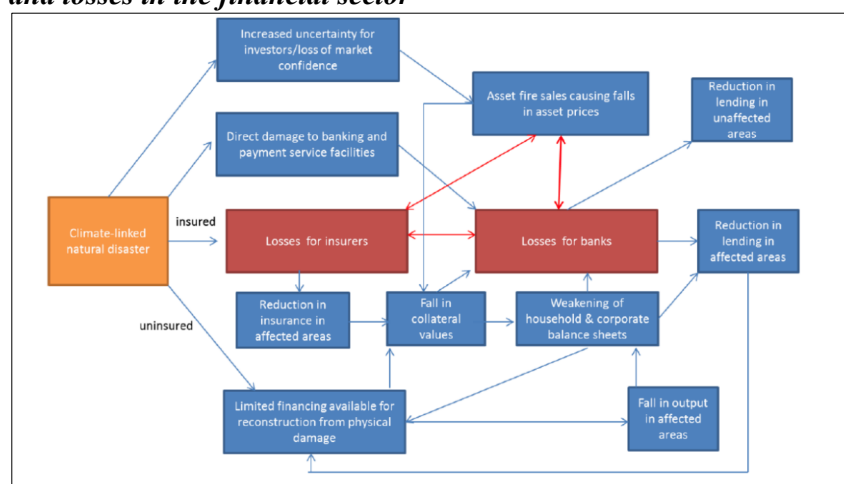
Further threats to financial stability, as already mentioned, may result from a disorderly transition to a low-carbon economy. A disorderly transition is a process characterized by uneven regulation among the different countries called upon to work to combat climate change (NGFS, 2019).

In this context, sustainable finance plays a central role, emphasizing the quality of economic growth and the ability to combine income generation and job creation with environmental and social protection, ensuring individual well-being and promoting the achievement of the goals of a sustainability-oriented economy.

Critical scenarios, banks and insurance companies could record a sharp increase in credit losses, linked both to the depreciation of securities on the market and to the need to cover compensation more than premiums collected, in the face of extreme weather events. The intermediation activity, through the transfer of monetary resources from surplus to deficit subjects, makes it possible to direct private capital towards sustainable investments, thus directing the decisions of economic units.

However, physical risk, if it occurs, can undermine this mechanism and the ability to generate income, causing damage to infrastructure, households and businesses, with direct repercussions on the stability of the financial system.

Figure 1.3 - A representative map of the effects of a natural disaster and losses in the financial sector



Source: Batten et al., (2016).

Figure 1.4 – Climate risks, opportunities and financial impacts
Climate-Related Risks, Opportunities, and Financial Impact



Source: TCFD - Task Force on Climate-Related Financial Disclosures, June 2017

In this scenario, investors face difficulties in predicting the impact of climate policies on their business models, and this element of uncertainty is indirectly reflected in the companies, banks and financial intermediaries that finance them. As a result, risk management and control become essential conditions for the creation of value along a sustainability-oriented path. In this perspective, the definition of an ESG identity allows banks, insurance companies and financial intermediaries to attribute centrality to the environmental and social dimension, transforming it into a strategic and competitive lever towards shareholders and reference stakeholders.

Figure 1.5 – The effects of climate risks on banks

	Credit risk	Market risk
Physical risk	- Extreme weather events affect the production of businesses / households and make them more vulnerable in financial terms, reducing their capacity to repay their debts. - Extreme weather events affect the value of the guarantees of indebted businesses / households.	- Losses resulting from the value of the bank's property (houses, land, etc.) being reduced by extreme weather events caused by the climate. - Losses resulting from a reduction in the value of bank portfolio securities issued by companies whose performance is affected by the material effects of climate change.
Transition risk	- Difficulties for businesses whose future performance is influenced by climate change policies (e.g. coal generating companies, energy-intensive companies in the oil and gas sector, companies for which the costs of energy products or the availability of specific fossil energy sources are essential to the production process).	- Losses resulting from the reduction in value of bank portfolio securities issued by companies whose future performances are influenced by climate change policies (e.g. companies generating electricity using coal, energy-intensive companies and companies in the oil and gas sector).
Systemic Risk	If the effects (especially those of the transition risk) affect a whole sector (construction, energy production and distribution, agriculture, etc.), the risk arises of spill-over effects on the whole financial system (shareholders, debenture holders, creditors).	

Source: Faiella et al., (2020), Bank of Italy.

Figure 1.5 highlights the impact of the two main risk categories on credit and markets. On the one hand, extreme weather events can compromise economic activities, reducing the ability of companies to repay their debts (so-called financial weakening), causing banks to lose the value of the assets granted as collateral. On the other hand, the transition risk manifests itself through the introduction of more stringent climate policies that affect the profitability of companies, increasing the probability of default and increasing market volatility.

In addition to the risks, there is the risk of civil liability, which is particularly relevant for the insurance sector, which emerges when the damage resulting from intense climatic events is transferred – due to the very nature of the activity they are called upon to carry out – to the insurance companies that deal with risk management.

To respond to these challenges and encourage the direct involvement of financial operators in achieving the objectives set by the 2030 Agenda and the Paris Agreement, the European Commission presented in 2018 the "Action Plan to finance sustainable growth", divided into two main objectives:

- increase the contribution of finance to sustainable and inclusive growth in the long term;
- strengthen the stability of the financial system by integrating environmental, social and governance factors into investment decision-making processes.

To achieve these objectives, the Commission has envisaged the implementation of several measures, including directing financial flows towards sustainable investments and integrating ESG criteria into financial decisions and promoting transparency and reliability of information.

The following figure illustrates the ten specific macro-areas of intervention identified by the Plan.

Table 1.1 – Actions and macro-areas of intervention for sustainable and financial growth

Actions	Macro-areas of intervention
Redirecting financial flows towards sustainable investments	Establish a classification system for sustainable activities (the so-called Taxonomy); Promote sustainable investments; Include sustainability policy in financial advice; Develop sustainability indicators
Integrating ESG preferences and risks into financial decision-making	In market valuations and research; Integrating sustainability into the prudential requirements of banks and insurance companies
Promote transparency and long-term vision	Strengthen sustainability communication; Promote long-term sustainable corporate governance;

Source: *The financial system: functions, markets and intermediaries.* - Giappichelli editore (2024)

In 2002, the Bank of Italy, in line with the initiatives promoted by the ECB and other supervisory authorities, published the report "Supervisory expectations on climate and environmental risks". In this document, it underlined how the Risk Management function, responsible for the correct implementation of the risk management process, is aimed at identifying, measuring and preventing the traditional, climatic and environmental risks assumed by the intermediary.

Their management, however, implies a high degree of uncertainty, linked both to the extension of the transmission channels and to the necessary adaptation actions.

The central role of financial intermediaries in promoting sustainability is clearly reflected in the management of ESG factors, which can have both positive and negative effects on overall financial performance. They are classified into three main categories:

- Environmental (E): concerns environmental factors that recall the urgency of policies aimed at the transition to low-carbon economies, increasing energy efficiency and responsible use of natural resources;
- Social (S): includes social factors related to the well-being of individuals and communities, which are embodied through policies aimed at improving working conditions, promoting diversity, protecting social security and ensuring respect for human and women's rights;
- Governance (G): refers to the set of good practices of the Board of Directors, homogeneity in the composition of the body, ability to enhance the value of the company and adoption of ethical and compliant behaviour by the persons who hold top positions.

The goal is to ensure that social and environmental aspects are integrated into the decision-making process, to guide the strategic choices of financial intermediaries with a view to sustainability.

These factors can have both positive and negative implications for financial performance, creating new opportunities while also introducing additional sources of risk. Negative impacts are typically associated with current or prospective ESG-related risks affecting financial institutions, their counterparties and invested assets, potentially influencing profitability, asset quality and creditworthiness (EBA, 2021).

In this context, the growing importance of data, now considered an essential asset for the management of the activities of financial intermediaries, raises crucial questions in terms of security and information protection. Technological innovation plays a decisive role in the transition process, as it can facilitate the access, processing and quality of ESG data, thus helping to reduce the information gap on the subject.

However, such progress requires careful assessment and constant monitoring to prevent and contain the negative effects of potential cyber-attacks that could compromise the integrity of systems. In conclusion, adequate risk management and strict control are essential conditions not only for the creation of value, but also for the affirmation of a fully ESG-oriented business model.

3. The national and international regulatory framework on climate change

In recent years, financial regulation has undergone a significant evolution, aimed at defining more effective practices for managing climate risk and strengthening awareness of the crucial role that the sector plays in the transition to a sustainable economy.

A key step came in March 2011 when the European Commission presented the "Action Plan on Sustainable Finance", drawn up in response to the recommendations of the High-Level Expert Group on Sustainable Finance. According to the Commission, sustainable finance is based on two main pillars: on the one hand, ensuring long-term sustainable and inclusive growth through the provision of financing and, on the other hand, strengthening financial stability by integrating ESG factors into investment decision-making processes.

One of the central objectives of the Plan and of the broader European strategy was to safeguard the stability of the financial system, in line with the instructions of the Task Force on Climate-related Financial Disclosures (TCFD) Regulation (EU) No. 2019/2088, known as the "Sustainable Finance Disclosure Regulation" (SFDR), which, through the introduction of harmonized standards, imposes stringent obligations on market operators in terms of transparency and clarity.

Financial institutions are required to provide timely information on the impact of their activities in environmental terms, both in portfolio management and in advisory services, to integrate sustainability risks and possible negative effects on investment instruments into their financial reporting processes. In parallel, the EU Taxonomy provides disclosure requirements and a classification system for sustainable economic activities, to ensure fairness and transparency among stakeholders and support the channeling of capital towards green investments.

The supervisory role of the European Central Bank has strengthened this framework, encouraging banks to develop methodologies to measure and manage climate-related and environmental risks.

To support the transition, the Network for Greening the Financial System (NGFS), composed of central banks and supervisors, promoted the exchange of information and best practices between financial entities for the homogeneous assessment of climate risks and strengthened the resilience of the financial system.

Among the concrete tools introduced by the ECB for climate risk management are stress tests with which banks simulate extreme weather events to assess the impact of natural disasters or regulatory and/or structural shocks on balance sheets, to develop appropriate mitigation strategies.

The Corporate Sustainability Reporting Directive (CSRD) has expanded the requirements for sustainability, requiring the collection and dissemination of detailed data on environmental performance and greater transparency towards stakeholders.

Instead, the guidelines of the Task Force on Climate-related Financial Disclosures (TCFD) and the principles developed by the International Sustainability Standards Board (ISSB) define a common framework for the assessment and communication of information relating to the risks and opportunities associated with the ecological transition.

Overall, these developments contribute to integrating risk management into banking processes, promoting a culture of environmental responsibility and virtuous competition aimed at strengthening internal governance.

Banks are called upon to set up sustainability committees, strengthen staff training and collaborate with public and private institutions to develop advanced technological solutions that can improve the traceability of emissions and the transparency of financial flows intended for sustainable activities.

As far as insurance companies are concerned, the regulatory framework has evolved with similar purposes.

For insurance companies, the Solvency II Directive introduced capital requirements and risk management requirements, with the aim of increasing the sector's ability to cope with climate change-related shocks.

Globally, the International Association of Insurance Supervisors (IAIS) has issued guidelines for integrating climate risks into business models, while the TCFD proposed a framework for reporting and transparency of mitigation and adaptation strategies. In parallel, supervisors have also launched climate stress tests for insurance companies, to encourage the sector to revise actuarial models to facilitate the inclusion of climate data in the forecasts of assets and liabilities on the balance sheet.

These regulatory changes not only strengthen the stability of the insurance system but stimulate the development of products that reward companies and citizens committed to promoting sustainable and resilient development. A further piece of the European framework was the proposal for the Corporate Sustainability Due Diligence Directive (CSDD), which introduced due diligence obligations for the identification, prevention and mitigation of the negative impacts of economic activities on human rights and the environment.

The Directive requires major financial and non-financial companies to comply with specific requirements along their supply chains, including risk assessment, continuous monitoring and corrective action. Companies are therefore called upon to prevent phenomena such as child exploitation, deforestation and corruption and money laundering practices, preparing action plans consistent with ESG principles and international treaties.

In the long term, this set of rules and directives must contribute to strengthening the stability of the global financial system and foster cultural and strategic change that makes banks and insurance companies central players in supporting the transition to a resilient and sustainable economy.

Further regulatory development is represented by the European Commission's proposal of July 2025, with which a new climate target was set: a 90% reduction in net greenhouse gas emissions by 2040 compared to 1990 levels. This milestone is an intermediate step towards climate neutrality by 2050 and is based on sound scientific recommendations. It aims to ensure greater predictability for companies and investors and, at the same time, strengthen European industrial competitiveness in the context of the green transition. Achieving this goal requires a holistic approach to decarbonizing all sectors, with a focus on energy, and involves the widespread adoption of zero- and low-carbon solutions.

Following the setting of the 2040 target, the Commission will develop a policy framework for the post-2030 period, geared towards balancing fairness, technological neutrality and economic efficiency, while strengthening the Union's competitiveness and ensuring a just and environmentally sustainable transition. In defining this future framework, specific emphasis will be given to how regulatory simplification and cross-sectoral flexibilities can facilitate the achievement of the 2040 target, promoting convergence between Member States while respecting their national specificities.

At the same time, new technological developments, including innovations in the space sector, will be enhanced, while the investment plan will have to consider both financial needs and opportunities useful for managing the social, economic and environmental repercussions of the transition. The entire strategy will be guided by the principles of solidarity and fairness, to ensure a just transition for all European citizens. In summary, the regulation reiterates the importance of the use of innovative technologies to reduce the carbon footprint and is part of the path outlined by the European Green Deal, updating the regulatory framework to make the financial, industrial and energy sectors more resilient and fully aligned with the goals of the Paris Agreement (European Commission, 2025). A further significant milestone in the European regulatory process was the adoption of the Nature Restoration Law in July 2024, the first EU regulation introducing binding targets for the restoration of degraded ecosystems, such as forests, wetlands and marine habitats (EBA, 2023). This intervention, closely linked to climate and financial policies, reflects the growing awareness that biodiversity loss constitutes a systemic risk for markets and that, as a result, financial intermediaries are called upon to channel resources towards projects capable of supporting both climate change mitigation and the protection of natural capital.

At the same time, supervisors have progressively raised their expectations of financial institutions. Already with the first climate stress exercises, launched in 2021 and continued in 2022, it has emerged that the costs deriving from an orderly transition are lower than those related to scenarios characterized by extreme weather events or disorderly transitions.

The European Central Bank's (2022) climate risk stress test shows that, on average, more than 60% of banks' non-financial corporate interest income is linked to greenhouse gas-intensive sectors, highlighting significant vulnerabilities related to climate transition risks. In the same vein, in 2023 the European Banking Authority (EBA) further incorporated ESG risks into the prudential supervisory framework, particularly under Pillar 2, by strengthening supervisory expectations and requiring banks and investment firms to integrate climate-related risks into their governance, risk management and capital planning processes. At the international level, a further step towards harmonization was taken in June 2023 with the publication (ISSB) by the International Sustainability Standards Board of the first two global standards, IFRS S1 and IFRS S2, relating to general sustainability disclosures and climate disclosures respectively.

These standards provide a common basis for reporting globally, strengthening transparency, comparability, and investor confidence.

Taken together, these regulatory innovations – ranging from biodiversity protection to sustainable finance instruments, from new reporting standards to supervisory stress tests – outline an increasingly organic framework for the integration of ESG factors into financial regulation and confirm the crucial role of the financial and insurance sector in directing capital flows towards sustainable activities and in ensuring the stability of the economic system during the transition to climate neutrality. Recent changes have also led to changes in the Solvency II prudential regime, aimed at increasing the resilience of the insurance sector, which is highly exposed to climate risk. The latest amendments to the directive include the consolidation of crisis prevention and management tools, with the aim of strengthening the protection of insurance companies and the stability of the system (Council of the European Union, 2024).

In parallel, EIOPA (2025a) has developed a package of technical standards and proposals for the revision of capital parameters, with a particular focus on catastrophe risk related to natural events, the frequency and intensity of which are increased by climate change.

In this context, the idea of a stricter prudential treatment for investments in carbon-intensive sectors also emerges, with a view to integrating transition risks into the calculation of capital requirements (KPMG, 2024). The supervisory guidelines have been updated to favor the inclusion not of environmental risks, but also of technological and IT risks, thus offering a more complete view of the vulnerabilities of the sector (EIOPA, 2025b).

Taking together, these interventions show how the Solvency II framework progressively evolved from a static system of capital calculation to a dynamic mechanism, capable of reflecting the transformations of the economic and climate environment and stimulating the insurance sector to play an active role in the transition to sustainability.

4. Climate change for financial intermediaries: Evidence from a Systematic Review and Bibliometric Analysis

The growing awareness posed by climate change and the political commitment made by the international community to address this challenge – as enshrined in the Paris Agreement – have contributed to generating broad and articulated research flows, characterized by innovative investigations that have also involved the academic field, with the aim of supporting the realization of green and sustainable finance (Dikau et al., 2019). The European Central Bank's (ECB, 2020) guidelines on sustainable finance highlight the importance of long-term value creation, based on respect for the principles related to fair remuneration of workers, the safeguarding of ethical and social values and the protection of the environment. The academic literature adopts different qualitative and quantitative approaches to analyze and organize research results.

Among these, the systematic review of the literature represents a structured, transparent and efficient method, aimed at ensuring the reproducibility of the results and based on the statistical measurement of the scientific activity of the authors under analysis. Bibliometric analysis is carried out through the use of two software: Biblioshiny, which provides a web interface to R's Bibliometrix package (Aria & Cuccurullo, 2017), and VOSviewer, a particularly effective tool for the construction, visualization and exploration of bibliometric maps based on network data and identity clusters (Baker et al., 2020; Khan et al., 2020). This analysis makes it possible to understand the evolution of the regulatory and environmental context that directly involves financial intermediaries and their networks. In addition, the observation of the evolution of literature also considers the number of collaborations between scholars belonging to the scientific community, a fundamental element for the creation and sharing of knowledge on the subject (Koseoglu, 2016).

Scientific mapping techniques can be traced back to three broad categories of research:

- the identification of the fundamental knowledge base and intellectual structure of a given field of study;
- the analysis of the research or conceptual structure of a disciplinary field;
- the construction of the social network of a specific scientific community.

In the design phase, it is essential to define the time interval, continuous or discrete, from which to extract data. During the collection phase, the database that will contain the necessary bibliometric information is selected; Next, you can find the relevant items (data step) and export a custom dataset (Waltman et al., (2016). In the past, literature reviews were mainly based on qualitative methodologies, adopted to analyze the emerging role of financial intermediaries and to interpret climate events, with the aim of highlighting existing knowledge gaps. With the introduction of the most recent tools offered by Bibliometrix, the approach has progressively moved towards quantitative methodologies, leveraging statistical tools.

From these premises the analysis begins, which is based on the following research question:

"How is the literature on green finance and climate risk structured and developed, and to what extent does it contribute to understanding the role of financial intermediaries?"

The aim of this work is therefore to analyze in depth the existing literature on climate change and its effects on the financial system.

In particular, the survey focuses on how financial institutions are addressing challenges related to environmental sustainability and the adoption of ESG criteria, whose integration into the financial sector is becoming increasingly important. To carry out the analysis, various eligibility criteria were defined, including scientific articles, conference proceedings, book chapters and other forms of popular contributions, using the Scopus database, considered by the academic community to be a reference source for the wide coverage of publications and reviews in the financial field. According to Paltrinieri et al. (2021), bibliometric analysis is more objective than traditional systematic reviews, since the selection and extraction of the sample are based on both qualitative and quantitative evaluations, reducing the risk of bias deriving from the subjective choice of keywords.

Further strength consists in the possibility of managing large volumes of data, facilitating the construction of research lines through the examination of previous scientific production (Galletta et al., 2022).

The operational phases that marked the analysis can be summarized as follows:

- Data collection: identification of reference materials;
- Data selection: identification of relevant works;
- Data analysis: processing and interpreting the information collected.

The research was conducted in September 2025 and the keywords used for the systematic review of literature examined the works in the database in the period between 2012 and 2024.

Given the different data structure between the different databases available, the literature generally recommends the use of a single source (Donthu et al., 2021).

In accordance with this methodological indication, it was decided to operate exclusively on Scopus, thus ensuring the homogeneity and consistency of the extracted data.

In the period between 2012 and 2024, a small sample of contributions on the topic was generated. The TITLE-ABS-KEY research structure in Scopus is based on the following terms: "climate risk*" OR "climate chang*" OR "physical risk*" AND "transition risk*" OR "ESG*" AND "financial intermediar*" OR "bank*" OR "insuranc*". The strategy adopted is summarized in the following table:

Following the application of the above criteria, the search returned a sample of 126 articles from Scopus. Despite the relatively small sample size, the research provides a solid and consolidated basis for the evaluation of thematic patterns, relevant authors, emerging trends and citation networks in the field of study. The use of Scopus, combined with the techniques and software adopted, has made it possible to obtain a complete and rigorous reconstruction of the literature on climate change and related risks, with specific reference to financial intermediaries such as banks and insurance companies.

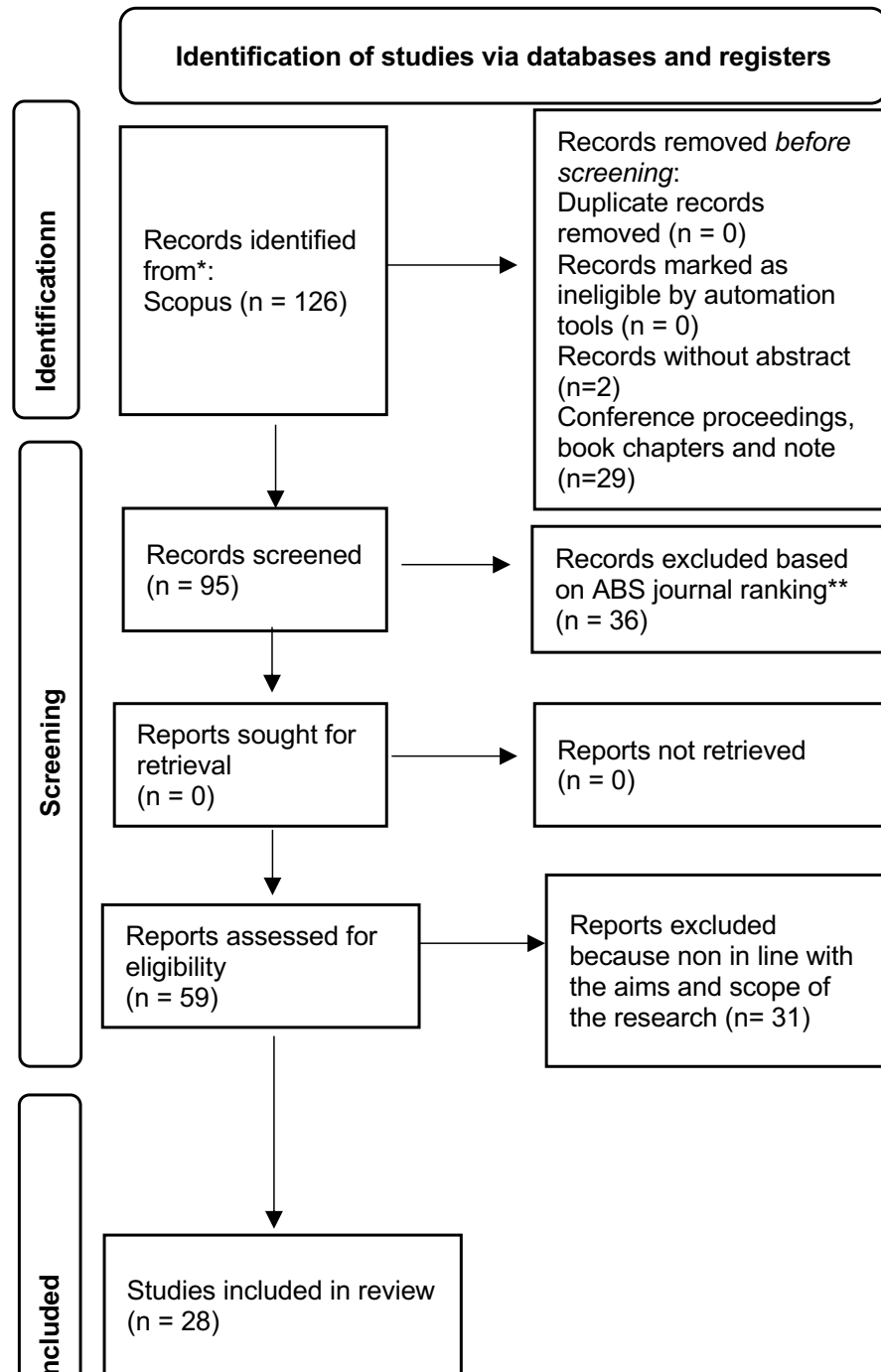
Table 1.2 – List of keywords used to produce the SLR – Personal elaboration

The analysis examines the influence of climate change on the activities carried out by financial intermediaries, with reference to environmental sustainability policies and the adoption of ESG criteria. Sustainability and climate change are recognized as both economic and social imperatives in the various scientific works published by leading scholars.
Reference period: 2012 – 2024 Selected language: English
Search strategy: The language used for analysis in Wos is as follows: (TS refers to the "topic" of the publication.) TS= ("climate risk" OR "physical risk*" AND "transition risk*" OR "ESG*") TS= ("financial intermediar*" OR "bank*" OR "insuranc*")
Scientific articles detected: 126 Total Citations: 2,064 H-Index: 20

In the initial phase of sample construction, the research identified a total of 126 items. Following the pre-established selection criteria, 2 articles were eliminated because the abstract was not available, 31 were excluded for non-relevance and another 29 for contributions that did not comply with the requirements of PRISMA, such as conference proceedings and book chapters. To conduct efficient bibliometric research, an additional criterion was applied for the selection of scientific articles consistent with the research topic.

