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Climate Strategies and Sustainability Pathways of Italian Small and Medium-Sized Enterprises

Vera Palea *et al*

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Vera Palea
Department of Economics and Statistics
University of Turin
Torino, Italy

Mascia Bedendo
Department of Management (DiSA)
University of Bologna
Bologna, Italy

Gloria Fiorani
Department of Management & Law
Tor Vergata University of Rome
Roma, Italy

Silvia Gordano
Department of Economics and Statistics
University of Turin
Torino, Italy

Andrea Caccialanza
Department of Management (DiSA)
University of Bologna
Bologna, Italy

Chiara Di Gerio
Department of Management and Law
Tor Vergata University of Rome
Roma, Italy

Cristina Gianfelici
Venice School of Management
Ca' Foscari University of Venice
Venezia, Italy

Lucrezia Macigno
Guglielmo Tagliacarne
Centro Studi delle Camere di Commercio
Roma, Italy

Sarfraz Nazir
Institute of Management
Sant'Anna School of Advanced Studies
Pisa, Italy

Lino Cinquini
Institute of Management
Sant'Anna School of Advanced Studies
Pisa, Italy

Lorenzo Dal Maso
Department of Management (DiSA)
University of Bologna
Bologna, Italy

Giulio Caldarelli
Department of Management
University of Turin
Torino, Italy

Giorgio Battaglia
Department of Economics and Statistics
University of Turin
Torino, Italy

Riccardo Camilli
Department of Management and Law
Tor Vergata University of Rome
Roma, Italy

Emanuele Doronzo
Department of Management and Law
Tor Vergata University of Rome
Roma, Italy

Michele Lemme
Department of Economics and Statistics
University of Turin
Torino, Italy

Aline Miazza
Department of Economics and Statistics
University of Turin
Torino, Italy

Annalisa Pancani
Institute of Management
Sant'Anna School of Advanced Studies
Pisa, Italy

Giacomo Pigatto
Institute of Management
Sant'Anna School of Advanced Studies
Pisa, Italy

Francesco Scarpa
Venice School of Management
Ca' Foscari University of Venice
Venezia, Italy

Marco Pini
Guglielmo Tagliacarne
Centro Studi delle Camere di Commercio
Pisa, Italy

Gian Luca Tassinari
Department of Management (DiSA)
University of Bologna
Bologna, Italy

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- Chapter 1: Palea V. (University of Turin, principal investigator and team leader), Cinquini L. (Sant'Anna School of Advanced Studies, principal investigator), Pigatto G. (Sant'Anna School of Advanced Studies), Nazir S. (Sant'Anna School of Advanced Studies)
- Chapter 2: Fiorani G. (Tor Vergata University of Rome, principal investigator), Bedendo M. (University of Bologna), Caldarelli G. (University of Turin), Camilli R. (Tor Vergata University of Rome)
- Chapter 3: Palea V. (University of Turin, principal investigator and team leader), Cinquini L. (Sant'Anna School of Advanced Studies, principal investigator), Gianfelici C. (Ca' Foscari University of Venice), Caccialanza A. (University of Bologna)

- Chapter 4: Fiorani G. (Tor Vergata University of Rome, principal investigator), Dal Maso L. (University of Bologna, principal investigator), Di Gerio C. (Tor Vergata University of Rome), Macigno L. (Centro Studi delle Camere di Commercio Guglielmo Tagliacarne)
- Chapter 5: Palea V. (University of Turin, principal investigator and team leader), Gordano S. (University of Turin), Pancani A. (Sant'Anna School of Advanced Studies), Tassinari G. (University of Bologna), Miazza A. (University of Turin), Lemme M. (University of Turin), Battaglia G. (University of Turin), Migliavacca A. (University of Turin), Scarpa F. (Ca' Foscari University of Venice)
- Chapter 6: Pini M. (Centro Studi delle Camere di Commercio Guglielmo Tagliacarne, principal investigator), Macigno L. (Centro Studi delle Camere di Commercio Guglielmo Tagliacarne)
- Chapter 7: Palea V. (University of Turin, principal investigator and team leader), Cinquini L. (Sant'Anna School of Advanced Studies, principal investigator), Pigatto G. (Sant'Anna School of Advanced Studies), Caccialanza A. (University of Bologna), Camilli R. (Tor Vergata University of Rome), Caldarelli G. (University of Turin), Gianfelici C. (Ca' Foscari University of Venice).

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Contents

Notes on Contributors

Giorgio Battaglia is a research bursary holder at the Department of Economics and Statistics, University of Turin. He holds a master's degree in Statistics from the University of Turin.

Mascia Bedendo is Professor of Finance in the Department of Management, University of Bologna. She previously held academic positions at Audencia Business School, Bocconi University, and Imperial College London. Her research output spans credit risk, credit rating agencies, social norms and corporate policies, and climate finance.

Andrea Caccialanza is a research fellow at the Department of Management of the University of Bologna. He holds a Ph.D. from the Agrisystem Doctoral School at Università Cattolica del Sacro Cuore (Italy). His research interests include sustainability reporting, sustainable transition in SMEs, and the assessment of social impacts in mega-projects, with published peer-reviewed articles in international journals.

Giulio Caldarelli is an Assistant Professor of Accounting at the University of Turin. His research focuses on emerging technologies and their impact on corporate sustainability, with a particular emphasis on SMEs and blockchain-based solutions. As part of his third mission activities, he is committed to building connections between fintech companies, academia, and young graduates.

Riccardo Camilli is a research fellow in Accounting at the University of Rome Tor Vergata (Italy). His main research interests pertain to

accounting judgment and decision-making, as well as corporate sustainability management and reporting. His works have been published in reputable international journals, such as *Accounting Forum* and *Production, Planning & Control*. He is a member of the Academy of Management.

Lino Cinquini is Full Professor of Management Accounting and Business Administration and the Director of the Institute of Management, Sant'Anna School of Advanced Studies of Pisa. His research areas are Management Accounting, Cost Management, Performance Measurement, and Business Reporting. He is currently a Research Board Member of the Chartered Institute of Management Accountants (CIMA: UK) and Chair of the Scientific Committee of the Italian Foundation for Business Reporting (OIBR). He is a member of the research team of the GRINS project, Spoke 1—Firms "Sustainable Value Creation."

Emanuele Doronzo is a research fellow in Public Accounting, Public Finance, and Sustainable Finance at the University of Rome Tor Vergata. He holds a Ph.D. in Economics and Management of Sustainability and Innovation from LUM University. His research focuses on sustainable finance, impact investing, and ESG practices, with publications in journals such as *Business Strategy and the Environment* and *Corporate Social Responsibility and Environmental Management*.

Gloria Fiorani is Professor of Strategies for Sustainable Development and Sustainability Reporting at the Department of Management and Law. Her research focuses on public management, social innovation, CSR, and sustainability strategies. She is the Director of the second-level Master MARIS in Reporting Innovation and Sustainability and of the first-level Master MEMIS in Economics Management and Social Innovation. She is the Coordinator of the Committee for the implementation of the University Mission and Vision for sustainable development. She is principal investigator of the GRINS project, Spoke 1—Firms "Sustainable Value Creation" for the Tor Vergata Unit.

Chiara Di Gerio is a research fellow at the Department of Management and Law, Tor Vergata University of Rome. Her research interests include sustainability reporting, ESG performance measurement, and public value co-creation. She is a member of national working groups focused on promoting education for sustainable development and improving sustainability reporting practices.

Cristina Gianfelici is an Associate Professor at the Venice School of Management of Ca' Foscari University of Venice. She holds a Ph.D. in Economics and Management of Public Sector Organizations from the University of Salerno. Her research focuses on financial and non-financial reporting, planning and control systems, and sustainability in public and private organizations. She is a Chartered Accountant.

Silvia Gordano is a research fellow at the Department of Economics and Statistics, University of Turin. She holds a Ph.D. in Business and Management from the University of Turin. Her research focusing on corporate sustainability and accounting has been published in high-quality journals, including *Sustainability Accounting and Management Policy Journal* and *Business Strategy and the Environment.*

Michele Lemme is a research fellow at the Department of Economics and Statistics, University of Turin. He holds a Ph.D. in Institution, Economics and Law from the University of Turin and has an international background, including experience as a lecturer in China. His research interests focus on the interplay between legal systems and sustainable development.

Lucrezia Macigno is a researcher employed in the research center G. Tagliacarne. Her academic interests intersect in areas related to international policy, economic studies, and environmental sustainability.

Lorenzo Dal Maso is an Associate Professor of Accounting at the University of Bologna, where he teaches International Accounting Standards and Financial Analysis. He is the Coordinator of the Master's Degree Program in Economics, Consulting & Professions. His main research interests focus on business valuation and on the impact of sustainability practices on firms' fundamentals. His work has been published in leading international journals, including the European Accounting Review, Journal of Financial Stability, Contemporary Accounting Research, Small Business Economics, Journal of Accounting & Public Policy, and Journal of Business Ethics. He serves on the editorial boards of several respected international journals, including The International Journal of Accounting, Accounting Forum, Accounting in Europe, and the European Accounting Review.

Aline Miazza is a research fellow at the Department of Economics and Statistics, University of Turin. She holds a Ph.D. in Innovation for the

Circular Economy from the University of Turin. Her research focuses on the inclusion of environmental factors in the investment strategies of financial intermediaries and climate-related risk management, with publications in the *International Review of Financial Analysis* and *Journal of Environmental Management*.

Sarfraz Nazir is a research fellow at Sant'Anna School of Advanced Studies in Pisa. He holds a Ph.D. in Business Administration and Management. His areas of expertise are in the circular economy, sustainable development, corporate governance, operational management, system dynamics, and board games.

Vera Palea is Full Professor of Corporate Finance and Accounting at the Department of Economics and Statistics, University of Turin. Her research covers financial reporting, corporate governance, and sustainable finance, with a specific focus on climate-related risks. Among other positions, she is a member of the Intergovernmental Working Group on International Standards of Accounting and Reporting at UNCTAD and chairs the working group on climate change at the Italian Foundation for Business Reporting. She is principal investigator of the GRINS project, Spoke 1—Firms "Sustainable Value Creation."

Annalisa Pancani is a Ph.D. candidate in Management and a Research fellow at Sant'Anna School of Advanced Studies in Pisa. With a background in financial accounting, she has gained international experience through a traineeship at the European Central Bank. Her research interest focuses on climate and environmental risk management, particularly in the context of banks and financial institutions.

Giacomo Pigatto is an Assistant Professor at Sant'Anna School of Advanced Studies in Pisa. His research focuses on accounting for biodiversity and sustainable development. His work has been published in high-ranked international journals such as *Accounting Forum*, *Accounting, Auditing & Accountability Journal*, *Sustainability Accounting, Management, and Policy Journal*, *Journal of Accounting & Organizational Change*, and *Meditari of Accountancy Research*. He is a member of the National Biodiversity Future Center (NBFC).

Marco Pini is Chief Economist at the Centro Studi delle Camere di Commercio Guglielmo Tagliacarne (Rome, Italy) and Adjunct Professor at LUISS Guido Carli University and LUISS Business School (Rome,

Italy). His research focuses on entrepreneurship, family business, internationalization, digital and green transitions, and bank–firm relationships. His work has been published in several high-impact international journals.

Francesco Scarpa is currently an Assistant Professor in Tenure-Track at the Venice School of Management of Ca' Foscari University of Venice. Author of publications in international academic journals, he has participated as a speaker at many international and national congresses. His main research interests include corporate sustainability, non-financial reporting, corporate tax planning, and ESG rating.

Gian Luca Tassinari is an Assistant Professor in Corporate Finance at the University of Bologna. He has authored articles published in international scientific journals, including *Quantitative Finance*, *International Journal of Theoretical and Applied Finance*, *Journal of Portfolio Management*, *Annals of Operations Research*, and *Computational Management Science*, and he is a co-author of the *Handbook of Heavy-Tailed Distributions in Asset Management and Risk Management*.

Abbreviations

AMELIA	Data platform for the transfer of knowledge and statistical analysis
ATECO	Classification of economic activities adopted by ISTAT
BIS	Bank for International Settlements
CATI	Computer-Assisted Telephone Interviewing
CAWI	Computer Assisted Web Interviewing
CG	Corporate Governance
CNDCEC	National Council of Chartered Accountants and Accounting Experts
CONSOB	The regulatory authority in charge of supervising the Italian securities markets
COP	Conference of the Parties
COVIP	Italian Pension Funds Supervisory Commission
CRD	Capital Requirements Directive
CRR	Capital Requirements Regulation
CSDDD	Corporate Sustainability Due Diligence Directive
CSR	Corporate Social Responsibility
CSRD	Corporate Sustainability Reporting Directive
DIPE	Department for the Planning and Coordination of Economic Policy
DNF	Non-financial statement introduced by the NFRD
EBA	European Banking Authority
EC	European Commission
ECB	European Central Bank
EFRAG	European Financial Reporting Advisory Group
EIB	European Investment Bank
EIOPA	European Insurance and Occupational Pensions Authority
EMS	Environmental Management Systems

ESEF	European Single Electronic Format
ESG	Environmental, Social and Governance
ESMA	European Securities and Markets Authority
ESRS	European Sustainability Reporting Standards
EU	European Union
FNC	National Foundation of Chartered Accountants
GDP	Gross Domestic Product
GHG	Greenhouse Gas
GRINS	Growing Resilient, Inclusive and Sustainable project
HR	Human Resources
IBIPs	Insurance-Based Investment Products
ICAAP	Internal Capital Adequacy Assessment Process
IEA	International Energy Agency
ISTAT	Italian National Institute of Statistics
IVASS	Institute for the Supervision of Insurance
KPI	Key Performance Indicator
MEF	Ministry of Economy and Finance
MUR	Ministry of University and Research
NFRD	Non-Financial Reporting Directive
NGFS	Network for Greening the Financial System
OECD	Organization for Economic Co-operation and Development
PAB	Paris-Aligned Benchmark
PNRR	Italy's National Recovery and Resilience Plan
PRI	Principles for Responsible Investment
RRF	Recovery and Resilience Facility
RRP	Recovery and Resilience Plan
SD	Sustainable Development
SDG	Sustainable Development Goals
SME	Small and Medium-sized Enterprises
TCFD	Task Force on Climate-related Financial Disclosures
TNFD	Task Force on Nature-related Financial Disclosures
UN	United Nations
WEF	World Economic Forum

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CHAPTER 1

Advancing the Sustainability Agenda in Small Businesses

Abstract This introductory chapter examines the growing relevance of sustainability for small and medium-sized enterprises (SMEs) and the need to integrate environmental, social, and economic dimensions into business activities. It introduces key conceptual frameworks, outlines a taxonomy of climate-related risks, and discusses their implications for SMEs, highlighting both structural constraints and emerging opportunities associated with green finance, supply chains, and regulation.

Keywords SMEs • Corporate sustainability • ESG • Climate risk • Triple bottom line • Green transition

This introductory chapter addresses the increasing relevance of sustainability for small and medium-sized enterprises (SMEs), emphasizing the importance of integrating ecological, social, and economic dimensions into business operations. Against the backdrop of escalating global environmental challenges, including climate change and biodiversity loss, SMEs are increasingly pressured to adopt sustainable strategies. The chapter begins by outlining foundational concepts such as the Triple Bottom Line, Corporate Social Responsibility, and Environmental, Social, and Governance frameworks. It then presents a taxonomy of climate risks, elucidating their implications for SMEs. While SMEs are crucial actors in

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advancing sustainable development, they face unique barriers due to limited financial, technical, and organizational resources. Nevertheless, opportunities exist in areas such as green finance, supply chain integration, and regulatory compliance.

1.1 The Sustainability Challenge

Global temperatures continue to soar, consistently surpassing previous records (Intergovernmental Panel on Climate Change (IPCC), 2023). Simultaneously, biodiversity is declining at alarming rates across all observed species groups (International Union for Conservation of Nature (IUCN), 2024), and numerous ecosystems, whether terrestrial, freshwater, or marine, are teetering on the edge of collapse, with some already having crossed that threshold (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2019). Social and economic inequalities are intensifying both within and between nations and generations. Democratic institutions, which have underpinned much of the global order since World War II (WWII), are increasingly under strain. Meanwhile, renewed and emerging geopolitical tensions are complicating efforts to coordinate responses to these pressing global challenges (Roubini, 2022). In this bleak scenario, market dynamics are alternately blamed for exacerbating the crisis and praised as potential saviors of the planet (Bonaiuti, 2014).

On one side, the post-WWII neoliberal capitalist framework, solidified after the fall of the Soviet Union, has been criticized for ignoring the adverse externalities associated with its investor-focused, shareholder-first approach. These include the overuse of natural resources, environmental degradation, animal exploitation, exploitative labor practices, greenhouse gas (GHG) emissions, systemic discrimination, and the disruption of local communities, harms for which economic agents are rarely held responsible (Bebbington & Larrinaga, 2014; Dechow, 2023; Unerman et al., 2018). On the other side, businesses, investors, and other economic stakeholders are increasingly viewed as essential contributors to solving these global issues. Innovations in technology and organizational practices, sustainable solutions, fairer business models, and more inclusive governance structures are often highlighted as critical pathways toward a more just and sustainable future (United Nations (UN), 1999). Despite their differences, both perspectives converge on one point: economic actors, whether as part of the problem or the solution, undeniably play a pivotal role.

1.1.1 Sustainability in Businesses

It is now impossible to browse a company's website or official reports without encountering references to "sustainability," "ESG," or "sustainable development." Over the past two decades, there has been a significant increase in the use of sustainability terms and in the implementation of sustainable strategies.

It is common to associate the beginning of the sustainability movement with the Brundtland Report *Our Common Future* by the World Commission on Environment and Development in 1987. In the report, sustainable development (SD) is defined as the ability to meet the demands of present generations without compromising the needs of future generations. This involves integrating both short and long-term social, economic, and environmental objectives, which are interdependent mechanisms of human progress (Brundtland, 1987).

Twenty-eight years after the Brundtland report, the UN launched the Agenda 2030 and the 17 Sustainable Development Goals (SDGs), marking another milestone in the SD movement. Furthermore, in 2018, the European Commission (EC) presented its objective of achieving net-zero GHG emissions by 2050 through a "socially fair and cost-efficient transition" (Tsiropoulos et al., 2020). Building on this vision, in December 2019, the EC adopted the European Green Deal (EC, 2019), a new growth strategy aimed at transforming the European Union (EU) into a fair and prosperous society, underpinned by a modern, resource-efficient, and competitive economy committed to climate neutrality by 2050 (Fetting, 2020).

Businesses do play a role in pursuing a more sustainable and equitable world and are facing increasing pressure from internal and external stakeholders to consider corporate performance beyond purely financial metrics (PwC, 2019; UN Global Compact & Strategy, 2019; Pigatto et al., 2024). In fact, companies are being asked to integrate sustainability into their strategies and measure, manage, and communicate social and environmental impacts through, for example, performance measurement systems, planning and control systems, accounting techniques and systems, stakeholder engagement, disclosure and communication, and assurance and certification (Hsiao et al., 2022).

The implementation of sustainability-related practices can boost competitiveness and value creation (Permatasari & Gunawan, 2023). The substantial impact of sustainability on corporate policies, operations and

performance is well established, especially as it resonates with the UN SDGs (Nazir & Capocchi, 2024; Nazir & Doni, 2024; Permatasari & Gunawan, 2023). Several studies have examined the link between sustainability-related practices and key dimensions of business performance. Permatasari and Gunawan (2023) highlight how a company's dedication to sustainability has a significant impact on brand perception and customer loyalty. Kitsis and Chen (2023) emphasize the crucial role of sustainability practices in maintaining the operational efficiency of the organization. Ngo et al. (2024) argue that internal sustainability elements such as green supply chain management and pollution control are critical for mitigating environmental risks, reducing costs, and generating profits. On the other hand, external sustainability actions, such as the development of eco-friendly products, help bolster a firm's credibility and positive reputation in the eyes of stakeholders (Hernández-Arzaba et al., 2022; Sharma et al., 2025; Wang, Heugens, and Wijen, 2024). Companies can commit to SD and significantly improve supply value chains by harmonizing internal and external sustainability initiatives (Ngo et al., 2024).

SMEs are not immune to the push toward sustainability. Even if not directly impacted by national and EU legislation (e.g., Corporate Sustainability Reporting Directive (CSRD), EU Taxonomy Regulation), SMEs will eventually be put under pressure as the legislation "trickles down." For instance, banks' lending to SMEs or larger companies whose value chains include SMEs may require specific information regarding the SME's sustainability performance to fulfill their ESG requirements. Additionally, the expectations of customers, employees, and business partners are increasingly centered on robust sustainability performance, encompassing climate and environmental management, social issues such as working conditions and modern slavery, or corporate governance practices.