The journals were ranked according to the rating provided by the Academic Journal Guide (AJG) which ranks journals from 1 to 4*. A common view of the classification is based on the selection of journals with an ABS rating of 3 or higher (Ribeiro et al., 2022; Patel et al., 2022; Migliavacca et al., 2022). Recent studies show that many journals of international relevance have an ABS score of 2, therefore, their exclusion would result in the omission of articles strictly related to the topic. To address this issue, a two-pronged approach has been adopted: (i) using the traditional ABS3+ cutoff and (ii) a larger selection that also includes journals classified as ABS2+. In addition, only journals in the fields of Finance, Economics and Accounting were selected. This comparison allows us to verify the robustness of the results obtained. Finally, to ensure transparency and reproducibility, the PRISMA framework has been applied, which allows the flow of information to be systematically tracked throughout the review process. At the end of the screening process, the final sample includes 29 articles judged to be relevant to the topic of climate change for financial intermediaries.

Figure 1.6 – Prisma model with identification of the studies included in the analysis



Source: Personal elaboration

Table 1.3 – Most relevant journals

Journal Titles	AJG 2024	Field
Journal of Risk	2	FINANCE
Finance Research Letters	2	FINANCE
International Review of Financial Analysis	3	FINANCE
International Review of Financial Analysis	4	FINANCE
European Economic Review	3	ECON
Energy Economics	3	ECON
International Review of Economics and Finance	2	ECON
Economic Modelling	2	ECON
Journal of Banking Regulation	2	FINANCE
Review of Accounting and Finance	3	FINANCE
Review of Corporate Finance	3	FINANCE
Journal of Financial Stability	3	FINANCE
Journal of Financial Stability	3	FINANCE
Research in International Business and Finance	2	FINANCE
Research in International Business and Finance	2	FINANCE
Global Finance Journal	2	FINANCE
International Review of Financial Analysis	3	FINANCE
Review of World Economics	2	ECON
Review of World Economics	2	ECON
Journal of Financial Stability	3	FINANCE
Journal of Financial Research	3	FINANCE
European Actuarial Journal	2	FINANCE
Annual Review of Financial Economics	3	FINANCE
Journal of Risk	2	FINANCE
Journal of Business Finance and Accounting	3	ACCOUNT
International Review of Financial Analysis	3	FINANCE
Journal of Financial Stability	3	FINANCE
Ecological Economics	3	ECON

Source: Personal processing based on data provided by ABS

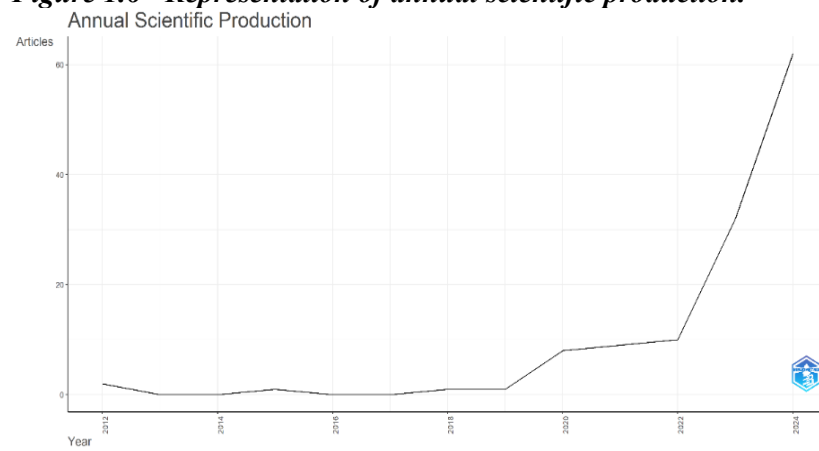
It should be noted that the procedure of a reflex has some limitations, linked to the choice of keywords and the search strategy adopted, elements that significantly affect the results obtained. The keyword selection process and the risk of bias deriving from the databases used also remain central.

In the following analysis, the construction of the clusters was carried out considering both financial and structural concepts, based on comparative analyses and empirical evidence developed by the main scholars recognized in the field of reference.

Figure 1.6 illustrates the trend of publications on the subject in the identified period, i.e. from 2012 to 2024. There is exponential growth starting from 2024, a sign that the worsening of climatic conditions remains the subject of debate due to the inhomogeneity of regulations and the failure to achieve the objectives established globally, for all states.

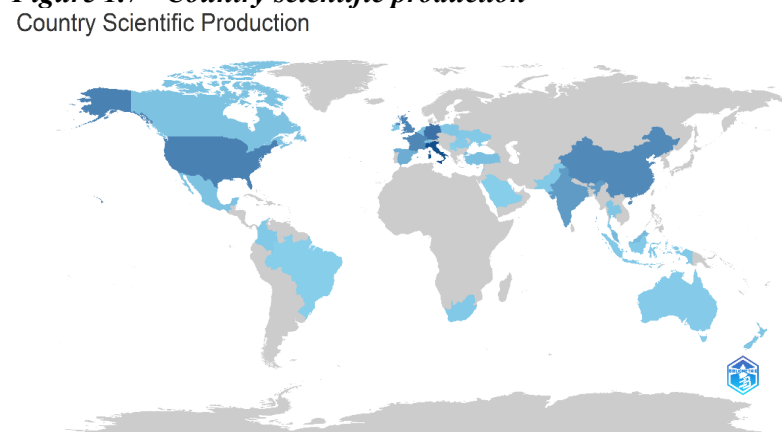
Fig. 1.7, shows for different intensity of blue between the different countries, the scientific production about climate change for intermediaries. Greater attention on the issue comes from the most developed countries such as Italy, the United States and China.

Figure 1.6 - Representation of annual scientific production.



Source: Bibliometrix with Biblioshiny

Figure 1.7 - Country scientific production



Source: Bibliometrix with Biblioshiny

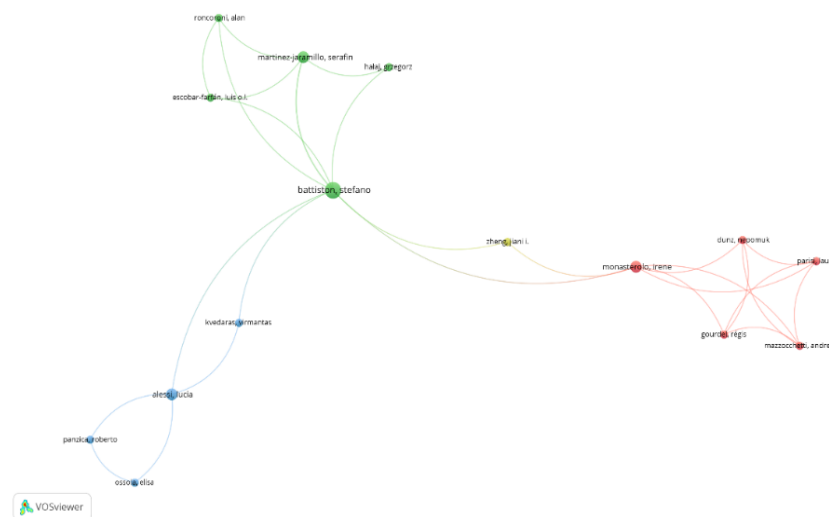
With the help of the clusters generated by VOSviewer, the literature was then analyzed - based on the connections between the key terms extracted from the selected abstracts - through the construction of co-occurrence maps. To ensure accuracy and minimize any bias, marginal terms have been removed and only the most recurring ones have been retained. The resulting output shows a high level of complexity, due to the breadth of the topic and its multidisciplinary nature and allows the identification of five distinct research areas (Fig. 1.8). The first cluster (red) confirms the centrality of the issue of climate change; The brown cluster focuses on ESG aspects, the banking sector and the event study methodology, based on the study of market uncertainty caused by shocks; the green cluster, on the other hand, on the banking sector and green finance, the yellow, orange, blue and lilac clusters, focus on the issues of physical risk, transition and carbon tax. However, this automated clustering, based solely on the relationships between words, does not capture the conceptual depth of the literature and does not allow, on its own, an adequate interpretation of the main keywords.



If we look at the co-authorship of the authors (Fig. 1.10), Battiston S. emerges as the central author of the network, acting as the main connector between different research clusters on the topic of climate change and financial intermediaries.

Its centrality is highlighted above all by the connections with various research clusters, including the one formed by Roncoroni A., Martinez-Jaramillo and the connection with Monasterolo I., among its most influential co-authors.

Figure 1.10 – Co-citation analysis



Source: VOSviewer

The analysis shows that climate risks now play an important role in financial stability. Extreme physical events reduce the capital resilience of financial intermediaries (Chabot and Bertrand, 2023) and, at the same time, transition risks triggered by new policies and changes in investor preferences affect both asset valuation and macro-financial market dynamics (Dafermos and Nikolaidi, 2021; Gourdel, Monasterolo, Dunz, Mazzocchi and Parisi, 2024). Prudential instruments produce positive effects only if accompanied by coherent fiscal measures and, above all, by credible and stable policy signals. Therefore, the lack of adequate regulation makes their long-term effectiveness in terms of capital allocation unstable (Alessi, Battiston and Kvedaras, 2024). On the information side, the market is still learning to quantify the true price of climate risk. The literature shows that ESG is a goal to be achieved (Giglio et al., 2021), but banks' environmental scores are often vulnerable to the risks of information asymmetries and greenwashing (Cregan, Kelly and Clinch, 2024). It is observed that, even though insurance companies are directly exposed to systemic damage, the sector has not received adequate attention from academic literature over time.

Closing this gap is essential to understand the real capacity of the sector to absorb and manage climate shocks. Overall, the literature and bibliometric analyses highlight a rapidly evolving field of research, which requires integrated and interdisciplinary approaches.

Future studies will need to focus on the development of ESG metrics related to capital flows and the systematic integration of climate risks into prudential supervisory frameworks, with a focus on the principle of double materiality, to capture the financial sector's growing exposure to climate change and support the transition to a sustainable economy.

***Part II: The normative and methodological
framework for climate and ESG risk assessment.***

Chapter 2

From sustainability reporting to climate and ESG risk assessment

CHAPTER OUTLINE

1.SUSTAINABLE REPORTING OF NON-FINANCIAL INFORMATION: REGULATORY EVOLUTION AND EUROPEAN GUIDELINES – 2.THE SOCIALLY RESPONSIBLE BEHAVIOUR OF FINANCIAL INTERMEDIARIES. – 3.REGULATORY DEVELOPMENT IN THE FIELD OF SUSTAINABILITY: THE CORPORATE SUSTAINABILITY DUE DILIGENCE (CSDDD) AND THE OMNIBUS REGULATION. – 4. THE ANALYSIS OF CLIMATE INDICATORS RELEVANT TO FINANCIAL INTERMEDIARIES AND QUANTITATIVE AND QUALITATIVE METHODOLOGIES FOR THE ASSESSMENT OF THE ESG DIMENSION. – 5. THE ADAPTATION OF EUROPEAN BEST PERFORMERS TO NEW RISK MANAGEMENT AND MITIGATION PRACTICES.

1. Sustainable reporting of non-financial information: regulatory evolution and European guidelines

Information is an important element for the strategic and operational management of a company. Through the interrelationship with technical and human resources, they define the information system of a company that guarantees the efficiency and effectiveness of internal and external cognitive needs.

The Maastricht Treaty of 1992 was among the first instruments to promote “balanced and sustainable economic and social progress”, and this concept was subsequently consolidated with the publication of subsequent treaties and regulations that recognized the importance of the dissemination of information not only of an economic but also of a social nature.

The need to have clear and detailed information becomes a necessary condition for encouraging the allocation of capital to sustainable companies and investments for an adequate assessment of the market value of companies in the long term and correct management of sustainability risks. Performance can no longer be summed up simple concept of maximizing profit and free cash flows. A long-term vision is needed in the management and governance structure that directs corporate strategies towards a long-term perspective that considers ESG risks and opportunities to improve the sustainability of the planet. Porter et al., (2011), argue that “sustainability translates into the ability or attitude of the company to contribute to the development of a sustainable society”.

According to Cavalieri (2012), “a company is sustainable if it consists of a clear corporate structure, mission and strategic position”, communicates its values externally in the reference markets and makes investments in research and development considering the specific needs of the community and the territory, for the respect of the environment and social partners”.

According to the international approach, Eccless et al. (2014), defined that “a company is sustainable if it manages to reorganize itself to establish leadership in a climate of transparency and trust with its employees and external competitors.” In 2010, the European Central Bank supported the need to introduce new “flexible” performance measures that would take into account the needs of the main stakeholders in qualitative and quantitative terms for the management of the level of risk assumed, the amount and quantity of investments made and the protection of the community and the environment according to processes carried out with fairness and transparency of the brand in terms of the sale of products and services.

The role taken by companies in the realization of SDGs and sustainable development is fundamental. It is defined as “an open and dynamic economic-social system, which, by establishing complex relationships with the outside world, influences its current and future economic performance.” For Friedman (1984), the stakeholder is "the one who can influence or can be influenced by the achievement of the objectives of an organization for the enhancement of the best production conditions and seek legitimacy in the environment of which he is a part." He therefore assumes a "socially responsible" behaviour for the respect of man and the environment. The participation of stakeholders in the internal governance structure is necessary for the correct understanding of their needs and the relevant definition of environmental issues for the growth and sustainable development of the company in compliance with ESG factors.

In recent years, corporate organizations have focused on the issue of social responsibility and the transparency of information in corporate communication processes for consistent coordination.

According to Gray (1995), information responsibility, expressed with the term accountability, is defined as a system of internal and external communications that aims to protect the rights of data subjects. The attention to the protection of the environment and social rights has led to the creation of new disclosure tools that integrate the economic, social and environmental dimensions to attract the consent of the community and promote comprehensibility towards third parties, combining traditional economic reporting with non-financial information. Therefore, corporate performance cannot be understood simply by maximizing profits, it becomes a more complex concept. Non-financial information on the vision, mission, business model, projects and social initiatives is useful for understanding the process of value creation and the achievement of objectives concerning the protection of society and ecosystems.

The EU Directives on Non-Financial Reporting (2014/95/EU) of the European Parliament and of the Council were relevant for orienting EU policies towards sustainability and ensuring the evolution of an economic system capable of guaranteeing social and economic development together with environmental protection.

With its entry into force in 2017, the European Parliament recognized the importance of sustainability information, with reference to social and environmental factors, to identify the associated risks and increase investor and consumer confidence in the business world. As recognized by the European Union, “the communication of non-financial information is useful for the correct management of the transition to a sustainable economy and to ensure profitability, social justice and environmental protection in the long term with the coordination of ethical, moral and social objectives and the adoption of socially responsible behaviours capable of generating positive effects on economic and financial performance.”

As underlined by the same, the need to improve the communication of social and environmental information emerged as early as October 2011 with the dissemination of the “Renewed EU Strategy on Corporate Responsibility”, in which it highlighted how the voluntary integration of companies' social and ecological concerns into their business operations and relations with stakeholders was necessary for the provision of benefits on better risk management, cost reduction, access to capital, management of human resources and internal and external relations”, ensuring the enhancement of the company and the development of new growth opportunities and markets.

Undertakings required to prepare non-financial statements must ensure the dissemination of information on "environmental aspects, the impact of their activities on the environment and, where appropriate, on health and safety, specific information on the possible use of renewable and/or non-renewable energy resources and water resources, the value of greenhouse gas emissions produced and air pollution. As regards social and personnel aspects, the information provided in the declaration may relate to actions taken for gender equality, the implementation of conventions enshrined by the International Labor Organization, working conditions, respect for workers' rights, trade union rights, health and safety at work and dialogue with local communities, and/or actions taken to ensure the protection and development of these communities. With regard to human rights and the fight against bribery and corruption, the non-financial statement may include information on the prevention of human rights violations and/or on existing instruments to combat bribery and corruption." Directive 2014/95/EU specifies that "the disclosure of non-financial information becomes of fundamental importance to ensure the transition to a sustainable economy at a global level that combines long-term profitability, social justice and environmental protection" by combining ethical, moral and environmental

objectives with the use of socially responsible behaviour that produces positive effects on economic and financial performance. The reporting obligation was not envisaged for companies outside the perimeter of public interest which were granted the right to draw up non-financial statements on a voluntary basis. The European Union's growing commitment to the economic and sustainable transition led to the publication of a new document called the Taxonomy Regulation (Reg. (EU) 2020/852), considered as the main legislative instrument for completing the framework outlined by Directive 2014/95/EU. Its importance can be strengthened if we consider the goals enshrined in the 2030 Agenda for Sustainable Development - and the related three dimensions of economic, social and environmental governance; and the 2016 Paris Agreement with the aim of limiting the effects of climate change and "fostering the development of low-carbon economies. It was intended to ensure the achievement of sustainable development that would guarantee a secure, climate-neutral and resilient economy in the long term."

Six environmental criteria were established for the definition of environmentally sustainable activities with the aim of removing barriers to the functioning of markets and encouraging the raising of funds for the implementation of "environmentally sustainable" projects.

With reference to the protection of investors' interests, the Regulation refers to the disclosure and sustainability obligations set out in Regulation (EU) 2019/2088 of the Council and the European Parliament for financial intermediaries.

Intermediaries are required to integrate information on sustainability risks and related negative effects on the financial performance of an investment into their pre-contractual disclosures (pre-contractual advice and risk monitoring on an ongoing basis are also provided), to ensure the proper functioning of the market and strengthen the comparability of financial products according to the principle of transparency and due diligence. Sustainable investment is defined as an investment in an economic activity that contributes to the achievement of an environmental and/or social objective, provided that the companies benefiting from it comply with good governance practices without causing significant harm to stakeholders (internal and external stakeholders).

In the initial advisory phase, intermediaries are obliged to provide information on sustainability risks and possible effects on investments. Market participants must include information in their pre-contractual disclosures on how sustainability risks are included in their investment decisions and their impacts on the performance of the financial products they subscribe to. It is also required that sustainability risks and possible effects be presented in the advisory phase.

Delegated Regulation (EU) 2021/1253 of April 2021 defined amendments to Regulation (EU) 2017/565 on the integration of sustainability factors, risks and preferences for organizational purposes and operating conditions of investment firms, to make financial flows consistent with the sustainable and climate-resilient transition path.

Such companies must take environmental, social and governance risks into account when managing risk, assessing their negative impact on the value of investments.

In the pre-contractual phase, consumer preferences and the aptitude to invest in environmentally sustainable activities must be assessed, without prejudice to the consistency of the financial product with the preferences expressed. Among the central aspects, the need to reduce the phenomena of greenwashing, considered not compliant with the principle of fairness and transparency established in the markets, emerges.

This practice could give investors an unfair competitive advantage, as well as undermine confidence in the financial markets. It is therefore prohibited to adopt unfair practices aimed at recommending a financial instrument as “environmentally friendly and sustainable” if it does not meet the relevant requirements. At the national level, the Directive was the subject of two public consultations by the Ministry of Economy and Finance (MEF) and subsequent transposition with Legislative Decree no. 254/2016, in which the areas of application and the information covered by the Non-Financial Statement (NFS) were defined. The reporting obligation was initially provided for public-interest entities with more than 500 employees and subsidiaries.

With regard to the content, the NFS must account for environmental and social issues relating to respect for human rights, the fight against active and passive corruption, promote the inclusion of women as board members and, as specified by Consob, must also describe the elements indicated in art. 3, paragraph 2 of Legislative Decree no. 254/2016 relating to the use of energy resources - distinguishing between renewable and non-renewable sources, use of water resources, level of emissions produced.

Such information must be provided to the extent of its significance with respect to the activity carried out by the company and its characteristics, socio-environmental aspects. A description of the management and organization model of the business model is required; business practices, results and measurability indicators of non-financial performance; the risks generated or suffered and the environmental, social and governance aspects.

The structure of the statement must also be provided in compliance with the methodologies and principles provided for by the regulatory standards - IIRC and GRI - and guidelines issued by supranational and international bodies. The information had to be disclosed in the *Report on Operations* in accordance with the provisions of Directive 2014/95/EU and implementing decree 254/2016, to promote greater transparency in communication and the development of socially responsible behaviour.

However, to assess the real value of companies, in terms of economic performance and measurement of environmental, social and governance impact, it is necessary to introduce the *sustainability report*.

The *sustainability report*, also called *social report*, is classified according to the *World Business Council for Sustainable Development* (WBCSD) as a “public report through which companies provide internal and external stakeholders with an overview of the company's position and the performance of activities concerning the environmental, social and economic dimensions.”

It illustrates the values, the governance model, methods and strategies through which the commitment to promote sustainable development is assumed. From the guidelines issued by the Ministry of Labor and Social Policies in 2019, the social report is defined as a “tool capable of guaranteeing structured and timely information” of the results obtained from the reporting and offers support for strategic planning to highlight the company's identity and organizational culture, as well as the expectations of stakeholders.

The structure must provide precise references concerning (as established by the Ministerial Decree of 4 July 2019):

- the methodology used for its drafting;
- information on the general nature of the entity;
- description of the structure, governance and administration;
- description of the persons who work for the entity;
- Objectives and economic-financial situation

The sustainability report illustrates the governance model and the strategies adopted for the promotion of sustainable development, taking into consideration all the pillars of sustainability.