Although the field of corporate sustainability is well established, the concept at times remains elusive and complex (Hart & Dowell, 2011; Hart & Milstein, 2003). Numerous corporate sustainability definitions have been presented in both academic literature and practitioners' work. For instance, Székely and Knirsch's (2005) definition emphasizes the need to balance ten different dimensions: (a) economic growth, (b) shareholder value, (c) prestige, (d) corporate reputation, (e) customer relationships, (f) product quality, (g) ethical business practices, (h) sustainable job creation, (i) value creation for all stakeholders, and (j) attention to the needs of the underserved. Some other scholars define the concept of corporate

sustainability exclusively in terms of environmental dimensions (Marshall & Brown, 2003). Conversely, Hall and Vredenburg (2003) address both the social and environmental concepts of corporate sustainability. Finally, a significant proportion of scholars concur with the definition that encompasses *economic*, *social*, and *environmental* dimensions (e.g., Bansal, 2005; Hart & Milstein, 2003). This perspective forms the foundation of the concepts of the Triple Bottom Line, Corporate Social Responsibility, and Environmental, Social, and Governance factors, which will be used throughout the book and are now briefly recalled.

Triple Bottom Line (TBL)

In the mid-1990s, John Elkington, one of the leading sustainability experts in the world and a founder of the sustainability movement, endeavored to measure sustainability through a new framework for assessing corporate performance. In his influential book *Cannibals with Forks: The Triple Bottom Line of 21st Century Business*, Elkington (1998) introduced the TBL, an approach designed to encompass environmental and social dimensions by extending beyond the calculations of classical profit and shareholder value. In particular, TBL is defined as the evaluation of sustainability across three dimensions: economic, social, and environmental (Elkington & Rowlands, 1999). Ultimately, it emphasizes the importance of balancing economic prosperity (profit), social equity (people), and the environment (planet) (Evans & Sawyer, 2010). Therefore, managing businesses from this perspective involves integrating social affairs, well-being, and environmental considerations with financial issues within a broad strategic context (González-Rodríguez et al., 2020) to create value and achieve competitive advantage (Schulz & Flanigan, 2016).

Corporate Social Responsibility (CSR)

CSR involves monitoring and limiting profit-driven behavior by stakeholders within a market economy. Beyond evaluating its own business performance, a company must also consider its broader impact on society and the environment, fulfilling responsibilities toward various stakeholders, including shareholders, employees, consumers, partners, the government, and the public (Arenas-Torres et al., 2021; Tibiletti et al., 2021). Corporate growth should not focus solely on short-term profit maximization but also contribute to social progress, allowing companies to advance SD through strong social responsibility (Lopez et al., 2022). Doukas and Zhang (2024) contend that fully integrating CSR is essential for creating a unique

and practical approach to building and developing corporate culture. These aspects can lead to product and process innovations and enable companies to achieve distinctive competitive positions and consequently enhance their economic returns. Similarly, Samet et al. (2022) state that CSR is not only a necessary response to contemporary challenges but also a vital driver of competitiveness, which helps companies maintain long-term relationships. This illustrates that CSR can be a "win-win strategy," facilitating the introduction of innovative approaches and providing a head start in SD.

Environmental, Social, and Governance (ESG)

The term ESG began gaining prominence in 2004, when the UN encouraged the financial industry to incorporate ESG considerations into investment strategies (UN Global Compact, 2004). This led to the creation of the UN Principles for Responsible Investment (PRI) in 2006. The UN PRI seeks to foster a more sustainable global financial system, with signatories committing to six voluntary principles that promote responsible investing and collaborative efforts to improve transparency. Moreover, in 2021, the Sustainable Finance Disclosure Regulation (SFDR) came into effect, directly affecting companies and their investors through their obligation to integrate ESG factors into their investment decisions and nonfinancial reporting (Martinez-Meyers et al., 2024). According to the SFDR, companies must provide a variety of ESG measures, such as GHG emissions, water and energy efficiency, waste treatment, renewable energy use, gender diversity, employee training and development, employee health and safety, human rights, product safety, bribery and corruption, transparency and anti-corruption measures, fraud, and shareholder rights.

In the past years, research on ESG has soared (Dinh et al., 2023). The most common topics revolve around the rating methodology used and the impact of ESG risk on companies' profitability and financial performance. For instance, a considerable number of studies have looked at the impact of ESG on credit risk, as expressed in terms of credit ratings, credit default swap prices, bond returns and defaults, and the cost of equity and debt.

1.2 Business Exposure to Environmental and Climate Risks

Every year, the World Economic Forum (WEF) publishes a ranking of the most relevant risks perceived by investors, nongovernmental organizations, public institutions, and civil society. The latest survey on long-term (ten-year) risks outlines that the four most severe risks all pertain to the environmental sphere: extreme weather events, biodiversity loss and ecosystem collapse, critical changes to Earth systems, and natural resource shortages (WEF, 2025). These environmental risks for the global economy have drawn the attention of the financial sector, resulting in the issuance of two important documents explaining and addressing them from a business perspective: the Task Force on Climate-related Financial Disclosures (TCFD, 2020) and the Task Force on Nature-related Financial Disclosures (TNFD, 2022). Combined, these two documents provide a clear overview of the types of environmental and climate risks businesses are exposed to.

In the following, we discuss climate risks, including *physical* and *transition*, as well as systemic risks.

1.2.1 Climate Physical Risk

Physical risks refer to the potential financial and operational impacts resulting from increasingly frequent and severe climate-related physical events. These risks can be *acute* if they arise from extreme weather events such as hurricanes, flooding, wildfires, or droughts (i.e., natural disasters), or *chronic* if they stem from long-term changes in climate patterns, including steadily rising temperatures, increasing sea levels, and more frequent or prolonged heat waves.

Physical risks can have both ongoing and sudden impacts on organizations' financial stability, disrupting operations such as logistics and supply chains and posing threats to the safety of employees and customers. Such risks may indeed affect financial performance through factors such as water availability, sourcing, and quality; food security; and extreme temperature fluctuations, which impact a firm's premises, operations, supply chains, transportation needs, and employee safety. Therefore, organizations must recognize potential climate change threats and assess their impacts on operations to initiate adaptation. Research suggests that a firm's sensitivity to physical climate risks is closely related to the extent to which its assets

and operations are exposed to near-term climate change impacts, including both direct physical effects and indirect influences on supply and demand. A lack of awareness leads to a lack of concern, and in the absence of concern, adaptation only occurs when mandated by an authority (Arnell & Delaney, 2006).

1.2.2 Climate Transition Risk

Transitioning to a low-carbon, nature-positive economy may involve extensive policy, legal, technological, and market changes to mitigate climate threats (TCFD, 2020; TNFD, 2022). Transition risk refers to the adjustment processes associated with climate transition. Depending on the nature, speed, and focus of these changes, transition risks may present varying levels of financial risk to organizations.

Reports issued by central banks and international financial institutions, such as the Bank of International Settlements, the European Central Bank (ECB), the International Monetary Fund, the Network for Greening the Financial System (NGFS), and the European Insurance and Occupational Pensions Authority (EIOPA), converge on the significant impacts that transition risks may pose to financial stability. These effects span credit, market, liquidity, operational, and systemic risks (Pointner & Ritzberger-Grünwald, 2019). For example, transition risks can increase the probability of loan defaults, risk premiums, exchange rate volatility, operating costs, and correlation risk. Concurrently, they may lead to declines in profits, sovereign bond prices, and the availability of risk-free assets. EIOPA (2014) and Battiston et al. (2017) note that although the direct exposure of various economic sectors to transition risks appears limited, the "second round effect" arising from the exposures and interconnections of financial investors could significantly amplify them. Roncoroni et al. (2021) find that systemic risk and its inherent losses remain constrained under mild shock scenarios. However, several combinations of climate policy scenarios and market conditions could pose a threat to financial stability. From another perspective, Battiston and Monasterolo (2020) demonstrate that countries with predominantly low-carbon economic activities tend to benefit from lower bond yields and spreads compared to countries with carbon-intensive economies. Thus, countries heavily reliant on fossil fuels may be further exposed to transition risks. When their economies remain carbon-intensive amid global efforts to promote decarbonization, these countries may experience higher bond spreads, which can affect their

sovereign risk and investors' portfolio performance, with potential repercussions for financial stability. Allen et al. (2020) provide evidence of the negative economic impacts of a disordered climate transition process, emphasizing substantial sectoral and infra-sectoral effects that give rise to financial stability risks.

Policy and Legal Risks

According to the TCFD, policy and legal risks are a key component of transition risks. Policy actions regarding climate change continue to evolve. Their objectives generally fall into two categories: actions aimed at mitigating the adverse effects of climate change and actions that seek to promote adaptation and resilience. Some examples include implementing carbon-pricing mechanisms to reduce GHG emissions, shifting energy use toward lower-emission sources, adopting energy-efficiency solutions, encouraging greater water-efficiency measures, and promoting more sustainable land-use practices. The risks and financial impacts associated with policy changes depend on the nature and timing of the change. Another significant risk is litigation or legal risk. In recent years, there has been an increase in climate-related litigation claims brought to courts by property owners, municipalities, states, insurers, shareholders, and public interest organizations. Reasons for such litigation include firms' failure to mitigate and adapt to climate change and inadequate disclosure regarding material financial risks. As the value of loss and damage from climate change increases, litigation risk is also likely to escalate.

Technology Risk

Technology risk refers to the potential financial and operational impacts on organizations from emerging technologies that support the transition to a lower-carbon economy, and the obsolescence of existing technologies that are carbon-intensive or inefficient. Technological advancements or innovations that support the transition to a lower-carbon, energy-efficient economic system can significantly impact organizations. For example, the development and use of new technologies, such as carbon capture and storage, will influence the competitiveness of specific organizations, their production and distribution costs, and, ultimately, the demand for their products and services from end-users. To the extent that new technology supplants older systems and disrupts some parts of the existing economic framework, winners and losers will emerge from this "creative

destruction" process. Nevertheless, the timing of technology development and deployment remains a key uncertainty in assessing technology risk.

Market Risk
Market risk refers to the potential financial losses organizations may incur as climate-related risks and opportunities become increasingly recognized and priced into markets. While the ways markets can be influenced by climate change are varied and complex, a significant aspect is the shift in supply and demand dynamics for certain commodities, products, and services, influenced by evolving market perceptions and regulatory responses to climate change.

Reputation Risk
Reputation risk refers to potential harm to an organization's brand, customer loyalty, investor confidence, or stakeholder trust resulting from perceived failures in responding to climate change. These include failures to meet stakeholder expectations on sustainability and negative media coverage related to environmental practices. Climate change has been identified as a potential source of reputational risk linked to customer or community perceptions of whether an organization is contributing to or hindering the transition to a low-carbon economy.

1.2.3 Systemic Risk

Systemic nature-related risk is the risk of widespread disruption to economic and financial systems due to the loss of critical ecosystem services or the collapse of natural systems that underpin human well-being and economic activity (TNFD, 2022). This type of risk encompasses a broader conception of climate-related risks, since it considers that ecosystems are deeply interlinked, because the collapse of one (e.g., coral reefs) can trigger cascading effects across others (e.g., fisheries, tourism, coastal protection). Moreover, many ecosystem losses are nonlinear and irreversible, meaning that once a tipping point is crossed, recovery is extremely difficult or nearly impossible. Lastly, local environmental degradation can scale up to global economic consequences (e.g., Amazon deforestation affecting rainfall patterns across South America). Therefore, systemic risks challenge traditional risk management frameworks because they are hard to quantify with conventional financial models, require cross-sectoral

collaboration and long-term thinking, and necessitate early action to avoid irreversible tipping points.

1.3 Environmental and Climate Risks in SMEs: Challenges and Opportunities

The shift toward sustainability has become a global necessity, urging organizations in all sectors and of all sizes to rethink and adjust their operational frameworks to more sustainable practices (Khattak et al., 2024; Pronti et al., 2024). SMEs, which comprise over 99% of businesses in the EU and play a significant role in employment and GDP, are central to the broader sustainability movement (Belas et al., 2024; Gyensare et al., 2024). SMEs are flexible and creative in implementing sustainable practices and business models that promote sustainable practices, such as waste reduction, efficient resource use, and embracing circular economy principles.

Nevertheless, SMEs encounter distinct challenges in integrating green practices due to limited resources and expertise, despite being quick and adaptive to environmental needs (Rehman et al., 2024). These challenges are multifaceted and stem from structural, financial, and informational constraints that limit their capacity to engage effectively in sustainability transitions. In fact, SMEs typically operate with constrained financial and human resources, which restricts their ability to invest in environmental risk mitigation strategies or adopt low-carbon technologies (OECD, 2021). This resource limitation also affects their capacity to comply with increasingly complex environmental regulations and reporting requirements. Moreover, SMEs suffer from an awareness and knowledge gap regarding climate-related risks and sustainability practices. This knowledge gap often results in uncertainty about how to assess environmental impacts or implement effective adaptation measures (EC, 2025).

SMEs face significant challenges also in terms of regulatory burdens and access to capital. Emerging legislative frameworks, such as the EU Corporate Sustainability Due Diligence Directive (CSDDD), impose new obligations on businesses to assess and manage environmental and human rights risks across their value chains. For many SMEs, meeting these requirements is particularly challenging due to limited internal capacity and the absence of dedicated compliance organizational infrastructure. Furthermore, access to green finance remains a persistent barrier. Financial

institutions often perceive SMEs as high-risk borrowers, and there is a lack of tailored financial products to support their transition to sustainable practices. This limits SMEs' ability to invest in energy efficiency, renewable energy, and other climate-resilient technologies. Also, SMEs are highly vulnerable to supply chain disruptions caused by climate-related events such as floods, droughts, and extreme weather. As integral components of larger supply networks, SMEs may also face pressure from upstream partners to meet sustainability standards, further exacerbating their exposure to environmental risks (OECD, 2021).

SMEs experience considerable pressures to enhance their sustainability performance, but they are also presented with new opportunities, such as *access to green finance* and *evolving consumer demands*, which can strengthen their competitiveness. While some small businesses may recognize this and proactively adopt sustainability principles in their businesses, many of them remain uncertain about the expectations to meet and which standards or criteria to follow. Meanwhile, SMEs tend to be more agile and flexible organizations closely connected to local economic sectors, which can give them advantages over larger entities and help facilitate sustainable operations. Caring about sustainability can help SMEs build strong supply-chain relationships with large companies, cater to green public procurement necessities, export their products, and gain access to green financing. However, while an all-encompassing strategy for sustainability is vital for businesses of any size, the degree to which SMEs succeed in adopting these practices is not fully understood.

1.4 Aim of the Book

This research book aims to generate knowledge that underpins decision-making, capacity development, and ecosystem enhancement. The ultimate objective is to transform SMEs from passive observers into proactive agents of a sustainable and inclusive transformation. SMEs are particularly vulnerable to physical and transition risks because they typically serve local markets and cannot diversify their clientele geographically (European Investment Bank (EIB) 2021). Moreover, their resources and capacity are often constrained in transitioning toward a net-zero emission future (Johnson & Schaltegger, 2016). Still, corporate climate regulations have tightened in the EU, and even if these regulations may not directly bind SMEs, they will still impact SMEs indirectly via supply chains. Therefore,

SMEs should consider adopting a proactive approach to managing climate risk.

The research has been carried out within the GRINS (Growing Resilient, Inclusive and Sustainable—www.grins.it) project, which aims to explore and evaluate how Italian SMEs perceive, interpret, and respond to the growing risks associated with climate change, particularly in light of the European Green Deal and the regulatory developments stemming from the EU Taxonomy and SFDR. In line with the objectives of the GRINS project and its Spoke 1, focused on firms, this study seeks to favor the transition of local production systems toward more resilient and sustainable models by producing actionable knowledge for public and private actors.

More specifically, the research objectives are threefold. First, the research aims at identifying, classifying, and mapping strategic behaviors of SMEs in the face of climate risks. The analysis is undertaken on businesses operating in six strategic Italian regions (Emilia-Romagna, Piemonte, Veneto, Toscana, Lazio, Puglia), providing a basis for developing geo-referenced sustainability maps and identifying regional readiness profiles.

The second objective is to identify the enabling and hindering organizational determinants. Therefore, we investigate key internal and external factors influencing SMEs' climate strategies. Variables such as risk perception, governance mechanisms, ownership structure, financial resources, legal form, and climate-related education are analyzed to understand their impact on strategic behavior. The study also examines the role of green finance access, including the use of instruments such as green bonds and green loans. These elements are considered within the broader framework of "sustainability maturity" and institutional embeddedness, seeking to highlight which organizational configurations and institutional factors better facilitate the adoption of sustainable behaviors. The analysis also supports the design of territory-level sustainability indicators and decision-support tools (e.g., algorithms for sustainability assessment).

Third, the research paves the way for the evaluation of climate risks under a double materiality perspective, considering firms' impacts under both financial and environmental dimensions. Indeed, our classification of strategies provides the foundation for further examination of the outcomes of different climate strategies in terms of both financial materiality (e.g., profitability, resilience to shocks, access to capital) and impact materiality (e.g., GHG emissions reduction, circularity, biodiversity

protection). This dual perspective allows the exploration of whether and how sustainable behaviors translate into measurable performance improvements and resilience outcomes.

1.5 Research Contributions

Despite SMEs' notable economic influence and inherent potential to drive sustainability, researchers and practitioners have primarily focused on larger corporations, often overlooking the unique challenges and opportunities SMEs encounter in incorporating sustainable practices into their operations. This neglect is evident amidst the pressing need for these enterprises to align with broader environmental goals while adapting to evolving regulatory and competitive contexts.

In this vein, this research sets out the conceptual foundations for analyzing how SMEs in Italy are responding to the increasing challenges posed by climate change. Recognizing the underrepresentation of SMEs in both academic research and policy design concerning sustainability transitions, the research places these firms at the center of the inquiry, in line with the overarching objectives of the GRINS project—Spoke 1, which aims to enhance the value creation capacity of local territories by supporting sustainable business models. One of the key contributions of the present work is the development of a structured framework for analyzing SMEs' climate strategies, which integrates a multidimensional set of variables—ranging from climate risk perception to governance practices, ownership structures, financial capacity, and education on climate-related issues. This framework, which draws upon and extends recent literature on strategic responses to climate risks, provides a typology of firm behaviors (i.e., "Wait-and-see," "Planners," "Foresighted," "Proactive")[1] that serves as a lens through which to assess the degree of preparedness and engagement of SMEs with both adaptation and mitigation pathways. It also allows for linking strategic behaviors to two fundamental dimensions of materiality, namely financial and impact materiality. In highlighting this double materiality perspective, the research contributes to bridging the "performance gap" often encountered in SME sustainability studies and to informing sustainability reporting standards, which increasingly require evidence-based metrics, especially for SMEs involved in larger supply chains subject to reporting obligations under the CSRD. Furthermore,

[1] The framework is presented in Chap. 3.

this perspective aligns with the evolving regulatory landscape at the European level (e.g., EU Taxonomy, CSRD, SFDR). Therefore, our results provide insights for stakeholders—policymakers, financial institutions, and managers—interested in advancing sustainable development involving all businesses, especially SMEs, thus supporting the overarching aim of the GRINS project: to integrate scientific knowledge and policy innovation in fostering a more resilient, inclusive, and sustainable entrepreneurial ecosystem.

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CHAPTER 2

The Evolving Sustainability Regulatory Framework

Abstract This chapter examines the evolution and implementation of the European Union's sustainable finance and ESG regulatory framework, highlighting the transition from voluntary sustainability practices to binding legal obligations. It reviews the development of key EU instruments, analyzes Italy's national transposition of these rules, and discusses the implications for Italian SMEs.

Keywords Sustainability regulation • NFRD • CSRD • SFDR • CSDDD • EU taxonomy

Over the past decade, the EU has established an increasingly robust regulatory framework to integrate ESG principles into financial markets and corporate governance. This chapter explores the evolution, national transposition, and operational implementation of this regulatory landscape, highlighting how legal instruments have progressively transformed sustainability from a voluntary commitment into a formal obligation across both the public and private sectors. The first section examines the development of EU-level legislation, from the Non-Financial Reporting Directive and SFDR to the more recent CSRD and CSDDD, illustrating a shift toward enforceable ESG standards, standardized disclosures, and corporate accountability. The second section analyzes Italy's transposition

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of these directives, detailing the roles of national institutions such as Consob, the Ministry of Economy and Finance, and the Bank of Italy in ensuring compliance and supervision. Finally, the third section turns to the financial dimension of sustainability regulation, focusing on the Next Generation EU recovery strategy, Italy's *Piano Nazionale di Ripresa e Resilienza*, and the GRINS project, particularly Spoke 1 Work Package 4, which offers research-based tools to support SME adaptation and ESG alignment within the broader EU sustainable finance framework.

2.1 Milestones in EU Regulatory Framework on Sustainable Finance and Corporate Disclosure

As anticipated, the following section outlines the EU's primary regulatory achievements over the past decade, emphasizing how sustainability has become a central pillar of corporate governance and financial regulation throughout the EU.