According to Dumay et. al. (2010), the most widespread frameworks for sustainable reporting can be traced back to the categories of the United Nations Global Compact, the Standard Accountability and the Global Reporting Initiative (GRI). The *Global Compact* refers to the global compact proposed by the United Nations in 1999 at the *World Economic Forum* and is defined as "a strategic policy initiative for companies that commit to aligning their operations and strategies with the universally accepted principles of respect for the environment, social rights and anti-corruption" - and respective adherence to the *Sustainable Development Goals* in the strategies, operations and culture of the business organization. Compliance with the objectives is certified through the drafting of reports and public documents (Communication on Progress - COP) which describe the ways

in which the principles are integrated into the company's strategies and operations.

In 2000, at the suggestion of the *International Business Council* (IBC), during the *World Economic Forum*, metrics for the evaluation of sustainability were published within a project entitled "*Measuring Stakeholders Capitalism: Toward Common Metric and Consistent Reporting of Sustainable Value Creation*" - drawn up by the World Economic Forum in collaboration with the "Big Four" (Deloitte, EY, KPMG, PwC), to promote ESG standardization and reporting and bring companies closer to a shared measurement of sustainable value. The context in which companies operate is constantly changing due to environmental and social unrest, which has been more evident with the spread of the COVID-19 pandemic.

Therefore, companies must be able to build their resilience and ability to operate, through the creation of sustainable value for the planet and people in the long term.

The project proposed a set of core metrics and advanced metrics (expanded metrics) for the consolidated and quantitative preparation of information on the sustainability of the activities attributable to the organization and the related environmental and social effects of the supply chain and to measure the degree of achievement of the sustainable development goals.

Table 2.1 Key areas of sustainability

		Issues	Sources
Governance	The concept of system governance declined in the set of elements that characterize an ESG - business governance system and integrate sustainability objectives into the core.	Purpose of management; Quality of responsive governance; Stakeholder engagement; Ethical behaviour; Monitoring of risks and opportunities in decision-making.	GRI (102-26) GRI (102-22) GRI (102-47) GRI (205-02) GRI (205-03) GRI (102-17) SABS (203a.1-2)
Planet	Efficiency in the management of natural resources for climate change mitigation and meeting present needs without compromising future ones.	Climate change; Sensitivity in the use of natural resources;	GRI (305-01) GRI (304-1, 304-3, 304-4) GRI (303-3) TCFD
People	Ensuring everyone has the same rights.	Equality Equal rights of health and the future.	GRI (405-2) GRI (408, 409) GRI (403-2 a.4) SABS

Prosperity	Integrating the economic-financial dimension with the ESG dimension to promote equal opportunities in harmony with the environment.	Wealth and employment creation; Technological and social innovation.	GRI (401-1a-b) GRI (201-1 201-4) GRI (207-4) OECD, 2015a
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Source: Galeone, G. (2023). *Non-financial reporting is the measure of sustainability factors. Theoretical profiles and future prospects. Studies and Research in Business Administration*, 1–232.

In the literature, the GRI guidelines represent an optimal solution for the correct reporting of sustainability information.

The Global Reporting Initiative (GRI) was founded in Boston in 1997 by an initiative of the Coalition for Environmentally Responsible Economies (CERES) and the Tellus Institute, in collaboration with the United Nations. According to the organization, sustainability reporting consists of "measurement, communication and accountability to stakeholders about *behaviours* assumed with respect to the impact on the environment."

In 2021, a more updated definition was indicated according to which *"the objective of sustainability reporting compliant with GRI standards is to provide transparent disclosure on how an organization contributes to the development of a sustainable economy."*

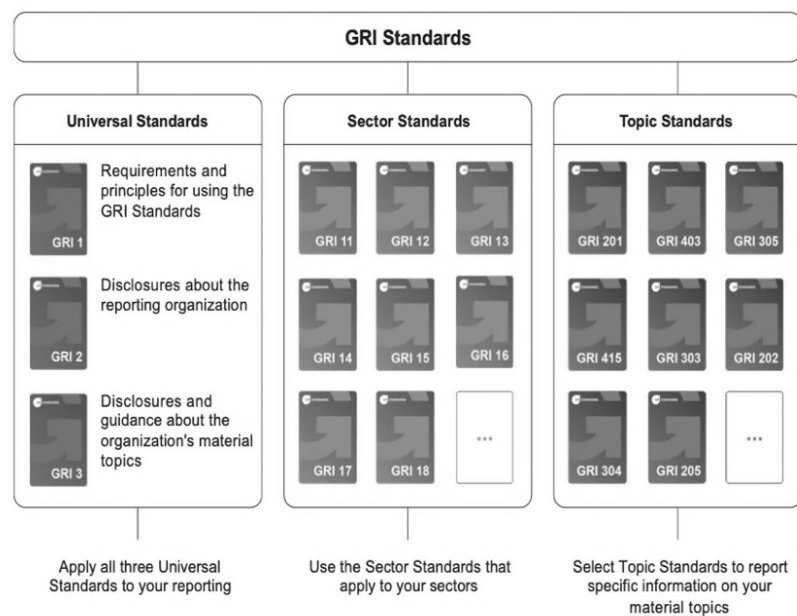
The framework consists of Universal Standards that outline the principles of reporting, the organizational context and the approach to management; Sectoral standards for the sectors involved; and Thematic Standards divided by economic (GRI 200), environmental (GRI 300) and social (GRI 400) areas.

According to the guidelines, the objective is to ensure that the information provided reflects the positive and negative aspects of the overall performance of the organization to ensure that stakeholders can carry out a comparative analysis on the evolution of performance over time.

The global diffusion of GRI and its ability to adapt to heterogeneous business contexts make it a solid basis not only for fulfilling the regulatory obligations provided, for example, by Directive 2014/95/EU or Legislative Decree 254/2016, but also to promote a conscious transition towards an integrated sustainability report, oriented towards the creation of value in the long term and the strengthening of stakeholder trust.

According to the GRI guidelines, the goal is to ensure that the information reflects the positive and negative aspects of the organization's overall performance within the report way that allows stakeholders to carry out a comparative analysis on the evolution of the organization's performance over time based on information drawn up in an understandable and accessible way.

Figure 2.1 – GRI Standards (2021): Universal, Sector and Topic Standards



Source: GRI Standards (2021) - globalreporting.org

The path towards sustainability, identified as a new paradigm, recognizes the value of the company, institution or organization not only in terms of economic and financial performance, reputation and ability to adhere to those essential standards for sustainable development.

EU Regulation no. 2020/852, in the regulatory system, introduced the taxonomy of eco-friendly economic activities into the regulatory system for the alignment of the European Union's environmental objectives and make financial flows consistent with the low-carbon and climate-resilient development path, by 2050.

The achievement of the set objectives can be guaranteed on three points:

- steering capital flows towards sustainable investments to achieve sustainable and inclusive growth;
- develop capacity in managing financial risks arising from climate change, resource depletion, environmental degradation and social issues;
- promote transparency and long-term vision in economic and financial activities.

Article 7 of the Regulation considers the "systemic" nature of global environmental challenges by establishing the need to adopt a *systemic* and forward-looking approach to eco-sustainability that addresses negative trends related to climate change, biodiversity loss, overuse of resources and their scarcity."

The growing attention to information that highlights the interdependence between *strategy, governance, operations and economic-financial performance* has led to the development of an integrated version of reporting.

The integrated report allows you to obtain a homogeneous representation of the internal and external context of the company, the strategy adopted, business model and forms of capital (financial and non-financial) involved in the production process. It represents, moreover, a strategic tool for satisfying the interests of stakeholders and shareholders. The first step towards the integration of sustainability reporting was taken with the publication of the European Directive 2003/51/EC which imposed the adoption of non-financial indicators, the so-called *Key Performance Indicators* (KPIs).

It effectively represented a first step towards the integration of non-financial indicators in the consolidated annual reports and in the subsequent integrated report specifying:

"The review shall be a balanced and comprehensive analysis [...] To the extent necessary for an understanding of such development, performance or position, the analysis should include both key financial and non-financial performance indicators relevant to the particular company, as well as information related to environmental and employee issues."

Therefore, its use had to ensure a "homogeneous representation of the corporate context and the different forms of capital, for the construction of value, including information on environmental and social issues.

Integrated reporting was primarily promoted by the *International Integrated Reporting Council* in 2010 to ensure "proper alignment between capital allocation and corporate behaviour for the achievement of financial stability and sustainable development objectives through the reporting cycle and integrated thinking."

The latest revision to the 2021 framework defined it as a "synthetic communication through which the strategy, governance, performance and prospects of an organization for the creation and preservation of value over time is illustrated" and as the result of "integrated thinking" understood as an active consideration of the relationships between operating units and organizational functions.

The involvement of all levels of company management and accounting presupposes the creation of a decision-making process that considers the needs of each stakeholder for optimal assessment of the value of the company.

Within the framework, reference is made to a plurality of resources, called "capital" and which impact the external environment. They are divided as follows:

- financial capital: consisting of a set of funds useful to produce goods and services;
- productive capital: defined by the set of capital goods and infrastructures that make-up a company;
- intellectual capital: the set of human resources that share knowledge, patents, software, rights and licenses for the realization of business production;
- human capital: the set of skills and knowledge within an organization;
- social and relational capital: the set of relationships established inside and outside the company environment;
- natural capital, i.e. the set of environmental resources.

Taking together, each can constitute positive impacts in the pursuit of the Sustainable Development Goals, promoting responsible management of resources, facilitating the integration of sustainability for the most accurate interpretation of information on corporate performance and governance.

Ultimately, its use can ensure the creation of a more sustainable society where the disclosure of information on economic, environmental, social and governance performance contributes to risk containment, greater transparency and financial stability thanks to the ability of investors to assess the real value of the company and its prospects.

Finally, the integrated report is considered defined as a useful tool for the strategic communication of information on the way capital is used according to the company's mission and vision. It more effectively represents the value generated by the organization, and its capabilities, in response to social and environmental needs.

Financial intermediaries play a strategic role in delivering on the challenges of the environmental and regulatory transition.

As pointed out by the Bank of Italy, sustainability represents not only a new business opportunity but also a strategic challenge due to the need to integrate environmental and climate risks into the management of traditional financial risks (so-called credit and market risk).

In this context, the socially responsible behaviour of financial intermediaries plays a central role in defining new operational and strategic models and in achieving a more inclusive and sustainable economy in compliance with ESG criteria.

2. The socially responsible behaviour of financial intermediaries.

In the process of transition to a sustainable economy, financial intermediaries are required to adopt socially responsible behaviour to actively contribute to the achievement of the Sustainable Development Goals through the integration of ESG factors into decision-making processes, business models and risk management for the achievement of better financial performance.

The commitment to sustainability has always been the subject of interest by the academic and institutional world.

The concept of corporate social responsibility (CSR) has evolved from a philanthropic to a strategic vision and has become an integral part of corporate governance.

The most accepted definition is contained in the European Community Green Paper according to which, a socially responsible approach involves "the voluntary integration of social and environmental issues into business operations and relations with stakeholders, in order to increase one's competitiveness".

For financial intermediaries, the adoption of socially responsible practices involves:

- the integration of environmental and climate risks into the management system to monitor and mitigate risk;
- the selection of investments and financing consistent with environmental, social and governance criteria (e.g. green bonds);
- transparency and truthfulness in ESG reporting of corporate financial statements.

A company, as an open economic system, must create value through a series of specific actions and policies that consider the expectations of stakeholders, environmental and socially responsible economic performance. The objective of assessing the level of corporate sustainability led to the development of the so-called Triple Bottom-Line (TBL) for measuring corporate performance on three points: economic prosperity, environmental quality and degree of social responsibility.

The creation of sustainable value was explored by Hart and Milstein in 2003, in a study in which they outlined four strategic dimensions and the related sustainability drivers that consider the increase in the world population and the scarce availability of resources, globalization and social problems.

It is necessary to consider the environmental consequences of industrialization and the need to reduce pollution levels, less proliferation of waste and greenhouse gases, to ensure the preservation of the planet and the interests of stakeholders, through an effective vision that aims not only at the creation of value but also at technological innovation. Porter and Kramer, analyzing the interdependencies between business and society, developed the theory of value creation, defined as "the set of policies and operational practices that aims to strengthen the competitiveness of the firm and the conditions of a society to ensure economic and social progress."

Financial intermediaries play a fundamental role in encouraging the allocation of investments towards more virtuous economic systems, with activities and projects consistent with the sustainable development model.

In fact, the ability to identify those sectors where economic activity is most exposed to climate risks is becoming a prerequisite for contributing, in an informed way, to financing the transition.

The European Central Bank is developing methodologies for managing and monitoring climate risks to preserve the soundness of banks and the financial stability of the entire system, given the significant threat posed by climate change.

The EU's commitment to net-zero greenhouse gas emissions for the creation of a modern, competitive and efficient society, as outlined by the European Green Deal, defined its active role in channeling capital towards sustainable activities that promoted more inclusive and green finance. In this context, the European Taxonomy framework defines a clear classification of "environmentally sustainable investments", to steer financial decisions towards projects in line with climate and environmental objectives. Regulations such as the Sustainable Finance Disclosure Regulation (SFDR) and the Corporate Sustainability Reporting Directive (CSRD) introduce new transparency requirements for ESG policies with the aim of encouraging the adoption of business models that promote investments in sustainable financial products and build trust across the market.

In addition, these Directives introduced the wording "sustainability reporting" to replace "non-financial reporting" to make sustainability reporting relevant to financial reporting and encourage a change of perspective in the collection of internal and external information.

The adoption of socially responsible behaviour by intermediaries therefore becomes not only an ethical duty but also a strategic opportunity to anticipate risks, seize new opportunities and strengthen their reputation. In fact, financial institutions that effectively integrate ESG criteria into their credit assessment processes, asset management and investment activities generate through their activities a positive impact not only on society but, above all, on their long-term economic performance.

At the European level, the European Regulation 2019/2088, called *the Sustainability Finance Disclosure Regulation - SFDR*, defined harmonized rules on transparency in terms of the integration of sustainability risks and the identification of principal adverse impacts in the provision of advisory activities, decision-making processes and portfolio management.

It was a key element in the European regulatory framework where the main idea was that everyone should be empowered to implement sustainable investments based on ESG factors. For the implementation, the European Commission envisaged a series of interventions as part of the Action Plan:

- the introduction of a discount factor to be applied to the capital of banks that granted green loans with benefits equal to the capital absorbed (Sustainability Supporting Factor);
- better transparency in the market for sustainable investment products to prevent greenwashing and increase transparency in terms of sustainability disclosures by financial operators and advisors (Article 8 of Regulation 2019/2088)
- reducing information asymmetry.

In the aforementioned regulation, the Commission, in addition to defining a clear distinction to be defined in the disclosure to end investors between ESG risks and the resulting adverse impacts on sustainability, sustainable investment objectives, and environmental and social characteristics to be promoted in the decision-making and advisory process; pointed out that the lack of harmonized rules on sustainability issues resulting in significant distortions due to the different approaches applied in different financial and financial sectors

For a correct harmonization of regulatory approaches in optimal sustainability, Regulation (EU) No. 2022/1288 has been introduced. It defines the methods for applying the "do no significant harm" principle, defining methodologies for the collection of sustainability indicators and the assessment of their negative impacts and the methods for presenting environmental or social characteristics and sustainable investment objectives described in pre-contractual documentation. According to the orientation of the two Regulations, financial market participants must distinguish their products according to the ESG scope by distinguishing between products that promote environmental, social and governance characteristics.

Through the MiFID II Directive, starting from August 2022, in the regulation of investment services, the obligation for financial intermediaries to integrate sustainability factors into investors' financial preferences, through the drafting of the profiling questionnaire for the assessment of financial adequacy and suitability, and the sustainability preferences expressed by the client, were defined. In the approach to sustainable finance, sanctioned by the European Commission, it must consider financial, environmental and social factors in investment decisions. Therefore, it was necessary to identify new objectives based on the creation of financial value in the long-term, for-profit maximization, in the long term and the integration of ESG factors into the production and consumption process. In conclusion, the socially responsible behaviour of the financial intermediary can no longer be understood as an ethical choice or as an element of competition. It is configured as a strategic element in a constantly evolving regulatory context where the integration of ESG factors into business and risk management processes is profoundly transforming the financial sector. Therefore, it is necessary to develop new skills, procedures and systems that integrate technological innovation into the corporate governance system for the creation of long-term value.

The fragmented regulatory framework and the multiple reporting standards have generated numerous application uncertainties, bringing financial intermediaries into a state of profound uncertainty. The SFDR and Taxonomy, while representing an important step forward, from a regulatory point of view, have highlighted the need for a more coordinated and systematic approach at the European level. In response to these needs, in the next paragraph we will define the important harmonization reforms undertaken by the European legislator.

3. Regulatory developments in sustainability: the Corporate Sustainability Due Diligence (CSDDD) and the Omnibus Regulation

For the achievement of sustainable development, in recent years the legislation on the subject has undergone a significant acceleration in response to the growing environmental and social challenges related to climate change, due to the need to create a regulatory framework that could efficiently direct financial flows towards the transition.

If the Non-Financial Reporting Directive 2014/95/EU (NFRD) and the Taxonomy Regulation no. 2020/852 represented fundamental points in identifying the direction, their limitations with reference to the scope of application highlighted the need for a more structured and ambitious intervention capable of bridging the qualitative-quantitative information gap on environmental, social and governance factors.

The Corporate Sustainability Reporting Directive (CSRD) not only extended the scope of the previous NFRD but also redefined the concept of sustainability according to the mandatory Standards issued by EFRAG to align ESG content with the broader framework of European economic policy objectives.

For financial intermediaries, the CSRD entailed both obligations for the disclosure of the characteristics of financial products issued according to transparency regulations, and the possibility of accessing more accurate and comparable sustainability information on the financed companies subject to the investment.

EU Directive no. 2024/1760, known as the "Corporate Sustainability Due Diligence Directive", establishes guidelines for responsible business conduct,

which can be achieved through an implementation process that is divided into six fundamental phases for the identification of negative impacts on the environment and human rights. They are classified as follows:

- I. Integration of due diligence into management policies and systems through the application of sustainability principles in the operational and decision-making phases;
- II. Identification and assessment of the effects generated by negative impacts on business activities and the environment;
- III. Prevention and limitation of adverse effects;
- IV. Periodic monitoring and evaluation of the actions taken;
- V. Transparent communication on the economic and financial state of society and the environment in accordance with the provisions of this Directive and the previous CSRD and SFDR directives;
- VI. Establishment of a "complaints mechanism" that allows interested parties to report any issues related to the negative impacts generated by companies.

It also recognizes the integrated and unified approach of 'One Health', a principle enshrined in the World Health Organization, to sustainably balance and optimize the health of people, animals and ecosystems, recognizing them as highly interconnected.

Therefore, environmental due diligence must include the prevention of environmental degradation that generally produces adverse health effects, for example due to the spread of epidemics, to ensure a clean, healthy and sustainable environment. In addition, factors such as active and passive corruption can be intertwined with or even reinforce negative impacts on human rights and the environment.

It is therefore necessary for companies to take these factors into account when exercising human rights and environmental due diligence, in accordance with the United Nations Convention against Corruption.

This Directive lays down obligations and responsibilities for the companies involved in relation to the reduction of actual and potential adverse impacts on human rights and the environment, from those of their subsidiaries and business partners operating along the value chain.

In addition, it is required that they develop and implement actions aimed at achieving the objectives enshrined in the Sustainable Finance Action Plan and the Paris Agreement to limit the increase in global warming as established.

Finally, the aim is to safeguard the already existing levels of protection in the field of human, employment, social, environmental and climate rights provided for by national and European law. Therefore, Member States are given the option of introducing stricter provisions.

This Directive shall apply to:

- EU-based companies with an average of 1000 employees and worldwide net sales of €450 million in the last financial year;
- EU-based parent companies that reach these thresholds in the latest annual financial statements;
- companies based in non-EU countries active in European countries with turnover in line with the requirements described above.

The objective of the directive is to promote mandatory sustainable behaviour by establishing rules that enable the

identification, mitigation, and adoption of socially responsible practices to address global challenges related to environmental degradation, climate change, and human rights within the European single market, thereby making ESG considerations an integral part of corporate and risk management strategies.

Table 2.2 – The European Taxonomy and the reporting requirements established by the Directives on the reporting and disclosure of non-financial information

Eu Taxonomy	Non-Financial Reporting Directive	Sustainability Finance Disclosure Regulation	Corporate Sustainability Reporting Directive	Corporate Sustainability Due Diligence Directive
Definition of sustainable activity;	Provide information on the development performance and environmental and social position of a company.	Improving transparency in the market for sustainable investment financial products.	Provide information on the impact of environmental and social issues on business performance.	Preventing human rights and environmental violations in the value chain, for responsible business conduct.
Classification of economic activities that contribute to the achievement of the SDGs goals.	References to environmental and social issues, respect for staff rights and the fight against active and passive corruption emerge	Combat the phenomenon of greenwashing and promote transparency on sustainability disclosures by financial intermediaries.	Focus on ESG topics and definition of standards for sustainability reporting issued by EFRAG, ISSB and GRI.	Promote responsible behaviour to ensure the achievement of sustainable finance objectives.

Source: Personal elaboration

In its 2025 communication, the European Commission, entitled “A simpler and faster Europe – Communication on implementation and simplification”, adopted a new package of proposals to simplify EU sustainability rules, boost competitiveness and investment capacity.

This innovative approach aims to simplify sustainability reporting and the application of due diligence, the obligations established by Taxonomy and the reporting burdens, provided for by EU Directive 2022/2464 and Directive No. 2024/1760 to strengthen competitiveness and ensure the achievement of the strategic objectives enshrined in the Green Deal and the Action Plan to finance sustainable growth.

The Directive establishes the obligation for parent companies, with more than 500 employees, to report on sustainability reporting for the year 2024, during 2025.

For insurance companies, this fulfilment has instead been postponed by the to 2026.

Otherwise, Directive (EU) 2024/1760 established the obligation to report non-financial information, for the remaining categories of companies, starting from 2027.

With the introduction of the so-called "Omnibus Directive", the application deadlines have been further reformulated: for large companies, particularly those with a turnover of more than 900 million euros, reporting will have to take place the following year compared to what was provided for by the previous provisions. This intervention is part of a logic of simplification and gradual adaptation, aimed at making the process of regulatory compliance by economic operators more sustainable. In this context, the question of the value of intangible elements in the creation of business value assumes particular importance. Already in the proposal of the CSRD Directive, the intention emerged to give formal recognition to those "invisible" resources which, although not represented in the Balance Sheet due to their intangible nature, contribute decisively to the economic performance and innovative capacity of organizations. The term "intangible assets" refers to human and relational capital, knowledge, skills and attitudes that allow the company to generate economic and social value in the long term. The new simplification strategy introduced in this directive therefore represents a significant change of perspective. The objective is twofold, namely, to ensure the pursuit of the environmental objectives set at European level and to facilitate a sustainable and economically compatible transition process.

By postponing and differentiating reporting requirements according to the size of the companies, the Union shows that it has a pragmatic approach, aimed at facilitating a more gradual but at the same time more robust and credible transition. The enhancement of intangibles constitutes, in this framework, an important step in the evolution of the concept of value creation, since it recognizes that sustainability does not only concern the material dimensions, but also the cognitive and relational skills that fuel innovation and competitiveness. However, it remains to be seen whether the simplification tools introduced will be able to preserve the competitiveness of European companies, in particular SMEs, in the face of global challenges, while ensuring that the climate and sustainability objectives set by the Union are met. This reflection is part of the broader European debate on the need to reconcile sustainability and competitiveness. In his report on the future of European competitiveness, Mario Draghi drew attention to the need for the Union to have a leaner and more coherent regulatory framework, capable of fostering the resilience of companies.