2.1.1 Initial Steps Toward Transparency (2014–2018)

The regulatory journey received a consistent push with the Non-Financial Reporting Directive (NFRD) in 2014, representing the EU's initial major effort to systematically integrate sustainability into corporate reporting. This directive required large, listed companies and other public-interest entities with over 500 employees to disclose non-financial information concerning ESG factors, constituting underlying expectations for corporate transparency (EC, 2014). In practical terms, companies were asked to disclose details of their business models, ESG policies, outcomes, key risks, and performance indicators, thereby incorporating sustainability concerns into standard corporate reporting practices. Implementation across member states took place by December 2016, and the directive became effective for corporate reports starting in 2018. Although the NFRD allowed considerable flexibility regarding the standards and guidelines companies could adopt, it marked a significant shift toward mainstream ESG integration. Companies had to address not only their financial health but also their broader social and environmental impacts in a systematic way. The NFRD's implementation embodied the growing importance stakeholders placed on corporate accountability beyond mere financial results.

Alongside this corporate disclosure initiative, the EU further demonstrated its commitment to sustainable finance through the comprehensive Action Plan on Sustainable Finance in 2018 (EU, 2018). This strategic document outlined a clear and ambitious roadmap designed to align financial markets with sustainability objectives, emphasizing the critical role that finance must play in driving sustainable economic growth. Specifically, the Action Plan highlighted three core aims: redirecting capital flows toward sustainable investments, systematically incorporating sustainability risks into financial decision-making, and enhancing overall transparency. The Action Plan included ten actionable steps that would subsequently inform and support future legislative measures, including the SFDR, the EU Taxonomy, and the Climate Benchmarks Regulation (EU, 2018, 2019b, 2019c, 2020b). By explicitly mentioning the crucial role of the financial sector in achieving sustainability goals, the Action Plan could radically transform the EU's financial landscape. Financial institutions were, in fact, asked to systematically include ESG considerations into their investment frameworks and strategies, thus establishing sustainability as a key dimension of financial risk management and opportunity assessment.

Collectively, the NFRD and the EU Action Plan on Sustainable Finance represented foundational milestones in the EU's regulatory journey. These measures established standard expectations for transparency and laid strategic foundations for comprehensive, rigorous, and enforceable regulations that would follow in subsequent years. They represented the transition from fragmented, voluntary sustainability initiatives to structured, systematic approaches that emphasized clear, standardized disclosures and robust investor engagement. Thus, by the end of this foundational phase, the EU had set the stage for deep regulatory changes that would soon redefine corporate responsibility and financial market operations, favoring a substantial move toward comprehensive sustainability integration across European markets (EC, 2024).

2.1.2 Consolidating the Core Regulatory Framework (2019–2021)

Between 2019 and 2021, the EU substantially consolidated its regulatory framework around sustainable finance, significantly incentivizing and systematizing sustainability integration into financial markets. Central to this transformative period was the adoption of the SFDR in 2019 (EU, 2019b). Implemented in March 2021, the SFDR required extensive ESG

disclosure obligations for financial market participants and financial advisors, explicitly requiring transparency regarding the integration of sustainability risks into investment processes and decisions. The SFDR finally addressed the pressing challenge of greenwashing by categorizing financial products based on their sustainability profiles, distinguishing clearly between products promoting ESG characteristics (Article 8 funds) and those explicitly targeting sustainable investments (Article 9 funds). The SFDR introduced standardized transparency obligations at both entity and product levels, significantly increasing the level of detail, comparability, and reliability of sustainability-related financial information available to investors. Financial market participants were invited to disclose specific ESG strategies, methodologies, and performance metrics, thus aligning investor expectations with clear, comparable ESG data (EU, 2019b). The regulation effectively reshaped the European investment landscape by standardizing ESG considerations across financial sectors, influencing the flow of trillions of euros in investment capital.

In addition to the SFDR, the EU Climate Benchmarks Regulation introduced standardized indices explicitly aligned with the Paris Agreement's climate targets (EU, 2019c). Adopted in accordance with the SFDR in late 2019, this regulation established two benchmark categories, specifically the EU Climate Transition Benchmark and the EU Paris-Aligned Benchmark (PAB). Both initiatives facilitated transparent tracking and measurement of investment portfolios' climate alignment. By standardizing metrics for climate-related investment performance, these benchmarks provided essential tools enabling investors to clearly assess and report their portfolios' carbon footprints and overall climate-related impacts. Therefore, the Climate Benchmarks Regulation directly supported the broader sustainable finance framework, enhancing investor confidence in climate-aligned financial products.

Arguably, the most transformative regulatory milestone during this period was the adoption of the EU Taxonomy Regulation in 2020 (EU, 2020b). This regulation addressed fundamental challenges related to inconsistencies in defining environmentally sustainable economic activities. The Taxonomy introduced a robust classification system that clearly and scientifically defined criteria to classify economic activities across six key environmental objectives: climate change mitigation, climate change adaptation, sustainable water and marine resource management, transition to a circular economy, pollution prevention, biodiversity, and ecosystem protection. The Taxonomy Regulation significantly improved

transparency by requiring corporations and financial market participants to disclose their taxonomy-aligned economic activities. The disclosure promoted by the taxonomy criteria effectively mitigated risks of greenwashing and enhanced investor trust, significantly influencing investment behaviors and corporate sustainability strategies across Europe. Companies now had precise benchmarks to guide their environmental performance reporting, while investors received clear, consistent, and standardized criteria to inform their investment decisions (EC, 2021a).

2.1.3 Broadening and Strengthening Disclosure (2022–2024)

Building on these emerging frameworks, the EU significantly broadened and reinforced corporate sustainability disclosure between 2022 and 2024 through the CSRD (EU, 2022). Intended to replace the earlier NFRD, which applied to approximately 11,700 companies, the CSRD vastly expanded the scope of mandatory sustainability reporting to cover around 50,000 companies across the EU, including all large corporations and listed SMEs.[1] The CSRD had a crucial role in introducing the mandatory application of specific European Sustainability Reporting Standards (ESRS), improving the standardization of sustainability disclosures (EU, 2023a). A key innovation was the adoption of the double materiality principle, obliging companies to disclose not only how sustainability issues impact their financial health but also how their operations impact environmental and societal safety (EU, 2019a). Furthermore, the CSRD introduced mandatory external assurance of sustainability reports, significantly improving the accuracy, comparability, and credibility of ESG disclosures across European markets.

A strategic addition to the CSRD implementation was the introduction of the EU Green Bond Standard regulation in 2023 (EU, 2023b). This voluntary yet stringent regulatory framework was designed explicitly to improve investor confidence and ensure the authenticity of green financial instruments. Bonds issued under the EU Green Bond Standard were required to demonstrate full alignment with the EU Taxonomy, ensuring

[1] In the context of the CSRD, listed SMEs refer specifically to small and medium-sized enterprises whose securities are admitted to trading on EU-regulated markets, as defined under the Markets in Financial Instruments Directive (MiFID II) (EU, 2014). This excludes SMEs listed only on alternative trading platforms, such as SME Growth Markets, which are not classified as regulated markets under EU law.

that the issued funds genuinely contributed to sustainable projects. Rigorous external reviews and standardized reporting over the impact of the financing further supported the instrument's transparency and credibility, thereby enhancing investor confidence and promoting robust market development for sustainable financial instruments. These regulatory advances represented a substantial advancement, radically introducing sustainability considerations within corporate reporting and financial market operations. By standardizing disclosures and enhancing accountability, the EU is significantly raising expectations and requirements for corporate sustainability, reinforcing its position as a global leader in sustainable finance regulation. However, in light of delays in finalizing the ESRS for certain company categories, particularly listed SMEs and non-EU undertakings, the EC introduced a formal postponement mechanism in 2025, commonly referred to as the "Stop the Clock" provision. This measure temporarily suspended the original CSRD reporting timetable for these entities, which were initially expected to begin reporting in 2026. Under the revised timeline, listed SMEs are now expected to begin reporting from 2027, with a voluntary opt-out still available until 2028, while non-EU undertakings will start reporting in 2029 instead of 2028. The measure was designed to ensure that companies are not required to disclose based on incomplete standards and reflects a pragmatic adjustment aimed at preserving reporting quality and regulatory coherence (EC, 2024).

2.1.4 Accountability and Corporate Responsibility (2024–2025)

The EU's regulatory journey toward sustainability reached a fundamental turning point with the adoption of the CSDDD, which entered into force on 25 July 2024, following its adoption earlier that summer. Although Member States were initially expected to transpose the directive by July 2026, the deadline was postponed by one year, until 26 July 2027, under the Omnibus I reform package. The Directive will apply in stages: initially to the very largest companies from July 2027, followed by large firms from July 2028 and the remaining in-scope firms from July 2029, with actual compliance aligned to financial years starting in 2027, 2029, and 2030, respectively. This directive determined a critical shift from voluntary disclosure-focused regulations to explicit accountability and mandated corporate responsibility. Under the CSDDD, large corporations within the EU and significant non-EU entities operating within European markets are legally required to actively identify, prevent, mitigate, and publicly

report environmental impacts throughout their operations and global value chains. Unlike prior regulations focusing predominantly on transparency, the CSDDD introduced mandatory due diligence procedures. Companies are, in fact, required to systematically assess potential ESG risks, proactively implement preventive measures, and address any identified negative impacts through specific improvement actions. This requirement effectively makes corporate due diligence a standardized expectation rather than a voluntary ethical practice. The directive explicitly targets large companies, extending accountability measures beyond their direct operations into their global supply chains, thus significantly raising the standards of responsible business conduct internationally (EU, 2024a).

Furthermore, the CSDDD redefined directors' responsibilities, requiring the integration of sustainability considerations into corporate governance and strategic decision-making processes. Directors are now legally accountable for ensuring that sustainability risks are adequately identified, assessed, and mitigated, with potential legal liabilities for failing to address sustainability impacts effectively. This approach profoundly transformed corporate governance practices across Europe, integrating sustainability into executive decision-making frameworks and incentivizing long-term, responsible corporate behavior. The effectiveness of the directive is supported by robust enforcement mechanisms, including transparent procedures for civil liability, enabling affected stakeholders to seek remedies for corporate failures in due diligence. These measures significantly enhanced the legal landscape for corporate accountability, setting the standard for an influential global precedent that other jurisdictions have increasingly begun to emulate.

2.1.5 A Forward-Looking Reflection

In conclusion, the regulatory developments from 2015 to 2025 marked a significant evolution in the EU's approach to sustainable finance and corporate sustainability. Starting from initial transparency-driven initiatives and gradually progressing toward stringent accountability frameworks, the EU has decisively reshaped the corporate and financial market landscapes, integrating sustainability into core business practices and decision-making processes. The comprehensive scope of these regulations, including the foundational NFRD, strategic measures such as the SFDR and the EU Taxonomy, the transformative CSRD, and finally the accountability-focused CSDDD, has collectively established a coherent and integrated

regulatory environment. Each subsequent measure built upon previous foundations, substantially increased the standard level for corporate responsibility and transparency, while clearly aligning corporate behaviors with long-term environmental and social sustainability objectives.

As companies and financial institutions continue adapting to this advanced regulatory landscape, the effectiveness of these frameworks will depend significantly on rigorous enforcement, continuous improvement of reporting standards, and active corporate commitment. Looking ahead, the EU will likely face ongoing challenges in maintaining regulatory relevance and ensuring practical effectiveness, particularly as global sustainability standards continue to evolve. Ultimately, the EU's regulatory achievements over this pivotal decade provide a powerful template for sustainable economic transformation, positioning Europe as a clear leader and innovator in sustainability governance. The comprehensive, integrated regulatory architecture developed during this period sets an influential benchmark for global regulatory practice, driving substantive progress toward a sustainable, resilient future for businesses, investors, and broader society.

2.2 Focus on Italy: Transposition and Implementation of EU Sustainability Regulations

This section analyzes how Italy has transposed and implemented the EU's evolving sustainability regulations over the past decade. It emphasizes national legislative measures, institutional roles, and supervisory practices that have influenced the domestic regulatory landscape.

2.2.1 From European Mandate to National Practice

Together with the EU's evolution toward a comprehensive regulatory framework for sustainable finance and corporate transparency, Italy has gradually shaped its own national response. This involved the transposition of EU directives into domestic law and the practical integration of EU regulations through coordination among key financial and institutional actors. While some measures required formal legislative action, such as the NFRD and the CSRD, others, like the SFDR and the EU Taxonomy, entered into force directly, although demanding national supervision and interpretative guidance. In all cases, Italy's institutional configuration,

based on a "twin peaks" supervisory model, with the regulatory authority in charge of supervising the Italian securities markets (Consob) and the central bank (the Bank of Italy) as principal authorities, has played a central role in ensuring compliance and adaptation.

This section traces the trajectory of Italy's regulatory implementation between 2015 and 2025, focusing on how European sustainability standards have been absorbed, enforced, and, in some cases, anticipated. It reviews the key legislative acts, the role of the supervisory authorities, and the practical impact on Italian companies and financial institutions. The analysis follows a chronological and thematic logic, beginning with the NFRD transposition, continuing with the adoption of the CSRD, and concluding with Italy's handling of the directly applicable regulations, SFDR and the EU Taxonomy.

2.2.2 Transposing the NFRD: Legislative Decree 254/2016

Italy was among the first EU Member States to transpose Directive 2014/95/EU, better known as the NFRD (EU, 2014). This was achieved through D.Lgs 30 December 2016, n. 254, which entered into force on 25 January 2017. The decree imposed an obligation on large listed and public-interest entities to publish an annual *Dichiarazione Non Finanziaria* (DNF), a structured non-financial statement disclosing information on ESG issues, including respect for human rights, anti-corruption policies, and diversity on company boards (Government of Italy, 2016).

The scope of application closely followed the directive's thresholds: companies with more than 500 employees and either a balance sheet total exceeding €20 million or net revenues above €40 million. Parent companies of qualifying groups were also required to publish consolidated non-financial statements. Uniquely, Article 7 of the Italian decree offered a voluntary regime for companies outside the mandatory scope, allowing them to issue compliant DNFs marked as such. This opt-in provision served as an early tool for promoting ESG transparency beyond formal legal thresholds.

2.2.3 Practical Implementation and Supervision

The DNF regime also introduced a requirement for external verification. Article 3 of D.Lgs. 254/2016 mandates that the non-financial statement be subject to "limited assurance" by the company's statutory auditor or

another accredited provider (Government of Italy, 2016). Most companies opted to use their financial auditors, reinforcing the connection between financial and sustainability reporting. The auditor's conformity report had to be attached to the DNF and made available to shareholders and the public. Responsibility for enforcement was assigned to Consob, which was empowered to issue implementing regulations, request corrections, and impose sanctions. Consob adopted Resolution No. 20267 in January 2018, establishing procedures for submitting DNFs and initiating reviews (CONSOB, 2018). If companies failed to comply, Consob could issue warnings and, in cases of material non-compliance, impose administrative penalties. Coordination with sector-specific authorities, such as the Bank of Italy for banks and IVASS for insurance companies, was also required when relevant (Bank of Italy, 2020). Consob maintained a public list of companies publishing DNFs and conducted thematic reviews to assess disclosure quality. In 2021, it issued a *Richiamo di Attenzione* (Attention Notice) to prepare companies for new disclosure requirements arising from the EU Taxonomy (CONSOB, 2021a). Meanwhile, the Ministry of the Environment and Energy Security (MASE) supported awareness campaigns and collaborated with business associations to promote best practices (MASE, 2024b). As of 2020, around 210 Italian entities, mainly listed companies, financial institutions, and some unlisted groups, were producing DNFs, either mandatorily or voluntarily (CONSOB, 2024b).

2.2.4 The Transition to CSRD: Legislative Decree 125/2024

The introduction of the CSRD in 2022 marked a fundamental shift in the EU's approach to non-financial disclosure (EU, 2022). Broader in scope and more detailed in content, the CSRD replaced the NFRD and required the use of ESRS. Italy transposed the directive through the D.Lgs. 125/2024, effective from 25 September 2024 (Government of Italy, 2024). The enabling authority came from Law 127/2022, which allowed the government to implement the CSRD via a delegated decree (Government of Italy, 2022). Decree 125/2024 revoked the earlier framework under D.Lgs. 254/2016 and introduced a vastly expanded perimeter of application. The new rules apply to all large companies (as defined by exceeding two out of three EU thresholds: >250 employees, >€20 million in balance sheet, >€40 million in revenues), regardless of listing status, and to listed SMEs on regulated markets, beginning in 2026

(with an opt-out option until 2028) (Government of Italy, 2024). Micro-enterprises are excluded. This shift is expected to raise the number of obligated Italian entities from a few hundred to several thousand, transforming sustainability reporting into a mainstream corporate obligation.

2.2.5 Content, Assurance, and Supervision Under CSRD

The Italian transposition of the CSRD reflects the core provisions of the directive, but it also introduces some distinctive national elements (Government of Italy, 2024). First, the law mandates structured dialogue with employee representatives. Companies must consult workers' councils or unions on the sustainability report, providing them with access to the document and enabling them to deliver feedback to management. This goes beyond CSRD requirements and aligns with Italy's emphasis on stakeholder engagement. Regarding assurance, Decree 125/2024 requires that the sustainability report be subject to limited assurance by a statutory auditor (*revisore legale*) or audit firm. Italy opted not to open the market to independent assurance providers (e.g., sustainability consultants or certifiers) at this stage. Instead, it reserved this responsibility for professionals already qualified under Italian audit law, provided they demonstrate at least five annual training credits in sustainability reporting. However, the decree mandates that the Ministry of Economy and Finance (MEF) and Consob will evaluate within 18 months whether to authorize other providers in the future, pending a cost-benefit study. This leaves open the possibility of a more plural assurance ecosystem later, if necessary.

Consob remains the designated supervisory authority for listed entities, with powers to monitor compliance, require corrections, and apply sanctions. For non-listed companies, oversight may be shared or delegated, but Consob's technical role remains central. Other institutional actors also contribute: MEF handles policy guidance and reporting, while the Bank of Italy, IVASS, and sectoral ministries (e.g., MASE for environmental data) assist in domain-specific enforcement. Sanctions for non-compliance start modestly, for example, fines of up to €125,000 for audit firms and €50,000 for individual auditors during the transitional phase, but can escalate in cases of serious breach or repeated violations (Government of Italy, 2024). Importantly, the CSRD also introduces mandatory digital reporting using the European Single Electronic Format (ESEF). Italian companies will be required to tag sustainability data digitally, starting from late 2025 or 2026, depending on their entry into scope, aligning with

broader EU objectives on digital transparency and data comparability (EU, 2022). At the time of writing, Italy is expected to adjust Decree 125/2024 to reflect the EU's Omnibus I proposal (adopted in April 2025), which delays reporting deadlines by one year for most companies and proposes raising the employee threshold to 1000 (EU, 2024b). These changes aim to ease administrative burdens and may reduce the number of Italian firms initially affected. MEF and Consob are monitoring this evolution, and legislative amendments are anticipated by the end of 2025.

2.2.6 SFDR: Coordinated Supervision of Financial Institutions

The SFDR, Regulation (EU) 2019/2088, has applied directly in Italy since 10 March 2021 (EU, 2019b). Although no transposition was required, Italian regulators were tasked with ensuring implementation and compliance. This included adapting supervisory frameworks, issuing guidance, and updating national regulations to align with SFDR's layered disclosure obligations. Consob, the financial markets regulator, played a pivotal role. Ahead of the SFDR's entry into force, it issued the *Richiamo di Attenzione* n. 3/21, reminding supervised entities of their new obligations (CONSOB, 2021a). This included the need to publish sustainability risk policies on websites, disclose ESG considerations in pre-contractual documentation, and provide detailed reporting for products classified under Article 8 or 9 of the regulation. Consob also encouraged the use of draft Regulatory Technical Standards (RTS) as interim templates before they became legally binding. Later, the authority amended its *Regolamento Emittenti* (Issuer Regulation) via Resolution No. 22437 of September 2022, explicitly aligning national fund disclosure requirements with the SFDR and the EU Taxonomy (CONSOB, 2022).

The Bank of Italy issued further communications reinforcing these expectations. It emphasized that financial intermediaries should follow draft EU guidance and integrate sustainability risks into their internal governance and risk management frameworks. Although the SFDR does not fall under prudential regulation per se, the Bank of Italy included ESG topics in supervisory discussions and on-site inspections, especially for asset managers and banks offering investment services (Bank of Italy, 2023). It also coordinated with Consob to ensure consistency across conduct and prudential oversight. IVASS, the insurance regulator, ensured that insurance-based investment products (IBIPs) complied with SFDR requirements. Insurers were required to update pre-contractual

documents and make public statements on how sustainability risks are integrated into product design and investment strategy. IVASS issued technical clarifications and worked with industry bodies like ANIA to ensure smooth adoption. While IVASS did not publish dedicated Q&As, its alignment with EU guidance was communicated through its supervisory letters and bilateral communications with market participants (IVASS, 2024).