He also underlined the weight of the compliance burdens deriving from the CSRD and the CSDDD, which risk having a disproportionate impact especially on small and medium-sized companies. The same need for simplification was reiterated in the Budapest Declaration, in which the representatives of European governments called for a lightening of the regulatory framework to reduce administrative costs for companies. In line with this direction, the European Commission, in its Communication on the EU Competitiveness Compass, expressed its intention to propose a first "omnibus simplification package" intended to streamline regulation in the areas of sustainable financial reporting, due diligence and taxonomy. The proposal for a directive of the European Parliament and of the Council, presented in February 2025, is the main substantive revision to Directives 2006/43/EC, 2013/34/EU, (EU) 2022/2464 and (EU) 2024/1760. The aim is to reduce reporting burdens and adapt the discipline to the current economic and geopolitical context full of fragmentation. Among the main changes are the exclusion from the reporting obligation for companies with less than 1,000 employees, the possibility for SMEs to voluntarily adhere to sustainable reporting of non-financial information and the simplification of the European reporting standards (ESRS) to reduce the number of mandatory targets and the elimination of sectoral standards.

These interventions are part of a broader rationalization perspective that aims to eliminate distorting effects along value chains and to redefine in a broader sense, the principle of proportionality.

Directive (EU) 2025/794, adopted in April 2025, provided for the postponement of two years for the implementation of the second and third phases of the CSRD and one year for the application of the CSDDD, allowing economic operators to have a longer time frame for compliance with the legislation. The aim is to ensure consistency and predictability in the transition process, avoiding that companies must incur excessive costs due to constantly evolving regulatory adaptation. Together with these amendments, Directive (EU) 2025/25 also provided for new measures to promote the digitization of business registers and promote the application of the "once-only" principle, aimed at avoiding distortions in the transmission of data. This intervention is part of the broader strategy of the "twin transition", which integrates the digital transition with the sustainable one, recognizing the reciprocal functionality of the two processes. In fact, digitization becomes an efficient tool to improve information transparency, reduce administrative burdens and promote sustainability based on reliable and therefore measurable data.

Overall, the initiatives in this last year configure an overall rebalancing of the European regulatory architecture on sustainability, oriented towards a more pragmatic model based on proportionality and concrete results. The European Union seems to be orienting its approaches towards the quality of information and the concreteness of actions to preserve the objectives of the Green Deal with more flexible tools calibrated on the actual operational capabilities of companies. Digitalization, the revision of reporting standards and the principle of proportionality therefore become the pillars of sustainable and competitive governance based on transparency, trust and innovation, as sustainability reporting is a strategic lever for aligning economic, social and environmental objectives.

4. The analysis of climate indicators relevant to financial intermediaries and quantitative and qualitative methodologies for the assessment of the ESG dimension

Having outlined the regulatory and reporting framework for sustainability, the analysis now shifts towards the methodological approaches used to assess climate and ESG risks in financial intermediaries.

ESG issues represent one of the main factors of change in the activity of financial intermediaries in recent years. Sustainability has in fact become a fundamental criterion in the evaluation of the results of banks and insurance companies, given the triple environmental, social and governance dimensions.

To achieve the objective of sustainable economic growth, regulators and supervisors have set expectations and guidelines within the broader framework of sustainability and ESG factors, where climate risk is one of the most relevant dimensions for the stability of the financial system, as it has a direct influence on the valuation and management of portfolios.

In terms of investment portfolio management, there has been a real transformation in the assessment of the risk/return ratio and ESG profile, including through the introduction of disclosure obligations towards investors. These obligations aim to provide operators with a set of data useful for the implementation of sustainable strategies and the reduction of carbon emissions (Merner et al., 2024).

The evolution of these issues in investment processes has fueled an important line of research aimed at estimating the added value of ESG factors within traditional models for evaluating financial portfolios. Friede et al. (2015), for example, analyzed about 2,000 empirical studies conducted between 1970 and 2014, examining the impact of ESG integration on asset allocation decisions. The meta-analysis revealed an overall non-negative relationship between financial performance and ESG and, in many cases, an improvement in the risk-return profile of investment strategies incorporating these factors.

Several studies suggest that asset managers adopting ESG principles may improve portfolio performance and better capture long-term risks. In this context, the pressure on investors to align portfolios with the goals of the Paris Agreement has grown significantly. Haalebos (2025) documents this trend, showing how carbon emission assessment metrics have multiplied. The integration of ESG indicators into traditional portfolio optimization models has proven to be complex, as it is not yet fully clear what impacts the stringent climate neutrality constraints may have on long-term choices. On the financial return front, Pedersen (2021) states that portfolios tend to perform better than traditional ones, demonstrating the empirical existence of the positive influence of the ESG premium on portfolio risk-return. Other authors suggest different views on the origin of this prize.

Some say that reducing the diversification of sectors/issuers, while respecting ESG principles, can improve portfolio performance.

Others argue that companies that are more attentive to environmental, social and governance aspects are less exposed to the risk of a systematic nature and therefore, protected from other risk categories as demonstrated by Giese et al., (2019), Minor and Morgan (2001).

Following the global financial crisis of 2007-2008, the European Central Bank (ECB) adopted a series of unconventional monetary policy measures to promote economic stability and strengthen investor confidence, providing reassurance and identifying alternative solutions to the rigid and traditional market mechanisms. Among the non-standard measures introduced was the Asset Purchase Programme (APP), which aims to support monetary policy and price stability through the purchase of public and private securities, to ensure a proper transmission of monetary policy and reduce official interest rates (Lewis and Roth, 2019).

The APP included four separate asset purchase programmes, differentiated by the nature of the issuers and the type of securities:

- The third Covered Bond Purchase Programme (CBPP3) was launched on 20 October 2014, through the purchase of covered bank bonds on the primary and secondary markets in proportion to the weight of the national markets of reference.
 - the Asset-Backed Securities Purchase Programme (ABSPP), operational since 21 November 2014, aimed at the purchase of securities issued following the securitization of bank loans. In a first phase, the purchase activity was entrusted to external management companies; starting from 2017, this function was assumed by the Bank of Italy.
 - the Public Sector Purchase Programme (PSPP), introduced on 9 March 2015, aimed at the purchase of securities issued by governments, public agencies and international institutions in the euro area.

- the Corporate Sector Purchase Programme (CSPP), launched on 8 June 2016, under which six national central banks were mandated to purchase, on the primary and secondary markets, securities issued by private non-banks based in the euro area, including commercial paper of adequate credit quality.

In the following years, as the economic environment evolved and sustainability objectives were integrated into the Euro system's policies, the ECB also progressively shifted its strategies towards portfolio decarbonization measures, as purchase decisions geared towards high-carbon or low-light assets directly affect market liquidity. financial stability and monetary policy interventions. This process has led to an increase in the share of illiquid assets, which have the potential to generate additional risks and reduce the ECB's operational flexibility and ability to manoeuvre in the event of any future crises.

However, scientific literature presents heterogeneous perspectives on the role of the ECB and the effects of its purchasing strategies.

According to Aloui et al. (2023), purchases of green bonds made under the CSPP program directly affect the liquidity of the instruments and, the increase in demand for them, leads to a reduction in their availability on the secondary market, causing a contraction in trading volumes and producing significant effects on price formation. Zaghini (2024), highlights how the ECB's purchase decisions generate rebalancing effects on investors' portfolios, with significant consequences on the liquidity of green bonds. In this perspective, market participants tend to adjust the composition of their portfolios to maintain levels of risk and return consistent with the new market conditions induced by the Institute's interventions. The picture outlined, albeit with different views, reflects the ECB's focus on combining monetary stability objectives with those of environmental sustainability.

However, the green bond market has characteristics that require greater understanding to assess the overall effectiveness of the Asset Purchase Programme (APP) and its broader effects on the financial system, due to the different liquidity profiles of green bonds compared to conventional bonds (Fatica et al., 2021; Flammer, 2021; Caramichael and Rapp, 2022, Ehlers and Packer, 2017; Tang and Zhang, 2020; Baldi and Pandimiglio, 2022; Benincasa et al., 2022).

These differences require a specific analysis for ECB policies, to identify the intersections between liquidity constraints and monetary policy objectives (Fender and Lewrick, 2015; Cohen, 2022; Dorfleitner et al., 2023). Ehlers et al. (2020) and Wang et al. (2022) highlight, respectively, the potential of green bonds to contribute to the achievement of environmental objectives and their ability to influence corporate climate risk management. In contrast, Shi et al. (2023) associate increased green bond applications with significant growth in green innovation-related patent issuance. It should be emphasized that this increase does not very often translate into an improvement in the quality of innovations but into greenwashing situations in which companies use green bonds to strengthen their image from a sustainability perspective.

To this end, the Markets in Financial Instruments Directive (MiFID II) and the Insurance Distribution Directive (IDD) introduce specific obligations for investment firms and insurance distributors, requiring them to detect investors' sustainability preferences and to take them into account in financial advisory processes, to contribute to the construction of investment portfolios that integrate. In addition to expected returns and risks, there is also the sustainability criterion.

In line with the objectives of the Paris Agreement, financial flows should be oriented towards the reduction of greenhouse gas emissions.

To meet this need and the growing demand for financial instruments with ESG characteristics, Morningstar has introduced the *"low carbon designation"¹* eco-label, which allows investors to identify funds aligned with the transition to a low-carbon economy more immediately (Ceccarelli et al., 2020).

¹ A carbon law designation is an award given by Morningstar that identifies low-carbon investment funds. To obtain it, a fund must meet two criteria simultaneously over a 12-month period: maintain an average Morningstar Portfolio Carbon Risk Score of less than 10 and have an average exposure to fossil fuels (Fossil Fuel Involvement) of less than 7% of net assets.

Reducing the carbon footprint within financial portfolios is one of the main challenges of sustainable finance and, in recent years, the tools for measuring the degree of decarbonization of portfolios have multiplied, moving from simple annual indicators to more complex and future-oriented metrics, such as *Net-Zero* models or *Implied Temperature Rise (ITR)*. The most basic measures were limited to reporting the emissions of individual companies, thus offering a static snapshot of a portfolio's carbon intensity.

The most recent indicators, on the other hand, aim to define a trajectory of emission reduction, consistent with investment strategies aligned with the objectives of containing global warming and achieving climate neutrality. Although many such tools are available today, their effective integration into portfolio optimization models is still limited. This raises the question of how different constraints related to emissions can influence investment choices and long-term performance, as pointed out by Leote de Carvalho et al. (2024).

Two principles for evaluating sustainable investments emerge from the contributions analyzed. Among these, the Paris-Aligned Benchmark (PAB), introduced by the European Commission in line with the objectives of the Paris Agreement, establishes specific criteria for reducing carbon intensity in investment portfolios, providing for an initial reduction in greenhouse gas (GHG) emissions of 50% compared to traditional benchmarks, accompanied by a progressive decarbonization path, with an annual decline of 7% in order to reduce the exposure of investment portfolios to carbon-intensive activities. However, some authors have pointed out that excessive attention to direct emissions alone can lead to the exclusion of strategic companies for energy transition. Roncalli (2024), for example, notes that while the application of PAB criteria tends to generate low-carbon portfolios, the sector composition is often unbalanced and not always consistent with the needs of the real economy. The second approach also identified by Leote de Carvalho et al. (2024) refers to the Net-Zero alignment, which aims to build investment portfolios including companies committed not only to reducing their emissions, but also to developing solutions for the transition to a sustainable and resilient economy.

It is essentially based on a scenario-based logic, which considers sectoral interdependencies as an integral part of the "climate coherence" assessment, attributing a central role to the mitigation of transition and reputational risks (Hoepner et al., 2024). However, the operational application of the Net-Zero approach is rather complex. Recent literature tends to define it in a narrower sense, oriented towards climate alignment (Institut Louis Bachelier et al., 2024), understood as the correspondence between the emissions of a portfolio and those projected by a specific decarbonization scenario.

From this perspective, two main modes of constraint emerge in portfolio models, defined as follows:

- Trajectory constraints, which impose an emissions reduction path consistent with the Paris Agreement;
- Cumulative constraints, which ensure that the overall level of emissions in the portfolio remains within the limits set by the climate scenario.

Another alternative approach for the inclusion of sustainability-related considerations is factor tilting, described by Wang et al. (2023) and Teti et al. (2023).

It is based on overweighting or underweighting stocks based on their exposure to certain risk factors, such as ESG scores, to steer the portfolio towards companies with desired characteristics without excluding entire sectors. This is a very effective method for building indices and analyzing data, but it does not allow for direct constraints, such as ensuring a specific reduction in emissions. As a result, it does not offer the certainty of full alignment with defined climate goals. A further approach was proposed by Bolton et al. (2022), who identified two decarbonization strategies that follow an emissions reduction trajectory while minimizing tracking error. In a first phase, companies with higher emission levels are excluded, and then the weights are reallocated to companies with less environmental impact, without altering the overall structure of the benchmarks.

Both strategies allow you to reduce the intensity of your portfolio, while maintaining a relatively close alignment with the target market.

Overall, these decarbonization approaches highlight some limitations of traditional metrics, whose statistical robustness is often insufficient to capture the complex and dynamic nature of climate risks. In recent studies by Azzone et al. (2024), Korn and Nurkanovic (2023) and Chen et al. (2025), quantitative models have been explored that explicitly integrate ESG constraints within optimization processes for more effective risk management. In the work of Chen et al. (2025), the authors analyze the dynamics of an optimal portfolio in the presence of a carbon risk constraint and assess its expected performance below a predetermined threshold. The authors examine a financial market that includes three types of assets: a risk-free asset, a green asset with low carbon emissions, and a brown asset associated with higher emission intensity.

Their objective is to understand how the introduction of carbon-related constraints influences portfolio choices, particularly in terms of expected utility maximization.

Overall, the findings suggest that incorporating climate risk considerations leads investors to shift their portfolios towards greener assets, increasing the relative importance of green bonds compared to brown ones.

However, the results show that this effect is not always guaranteed: under certain conditions, the constraint can produce an opposite effect, paradoxically incentivizing a greater allocation to the brown asset.

To avoid such a counterproductive outcome, the authors introduce an additional constraint, the Brown-Green Score (BGS), proposed by Górgen et al. (2020) and intended as an alternative metric for the assessment of traditional carbon risk.

It is no longer assessed in terms of the greenhouse gas emissions of the undertaking analyzed, either in relation to the level of emissions or to the size of the undertaking itself. Instead, it assesses a company's carbon risk based on three dimensions: value chain, public perception, and adaptability. The results of the study underscore the importance of considering the heterogeneity of investor preferences and market frictions that greatly influence portfolio composition and market balances.

The work prepared by Korn and Nurkanovic (2023) examines the possible consequences of European regulations, in particular the EU taxonomy and the Green Deal, on the portfolio choices of life insurance companies.

The authors underline the need for these companies to integrate constraints related to ESG ratings into investment decisions, using a continuous-time model that allows them to analyze the dynamics of a portfolio composed of traditional and sustainable assets, considering the growing demand for "green" investments and the sustainability ratings associated with them.

The results indicate an increase in the share of green investments and a simultaneous reduction in non-sustainable investments. However, it should be noted that under certain market conditions, this dynamic can have counterproductive effects on the composition of the portfolio.

In addition, the authors show that the inclusion of the actuarial reserve fund with a positive sustainability rating can partially offset any reductions in the valuation of other assets, helping to maintain overall stability.

Overall, the study offers a theoretical framework adapted to the specific needs of the insurance sector, highlighting how sustainability can be consistently integrated into investment models without compromising financial efficiency, while introducing new levers for risk management and greater long-term stability.

Finally, the work carried out by Azzone et al. (2024) analyzes the effect of introducing an ESG mandate for asset managers on investment funds, as this mandate tends to reduce the investable universe, leading to under-diversification and potentially conflicting with the performance objective in the presence of a trade-off between ESG score and return.

The authors show that integrating ESG criteria into the asset management optimization process can help mitigate the inefficiencies of constructed portfolios by minimizing tracking error volatility (TEV).

Under certain conditions, in fact, in the face of a moderate outperformance target, between 0% and 5% in their analysis, the introduction of an ESG mandate allows for less variance along the efficient frontier of the portfolio. It should be noted that as the performance target increases, ESG constraints tend to increase variance, leading the manager to overinvest in assets with a high ratio of return to standard deviation and, therefore, low variance.

These results occur when the ESG mandate is binding for a positive outperformance target relative to the benchmark, which occurs when there is a negative relationship between expected returns and ESG scores, and a benchmark that is not overly challenging, i.e. characterized by high ESG returns and scores.

The models analyzed in the contributions presented highlight how the integration of ESG criteria into portfolio optimization processes requires a careful definition of input variables and sustainability constraints. However, the robustness of these models depends largely on the quality and consistency of the ESG data used in the assessments.

From this point of view, ESG ratings represent the tool through which information relating to the environmental, social and governance performance of companies is collected, normalized and translated into comparable score across sectors and markets.

These ratings form the empirical basis for measuring climate risks and for the operational application of sustainable allocation models.

Rating agencies use different methodologies to express an overall opinion on the ESG profile of a company. In the literature, the calculation of the ESG score is often described as a "black box", Del Giudice et al., (2020).

The process of assigning an ESG rating is divided into several levels. Typically, it starts with the collection of data to be analyzed, relating to a company to be examined and its activities, and then calculates ESG metrics, which constitute the second level of the process and represent quantitative measures that reflect the company's performance in areas related to the environment, social responsibility and governance.

The data comes from different sources, in accordance with European directives (CSRD, CSDDD, SFDR) and the main international frameworks (PRI, TCFD, CFD), as well as from reports by non-governmental organizations, web analytics and internal company questionnaires.

In the next level, ESG indicators are aggregated to obtain a synthetic view of performance in the various areas analyzed, flowing into the overall assessment of environmental management, protection of workers' rights and business ethics, which constitute the three pillars underlying the company's overall ESG score, allowing an articulated evaluation of its performance from multiple profiles. Information is typically aggregated according to internal patterns.

However, the lack of transparency on the criteria and methodologies adopted makes it difficult to compare data between different agencies.

Given the importance of data quality and consistency in sustainable assessment models, this chapter details the methodology used by LSEG Workspace (formerly Refinitiv) for the construction of ESG ratings.

The platform, controlled by the London Stock Exchange Group, offers one of the most comprehensive ESG databases on the market in which coverage extends up to 70% of global capitalization, with time series available since 2002.

The ESG score is assigned through the evaluation of ten categories of analysis: resource use, emissions, innovation, human rights, community, product responsibility, management, CSR strategy and shareholders, divided into 186 overall metrics.

The contribution of each category to the final rating is determined according to the number of metrics associated with it. The percentile rank methodology is used to define the overall score, which is not very sensitive to outliers and is based on the comparison between the final score of competing companies and the number of companies evaluated according to the same metrics. Through this methodology, Refinitiv directly compares companies with their sector for environmental and social components, while the comparison for the governance component takes place at the national level.

To assess risk scenarios and related losses, the stress test practiced in the financial sector is a technique used for measuring the vulnerability of a portfolio, a financial institution or an entire system in adverse scenarios (Ong and Jobst, 2020). Stress tests are designed to estimate the effects of certain variables in adverse scenarios, which have not yet materialized. (Slijkerman et al., 2013; Bolton et al., 2020).

Climate-related risks have distinct features, but at the same time they are intertwined with the forms of risk already known to the financial sector. A first difficulty arises from the high uncertainty that characterizes climate change and its often-non-linear effects, destined to manifest themselves over many years (Monasterolo, 2020).

In addition, most climate variables evolve slowly, which means that the heaviest consequences only emerge after long time intervals, sometimes even beyond the planning horizon of financial operators.

In addition, the degree of climate change mitigation does not depend only on natural factors but is the result of economic and political decisions: any losses for investors and financiers can influence public choices, for example on carbon prices.

Finally, there is a link of mutual dependence between the economy and climate: climate change affects economic activity, while practically every productive activity contributes to varying degrees, to the greenhouse gas emissions that fuel its evolution (Battiston et al., 2017).

Calculating exposure to climate risks for an investment portfolio is useful for at least two reasons. On the one hand, it allows us to understand how much the risk really is, and what measures could be implemented over time. On the other hand, mitigation tools are not always reliable and can lose effectiveness and become inadequate.

Within the framework outlined by the BIS, the construction of a climate stress test starts with the definition of physical and transition scenarios generally based on the definitions developed by international bodies such as the NGFS. Compared to traditional stress tests, which generally focus on rather short time horizons, climate-related stress tests require extending the analysis to much longer periods to consider the effects of decarbonization policies, technological changes and extreme weather events.

This lengthening of the time horizon inevitably increases the degree of uncertainty: not only about possible future climate pathways, but also about the economic and financial relationships that influence the transmission of shocks. The methodology proposed in the report is developed in several phases.

The first is to identify the climate shocks to be analyzed, which can result from a sudden tightening of transition policies or from the increase in the frequency and severity of physical events. Once selected, shocks are translated into macroeconomic variables such as GDP growth, inflation or energy prices, which are then evaluated in econometric models. To make the analysis more in line with economic reality, many exercises also provide for a distinction between sectors, given that sensitivity to climate shocks varies significantly from one sector to another. Stress tests developed by some European central banks show how this differentiation improves the model's ability to represent the effects of the transition.

Once the macroeconomic scenario has been constructed, shocks are applied to financial institutions' portfolios through risk parameters such as the probability of default, loss given default, changes in asset values or spreads. Some exercises are based on very detailed data on the location of assets, the economic sector or the emission profile of debtors, others focus their analysis on portfolios considered to be more exposed to climate dynamics, with the aim of estimating the impact of shocks on the repayment capacity and profitability of counterparties.

Despite methodological progress, the assessment of climate scenarios through quantitative estimates still has significant limitations, due to the limited availability of reliable data and the difficulty in correctly representing and quantifying climate events. This makes these exercises less robust than traditional stress tests.

For this reason, climate stress tests are mainly used to highlight possible risk channels and points of vulnerability in portfolios and models, to facilitate the development of more robust analytical approaches.

There is another methodology that deserves attention. Climate Value at Risk, adapting traditional financial risk assessment techniques, makes it possible to estimate the impact of climate on the value of an investment. Interest in this tool has grown especially in the low-emission technology sector, both for assessing potential returns and for analyzing the long-term effects of climate change, particularly in portfolios subject to regulatory transparency requirements (TCFD, 2020).

VaR assesses the magnitude of a potential loss and the likelihood of it occurring over a given time horizon. Applied to the climate context, this approach makes it possible to estimate the sensitivity of the financial system to climate-related risks and opportunities, returning a result expressed as a numerical value or as a range in the reference currency.

In MSCI's 2020 case study, a sample portfolio representative of an actively managed global fund was selected by risk/return characteristics and, using the MSCI Climate Value-at-Risk ("Climate VaR") model, the different dimensions of climate risks were analyzed and the most exposed sectors, countries and securities within the portfolio were explored.

The analysis showed a negative impact of 7.75%, attributable both to transition risks (related to the introduction of new climate policies or new low-carbon technologies), and to physical risks, related to the increase in intensity and frequency of extreme weather events. This vulnerability was mainly found to be in Chinese operating areas, where several commercial facilities are in regions with high climate risk. To assess whether and how it was possible to reduce the climate risk of the portfolio without compromising its financial profile, MSCI tries four very simple strategies: in each of them, only the securities that, for a specific climate metric, are among the worst in the portfolio are eliminated.

Despite this minimal change, the effect is substantial: overall climate risk decreases by up to 74% in the case of aggregate Climate VaR and almost 90% in the case of carbon intensity, while the portfolio's performance, volatility and exposures remain largely unchanged. In other words, removing the financial securities most exposed to climate risks makes it possible to significantly improve the performance of the portfolio without altering its financial balance.