COVIP, the pension funds supervisor, also implemented SFDR requirements for second-pillar pension schemes. It updated its reporting templates to reflect new disclosure obligations and monitored compliance through its regular supervisory tools (COVIP, 2022). Notably, SFDR enforcement in Italy has been soft but strategic. Regulators have prioritized education, compliance encouragement, and dialogue over punitive actions. However, by 2023–2024, Consob had begun to explicitly warn against greenwashing, requiring asset managers and financial advisors to ensure that products marketed as "sustainable" genuinely meet SFDR classification standards (CONSOB, 2024a). European Securities and Markets Authority (ESMA) warnings on ESG misrepresentation were spread at the national level, and by 2025, Italian regulators were enhancing supervisory analysis on the credibility of ESG claims in reports and advertisements.

2.2.7 The EU Taxonomy Regulation: Integration Without Transposition

Unlike the CSRD or the NFRD, the EU Taxonomy Regulation (Regulation 2020/852) is directly applicable across Member States and does not require national transposition (EU, 2020b). Nevertheless, its implementation in Italy necessitated significant adjustments in both corporate reporting practices and financial market supervision. Italy's approach has focused on integrating Taxonomy-related disclosure obligations into existing regulatory frameworks and facilitating institutional support for understanding and applying the new system. The regulation introduced obligations for companies subject to non-financial reporting (initially under the NFRD and now the CSRD) to disclose how and to what extent their economic activities are aligned with the Taxonomy's environmental objectives. In Italy, companies began reporting Taxonomy-aligned KPIs, including the proportion of turnover, capital expenditure (CapEx), and operating expenditure (OpEx), for the first two environmental objectives

(climate change mitigation and adaptation) in their 2021 non-financial statements (CONSOB, 2024b).

To support implementation, Consob issued specific communications and adjusted its supervisory scope. As early as 2021, the authority reminded companies that the Taxonomy's Article 8 disclosures were mandatory and should be included in DNFs alongside standard ESG indicators (CONSOB, 2021b). By reviewing non-financial statements for Taxonomy compliance, Consob further integrated sustainability metrics into its monitoring practices. It also amended its Issuer Regulation in 2022 to ensure that fund periodic reports referencing sustainable investments complied with both the SFDR and the Taxonomy (CONSOB, 2022). For financial products, the Taxonomy's definitions and criteria became mandatory elements of SFDR-related disclosures. Funds marketed under SFDR Articles 8 and 9 had to state the extent of their Taxonomy alignment, and Consob required that this be reflected in pre-contractual documentation and investor communications. The regulator worked closely with IVASS and the Bank of Italy to ensure consistency in the treatment of green financial products, particularly in the insurance and banking sectors (Bank of Italy, 2023; IVASS, 2024). These institutions incorporated ESG considerations into supervisory reviews and encouraged product manufacturers to align with the latest Delegated Acts and EU guidance.

From a policy point of view, Italy also took steps to institutionally promote the use of the Taxonomy beyond minimal compliance. MASE promoted stakeholder education by hosting webinars and publishing guidance on applying the Taxonomy criteria. It also contributed to Italy's positions in EU-level negotiations on the development of the Taxonomy's technical screening criteria, ensuring that national priorities, such as renewable energy, sustainable agriculture, and clean transportation, were considered in the evolving definitions (MASE, 2024a). Furthermore, Italy's National Recovery and Resilience Plan (PNRR) explicitly references the Taxonomy as a guiding principle for identifying green investments (Presidency of the Council of Ministers, 2021). The Interministerial Committee for Economic Planning and Sustainable Development (CIPESS) recommended using Taxonomy alignment as a benchmark for public spending eligibility, especially in infrastructure, energy, and circular economy projects (Department for the Planning and Coordination of Economic Policy (DIPE), 2022). This cross-institutional integration reflects an intention to make the Taxonomy not only a compliance tool but also a strategic lens for public and private investment.

2.2.8 A Coherent and Timely National Implementation

From the transposition of the NFRD via D.Lgs. 254/2016, to the recent adoption of D.Lgs. 125/2024 implementing the CSRD, and through the layered supervisory strategies supporting the SFDR and the EU Taxonomy, Italy has gradually integrated EU sustainability frameworks into its national legal and institutional system. Each regulation presented unique challenges, either legislative, technical, or operational, but Italy's approach has been generally timely, coordinated, and forward-looking. While some countries have lagged in transposition or struggled with institutional misalignment, Italy has demonstrated regulatory maturity and cross-sector collaboration. The clear delegation of enforcement responsibilities, the anticipation of assurance standards, and the incorporation of digital and environmental dimensions show that Italy has moved beyond minimum compliance. Italian authorities have also been active contributors at the European level, participating in ESMA, European Banking Authority (EBA), and EIOPA working groups and shaping the direction of future sustainability reporting and finance regulations.

Looking ahead, some uncertainties remain, particularly regarding the final structure of the ESRS, the possible expansion of assurance markets, and the effects of the Omnibus I revision. However, the groundwork laid between 2015 and 2025 has positioned Italy to navigate this evolving landscape effectively. By embedding European mandates within a coherent and adaptive national system, Italy has not only fulfilled its legal obligations but also advanced a credible strategy for sustainable corporate governance and financial market development.

2.3 EU Financing and National Recovery Strategies: Embedding Sustainability in Governance

This section examines how the EU's recovery strategy, particularly through Next Generation EU and Italy's PNRR, has integrated sustainability into economic governance. It emphasizes the role of funding instruments, institutional coordination, and research initiatives such as the GRINS project, which is at the base of the research presented in this book.

2.3.1 *Framing the Financial Architecture of the EU's Recovery*

In response to the profound socio-economic shock induced by the COVID-19 pandemic, the EU launched an unprecedented supranational financial package: Next Generation EU (NGEU). This initiative, formally adopted in 2020, mobilized €806.9 billion to support Member States in a coordinated recovery aimed not only at economic rebound, but also at accelerating the green and digital transitions. Central to the NGEU framework is the Recovery and Resilience Facility (RRF), which accounts for the largest share of funding, initially €723.8 billion, later revised in light of inflation and partial additions (EC, 2020; EU, 2021b). This mechanism is not merely financial; it represents a radical shift in EU economic governance, linking the funding process to reform commitments, performance monitoring, and strategic policy alignment.

The RRF operates on a results-based logic. Funds are distributed in tranches, subject to the achievement of previously agreed milestones and targets embedded in each national Recovery and Resilience Plan (RRP). Member States were required to design multi-annual plans detailing structural reforms and public investments, with explicit contributions to six EU priority pillars: green transition, digital transformation, smart growth, social and territorial cohesion, health resilience, and policies for the next generation (EC, 2021b; EU, 2021c). This condition-based model introduces an element of governance reform through financial leverage. Therefore, only if a Member State delivers on commitments, such as public administration modernization or regulatory simplification, can it access successive disbursements. Sustainability and responsible governance are integrated into the RRF's legal architecture. Member States must allocate at least 37% of expenditure to climate and environmental objectives and a further 20% to digitalization. Moreover, all funded measures must comply with the "do no significant harm" principle, ensuring alignment with the EU's broader climate objectives (EC, 2021b). These requirements position the RRF not merely as a macroeconomic stimulus tool, but as a strategic catalyst for ESG-aligned reforms at the national level.

While the RRF primarily targets public sector investments, its design fosters a broader regulatory ecosystem conducive to sustainable finance and corporate transparency. For example, although the RRF itself does not impose reporting obligations on firms, it operates alongside, and reinforces EU-wide legislative reforms such as the CSRD, SFDR, and EU Taxonomy Regulation (EC, 2022b). These frameworks shape the context

in which firms receiving public support, or participating in green procurement, must operate. In this sense, the RRF contributes indirectly to the governance evolution of corporate actors, particularly through reform milestones targeting the business environment, competition law, and digital tools for public–private engagement.

2.3.2 Italy's PNRR: Structure, Sustainability Goals, and Governance Orientation

Italy, as the largest recipient of RRF resources, developed a comprehensive *Piano Nazionale di Ripresa e Resilienza* (PNRR) with a total budget exceeding €191.5 billion in EU funds, later integrated by national co-financing and the *Fondo Complementare*, bringing the total recovery effort to approximately €235 billion (Presidency of the Council of Ministers, 2021). Structured around six Missions, the Italian PNRR is conceived not merely as a stimulus program but as a national reform and investment strategy. Its missions range from digital transformation and ecological transition to social cohesion, health, education, and research, all mapped into 16 thematic components (EU, 2021a).

The PNRR aligns with NGEU's ESG architecture. Mission 2, titled *Green Revolution and Ecological Transition*, is particularly prominent, absorbing approximately €59 billion and covering renewable energy, energy efficiency, sustainable agriculture, circular economy, biodiversity conservation, and water management (MEF, 2022). The emphasis on green investments also overlaps with other missions, for example, sustainable mobility in Mission 3 and urban regeneration projects in Mission 5. Moreover, the cross-cutting themes of gender equality, youth inclusion, and territorial cohesion reflect a clear commitment to social sustainability and governance improvement (Government of Italy, 2021). Mission 1 (*Digitalization, Innovation, Competitiveness, Culture*) and Mission 4 (*Education and Research*) introduce significant investments in digital infrastructure and public sector modernization, aiming to improve administrative transparency, regulatory quality, and access to data (Digitale, 2022). These objectives replicate the broader EU agenda for digital governance and indirectly support corporate transparency by enhancing the quality and accessibility of administrative, economic, and environmental data relevant for ESG disclosures. The PNRR also introduces structural reforms as a precondition for investment. Among the most significant are the reform of public administration, aimed at simplifying procedures and

digitalizing services, and the justice system reform, designed to accelerate civil and criminal trials. Both reforms are longstanding challenges in Italy's governance architecture and are viewed as enablers of regulatory certainty, investor confidence, and policy delivery (EC, 2022a).

2.3.3 Governance of the PNRR: Conditionality, Transparency, and Institutional Coordination

The scale and complexity of Italy's PNRR required an innovative, multi-tiered governance structure designed to ensure accountability, transparency, and timely execution. The MEF is coordinating this system. Within the MEF, a dedicated PNRR Task Force monitors the alignment of projects with EC requirements, manages milestone reporting, and interfaces with EU institutions on funding decisions. Strategic direction and inter-ministerial coordination are further ensured by the *Cabina di Regia*, a steering committee housed within the Presidency of the Council of Ministers (Presidency of the Council of Ministers, 2023). Implementation responsibilities, however, are decentralized. Specific ministries, regional governments, and public agencies are assigned direct authority over investments and reforms within their domain. This vertical delegation aims to match sectoral expertise with administrative capacity but also increases the need for consistent monitoring and control mechanisms. To this end, Italy has equipped itself with a robust auditing infrastructure. The *Corte dei Conti* (Court of Auditors) plays a pivotal role, conducting independent performance and financial audits (MEF, 2022). Moreover, a dedicated Anti-Fraud Plan and interoperability between databases have been implemented to detect anomalies and ensure the efficient use of public funds.