This leads MSCI to a clear conclusion: integrating advanced tools such as Climate VaR can improve the performance of portfolios by making them more robust against the effects of climate change, while aligning them with regulatory needs and the transition to a more sustainable economy.

The assessment of climate risk in investment portfolios is based on a set of indicators now recognized in European and international regulatory practice, which make it possible to measure both the current level of emissions of the companies financed and their degree of alignment with the objectives set out in the Paris Agreement.

They allow intermediaries to assess their exposure to physical and transition risks in a concrete way and to obtain a complete representation of risk profiles.

The guidelines established by the EBA, EIOPA, ECB and NGFS outline the need to jointly use emission intensity indicators, forward-looking metrics and sectoral indicators, to capture both physical and transition risks more accurately.

Among the most widely used climate indicators are the greenhouse gas accounting standards established by the GHG Protocol, often referred to as carbon accounting. It defines guidelines, tools and principles useful for measuring the emissions responsible for global warming. This system provides a standardized framework for measuring and reporting greenhouse gases, divided into Scopes 1, 2 and 3. This classification makes it possible to reconstruct the overall footprint of a company along the entire value chain, including, in the case of financial institutions, also the emissions considered in Scope 3, which usually represent the most significant part. The carbon intensity of the companies in the portfolio is generally assessed through the *Weighted Average Carbon Intensity (WACI)*, an indicator that considers the emission intensity of each company in relation to its weight within the portfolio. Along with metrics based on historical data, Implied Temperature Rise (ITR) is also increasingly used, which makes it possible to assess the degree of alignment of companies with the commitments set out in the Paris Agreement.

These measures are also accompanied by indicators relating to physical risks and transition risks, useful respectively for measuring the exposure of companies to extreme weather events and their sensitivity to factors such as the increase in the carbon price, already discussed in Chapter 1.

The methodologies illustrated define a common language for measuring environmental impact and represent a central element in risk management processes for financial intermediaries. Although their adoption is increasingly widespread, assessment methodologies differ between operators in terms of application capacity, data quality and integration into internal models.

To understand its application, the next paragraph will examine the *best performing European companies*, highlighting the organizational and methodological solutions that are guiding the sector towards more effective and conscious management.

The assessment of climate-related and ESG risks relies on a wide set of indicators and methodologies that differ in terms of objectives, level of aggregation and analytical approach. Table 2.3 provides a synthetic overview of the main climate and ESG indicators discussed in the literature and in supervisory practice, highlighting their relevance for the risk assessment and portfolio management activities of financial intermediaries.

Table 2.3. - Climate and ESG indicators and assessment methodologies

Dimension	Risk / objective	Indicator category	Examples of indicators	Methodological approach	Main application for financial intermediaries
Climate risk	Physical risk	Exposure and vulnerability indicators	Flood risk, heat stress, geographic exposure	Quantitative, scenario-based	Assessment of asset vulnerability and operational risk
Climate risk	Transition risk	Emissions and carbon exposure	Carbon intensity, fossil fuel exposure, carbon pricing sensitivity	Quantitative, indicator-based	Credit risk, market risk and repricing effects
Environmental (E)	Environmental performance	Environmental scores	Emissions management, energy efficiency	Score-based, composite indices	Long-term resilience and reputational risk
Social (S)	Social sustainability	Workforce and stakeholder indicators	Human rights, diversity, employee relations	Qualitative/quantitative	Operational risk and business continuity
Governance (G)	Corporate governance	Governance indicators	Board structure, risk oversight, CSR strategy	Qualitative and rule-based	Risk management effectiveness and internal controls
ESG (composite)	Overall sustainability	ESG aggregate scores	ESG ratings	Composite scoring models	Comparative risk assessment and portfolio screening
Portfolio alignment	Climate neutrality objectives	Forward-looking climate metrics	Implied Temperature Rise (ITR), Net-Zero alignment	Scenario-based, forward-looking	Assessment of alignment with the Paris Agreement

Portfolio decarbonization	Emissions reduction	Carbon accounting metrics	Scope 1, 2 and 3 emissions, WACI	Accounting-based	Measurement of portfolio carbon footprint
Stress testing	Systemic climate vulnerability	Scenario-based indicators	NGFS climate scenarios	Stress-test framework	Estimation of losses under adverse climate scenarios
Market valuation	Climate-related financial risk	Climate Value-at-Risk (Climate VaR)	Climate VaR estimates	Risk-based quantitative models	Measurement of climate impact on portfolio value

The table highlights the heterogeneity of existing indicators and assessment methodologies, reflecting the absence of a fully standardized framework for measuring climate and ESG risks in the financial sector. This diversity underscores the importance of selecting indicators that are consistent with the objectives of the analysis and with the specific business models of financial intermediaries. To understand their operational application, the next paragraph focuses on the practices adopted by best-performing European companies.

5. The adaptation of European best performers to new risk management and mitigation practices

In recent years, European financial intermediaries have progressively strengthened their climate risk management systems, integrating new methodologies into governance processes, risk assessment and capital allocation. Increasing regulatory pressure, evolving reporting standards, and the

increased availability of carbon footprint metrics has helped create a more defined operating model while highlighting significant differences. The following section aims to analyze the companies that have contributed significantly to the development of advanced approaches characterized by a level of transparency, data granularity and methodological integration above the industry average.

The criteria for identifying them will be examined, highlighting the elements that distinguish their approach to climate risk and the reasons why their experience can be considered representative of best market practices.

In order to identify the best European performers, it is necessary to define criteria that make it possible to distinguish the intermediaries with the most advanced level of integration of climate risks and ESG factors into their operating models, based on regulatory directives and the most recent literature, especially considering that the adoption of the methodologies is very heterogeneous among operators. The selection is based on recurring elements in literature and in the main international frameworks, such as the Net-Zero Banking Alliance, the Net-Zero Asset Owner Alliance (NZAOA), the United Nations Principles for Responsible Investment (PRI) and the standards defined by the Science Based Targets initiative (SBTi).

The PRI is based on the idea that environmental, social and governance factors should constitute a structural component of investment activities, providing for the systematic integration of ESG parameters into financial analysis processes and capital allocation decisions, together with the conscious exercise of shareholder rights through voting and engagement policies that incorporate considerations related to sustainability and responsible management of companies Participate. The new 2024-2027 strategy defines a twofold objective: to offer more concrete value to participating in investors, becoming a link between global investors to encourage the spread of sustainable investment practices, and to contribute to the construction of a more sustainable global financial system.

With the introduction of Progression Pathways, PRI offers customized pathways to help signatories improve their responsible investment practices, based on their level of maturity, specific needs and the regulatory environment in which they operate. The aim is to streamline the reporting process, recognizing equivalent reporting standards in the various countries, integrating existing regulatory obligations and contributing to the definition of market rules and structures that are more consistent with sustainability objectives.

A further useful element for assessing the level of progress of European intermediaries concerns the adoption of the main international guidelines dedicated to the definition of climate targets published by the United Nations.

The latest report, entitled "Guidance for Climate Target Setting for Banks", confirms that best practices are distinguished by a systematic approach to setting decarbonization targets, in line with the trajectories set out in the Paris Agreement, through the introduction of intermediate targets for 2030 and the pursuit of climate neutrality by 2050.

This approach also requires the inclusion of Scope 1, 2 and 3 components in the processes for assessing emissions along the entire customer value chain, providing a complete representation of the carbon footprint of a financial intermediary.

The more mature institutions are also characterized by the adoption of reporting systems that systematically illustrate both the evolution of the overall share of emissions and sectoral indicators, accompanied by information on the quality and coverage of data.

These systems are based on transparent methodologies consistent with the scenarios developed by NGFS and are integrated by engagement activities that play a central role in transition strategies. In this context, the ongoing dialogue with clients is aimed at promoting the adoption of credible decarbonization plans, regularly monitoring progress and, where necessary, introducing escalation mechanisms regarding counterparties most exposed to transition risks. This is accompanied by the review of sectoral policies and the promotion of financial instruments consistent with emission reduction objectives, elements that together contribute to outlining an operating model more aligned with international best practices.

To further understand the maturity of the models used by European intermediaries for the definition of climate standards, it is useful to recall the criteria provided by the Science Based Targets initiative (SBTi), which in recent years has contributed to outlining an international methodological framework for the formulation of decarbonization targets.

Although these standards are mainly aimed at non-financial companies, the guidelines developed by the initiative are now also used by banks and insurance companies as a structural reference to ensure consistency between the climate commitments made and the emission reduction targets.

Attention is paid to the requirements of transparency and annual reporting of the targets which, although born in the corporate sphere, provide for the publication of information on the methodologies adopted, the progress made and the margins of uncertainty in the measurement of the objectives, also offer support to financial intermediaries for the drafting of evaluation models.

These elements, although born in the corporate sphere, are now also a significant support for financial intermediaries, who use them to strengthen the credibility of their transition paths.

The integration of climate risks into assessment models is particularly evident in the analysis conducted by the Net-Zero Asset Owner Alliance (NZAOA), which offers a privileged vantage point to understand how institutional investors are progressively orienting their portfolios towards climate neutrality objectives.

The approach developed by the Alliance is based on the idea of ensuring that the commitments made by members are truly consistent with the trajectories indicated by the Paris Agreement and with the most authoritative scientific scenarios, such as those of the IPCC, through a system of intermediate targets, periodic checks and transparent monitoring tools.

The 2025 report highlights a particularly structured approach by participating asset owners to the adoption of emission reduction targets based on verifiable indicators and control tools aimed at measuring the effective alignment of portfolios.

It also shows a significant reduction in financed CO₂ emissions between 2023 and 2024 accompanied by an improvement in carbon intensity for the main asset classes for listed equities and corporate bonds. At the same time, investments for environmental purposes have increased to a value of about 700 billion dollars, a sign of the increasing allocation of resources towards clean technologies, resilient infrastructure and energy efficiency projects.

Alongside the measurement of emissions, a central role is attributed to engagement activities, considered an essential lever to support the transition to a more resilient economy,

promoting continuous dialogue with customers and financial partners, aimed at orienting counterparties towards more ambitious climate strategies and consolidating a stewardship model that is more attentive to environmental impact.

With regard to financial transition, the body has also developed a set of criteria dedicated to assessing the credibility of the decarbonization plans of companies active in the most emission-intensive sectors, with the aim of promoting a capital allocation that is more consistent with long-term climate objectives and supporting, overall, the transformation towards a low-carbon economy. There are significant differences in the ESG business models adopted by banks and insurers, reflecting the heterogeneous nature of their activities and influencing how the two sectors integrate climate risks into their operational and decision-making processes.

The guidelines published by the EBA confirm that the integration of ESG factors cannot be considered a uniform process, as each intermediary is required to incorporate these elements into its operating models considering the characteristics of the portfolio, the structure of the sources of profitability and the time horizon of the activities carried out.

In the assessment process, the risk-based model is generally the first mandatory step in the development of ESG methodologies for the identification and assessment of the potential impact of climate on traditional risk profiles. Banks, which are highly exposed to credit and transition risks, tend to integrate these factors into the lending processes, the assessment of risk parameters, capital adequacy and climatic stress tests, while insurance companies are more involved in the technical component of claims and the impact of physical risks on property and catastrophe classes. The assessment of social risk remains more complex, which is mainly configured as a compliance risk, as it is linked to regulatory evolution, and as a reputational risk, strongly dependent on social expectations and therefore subject to geographical variations.

Performance-based models assess the intermediary's ability to improve its ESG metrics over time in terms of positive impact on portfolio quality in terms of carbon intensity, alignment with climate targets and increase in the share of sustainable investments.

The empirical perspective offered by Bellavite Pellegrini et al. (2024) shows that the ESG performance of banks is

strongly correlated with the business model adopted, whose operational structure significantly influences the composition of the portfolio and the ability of the intermediary to achieve consistent and measurable results from a sustainability perspective. KPMG, in its latest report, confirms the distinction between the two models, defining a risk-based approach for banks, aimed at measuring the vulnerability of the intermediary, and a performance-based approach, which makes it possible to assess the ability to actively contribute to the transition, support green investments and strengthen the credibility of decisions on sustainability policies.

As far as insurance is concerned, these show a significant balance between the two models, since the risk of financial assets is added to that deriving from claims, making it necessary to double integrate ESG factors both in investment portfolios and in underwriting criteria.

Overall, the distinction between risk-based and performance-based models makes it possible to understand the different ways in which banks and insurance companies incorporate climate factors into their operating processes and business models, which on the one hand identify the vulnerability of the intermediary to ESG risks and on the other measure the organization's ability to generate sustainable value and steer the real economy towards decarbonization goals.

In the light of the theoretical framework outlined in the previous sections, there is a need to empirically verify whether – and to what extent – sustainability-oriented management practices affect the economic and financial performance of intermediaries. The in-depth analysis of ESG methodologies and the distinction between risk-based and performance-based approaches show how the quality of environmental, social and governance management can represent, on the one hand, a risk factor and, on the other, a potential value driver.

In recent years, some European financial institutions have taken a leading role in integrating ESG factors into business models, developing advanced methodological approaches for measuring physical and transition risks and innovative organizational structures characterized by strengthened governance with committees dedicated to sustainability and the integration between strategic planning and capital allocation to achieve long-term climate goals period. Among the operators that have distinguished themselves in recent years for the maturity of their processes and transparency, we identify Allianz, AXA and Zurich for the insurance sector while, for the banking sector,

ING, BNP Paribas and Banco Santander stand out. Allianz is one of the most advanced players in the integrated management of ESG risks and has developed its own Climate Risk Framework that combines NGFS analysis methodology and portfolio valuation through sectoral indicators that estimate the economic impact of extreme climate events and the transition according to alignment with Net Zero targets. The company is also one of the founding members of the Net-Zero Asset Owner Alliance and transparently publishes methodologies and benchmarks to ensure transparency towards stakeholders. AXA is one of the first European institutions to have integrated divestment policies and stringent criteria for the exclusion of carbon-intensive activities according to a Transition Risk Model for assessing the risk profile of counterparties in adverse scenarios, as well as an internal framework for estimating Climate Value at Risk in capital allocation processes.

Zurich, also in the insurance sector, stands out for the high integration of climate risks in the ORSA (Own Risk and Solvency Assessment), through internal models that quantify the exposure to physical and transition risks of the most vulnerable sectors. It also uses forward-looking metrics based on indicators aligned with the Paris Agreement and green methodologies, among the most developed in Europe.

For the banking sector, ING is one of the developers of the "Terra Approach", one of the most advanced methods for assessing the climate alignment of loan portfolios according to industry benchmarks and monitoring is carried out through quantitative indicators that define the guidelines of credit granting policies and engagement with corporate customers.

BNP Paribas has developed an internal "ESG scoring" model that combines Refinitiv, MSCI and CDP data for the direct valuation of counterparties and the respective pricing of loans. In addition, it is among the institutions most aligned with Net Zero targets.

Banco Santander, on the other hand, has developed an approach based on the territorial management of physical risks and the identification of climate vulnerabilities in the regions in which it operates, aligning itself with SBTi standards for reducing emissions according to pre-established targets. The different practices described highlight a growing attention of the sectors towards suitable sustainable models. The methodologies illustrated above are not applied directly in the model that will be presented later but serve to present the evolutionary context in which ESG scores have established themselves as synthetic indicators for the evaluation of the management capacity of intermediaries.

The practices discussed in this section illustrate how regulatory requirements and ESG indicators are translated into operational risk management frameworks, providing the basis for the empirical analysis developed in the following chapter.

***Part III: Econometric analysis of climate risks
for financial intermediaries in the international
context.***

Chapter 3

Econometric analysis of climate risks for financial intermediaries in the international context

CHAPTER OUTLIER

1.DEFINITION OF THE RESEARCH METHODOLOGY. – 2.EMPIRICAL EVIDENCE AND DISCUSSION OF THE RESULTS. – 3.RESEARCH PERSPECTIVE: CONCLUDING REFLECTIONS AND INTERNATIONAL COMPARISONS.

1. Definition of the research methodology

This chapter presents the original empirical analysis of the thesis. Building on the conceptual, regulatory and methodological framework developed in the previous chapters, it empirically investigates the relationship between climate-related risks, ESG factors, and the financial performance and solvency of banks and insurance companies using panel-data econometric techniques. The analysis is designed to assess whether and to what extent climate and ESG risks translate into measurable differences across financial sectors, in line with the evidence emerging from the literature and the growing supervisory focus on climate-related financial vulnerabilities.

Numerous empirical studies show how climate shocks can amplify market vulnerabilities, heighten volatility and cause sudden reductions in asset values following extreme events such as hurricanes, floods and wildfires (BIS, 2023; Hsu et al., 2022; Giglio et al., 2021; Di Tommaso et al., 2023; Jiang et al., 2024; Guo et al., 2024).

As discussed in previous chapters, the commitments made with the Paris Agreement require the European Union to limit the increase in the global average temperature compared to the pre-industrial period.

This implies for financial intermediaries the need to reduce the negative externalities generated by their activities and to interpret the relationship between the environment and financial statements according to the dimensions of environmental materiality and financial materiality. Climate risks, in their articulation into physical risks and transition risks, expose banks and insurance companies to complex scenarios. It should be remembered that the former derives from the direct effects of extreme weather events and long-term environmental changes that can compromise operations, asset value and solvency profiles.

Transition risks, on the other hand, emerge from the processes of adaptation to a low-emission economy, including regulatory evolution, technological innovations and financial market dynamics, with potential repercussions on profitability and asset valuations (Balvers et al., 2017; Griffin et al., 2019; Ren et al., 2022). The IPCC identifies hazard, exposure and vulnerability as central factors in determining climate risk (Cardona et al., 2012; Oppenheimer et al., 2015).

In response to these dynamics, the European Central Bank, together with other authorities, has developed climate stress tests based on macro-and-micro-data which, through both qualitative and quantitative indicators, assesses the long-term impact of climate shocks on the balance sheets of European intermediaries (Budnik, 2020).

These exercises make it possible to estimate potential losses in different transition scenarios developed by the NGFS, demonstrating how climate damage can generate systemic risks in the insurance sector, which is more exposed to the increase in claims due to extreme events (Curcio et al., 2023; Chen et al., 2023). At the same time, the European regulatory framework has progressively been consolidated through initiatives that include the

Sustainable Finance Disclosure Regulation (SFDR), which strengthened transparency requirements on the environmental impacts of financial assets, and the EU Taxonomy, which introduced a harmonized classification framework to identify economically viable assets. The evolution of the information perimeter was further consolidated with the Corporate Sustainability Reporting Directive (CSRD), while, at the international level, the recommendations of the Working Group on Climate-Related Financial Disclosures (TCFD) have favored greater standardization and comparability of climate disclosures. Banks are encouraged to set up committees dedicated to sustainability, to strengthen the training of personnel involved in credit and investment processes and to collaborate with public and private entities for the development of advanced tools for measuring environmental impact, through emission traceability models and indicators for assessing exposure to climate risks.

A similar evolution characterizes the insurance sector where the Solvency II directive provides for capital requirements and risk management methodologies aimed at strengthening resilience to climate shocks, while the International Association of Insurance Supervisors (IAIS) promotes the integration of climate risks into underwriting and investment processes. The framework outlined by the TCFD also provides for transparent reporting obligations to stakeholders in this sector. The supervisory authorities have also introduced climate stress tests for this sector to assess the potential impact of climate on companies' assets and liabilities. Taking together, these instruments contribute to strengthening the stability of the entire European financial system to support the transition to a more resilient and climate-sustainable economy.

The maintenance of responsible and sustainable behaviour by financial intermediaries can therefore generate benefits not only on their performance but also on overall economic development (Bencivenga & Smith, 1991; Forcadell & Aracil, 2017). Considering the theoretical and regulatory framework outlined, this chapter will develop an econometric analysis to assess the extent to which climate risks, ESG indicators and prudential factors influence the soundness and performance of financial intermediaries.

2. Empirical evidence and discussion of results

To develop an empirical model consistent with the research objectives, we begin by examining the main contributions of the literature on ESG practices, profitability and risk management. Subsequently, the sample and its composition, data sources and methodology adopted for the construction of the model are presented. As stated by stakeholder theory (Freeman, 1984), the balance of interests between different stakeholder groups, understood as shareholders, customers, employees and supervisors, is considered a key element in the risk mitigation process.

From this initial perspective, intermediaries that incorporate sustainability principles into their operating strategies, adopting more prudent credit and investment policies, are more likely to rely on robust governance mechanisms by selecting assets with greater strategic consistency. Existing empirical evidence suggests that the integration of environmental, social and governance dimensions could lead to improved financial performance and reduced risk exposure, although results remain mixed across sectors and different methodologies adopted (Zarea et al., 2025; Bressan et al., 2022; Carè, 2022; Lagasio & Cucari, 2019; Gangi et al., 2019; Brogi & Lagasio, 2019). It should also be noted that the adoption of ESG practices can reduce information asymmetries and improve allocative efficiency, while more robust governance mechanisms can contribute to financial stability. Overall, ESG performance can be interpreted as a relevant factor in shaping the risk-return profile of financial intermediaries. On the basis of these considerations, the following research hypothesis is formulated:

H1: A higher level of ESG performance, as measured by ROA and ROE, can be associated with improved financial performance.

The empirical analysis therefore focuses on the relationship between ESG performance and the profitability of financial intermediaries, using a sample of European banks and insurance companies extracted from the Refinitiv LSEG database for the period 2017–2024.

2017 is included for the purpose of constructing the delayed explanatory variables, while the estimation period starts in 2018. More specifically, the initial sample includes all listed European banks and insurance companies available in Refinitiv. Subsequently, it was restricted to companies for which the ESG score indicator was available for the entire period considered, together with the main financial variables, thus giving rise to a final balanced and complete dataset for all the variables observed over the entire time horizon. This allows you to preserve comparability both between units and over time. The final sample includes 67 banks and 26 insurance companies and provides a significant representation of the European financial sector covered by Refinitiv, in which ESG disclosure and climate risk management have progressively gained relevance in the regulatory and institutional framework.

Financial performance is measured by two indicators: return on assets (ROA) and return on equity (ROE). ROA captures operational performance in relation to total assets and is particularly suitable for comparison between institutions characterized by heterogeneous capital structures (Brogi et al., 2019). It is also widely used by supervisors, such as the ECB, EBA and EIOPA. ROE is included as a complementary indicator, to capture profitability for shareholders and verify the robustness of results against different performance measures (Rahi et al., 2022). Macroeconomic conditions are controlled by including GDP growth, which reflects the overall business cycle, and aggregate demand, both of which can influence the performance of intermediaries. Geopolitical risk is introduced only as an additional control variable in the extended specifications, to capture the time-varying macro-financial uncertainty. Caldara and Iacoviello (2022) developed the Geopolitical Risk Index as a measure based on news related to adverse geopolitical events and the risks associated with them, showing that higher geopolitical risk heralds' weaker macroeconomic outcomes, lower investments and lower employment levels.

Demir and Danisman (2021) show that geopolitical risk can influence the dynamics of bank lending, while Shabir et al. (2023) note that geopolitical uncertainty increases bank risk, compromising the stability of banks. More recent evidence from euro area banks also suggests that geopolitical risk could widen spreads and reduce equity prices, potentially having negative implications for the strength and profitability of banks. In this way, the inclusion of GPR allows the analysis to isolate the effect of ESG performance from broader systemic and macro financial shocks.

The empirical strategy adopts a perspective in which ESG performance is considered the main explanatory variable. In line with the reviewers' suggestions, reverse causation is not explicitly analyzed. All explanatory variables are introduced with a delay of one period, to ensure the correct temporal order between regressors and dependent variables and to mitigate potential endogeneity problems. To test the hypothesis, a balanced panel model with fixed effects is used, estimated separately for banks and insurance companies. The choice of fixed effects is motivated by their ability to control for unobserved characteristics, such as business models and risk profiles,

while time effects capture common macroeconomic shocks. Standard errors are clustered at the firm level to account for heteroskedasticity and intra-entity serial correlation. Geopolitical risk is included only in the extended specifications, to preserve a larger sample in the baseline models.

For each sample, the fixed-effects model is specified as follows:

Banks:

$$Y_{i,t} = \beta_0 + \beta_1 \text{ESG}_{i,t-1} + \beta_2 \ln(\text{TotalAsset})_{i,t-1} + \beta_3 \text{GDP}_{c(i),t-1} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Insurance:

$$Y_{i,t} = \beta_0 + \beta_1 \text{ESG}_{i,t-1} + \beta_2 \text{Leverage}_{i,t-1} + \beta_3 \ln(\text{TotalAsset})_{i,t-1} + \beta_4 \text{GDP}_{c(i),t-1} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Extended specification including GPR:

Banks:

$$Y_{i,t} = \beta_0 + \beta_1 \text{ESG}_{i,t-1} + \beta_2 \text{GPR}_{c(i),t-1} + \beta_3 \ln(\text{TotalAsset})_{i,t-1} + \beta_4 \text{GDP}_{c(i),t-1} + \alpha_i + \gamma_t + \varepsilon_{i,t}$$

Insurance:

$$Y_{i,t} = \beta_0 + \beta_1 ESG_{i,t-1} + \beta_2 GPR_{c(i),t-1} + \beta_3 Leverage_{i,t-1} \\ + \beta_4 \ln(TotalAsset)_{i,t-1} + \beta_5 GDP_{c(i),t-1} + \alpha_i + \gamma_t \\ + \varepsilon_{i,t}$$

Similar estimates are also obtained by considering the three ESG pillars (Environmental, Social, and Governance) separately as explanatory variables.

Where:

- $Y_{i,t}$ denotes the dependent variable and is alternatively measured by Return on Assrt (ROA) or Return on Equity (ROE) for banks and insurance (i) at time (t);
- $ESG_{i,t-1}$ denotes the one period lagged ESG score;
- $GPR_{c(i),t-1}$ captures geopolitical risk in the country c in which intermediaries operates;
- $GDP_{c(i),t-1}$ controls for country-level macroeconomics conditions;
- $Leverage_{i,t-1}$, is included only in the insurance models, where it is available and relevant under the Solvency II regulatory framework;
- $\ln(TotalAsset)_{i,t-1}$ accounts for firm-specific balance-sheet characteristics and size effects;

- α_i captures unobserved, time-invariant heterogeneity across intermediaries;
- γ_t denotes time fixed effects controlling for common shocks affecting all intermediaries;
- $\varepsilon_{i,t}$ represents the idiosyncratic error term.

All explanatory variables are lagged by one year in order to preserve the temporal ordering between regressors and the dependent variable.

Further regressions based on the Environmental, Social, and Governance pillars are reported in the Appendix, together with descriptive statistics and correlation matrices, to provide additional detail on the components underlying the aggregate ESG score.

Table 1: Variables description

<i>Variables</i>	<i>Definition</i>	<i>Source</i>
<i>Return on Asset (roa)</i>	<i>Net income divided by total assets.</i>	<i>Refinitiv</i>
<i>Return on Equity (roe)</i>	<i>Company Net Income divided by total equity of common shares.</i>	<i>Refinitiv</i>
<i>Total Asset (lna)</i>	<i>Total assets of the company, expressed as the natural logarithm.</i>	<i>Refinitiv</i>
<i>ESG score (esgscore)</i>	<i>Summary score of the information reported in the environmental, social and corporate governance pillars</i>	<i>Refinitiv</i>
<i>Environmental Pillar Score (envpill)</i>	<i>Environmental dimension of ESG score</i>	<i>Refinitiv</i>
<i>Social Pillar Score (socpill)</i>	<i>Social dimension of ESG score</i>	<i>Refinitiv</i>
<i>Governance Pillar Score (govpill)</i>	<i>Governance dimension of ESG score</i>	<i>Refinitiv</i>
<i>Leverage ratio (leverage)</i>	<i>Non-risk-based leverage measure based on gross exposures, used as a supplementary indicator to risk-weighted capital ratios.</i>	<i>Refinitiv</i>
<i>Geopolitical Risk (gpr)</i>	<i>Index of geopolitical risk and uncertainty.</i>	<i>Caldara and Iacovello (2022)</i>
<i>Gross Domestic Product (gdp)</i>	<i>Annual real GDP growth rate</i>	<i>World Bank</i>

Source: Personal elaboration

Regression results for banks

Table 3.1: Regression results: ESG score and financial performance

Variable	ROA (1)	ROE (2)
L_esgscore	0.00 (0.00)	0.1 (0.05)*
L_lnta	-0.64 (0.30)**	-7.02 (3.78)*
L_gdp	0.01 (0.01)	0.03 (0.14)
Year		
2019	-0.07 (0.05)	-1.50 (0.57)**
2020	-0.39 (0.07)***	-5.29 (0.91)***
2021	0.00 (0.12)	-0.40 (1.11)
2022	0.01 (0.12)	1.26 (1.26)
2023	0.47 (0.11)***	5.91 (1.05)***
2024	0.60 (0.12)***	6.23 (1.07)***
_cons	16.85 (7.47)	180.82 (93.24)
N	377	385
RSq	0.33	0.40

Standard errors robust to arbitrary heteroskedasticity and cluster correlation.

***p < 0.01, **p < 0.05, *p < 0.1.

Table 3.2: Regression Results: ESG pillars and financial performance

Variables	ROA (1)	ROE (2)
L_esgpill	-0.00(0.00)	-0.05 (0.03)
L_socialpill	0.00 (0.00)**	0.11 (0.03)***
L_govpill	0.00(0.00)	0.03 (0.03)
L.lnta	-0.66 (0.31)**	-7.11 (3.80)*
L.gdp	0.01(0.01)	0.03 (0.14)
Year		
2019	-0.09 (0.04)**	-1.67 (0.51)***
2020	-0.43 (0.07)***	-5.61 (0.79)***
2021	-0.06 (0.11)	-1.09 (1.05)
2022	-0.04 (0.12)	0.78 (1.21)
2023	0.44 (0.11)***	5.64 (1.06)***
2024	0.58 (0.12)***	6.05 (1.09)***
_cons	17.26 (7.87)	183.97 (94.44)
N	377	385
RSq	0.35	0.41

Standard errors robust to arbitrary heteroskedasticity and cluster correlation.

***p < 0.01, **p < 0.05, *p < 0.1.

Table 3.3: Regression results: Robustness checks for the banking sample (ESG+GPR)

Variables	ROA (1)	ROE (2)
L_esgscore	0.01 (0.01)*	0.17 (0.7)**
L_lnta	-0.64 (0.32)*	-10.24 (4.17)**
L_gdp	-0.00 (0.01)	-0.16 (0.14)
L_gpr	0.37 (0.43)	0.38 (3.87)
Year		
2019	-0.14 (0.04)***	-2.14 (0.65)***
2020	-0.43 (0.07)***	-5.29 (0.91)***
2021	-0.12 (0.16)	-1.86 (1.43)
2022	-0.08 (0.13)	0.72 (1.28)
2023	0.31 (0.11)***	5.52 (1.30)***
2024	0.47 (0.11)***	5.80 (1.12)***
cons	16.59 (8.08)	260 (103)
N	277	285
RSq	0.43	0.50

Standard errors robust to arbitrary heteroskedasticity and cluster correlation.

***p < 0.01, **p < 0.05, *p < 0.1.

Regression results for insurance companies

Table 3.4: Regression results: effect of ESG score on the financial performance of insurance companies

Variables	ROA (1)	ROE (2)
L_esgscore	0.01 (0.03)	-0.12 (0.29)
L_leverage	-3.92 (4.06)	198.69 (231.75)
L_lnta	-0.50 (0.84)	-41.46 (39.21)
L_gdp	0.06 (0.03)*	-5.49 (4.45)
Year		
2019	-0.50 (0.67)	-3.55 (3.62)
2020	-0.53 (0.83)	-3.83 (3.45)
2021	0.48 (0.94)	-35.31 (26.14)
2022	-0.70 (0.88)	0.29 (6.52)
2023	0.64 (0.88)	-14.37 (20.5)
2024	0.21 (1.06)	-10.70 (14.48)
cons	14.89 (20.21)	1024.62 (953.14)
N	130	164
RSq	0.10	0.10

Standard errors robust to arbitrary heteroskedasticity and cluster correlation.

***p < 0.01, **p < 0.05, *p < 0.1.

Table 3.5: Regression results: effect of ESG pillars on the financial performance of insurance companies

Variables	ROA (1)	ROE (2)
L_envpill	0.00 (0.00)	0.11 (0.22)
L_socialpill	0.03 (0.03)	-0.84 (0.89)
L_govpill	-0.02 (0.02)	0.45 (0.42)
L_leverage	-2.18 (4.86)	152.92 (188.39)
L_lnta	-0.61 (0.74)	-40.77 (38.50)
L_gdp	0.04 (0.04)	-5.12 (3.98)
Year		
2019	-0.39 (0.59)	-6.56 (5.28)
2020	-0.40 (0.76)	-5.12 (4.57)
2021	0.47 (0.93)	-32.31 (20.95)
2022	-0.44 (0.68)	-1.21 (8.47)
2023	0.23 (0.72)	-15.24 (20.58)
2024	0.25 (0.93)	-11.64 (14.31)
_cons	17.07 (18.24)	1025 (949)
N	130	164
RSq	0.13	0.11

Standard errors robust to arbitrary heteroskedasticity and cluster correlation.

***p < 0.01, **p < 0.05, *p < 0.1.

Table 3.6: Regression results: Robustness checks for the insurance sample (ESG+GPR)

Variables	ROA (1)	ROE (2)
L_esgscore	0.01 (0.04)	-0.01 (0.08)
L_leverage	-3.57 (4.44)	-29.57 (8.54)***
L_lnta	-0.51 (0.87)	-3.99 (2.88)
L_gdp	0.08 (0.07)	0.57 (0.36)
L_gpr	0.08 (0.79)	3.75 (4.28)
Year		
2019	-0.61 (0.77)	-0.53 (1.60)
2020	-0.56 (0.93)	-0.78 (1.91)
2021	0.57 (1.20)	5.34 (3.38)
2022	-0.86 (0.94)	-1.27 (2.03)
2023	-0.33 (1.19)	4.49 (3.14)
2024	0.09 (1.21)	6.05 (2.57)
_cons	14.58 (20.92)	115.07 (71.39)
N	117	144
RSq	0.10	0.24

Standard errors robust to arbitrary heteroskedasticity and cluster correlation.

***p < 0.01, **p < 0.05, *p < 0.1.

Before moving on to the analysis of the empirical results, it is appropriate to clarify some methodological choices. Firstly, geopolitical risk (GPR) is included as an additional control variable only in the robustness specifications, as this indicator, developed by Caldara and Iacoviello, measures changes in international geopolitical tensions and is useful for capturing changes in the broader macro-financial context in which financial intermediaries operate, reflecting any uncertainty that may affect profitability, on market expectations and risk. Therefore, its inclusion makes it possible to verify whether the relationship between ESG variables and performance remains stable even considering a broader dimension, understood at a global level. Secondly, all explanatory variables are introduced with a delay of one year, to preserve the timeline between sustainability indicators and financial results, relating past ESG conditions with current performance. The use of lag helps reduce concurrency issues and makes the empirical approach more consistent with the assumption that sustainability-related governance strategies and practices do not have immediate effects on profitability. The fixed-effects panel model, supported by Hausman testing, allows you to check for unobserved and time-invariant business characteristics that can influence both ESG behavior and financial performance.

In addition, fixed annual effects are included in all specifications, to control common macroeconomic and institutional shocks affecting the entire observed sample. Overall, these choices make it possible to analyze the association between ESG dimensions and performance in the two sectors analyzed in a consistent and comparable way.

3. Research perspective: concluding reflections and international comparisons

The empirical results highlight a marked heterogeneity between the banking and insurance sectors in the relationship between ESG variables and financial performance.

In the banking sample, the aggregate ESG score does not show a statistically significant association with ROA, while it is more informative than ROE, with a positive coefficient that is strengthened in robustness analyses that include geopolitical risk.

The breakdown into the three pillars, however, gives a clearer indication: the social dimension emerges as the main driver of profitability, with a positive and statistically significant association with both ROA and ROE.

This result suggests that, in the banking sector, the impact of sustainability is not evenly distributed among the different ESG components.

Stakeholder-oriented practices — such as employee management, customer relations and broader social involvement — appear to be closely linked to the core business of intermediation and therefore more easily translatable into observable economic and financial results. On the contrary, the environmental and governance dimensions do not show equally robust effects: in the first case, the impact can only manifest itself indirectly, through the composition of the loan portfolio and exposure to transition risk; in the second, the lower significance may reflect the high degree of regulatory and organizational standardization that characterizes the sector.

For insurance companies, however, the evidence follows a different trajectory. Neither the aggregate ESG score nor the individual pillars show robust linear relationships with ROA and ROE. This does not necessarily imply that sustainability is irrelevant to the insurance sector but suggests that its effects are mediated by specific mechanisms, such as the structure of liabilities, reserve policies, pricing strategies, underwriting dynamics and prudential constraints. In addition, there is a significantly higher volatility of ROE than that which emerged for banks and, this element signals how short-term profitability can be strongly influenced by the dynamics of claims and other structural shocks, attenuating the immediate signal of ESG variables.

Overall, the results indicate the uneven relationship between ESG and performance for the respective sector intermediaries. In fact, the comparison between banks and insurance companies shows that the economic significance of ESG dimensions depends on the channels through which they affect business activity and institutional specificities as well as on the business model. As a result, the aggregated ESG score alone may be insufficient to capture these differences, while a disaggregated reading of the pillars makes it possible to identify more precisely which components of sustainability are relevant to economic and financial performance.

Appendix: Descriptive analysis, correlation matrix and multicollinearity diagnostics

Banks sample

Company name	Country
ABN Amro Bank NV	Netherlands
AIB Group PLC	Ireland
Aktia Bank Abp	Finland
Alandsbanken Abp	Finland
Alior Bank SA	Poland
Alpha Bank SA	Greece
Arion banki hf	Iceland
ASA International Group PLC	Netherlands
Axactor ASA	Norway

B2 Impact ASA	Norway
Banca Generali SpA	Italy
Banca IFIS SpA	Italy
Banca Mediolanum SpA	Italy
Banca Monte dei Paschi di Siena SpA	Italy
Banca Popolare di Sondrio SpA	Italy
Banca Transilvania SA	Romania
Banco Bilbao Vizcaya Argentaria SA	Spain
Banco BPM SpA	Italy
Banco Comercial Portugues SA	Portugal
Banco de Sabadell SA	Spain
Banco Santander SA	Spain
Bank Handlowy w Warszawie SA	Poland
Bank Millennium SA	Poland
Bank of Cyprus Holdings PLC	Ireland
Bank of Greece	Greece
Bank of Ireland Group PLC	Ireland
Bank Polska Kasa Opieki SA	Poland
Bankinter SA	Spain
BAWAG Group AG	Austria
BFF Bank SpA	Italy
BNP Paribas SA	France
BPER Banca SpA	Italy
BRD Groupe Societe Generale SA	Romania
CaixaBank SA	Spain
Commerzbank AG	Germany
Credit Agricole SA	France
Credito Emiliano SpA	Italy
Danske Bank A/S	Denmark
Deutsche Bank AG	Germany
Deutsche Pfandbriefbank AG	Germany
DNB Bank ASA	Norway
Erste Group Bank AG	Austria

Eurobank Ergasias Services and Holdings SA	Greece
FinecoBank Banca Fineco SpA	Italy
Getin Holding SA	Poland
Grenke AG	Germany
Hoist Finance AB (publ)	Sweden
ING Bank Slaski SA	Poland
ING Groep NV	Netherlands
Intesa Sanpaolo SpA	Italy
Jyske Bank A/S	Denmark
Kbc Groep NV	Belgium
Komerční Banka as	Czech Republic
Kruk SA	Poland
mBank SA	Poland
Mediobanca Banca di Credito Finanziario SpA	Italy
Moltiply Group SpA	Italy
Moneta Money Bank as	Czech Republic
National Bank of Greece SA	Greece
Nordea Bank Abp	Finland
Nordnet AB (publ)	Sweden
OTP Bank Nyrt	Hungary
Permanent TSB Group Holdings PLC	Ireland
Piraeus Financial Holdings SA	Greece
Powszechna Kasa Oszczędności Bank Polski SA	Poland
ProCredit Holding AG	Germany
Raiffeisen Bank International AG	Austria
Ringkjøbing Landbobank A/S	Denmark
Santander Bank Polska SA	Poland
Skandinaviska Enskilda Banken AB	Sweden
Société Générale SA	France
Sparebank 1 Nord-Norge	Norway
Sparebank 1 Ostlandet	Norway
Sparebank 1 SMN	Norway
Sparebank 1 Sor-Norge ASA	Norway

Sparebanken Norge	Norway
Svenska Handelsbanken AB	Sweden
Swedbank AB	Sweden
Sydbank A/S	Denmark
TF Bank AB	Sweden
Unicaja Banco SA	Spain
UniCredit SpA	Italy

Table 3.7. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
roa	403	0.85	0.93	-6.79	9.20
roe	413	10.42	7.30	-41.85	31.60
esgscore	428	64.18	19.10	1.87	95.26
envpill	428	68.16	24.33	0.00	97.70
socialpill	428	66.67	19.74	0.64	96.70
govpill	428	60.58	23.10	3.53	95.13
lnta	468	24.98	1.79	18.77	28.63
gdp	469	2.00	4.18	-10.94	16.26
gpr	336	0.18	0.19	0.01	1.25

Note. The table shows the descriptive analysis of the variables included in the model. The observations are constructed based on the following variables: ROA, ROE, ESG score, Environmental Pillar Score, Social Pillar Score, Governance Pillar Score, Geopolitical Risk (included as an exogenous variable), GDP and the natural logarithm of total assets.

Table 3.8 Correlation Matrix

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
roa	1									
roe	0.79	1								
esgscore	-0.25	-0.03	0.03	1						
envpill	-0.29	-0.05	0.05	0.75	1					
socialpill	-0.27	-0.10	-0.05	0.89	0.66	1				
govpill	-0.13	0.03	0.09	0.85	0.50	0.56	1			
lnta	-0.44	-0.16	-0.08	0.68	0.72	0.61	0.50	1		
gdp	0.13	0.16	-0.07	-0.06	-0.02	-0.06	-0.04	-0.08	1	
gpr	-0.19	-0.15	-0.17	0.20	0.20	0.18	0.1	0.23	-0.01	1

Table 3.9 - VIF Analysis - ROA

Variable	VIF	1/VIF
L_esgscore	1.80	0.55
L_lnta	1.76	0.57
L.gdp	3.02	0.33
Mean	2.21	

Table 3.10 - VIF Analysis - ROE

Variable	VIF	1/VIF
L_esgscore	1.97	0.51
L_lnta	1.90	0.52
L.gdp	2.99	0.33
Mean	2.20	

Table 3.11 - VIF Analysis with ESG pillars - ROA

Variable	VIF	1/VIF
L_envpill	2.42	0.41
L_socialpill	2.10	0.47
L_govpill	1.38	0.72
L_lnta	2.15	0.47
L_gdp	3.03	0.33
Mean	2.24	

Table 3.12- VIF Analysis with ESG pillars - ROE

Variable	VIF	1/VIF
L_envpill	2.68	0.37
L_socialpill	2.49	0.40
L_govpill	1.50	0.66
L_lnta	2.32	0.43
L_gdp	3.01	0.33
Mean	2.29	

Insurance sample

Company name	Country
Aegon Ltd	Netherlands
Ageas SA	Belgium
Allianz SE	Germany
ALM. Brand A/S	Denmark
Aon PLC	Ireland
ASR Nederland NV	Netherlands
Assicurazioni Generali SpA	Italy
AXA SA	France
Coface SA	France
Gjensidige Forsikring ASA	Norway
Grupo Catalana Occidente SA	Spain
Hannover Rueck SE	Germany
Mapfre SA	Spain
Muenchener Rueckversicherungs AG	Germany
NN Group NV	Netherlands
Powszechny Zaklad Ubezpieczen SA	Poland
Protector Forsikring ASA	Norway
Sampo Oyj	Finland
Scor SE	France
Talanx AG	Germany
Tryg A/S	Denmark
Unipol Assicurazioni SpA	Italy
Uniqa Insurance Group AG	Austria
Vienna Insurance Group AG	Austria
Wuestenrot & Wuertembergische AG	Germany

Table 3.13 - Descriptive analysis

Variables	Obs	Mean	Std. Dev.	Min	Max
roa	139	1.92	2.21	-2.47	9.36
roe	175	8.63	50.55	-449	125
esgscore	171	64.08	19.91	5.57	94.88
envpill	171	63.78	24.75	0.20	99.06
socialpill	171	62.65	22.11	1.14	93.37
governance	171	66.93	22.01	4.73	97.67
lnta	175	24.83	1.56	20.98	27.76
leverage	175	0.22	0.13	0.04	0.69
gdp	175	1.48	3.75	-10.94	16.26
gpr	154	0.29	0.28	0.02	1.25

Table 3.14 - Correlation Matrix

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
roa	1									
roe	0.51	1								
leverage	0.67	0.19	1							
esgscore	-0.50	-0.11	0.21	1						
envpill	-0.43	-0.13	0.26	-0.53	1					
socialpill	-0.40	-0.02	0.22	-0.51	0.81	1				
govpill	-0.43	-0.14	0.11	-0.55	0.83	0.54	1			
lnta	-0.66	-0.22	0.27	-0.75	0.77	0.56	0.67	1		
gdp	0.08	0.04	-0.01	0.05	0.05	0.16	-0.09	0.16	1	
gpr	-0.22	-0.08	0.51	-0.26	0.34	0.25	0.20	0.35	0.36	1

Table 3.15- VIF Analysis - ROA

Variable	VIF	1/VIF
L_esgscore	3.65	0.27
L_leverage	2.03	0.49
L_lnta	4.41	0.23
L.gdp	2.67	0.37
Mean	2.53	

Table 3.16 - VIF Analysis - ROE

Variable	VIF	1/VIF
L_esgscore	2.60	0.38
L_leverage	1.93	0.52
L_lnta	3.86	0.26
L.gdp	3.12	0.32
Mean	2.59	

Table 3.17 - VIF Analysis with ESG pillars - ROA

Variable	VIF	1/VIF
L_envpill	2.97	0.33
L_socialpill	3.04	0.33
L_govpill	2.68	0.37
L_leverage	2.13	0.47
L_lnta	4.54	0.22
L_gdp	2.88	0.35
Mean	2.63	

Table 3.18 - VIF Analysis with ESG pillars - ROE

Variable	VIF	1/VIF
L_envpill	3.07	0.32
L_socialpill	2.59	0.39
L_govpill	2.20	0.45
L_leverage	2.05	0.49
L_lnta	3.91	0.26
L_gdp	3.27	0.31
Mean	2.67	

Chapter 4: Cybersecurity dimension and Climate Risk Management. Future Perspective

CHAPTER OUTLIER

1.LINK BETWEEN CYBER RISK AND CLIMATE RISK. – 2.CYBER RISK: ORIGINS AND REGULATION. – 3.POSSIBLE SYSTEMIC EFFECTS. – 4. CYBERSECURITY SURVEY: EVIDENCE ON A SAMPLE OF INSURANCE COMPANIES. – 5. STRENGTHS AND WEAKNESSES EMERGED. - 6.STRENGTHS AND WEAKNESSES THAT EMERGED

1. Link between cyber risk and climate risk

Cybersecurity has a major impact in the financial sector, due to the rise of increasingly sophisticated digital threats that put users at risk (Aripin, 2024). Traditional security measures are now insufficient in dealing with the complexity of cyber-attacks, making it necessary to adopt new technological solutions. In particular, the increase in digital transactions and the increasing sophistication of the techniques employed by cybercriminals requires the adoption of a proactive and flexible approach that can adapt to the continuous evolution of threats. (Brender et al., 2024).

Digitalization is a key factor: new technologies can optimize the accessibility and use of ESG data, to fill existing gaps. The new legislative regime on cybersecurity, at European and Italian level, introduces specific measures for the protection of online systems and services, promoting stricter standards for the security of infrastructures and operators. Information on a company's cyber security is relevant from several points of view: i) the transmission of a considerable amount of data and information between insurance companies and client companies is destined to grow due to the complexity of the valuation models used by intermediaries that provide for the integration of sustainability information; (ii) as a result, the importance of safeguarding and protecting data provided by third parties increases; iii) and therefore the ability of the subjects who manage the data (insurance companies) to protect themselves from cyber risks. The choice to turn to one insurance company, rather than another, could be influenced in the future precisely by the better ability to manage risks related to data security.

2. *Cyber risk: origins and regulation*

In recent years, the adoption of advanced technological systems has become essential for the economy and society. Technological innovation is profoundly redefining the different sectors of the economy, affecting operating methods, decision-making processes and relations with stakeholders. This evolution, while representing an important step forward, exposes organizations - particularly those in the financial sector - to new risk profiles, including cyber risk, which is now recognized as one of the main threats to business continuity and system stability.

In the past, cyber defense strategies were predominantly based on a reactive approach, oriented towards identifying potential attackers.

Today, the high interconnection between institutions, financial markets and infrastructures can intensify the effects of an attack that can spread globally and cross geographical borders, to the point of compromising both national and international operations.

The increasing digitalization of economic processes and social relations, while acting as a catalyst for development and innovation, at the same time leads to greater exposure to the risk of cyberattacks.

New technologies, such as artificial intelligence, blockchain and cloud computing, offer unprecedented opportunities, but also expand the perimeter of digital risks. All financial entities, such as banks, insurance companies and other intermediaries, systematically assess cyber risk throughout the entire life cycle of the company, considering it an essential component of corporate risk management and governance.

Despite the growing attention from authorities and academics, there is still no shared and unambiguous definition of cyber risk. This absence, as observed by Strupczewski (2021), probably reflects its complex and constantly evolving nature that can refer to both accidental and malicious events, with impacts on the availability, integrity and confidentiality of data and information systems.

In its most complete sense, cyber risk means "potential economic, financial and operational damage" that an organization can suffer due to cyber threats, malicious attacks, security breaches, malware or other harmful events capable of compromising the integrity, confidentiality and availability of information and digital systems.

The term "cyber risk" takes on a dual dimension of a technical and economic nature defined as follows:

- Technical dimension: characterized by a high design complexity, the reprogrammable nature of network components and the continuous change of global threats;
- Economic dimension: characterized by the lack of complete information, the externalities produced and the correlation between common risks.

According to the CRO Forum, cyber risk encompasses aspects related to the use of digital data and the Internet of Things, including potential physical damage resulting from cyberattacks, fraud and data breaches, which can affect companies, individuals, entire economic sectors and geographical areas (cyber threat landscape).

Cyber risk management, known as cyber risk management, encompasses identification, assessment, mitigation, and monitoring of cyber threats, with the goal of protecting sensitive data and assets from potential attacks, fraud, and vulnerabilities that could compromise the overall security of the organization. The main phases of the process are divided into:

- identification and analysis of potential threats and vulnerabilities of information systems;
- assessment of the probability of a potential event and the expected impact;
- mitigation of effects through security checks, software updates and other corrective actions;
- continuous monitoring and management of the IT environment through regular review of security policies.

The purpose is to ensure the protection of sensitive data and assets from potential attacks, fraud and other vulnerabilities that could compromise the overall security of an organization, through appropriate strategies and levels of protection that involve all its components.

A cyber incident, if not managed correctly, can in fact compromise not only the stability of financial infrastructures, but also that of the entire system.

Despite numerous measures being taken at European and national level, cyber risks continue to be a major challenge and attract the attention of policymakers and regulators, who seek to strengthen digital resilience also through greater coordination between different institutions.

Directive (EU) 2016/1148 issued by the European Parliament and of the Council on 6 July 2016, known as the "NIS Directive" (Network and Information System Security), represented the first legislative measure that introduced a common regulatory framework for the security of network and information systems, imposing specific protection obligations for operators of essential services and digital service providers.

EU Regulation 2016/679 of the European Parliament and of the Council of 27 April 2016, known as GDPR (General Data Protection Regulation), established a regulatory framework for the protection of personal data of natural persons, providing for the first time a definition of "personal data" as any information relating to an identifiable or identified natural person. The legislation aims to ensure the protection and free movement of such data within the common territory.

It also promoted cooperation between Member States, encouraging the sharing of information and the adoption of security standards and good practices in the digital sector.

The European Commission, in its Communication of 3 March 2018 entitled 'FinTech Action Plan: for a more competitive and innovative European financial sector', highlighted the importance of strengthening the resilience of the financial system to ensure continuity of services and consumer protection in stressful situations. At the same time, sectoral policies have also faced challenges in the various economic sectors.

EU Regulation 2016/679 was revised by EU Directive 2022/2555 (NIS 2), approved in December 2022, which expanded the scope and introduced a uniform level of security across sectors against cyberattacks.

Key innovations included identifying strategic cybersecurity areas and taking stricter measures to manage cyber incident risks. These interventions include a multi-layered approach that includes risk analysis policies, network security systems, continuous incident management, security in the acquisition, development and maintenance phases, as well as strategies to assess the effectiveness of management techniques.

A significant shift for the financial sector took place on 14 December 2022, with the adoption of EU Regulation No. 2022/2554 known as the Digital Operational Resilience Act (DORA), adopted together with Regulation (EU) No. 2022/2555. Regulation regulates ICT risk management in financial services, an area profoundly transformed by technological innovation, in digital payment systems, electronic securities trading, financing platforms and credit management.

In particular, the insurance sector has experienced significant evolution with the spread of online services provided by insurance intermediaries and the introduction of digital policies.

To address the cyber risks associated with these innovations, financial companies are now called upon to adopt effective ICT risk management policies and tools to strengthen the operational and digital resilience of the entire sector. Key obligations include:

- the secure and efficient management of information and communications technologies (ICT);

- reporting to the competent authorities of any significant threats and operational incidents related to the security of payments;
- sharing data and information on potential risks, including with third parties and ICT service providers.

It is based on a holistic and multidimensional approach, which integrates organizational, technical and contractual aspects. The financial entity, after entering a contract with a potential digital service provider, must carry out due *diligence* to assess its qualifications and characteristics.

As highlighted in the 2018 Action Plan, the aim is to strengthen the resilience of the financial sector not only from a technological point of view, but also from an operational point of view, to foster the adoption of good practices and ensure its proper functioning.

It is important to underline that ICT risk, given its nature, is configured as a reputational, operational, regulatory and geopolitical risk. Its occurrence can affect not only the continuity of services, but also the financial solidity, reputation and stability of the system.

As regards the digital resilience of the entire European financial sector, DORA regulates various aspects: (i) ICT risk management, introducing a harmonized governance and risk management framework in line with the EBA and EIOPA guidelines; ii) incident reporting, with common criteria for the classification and mandatory reporting of technological risks to supervisory bodies; stress tests to assess the operational resilience of financial intermediaries' ICT systems; iii) European oversight, through a specific supervisory regime on critical ICT providers; iv) info sharing mode, i.e. the voluntary sharing of information between financial entities to prefigure cyber threats and define collective responses that favor risk mitigation and the dissemination of knowledge between different geographical areas.

Pursuant to art. 6 of the DORA, financial entities are required to develop an ICT risk management framework based on a resilient strategy consistent with their governance and internal audit model. Intermediaries can decide, independently, to set up a dedicated control function or to assign this responsibility to risk management and compliance.

As for art. 19 and 28 of the Regulation, financial entities must promptly inform the competent authority of any contractual arrangements with third-party providers, which are required to notify, on a voluntary basis, of any serious incidents suffered.

Among the most recent regulations, Regulation (EU) 2024/2847, known as the Cyber Resilience Act (CRA), stands out, which aims to ensure a high level of cybersecurity for digital products (hardware and software) and foster an environment conducive to development and marketing in the internal market, strengthening trust and transparency throughout the product lifecycle.

The CRA requires manufacturers to adopt more secure design systems and ensure tighter updates and compliance controls, with a focus on IoT devices classified as "critical". As of 17 January 2025, the previous national legislation on the reporting of major ICT incidents has been repealed and replaced by the notification scheme introduced by the DORA Regulation and the related delegated acts (RTS) and implementing acts (ITS) issued in its implementation.

Delegated Regulation (EU) 2024/1772 defines in detail the technical criteria for determining when a cyber incident can be considered "significant", taking into consideration various elements such as the type of customers involved, any data loss, the impact on the reputation of the company, the geographical scope of the event and its economic consequences.

Instead, Delegated Regulation (EU) 2024/1774 focuses on the internal organization of companies, offering practical guidance on how to structure security policies, procedures and protocols appropriate to the size and risk profile of each entity. The main objective is to limit the misuse of data and ensure its protection, including using cryptographic solutions and consistent technical measures. In the insurance sector, EIOPA has published guidelines on governance and cybersecurity, highlighting how digital risk is now an integral part of the system. As a result, companies are required to manage it with the same attention as other risks relevant to the company's business. The Authority's recommendations refer to issues such as ICT strategy, data and information protection, business continuity and the administration of activities entrusted to third parties.

In particular, the need to always maintain direct control over the most critical processes is reiterated, even when they are entrusted to external suppliers. EIOPA contributes to creating greater coherence between different national practices, strengthening the measures provided for in the DORA Regulation. More recently, the Cyber Solidarity Act (EU Reg. 2025/38) introduced a European Cyber Solidarity Mechanism.

The regulation aims to strengthen cooperation between member states and promote the growth of European industry as a global player in the field of digital technologies, improving the competitiveness and resilience of infrastructure. To achieve these goals, it introduces two tools: a cybersecurity alert system and an emergency mechanism. Both are designed to constitute a supranational infrastructure capable of collecting and analyzing data on cyber threats, coordinating with national hubs in crisis management and operating with adequate and efficient resources.

In Italy, Italian Law No. 90 of 28 June 2024 has set as its objective the strengthening of the country's overall cybersecurity with a focus on public administrations, autonomous provinces and local authorities in the face of growing cyber threats.

Directive (EU) 2022/2555 (NIS 2), on the other hand, was transposed with Legislative Decree No. 138 of 2024, which strengthens the strategic role of the National Cybersecurity Agency (ACN), expands the scope of the legislation and introduces a clearer distinction between "essential entities" and "important entities".

This distinction is based on an assessment that considers the sector to which it belongs, the level of criticality and the organizational size of each entity involved. Essential subjects include companies that operate in highly critical sectors and that have characteristics typical of large companies - such as the energy, transport, health, finance, public administration and communications sectors.

To facilitate the understanding of the current European and national regulatory framework, a summary table is presented below (Table 1).

Table 1 - Main European regulatory acts on cybersecurity and ICT risk management – Authors' elaboration

Directive (EU) 2016/1148 of the European Parliament and of the Council of 6 July 2016 concerning measures for a common and high level of security of network and information systems across the Union.
Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of the personal data of natural people regarding and on their free movement.
Directive (EU) 2022/2555 of the European Parliament and of the Council of 14 December 2022 on measures for a common and high level of cybersecurity throughout the European Union.
Regulation (EU) 2022/2554 of the European Parliament and of the Council of 14 December 2022 on operational and digital resilience for the financial sector.
Regulation (EU) 2024/2847 of the European Parliament and of the Council of 23 October 2024 on horizontal cybersecurity requirements for products with digital features.
Commission Delegated Regulation (EU) 2024/1772 of 13 March 2024 supplementing Regulation (EU) 2022/2554 of the European Parliament and of the Council regarding regulatory technical standards specifying criteria for the classification of ICT-related incidents and cyber threats, setting out materiality thresholds and setting out details on reporting major incidents.
Commission Delegated Regulation (EU) 2024/1774 of 13 March 2024 supplementing Regulation (EU) 2022/2554 of the European Parliament and of the Council regarding regulatory technical standards specifying the tools, methods, processes and policies for the management of ICT risks.
Regulation (EU) 2025/38 of the European Parliament and of the Council of 19 December 2024 laying down measures to strengthen the Union's solidarity and capabilities on, in the detection, preparedness and response to cyber threats and incidents.
Italian Law No. 90 of 28 June 2024 laying down provisions on the strengthening of national cybersecurity and cybercrimes.
Legislative Decree No. 138 of 4 September 2024, transposing Directive (EU) 2022/2555 on measures for a common and high level of cybersecurity across the Union.

Against a backdrop of increasing uncertainty, the Financial Stability Board (FSB) has developed a toolkit of good practices to support financial entities and strengthen the overall stability of the system in the event of cyberattacks. Recognizing the importance of incident reporting and the need for rapid and effective responses, the FSB promotes greater collaboration between institutions, encouraging timely information sharing.

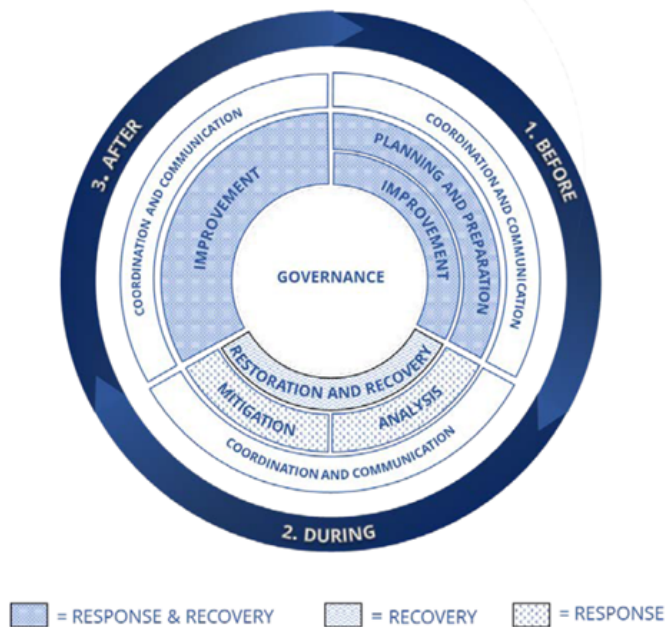
Alongside it, national authorities play a key role in managing incidents with potential systemic impact, offering support to organizations and encouraging the adoption of common preventive measures.

The "Effective Practices for Cyber Incident Response and Recovery (CIRR)" toolkit, developed by the FSB in 2020, is divided into seven components and includes 49 effective practices.

It can be adapted in different regulatory contexts, based on the size of the organizations and the role assumed within the financial ecosystem, promoting the coordinated involvement of all stakeholders.

It is a reference resource for governance and risk management, aimed at top management, boards of directors and compliance, risk management and legal professionals. It is also designed for those who work with cybersecurity experts, Standard Setting Bodies (SSBs) and regulators, providing guidance for adopting practices consistent with cyber taxonomies and international industry standards.

Figure 1 - Representation of the components of the FSB Toolkit.



Source : <https://www.fsb.org/>

Cyber threats can pursue different goals and purposes. In the current context, characterized by a strong interconnection between technology, society and economy, these aspects are closely linked and mutually influenced. As a result, cyber risk is no longer considered an abstract concept linked exclusively to the possibility of a cyber-attack. Rapid technological evolution, along with the emergence of tools such as artificial intelligence and blockchain, has made the actions of cybercriminals increasingly sophisticated and pervasive. Therefore, cyber risk is now a concrete risk that requires a systematic approach and a well-structured strategy of analysis and prevention. The term "Cyber Risk Assessment" indicates a procedure aimed at countering the phenomenon through the analysis of information systems, with the aim of identifying weaknesses that could compromise the security of company data. This activity considers the continuous evolution of the sector and the possibility of transferring part of the risk through the stipulation of specific policies, directly involving insurance companies.

Figure 2 presents the results of the analysis of the keywords extracted from the Scopus database and processed using the VOSviewer software, which identified five main clusters, distinguished by specific colors. The nodes of the network represent the most recurring keywords within the analyzed corpus, with dimensions proportional to their relevance in the publications examined.

The analysis shows the close interconnection between cyber risk, financial stability, risk management and cybersecurity, highlighted both in scientific literature and in international policies.

This interrelationship confirms the complexity of the phenomenon and the need for an integrated approach that can combine the regulatory and managerial dimensions to safeguard the balance of the economic-financial system.

3. *Possible systemic effects*

Cyber risk is not limited to the effects that an attack can produce on a single organization but takes on a systemic dimension when the consequences of a single event propagate through interconnected networks, with repercussions on the stability of the entire system.

In this context, numerous studies (Perrow, 1984; Rinaldi, Peerenboom & Kelly, 2001; Helbing, 2013; Svindland, 2023; Assenza and Pannetta, 2024) have highlighted how the interdependence between critical infrastructures, digital service providers and financial operators makes the onset of crises on a global scale more likely.

The concept of systemic risk originated in the financial and economic sector, as early as the Great Depression, when economists and politicians began to recognize that the failure of banks and other financial institutions could compromise the stability of the entire economic and financial system. However, more structured definitions of systemic risk only began to spread in the 1990s and were then fully confirmed during the global financial crisis of 2007-2008.

In this context, the failure of the main financial institutions and the interconnectedness of markets highlighted the rapid ability of a shock to propagate rapidly, causing recessions of extensive financial and economic scope.

Similarly, due to the interconnections between the nodes of the digital network, cyber risk, given its systemic nature and the speed with which it propagates, can contribute to the massive spread of attacks of various kinds.

These risks are characterized by their remarkable dynamism and the ability to propagate along complex chains of interdependencies.

Therefore, it becomes essential to put in place governance structures and resilience tools that ensure data protection and business continuity for all actors in the system.

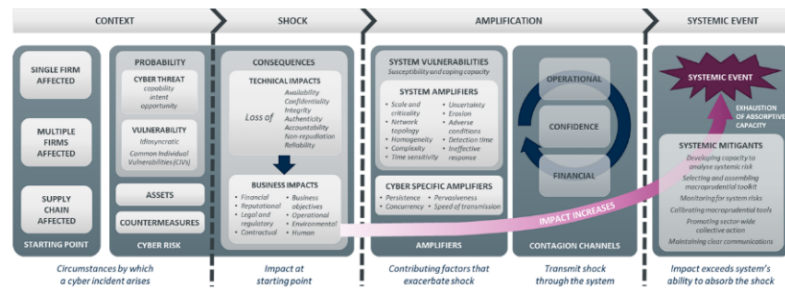
As highlighted by Bouveret (2019), cyber risk can involve the entire financial system, causing significant losses. In line with this perspective, the ESRB (Systemic cyber risk, ESRB, February 2020) defined systemic cyber risk as the likelihood that a series of major cyber incidents capable of compromising critical financial operations and services could turn into a systemic risk for the entire financial system.

For this reason, macroprudential authorities are called upon to contribute to the mitigation of the negative effects of cyber-attacks, which can evolve into a systemic crisis and put financial stability at risk through operational or financial contagion, or through an erosion of trust in the system. Systemic cyber risk can be addressed through measures that reduce, on the one hand, the probability of an attack occurring and, on the other hand, that it will manifest itself, to limit amplification factors and contagion channels. In this context, micro-prudential and supervisory authorities have developed specific ex-ante prevention tools to manage the early stages of a cyber incident. However, these tools prove insufficient in limiting contagion mechanisms once the crisis is underway, thus making it necessary to combine them with macroprudential interventions, aimed at ensuring the stability of the system. In the report, the ESRB set out an analytical framework to assess the incidence of cyber risk and the systemic character for financial institutions. The four phases of the conceptual model – context, shock, amplification, systemic event – facilitate the systematic analysis of how a cyber incident can evolve from a simple operational disruption to a systemic crisis.

Especially:

- Background: In the initial phase, a detailed description of the structure and functioning of the financial system, the level of IT security, the vulnerabilities present, the degree of interconnectedness between the institutions and the regulatory framework is provided.
- Shock: In the presence of a cyberattack with a direct impact on one or more entities in the financial system, the nature, intensity and objectives of the event must be analyzed.
- Amplification: The impact of the incident can intensify if information is not shared between financial institutions in a timely manner or if incorrect information is disseminated, causing critical operations to malfunction.
- Systemic event: At this stage, the attack causes a significant disruption or destabilization of the entire financial system. The economic and financial consequences that could compromise the stability and operation of the sector are then analyzed.

Figure 3 – Systemic cyber risk model



Source: ESRB, 2020

The analysis conducted by the ESRB highlights how a major cyber event can produce systemic effects, affecting the overall stability of the financial system. The study shows that the macroprudential tools available today have not been designed to manage large-scale cyber-attack scenarios and therefore show limited margins of effectiveness.

The speed and scale with which a cyber incident can propagate between interconnected institutions make it necessary to develop specific tools for the prevention and management of systemic cyber risk.

In this context, authorities are called upon to strengthen their skills in risk prevention and management and strengthen their capacities in rapidly identifying vulnerabilities, effectively coordinating response actions and reducing the potential contagion effect between institutions and financial infrastructures.

Cooperation between supervisory and governance bodies becomes an essential element to ensure consistent and timely interventions.

The ESRB suggests the creation of a European coordination framework to improve the digital resilience of the financial system and foster a clear and continuous flow of information between the different competent authorities.

This proposal is divided into three main guidelines:

Recognize systemic cyber risk among the operational objectives of the European macroprudential policy for the overall stability of the entire system;

- Enhance analysis and surveillance tools, developing vulnerability indicators and stress tests capable of realistically representing the transmission of a cyber shock;
- Develop specific measures to contain the spillover and ensure the business continuity of essential financial services even in protracted crisis scenarios.

The study published by ESMA (Operational and Cyber Risks in EU Financial Markets: Measurement and Stress Simulation, ESMA, 2025) offers a significant contribution to the consolidation of the empirical and quantitative dimension of European macroprudential supervision.

The document introduces an innovative approach in terms of IT risk measurement and simulation of stress scenarios and demonstrates how cyber events can affect the overall stability of the financial system.

The analysis starts from the assumption that cyber risk should not only be evaluated in terms of probability but also in relation to the ability to propagate along operational, technological and interinstitutional networks. Traditional operational risk management tools, while providing a useful framework, fail to fully represent the complexity and non-linearity of digital interconnections.

To overcome these critical issues, ESMA has developed an analysis model divided into three distinct dimensions: the first concerns the materiality of the shock, i.e. the assessment of the operational and financial impact that a cyber-attack can generate; the second examines the propagation channels, i.e. the mechanisms through which a single event can extend to other institutions through shared infrastructures or common suppliers; finally, the third focuses on preventive vulnerabilities, identified thanks to simulations that make it possible to recognize in advance the weaknesses of the system and to strengthen its response capacity.

The framework described above was applied in the stress test conducted on the European repo market, a key sector for liquidity stability. Using data collected under the Securities Financing Transactions Regulation (SFTR), the Authority simulated a cyberattack scenario targeting one of the ten main settlement nodes, resulting in the temporary suspension of post-trading operations.

The results were eloquent: an event of this type could generate a reduction in liquidity of about 35 billion euros, equal to 6% of daily repo transactions, with peaks that, in the most severe scenarios, would exceed 16%. The analysis was then expanded with a reverse stress test, aimed at understanding the impact of an attack against smaller nodes. Also in this case, the effects are far from marginal: the estimated loss of liquidity reaches about five billion euros, confirming the fact that even a limited incident can have systemic consequences in a highly interconnected context, where technology and finance are now inseparably intertwined.

Overall, the study shows how the combination of quantitative analysis and stress testing can contribute to shaping a future in the European macroprudential framework geared towards cyber resilience.

Through simulations, in fact, it becomes possible to quantify potential economic losses and understand the dynamics and spread of cyber shock, which critical functions are involved and what factors can amplify or mitigate its effects.

This empirical and systemic approach brings IT risk management closer to the other areas of macroprudential policy, favoring its integration into the broader objective of financial stability of the European Union.

Among the various sectors, the insurance sector is among the most vulnerable, considering the losses deriving from compromises of IT systems. The complexity inherent in the actuarial assessment of cyber risk, combined with the possibility of rare events with high impact, requires the adoption of innovative techniques to support underwriting and quantitative risk management activities. Cyber risk in insurance has been widely analyzed in academic literature that distinguishes three main forms: idiosyncratic, systematic and systemic. This classification, initially proposed by studies such as those of Kaffenberger (2019) and Weber (2023), and taken up in more recent research, allows us to better understand the complex nature of this risk and its implications for the insurance market.

Idiosyncratic risks refer to cyber risks that affect individual policyholders independently. These risks can relate to internal errors in companies and are assessed using standard actuarial techniques. In this sense, reference can be made to the principle of risk pooling, according to which a risk borne by a single individual is shared among the subjects. Systematic risk mainly stems from the sharing of common vulnerabilities among multiple counterparties. This category includes risks that are distinguished by sector, by geographical area or using the same software or IT infrastructure. Systemic risk, as already mentioned, arises from local or global contagion effects within interconnected network systems. It differs from systematic risk in addition: while systematic risk depends on exogenous factors, systemic risk refers to the internal behaviour of multiple entities that, interacting within a system, produce a sequential impact.

Insurance companies, as part of their cyber risk management activities, offer not only specific coverage for cyber risks, but also assessment, consulting and prevention support services.

When offering services, insurers must analyze both individual aspects of cyber risks and the connections between different procurement partners.

In the last period, the European insurance market has recorded a significant growth in the demand for cyber policies, determined by the increase in cyber incidents - both in frequency and severity - and by a greater awareness, on the part of companies and individuals, of the need to equip themselves with adequate financial and operational protection.

Cyber policy is configured as a risk financing² tool, complementary to traditional insurance instruments, aimed at covering losses of a financial nature and promoting civil liability towards third parties.

To assess the effectiveness of the security measures adopted by an organization and, at the same time, limit exposure to risk, the impact underwriting strategy can be adopted,³ which involves assigning a rating to the quality

² Risk financing: set of financial strategies and instruments for covering costs deriving from adverse events. In the case of insurance policies, the IT risk is transferred to the insurer, who undertakes to reimburse the economic losses suffered.

³ Impact underwriting: methodology through which the risk, price and contractual conditions of an insurance policy are assessed. Originally, it was developed to assess policyholders' climate risk exposure according to a rating score assigned to determine the level of risk and establish the price and contractual terms.

of the risk, determined based on of the level of exposure of the customer, and constitutes the reference parameter for defining the price of the hedge, of the contractual terms and conditions. It is closely related to verifying the adoption of minimum requirements, such as multi-factor authentication (MFA) and Endpoint Detection & Response (EDR) solutions, for the control and management of ransomware, as well as to promote staff training and awareness.

At the same time, insurance companies use cybersecurity assessment procedures based on automated screening systems and standardized questionnaires, developed according to internationally recognized frameworks such as ISO 27001, NIST, ISF and the International Framework for Cyber Security and Data Protection.

These tools not only improve risk assessment but also help to raise awareness of cyber security among policyholders. In this way, the overall exposure to risk is reduced and the adoption of more appropriate coverage is promoted, designed to protect the organization from possible economic losses deriving from cyber-attacks.

The ISO/IEC 27001 certification, together with the ISO/IEC 27005 standard, attests to the adoption of an information security management system based on best practices consistent with the European regulatory framework and with the NIS2 and DORA regulations that provide a structured methodology for the identification, assessment and monitoring of risk in risk management procedures in different organizational contexts.

Banks and insurance companies play a strategic role in IT risk management, encouraging the adoption of more robust valuation models and the transfer of residual risk to the insurance market, following the verification of the organization's security posture and compliance with applicable standards. The decision to subscribe to a cyber policy depends not only on the level of the premium, but also on the perceived value of the coverage (value for money), influenced by the degree of information and awareness of the potential insured. The lack of trust, the absence of uniform standards, the complexity of the products and services provided, together with the lack of contractual transparency can increase uncertainty about the real perception of risk and reduce the propensity of households and businesses to insure.

At an international level, the IAIS (International Association of Insurance Supervisors) Global Insurance Market Report 2024 highlighted how cyber threats are now among the main operational risk factors for the insurance sector. The increase in claims related to cyberattacks has prompted companies to review their underwriting models and premium calculation criteria. The report reads:

"Cyber threats involve malicious attacks on computer systems... leading to increased claims for cyber insurance and higher underwriting risks, requiring enhanced cybersecurity measures and pricing adjustments."

The survey on cyber risk coverage policies, published by IVASS in October 2023, highlighted a growing diffusion of cyber coverage in Italy, among SMEs, businesses and households. The fifty policies analyzed offer increasingly extensive guarantees: not only coverage of direct financial losses and civil liability towards third parties, but also technical assistance services, legal protection and post-accident consultancy. The coverage identified for SMEs is divided into:

- Stand-alone *policies*, designed to cover cyber risk;
- Modular policies, i.e. contracts that offer a wider range of guarantees for the customer structured in modules that can be combined with each other, within which it is possible to insert specific extensions relating to IT risk.

- *Stand-alone cyber policies* aimed at small and medium-sized enterprises were created with the aim of protecting the assets of the insured – whether it is an entrepreneur, a professional or a company – from the costs and damage caused by an attack on the company's IT systems.

These are insurance instruments that cover, in addition to the costs for the restoration of compromised data and digital infrastructures, also the compensation due to injured third parties (so-called civil liability) and the legal costs related to the management of disputes that may arise. Some companies insure other cases, such as civil liability for reputational damage to third parties, intellectual property infringements, costs incurred for the intervention of experts aimed at containing the damage or eliminating it, costs incurred by third parties for business interruption, financial and image damage and for inadequate technical solutions adopted by the insured for the use of advanced electronic signature (AES).

A significant increase has been recorded for ransomware attacks, types of malwares that act to block or compromise an organization's computer systems, altering their integrity and making them inaccessible.

In this way, the attacker obtains the power of blackmail over the affected company, which often finds itself having to choose between paying the requested sum and the definitive loss of its information. Coverage is provided on condition that the subscription of the policy is kept confidential and that any request for extortion is promptly communicated to the Authorities.

To access coverage, insurance companies require companies to comply with minimum insurability requirements, i.e. to have operated in conditions of preventive safety and to allow them to operate with an accurate analysis of the risk, the technologies adopted and the level of knowledge of employees and safety managers.

The main conditions required include:

- i) presence of IT devices suitable for the prevention of cyber-attacks;
- ii) frequent installation and updating of adequate antivirus systems;
- iii) frequent backup of computer systems;
- iv) adequate internet connection to allow technical repairs even remotely;
- v) signing of a contract for technical assistance and maintenance of hardware and software systems.

In addition, the report shows that insurance policies intended for private customers are still limited. The services offered include protection against economic losses in the event of theft or cloning of cards (credit, debit or prepaid), digital identity theft and fraudulent online purchases.

Generally, there are additional clauses that may concern compensation for copyright or copyright infringement, invasion of privacy and unlawful dissemination of content. However, coverage is guaranteed only if the dissemination of personal data takes place by electronic devices or computer networks.

In conclusion, we can once again confirm how the growing interconnection between operators and market infrastructures highlights the systemic nature of cyber risk. A common vision, based on shared models of analysis and stress testing, together with effective cooperation between supervisors, can ensure a timely and efficient response to such events that undermine confidence in the economic system and its resilience.

4. Data on the spread of cyber risk in the insurance sector

In recent years, the cyber risk insurance market has shown significant growth, driven by the increase in digital attacks, the intensification of technological innovation processes and the constant updating of the regulatory framework on data protection.

Among the main data providers is Bitsight, a company founded in 2011 and specialized in the analysis of cybersecurity security performance through "cyber risk quantification" mechanisms that assign a numerical score to organizations.

Information on IT security plays a role of primary importance in many respects. On the one hand, the transmission of increasing volumes of data between insurance companies and corporate customers is destined to intensify in parallel with the growing complexity of the valuation models adopted by financial intermediaries.

On the other hand, variables related to sustainability, climate risks and emerging geopolitical risks are increasingly integrated into assessment models, with the aim of assessing the overall stability of the financial system.

It follows that the protection and protection of data provided by companies becomes an essential condition to ensure business continuity and the safeguarding of the company's reputation.

In this perspective, the ability of insurance companies to mitigate cyber risks is a determining factor in terms of competitiveness and secure and efficient management of sensitive data.

Bitsight collects information, in compliance with national and international regulations, related to data breaches and other cybersecurity incidents from a wide range of sources, including news from major news outlets and reports from regulators.

In addition, the platform collects data from public and third-party sources by assessing the presence of malware and analyzing network configurations and expired security certificates.

In detail, these data are divided into:

- Public data: such as domains, TLS/SSL certificates, information about their vulnerabilities and information visible to the public without the need to access internal systems directly;

- Passive monitoring and data provided by third-party partners: It does not require access to a company's internal data, as monitoring is ensured through the detection of public sources and the contribution of partners.

The data made available by the company relates to different types of security incidents, including data breaches, system intrusions, ransomware, phishing and other related events. These events are distinguished, depending on their severity, into four categories:

- Informational: signal-only events, which do not directly impact safety. Their purpose is to identify system vulnerabilities or configurations to be improved;
- Minor: low-severity incidents, such as phishing attempts or malware infections;
- Moderate: Medium-severity events that could compromise corporate security;
- Severe: Incidents that directly involve sensitive user data.

The score assigned is updated daily and reflects changes in an organization's security posture, gaps, and vulnerabilities in real-time to identify the best measures to take to manage risk.

The security rating in Bitsight reflects an organization's security posture based on the data collected. The score is expressed on a scale of 250 and 900, and generally, higher values indicate a better security posture and lower risk. The risk vectors analyzed represent aspects of the technological infrastructure and security practices adopted. Below is a list of the main risk vectors:

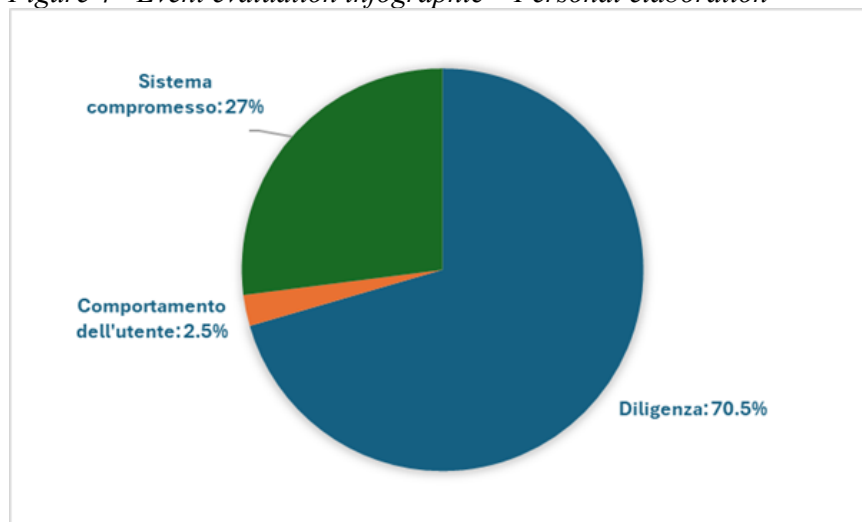
Table 3 - Main risk vectors in Bitsight – Authors' processing

Malware: Detection of active and recurring infections (e.g. ransomware or Trojans) that can have a material impact on risk assessment.
Botnet: The presence of compromised devices that are connected to or controlled by botnet networks.
E-mail compromise: Signs of exposure to phishing campaigns, spoofing, or sending messages containing malicious links.
Network and infrastructure configuration: Check for weak settings, outdated protocols, or unsecured ports that could facilitate an attack.
Certificate security policies: Use of SSL/TLS certificates that are non-compliant, insecure, or no longer valid.
Vulnerability exposure: Presence of outdated software, failure to release patches, or exposure to public vulnerabilities.
Past breaches: Analysis of breaches that have already occurred that may affect the current risk profile.

The safety score is determined through an algorithm that evaluates the data that can be observed from the outside, distinguishing them by configuration and type of event, assigning a weighted evaluation as follows:

- Compromised systems = 27%
- Due diligence = 70.5%
- User Behaviour= 2.5%
- Public disclosures= considered only in the case of material events.

Figure 4 - Event evaluation infographic – Personal elaboration



In addition to the main risk vectors, the assessment considers additional categories:

- **System vulnerabilities:** compromised network configurations or exposure to insecure services (e.g. internet).
- **Security incidents:** Malware, botnets, phishing, and related malicious activity.
- **Certificate management:** Proper use and proper renewal of digital certificates.
- **Previous breaches:** A study of past cyberattacks.
- **Compromised systems:** identification of the hosts involved by number and type.
- **Event duration:** The time between the first and last detections in a system compromised by a cyber-attack is recorded.
- **Due diligence:** this consists of verifying that the organization has taken all the necessary measures to prevent possible attacks, considering the main risk vectors.

The final score is updated regularly based on the collection of new data, usually on an annual basis.

However, once the monitoring by the company has been activated, the rating value may change in real time, or in any case daily, in relation to the emergence of new attacks or the detection of new vulnerabilities.

The evaluation process considers, among other things, the organization's ability to mitigate the effects deriving from an attack suffered: if the measures adopted are successful, the overall score will tend to improve.

To facilitate a correct interpretation of the score in BitSight, the relative evaluation scale is shown below.

Each level of risk is assigned a rating expressed in letters (from A to F, from excellent to critical) and a numerical score on a scale from 250 to 900, in which 250 represents the lowest level of security performance and 900 the highest. A company's security rating is determined by aggregating information from all risk vectors related to the individual organization examined. Safety scores are expressed in 10-point increments, rounded down.

For example, an overall rating of 740 represents a score between 740 and 749. Similarly, an actual score of 735 is represented as 730.⁴

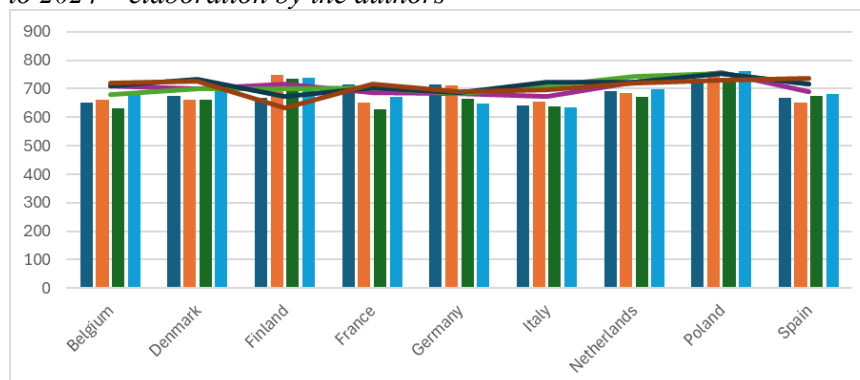
⁴ BitSight: Ratings Methodology. How BitSight Security Ratings are calculated. help.bitsighttech.com

In the next paragraph, an analysis of the data provided by BitSight will be presented, to offer an overview of the distribution of the cyber security rating of financial companies divided by country. For reasons related to the compliance clauses established by the data provider, it is not possible to disclose the names of the sampled companies.

5. Cybersecurity survey: evidence on a sample of banking and insurance companies

To verify the dynamics described in the field, we use data extracted from a sample of twenty-nine companies divided between banks and insurance companies on the European continent, whose names, according to agreements with Bitsight, cannot be disclosed. The aim is to highlight differences in resilience and exposure to cyber risk, presenting the results through Excel graphs to support the discussion.

Figure 5 – Geographical distribution of the security rating from 2017 to 2024 – elaboration by the authors



The analysis conducted highlights significant differences in cyber risk management between the European countries considered. Spain and Italy have a lower distribution than the other countries observed, with fluctuations that highlight structural fragilities and still partial resilience. Finland and Poland, on the other hand, show higher and more consistent levels, a sign of a more integrated approach to security with long-term planning.

Overall, a heterogeneous picture emerges, in which the robustness of governance structures and the dissemination of good practices directly affect the stability of results. This variability is a critical element for the insurance sector, which is called upon to operate in a context characterized by high complexity in the assessment of this risk due to the absence of internationally shared standards.

6. *Strengths and weaknesses that emerged*

The financial sector is undergoing profound transformation. The evolution of the European and national regulatory framework has strengthened the culture of digital resilience, offering companies a more structured set of obligations, tools and methodologies. Banking and insurance companies are becoming more sensitive to this risk, which has become central to decision-making processes and governance models. Research and macroprudential authorities are also redefining their econometric models, updating their econometric models, integrating factors such as economic soundness, the level of financial globalization and political instability. These elements are increasingly recognized as an integral part of the systemic nature of cyber risk and, its inclusion in systemic risk models and complex scenario analyses is aimed at strengthening the overall stability and resilience capacity of the financial system. Despite this growth path, cyber risk assessment requires greater commitment.

It is necessary to ensure greater regulatory uniformity, a more widespread digital culture, shared assessment tools and closer collaboration between all the players in the financial system.

Only through common cooperation will it be possible to ensure the construction of a financial ecosystem capable of withstanding the challenges of digital. Investing in cybersecurity will mean not only protecting the business for insurance companies but also reducing the spread of risk and taking advantage of the opportunities offered by digital transformation.

Final Conclusions

Climate change and sustainability are playing an increasingly important role in the assessment of financial stability and in the supervision activity within the European regulatory framework. This thesis has analyzed climate risks and ESG dimensions from an integrated perspective, combining theoretical and regulatory analysis with a comparative empirical survey of banks and insurance companies operating in the European context. The main objective was to understand the extent to which sustainability factors are associated with the performance and risk profile of financial intermediaries, and how these relationships are influenced by specific sector and institutional characteristics.

The first part of the work highlighted how climate change can no longer be considered only as an external environmental issue and that therefore it must be considered as a structural source of risk, capable of affecting the stability of markets, the allocation of capital and the resilience of economic systems. The analysis of the regulatory and methodological framework highlighted the growing role of European and international institutions in integrating ESG profiles into disclosure requirements and, more generally, in including environmental, social and governance dimensions in decision-making processes, strategic planning, internal control systems and supervisory expectations, as well as in risk management practices. The empirical analysis developed in Chapter 3 provides a more nuanced picture than would emerge from a simply linear reading of the relationship between ESG and performance. The results show that the relationship between ESG variables and performance is neither automatic nor uniform across sectors. For banks, the aggregate ESG score appears to be more informative in nature than ROE and ROA, while the disaggregated analysis of the pillars suggests that the social component is the most consistent and statistically relevant to explain the profitability outcomes obtained, suggesting that in the banking sector,

stakeholder-oriented practices and more generally the social dimension may constitute the most immediate channel through which sustainability is reflected on company performance. On the other hand, the situation that emerges from the insurance sample is different, for which there is no solid evidence to support a linear relationship between ESG indicators and performance. Neither the aggregate ESG score nor the individual pillars show a stable and statistically significant association with ROA and ROE. This divergence between banks and insurance companies is one of the most relevant results of the thesis. It suggests that the financial materiality of sustainability factors depends to a significant extent on sectoral business models, balance sheet structures, liability profiles, regulatory constraints and different risk transmission channels. The contribution of the paper, therefore, does not consist in supporting the existence of a generalized positive relationship between ESG and financial performance, but rather in showing that this relationship is selective, mediated and highly dependent on the sector considered. Empirical evidence also indicates that the aggregate ESG score alone is not sufficient to capture the complexity of sustainability dynamics in the financial sector and that the approach based on the separate analysis of individual pillars has offered significant evidence only in the case of banking intermediaries.

The thesis also draws attention to the importance of the broader macro-financial and institutional environment. The inclusion of geopolitical risk in robustness analyses confirms that financial intermediaries operate in an environment where sustainability-related variables are intertwined with broader sources of uncertainty and, the different results observed across sectors suggest that external shocks and climate-related pressures are absorbed and transmitted through different institutional and organizational structures. This is particularly significant in the European context, where climate and ESG dimensions are increasingly integrated into prudential and supervisory frameworks, but their effective translation at the corporate level continues to depend on sector-specific frameworks and distinct adjustment mechanisms. From a scientific point of view, the thesis contributes to the literature in three main directions. Firstly, it adopts a comparative approach that considers both banks and insurance companies, thus overcoming the predominantly banking approach that has characterized much of the existing literature. Second, it combines the use of the aggregated ESG score with a disaggregated analysis of its pillars, showing that the information content of ESG variables changes significantly when environmental, social and governance dimensions are examined separately.

Thirdly, it inserts empirical evidence into a broader regulatory and methodological reflection on the measurement of climate and ESG risk, thus linking results at the company level with the evolution of supervisory expectations and with financial governance increasingly oriented towards sustainability. However, it remains appropriate to recognize some limitations. The availability and comparability of ESG data remains imperfect, and this criticality is particularly evident in the insurance sample. In addition, the time horizon considered, while adequate to capture the recent intensification of ESG regulatory pressures and developments, may still be too short to fully observe the long-term sustainability effects. More generally, accounting performance measures such as ROA and ROE may not be sufficient to intercept all the channels through which the climate and ESG dimensions affect the financial condition of intermediaries. These limitations do not reduce the relevance of the results, but they suggest caution in their interpretation and indicate the need for further refinement in future empirical research. Consequently, several possible future directions emerge from the thesis that may concern the use of dynamic panel methodologies, which would allow to grasp more explicitly the persistence of the effects, between the different dynamics.

A second concerns the measurement of sustainability itself: the comparison of ESG scores processed by different providers could help to understand to what extent the empirical results depend on the specific rating methodologies adopted. A third research direction could extend the analysis to a broader comparison between countries and jurisdictions, so as to verify whether the differentiated effects observed in the European context reflect a more general structural model or are, at least in part, the product of the peculiarities of the European regulatory framework, considering the interaction between climate risks, ESG governance and operational resilience - including the cybersecurity dimension examined in the last chapter - the resilience of financial intermediaries, which increasingly depends on the ability to jointly manage environmental, technological and systemic vulnerabilities. Overall, it shows how sustainability can no longer be read as a merely reputational or ethical addition to financial intermediation but becomes an integral part of the institutional, strategic and regulatory architecture within which financial intermediaries operate. Its financial implications, however, are neither immediate nor uniform.

The evidence presented suggests that the climate and ESG dimensions take on a different weight depending on the sectors, indicators considered and institutional characteristics, thus contributing to a more realistic understanding of sustainable finance policies, in which the transition to a more resilient financial system must not depend only on the commitment in ESG terms but on the concrete ways in which sustainability is incorporated into governance, risk management and supervisory practices.

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