A critical feature of this governance model is the emphasis on transparency and data accessibility. Through the *Italia Domani* public portal, citizens, journalists, and civil society can access detailed information on project progress, disbursement status, and implementation timetables (Presidency of the Council of Ministers, 2021). This approach signals a shift toward open government and aligns with the digital governance aspirations included in Mission 1. Meanwhile, periodic monitoring reports, both at national and EU levels, create pressure for continuous improvement and correction, reinforcing the accountability logic of the RRF (EC, 2022a). These mechanisms are not limited to project execution but extend to reform delivery. Funding from the EC is conditional on verifying specific reform milestones, including laws passed, institutions restructured,

and new public services activated (EU, 2021c). In this way, the PNRR represents not only a financial injection but a policy delivery contract between Italy and the EU, reshaping the dynamics of national governance through external benchmarking and internal institutional renewal.

2.3.4 The GRINS Project: Research-Based Support for Inclusive and Sustainable Governance

With institutional reforms and public investments, Italy's PNRR allocated resources to strengthen the scientific and data infrastructure necessary to support long-term governance improvements. Within Mission 4 (*Education and Research*), the investment line 1.3 finances Extended Partnerships, large-scale, multi-actor research networks tasked with addressing key societal challenges (Ministry of University and Research (MUR), 2022). One of the most significant of these is the GRINS project (MUR, 2023). Funded through the NextGeneration EU program and coordinated by a consortium of Italian universities and research institutions, GRINS operates under a hub-and-spoke model. It brings together leading academic institutions, as well as applied research centers, economic think tanks, and private sector partners. The total funding allocated to GRINS exceeds €110 million, making it one of the flagship research projects under the Italian PNRR framework (MUR, 2022).

The ultimate aim of GRINS is to develop new tools, data platforms, and analytical models that support evidence-based public policy, sustainable finance, and inclusive development. At the heart of the project is the creation of a next-generation data platform named AMELIA[2] (dAta platforM for the transfEr of knowLedge and statistIcal Analysis), capable of integrating a wide range of geo-referenced, cross-sectoral data. This platform will make high-quality, timely, and accessible information available to policymakers, businesses, and civil society actors, enabling informed decision-making crucial when facing complex challenges (GRINS, 2024). GRINS is explicitly aligned with the strategic pillars of the EU's and Italy's recovery plans. It addresses the need for sustainable growth by focusing on environmental and climate data, supports inclusion through the analysis of social inequalities and territorial disparities, and promotes digital transformation by building an advanced, user-oriented data infrastructure. In doing so, it functions as a research-based policy engine,

[2] AMELIA Platform: https://grins.it/progetto/piattaforma-amelia

complementing administrative reforms and providing scientific underpinning for the implementation and evaluation of PNRR investments and reforms (EU, 2021c).

2.3.5 Work Package 1.4 (WP1.4): Advancing SME Sustainability and Territorial Resilience

Within the GRINS framework, Spoke 1 focuses on corporate sustainability, value creation, and circular economy dynamics at the firm and regional level (GRINS, 2023a). Work Package 4 (WP1.4), whose team includes the authors, specifically addresses the sustainability practices and transformation pathways of SMEs, the backbone of the Italian economy and a strategic lever for ecological and social transition (GRINS, 2023b). WP1.4 is developed on the rationale that, while large corporations are increasingly aligning with European sustainability standards, many SMEs face structural, informational, and organizational barriers that limit their ability to meet new expectations under the CSRD, the EU Taxonomy, and the broader European Green Deal (EC, 2021a; OECD, 2022). Accordingly, WP1.4 aims to map, assess, and support SME engagement with sustainability, producing both empirical evidence and actionable tools to foster territorial resilience and policy alignment.

At its core, the aim is to develop an integrated, multidimensional dataset that captures the sustainability profile of SMEs across several pilot territories. This includes not only financial and operational data, but also firm-level ESG indicators, governance practices, climate risk strategies, and participation in circular economy networks. Special attention is paid to how sustainability is integrated into business models, how SMEs perceive regulatory change, and what capabilities they are developing (or lacking) to manage environmental and social risks. The approach is both diagnostic and improvement-oriented. The project does not merely classify firms based on their ESG maturity but actively supports the co-design of metrics, guidelines, and decision tools. These outputs are oriented toward helping SMEs build internal systems that meet new reporting and transparency requirements, while also improving their strategic positioning in global value chains (European Financial Reporting Advisory Group (EFRAG), 2024).

2.3.6 *ESG Alignment and EU Regulatory Integration*

The study of this book explicitly links its objectives to the evolving landscape of EU sustainability regulation, making it a crucial bridge between high-level policy and firm-level implementation. The CSRD, adopted in 2022 and gradually extending to large private and listed SMEs, represents a transformative shift in corporate transparency, mandating the disclosure of risks, impacts, and sustainability strategies in line with the ESRS (EFRAG, 2024; EU, 2022). While many SMEs will only be directly affected in later phases, they are already indirectly impacted through supply chain pressure and investor expectations (EC, 2021c). Our work anticipates this trend and provides a structured framework for evaluating SME readiness for CSRD compliance, including support in understanding materiality, stakeholder engagement, and ESG data governance.

Moreover, by collecting data and developing indicators aligned with the EU Taxonomy Regulation, the study may contribute to increasing the visibility of SMEs to sustainable finance (EU, 2020b). Firms that can demonstrate alignment with Taxonomy criteria are, in fact, better positioned to access green loans, ESG funds, and public procurement opportunities linked to environmental performance. In this context, the analytical output directly supports broader EU objectives to channel capital flows toward sustainable economic activities, as articulated in the EU Action Plan on Sustainable Finance (EU, 2018). WP1.4 also supports the broader strategic rationale of the European Green Deal, which envisions not only emissions reduction but also a just and inclusive transition (EC, 2019). By investigating the territorial and sectoral distribution of sustainability readiness, the study offers granular policy insights into where support is most needed, be it through incentives, training, or technical assistance. In this sense, it extends the impact of EU policy beyond formal compliance, promoting a culture of sustainability and innovation among SMEs in Italy's industrial and regional ecosystems (EU, 2020a).

2.3.7 *Policy Engagement and Knowledge Transfer*

The activities of WP1.4 are designed to generate not only academic knowledge but also practitioner-oriented outputs that facilitate institutional and corporate learning. Through extensive surveys, which have engaged 10,381 and regional case studies, the project has built a unique dataset on business sustainability practices, climate risk perceptions, and adaptation

strategies. These insights are disseminated through dedicated policy briefs, stakeholder reports, and regional workshops involving Chambers of Commerce, industry associations, and local public authorities.

Notably, WP1.4 has prioritized collaboration with national institutions such as *Unioncamere*, the *Centro Studi Tagliacarne*, and representatives from MASE and MEF, ensuring that its work complements official strategies for sustainable enterprise development. It also interacts with professional associations and the National Council of Accountants, providing technical input relevant to the evolving ESG disclosure framework for SMEs. Among its key deliverables, WP1.4 is finalizing a web-based decision support platform, integrated within the AMELIA architecture, which allows users to explore geo-referenced sustainability data, benchmark performance by sector and region, and identify best practices. The platform, combined with toolkits for ESG integration tailored to the SME context, enables both firms and policymakers to move from assessment to action.

2.3.8 Empowering SMEs for a Sustainable Transition

In sum, WP1.4 of the GRINS project exemplifies the convergence of research, policy, and enterprise action in the context of the EU's sustainability transition. By focusing on SMEs, a segment often underserved in regulatory discourse yet vital to economic and environmental transformation, our work fills a critical implementation gap. It supports Italy's commitments under the PNRR and strengthens the country's capacity to meet the challenges of EU-level sustainability regulation, from the CSRD to the Green Deal. More broadly, this work supports the view that building effective governance for recovery and sustainability is not just about institutions and funding. It also requires solid knowledge, accessible data, and practical support to help businesses meet new regulatory expectations. By generating tools that translate policy into practice and by fostering multilevel cooperation, the activities of WP1.4 contribute to including sustainability into the core of Italian economic governance.

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CHAPTER 3

Conceptualizing Corporate Responses to Climate Change

Abstract This chapter develops the conceptual framework guiding the analysis of SMEs' strategic responses to climate-related risks. Building on the existing literature, it examines how organizational determinants influence firms' climate strategies and their outcomes through a double materiality perspective that captures both financial and environmental dimensions. The chapter provides a coherent analytical foundation for empirical analysis and offers insights relevant to academic research, managerial decision-making, and policy design.

Keywords Climate strategies • Climate risk management • Adaptation • Mitigation • Double materiality

This chapter sets out the conceptual framework guiding the analysis of how SMEs respond strategically to climate-related risks. Grounded in a review of the relevant literature, the proposed framework aims to explore the relationship between organizational factors of SMEs, strategic responses, and their outcomes through a double materiality lens. By linking internal drivers, strategic behavior, and financial and environmental impacts, the research offers an integrated perspective to inform academic research, management practice, and policymaking.

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3.1 Research Context and Conceptual Framework

In the face of accelerating climatic volatility and intensifying environmental disruptions, corporate resilience increasingly hinges on the capacity to internalize and strategically respond to climate-related risks (Aragón-Correa & Sharma, 2003). The IPCC warns that, if global greenhouse-gas emissions continue on their present trajectory, the planet is likely to reach a mean temperature anomaly of +1.5 °C sometime between 2030 and 2052. This projection triggered the landmark 2015 UN Conference of the Parties (COP 21), where 196 parties adopted the Paris Agreement. The accord commits signatories to an accelerated, concerted reduction of global emissions to hold the temperature rise below certain thresholds viewed as critical for safeguarding socio-economic systems from environmental disruptions. The proliferation of forward-looking scenarios that depict a troubling economic outlook has spurred the publication of numerous assessments of climate-related impacts at both the macro and micro levels. For example, across the EU, the European Environment Agency estimates that climate-related extremes inflicted €650 billion in economic losses between 1980 and 2022. Hydrological hazards accounted for roughly 42% of these damages, storms for 29%, and heatwaves for about 20%. Italy alone absorbed €111 billion in losses, the third-highest figure in Europe after Germany and France. These aggregate numbers foreshadow rising insurance costs, infrastructure disruptions, and productivity shocks that filter directly into corporate balance sheets.

As anticipated in Chap. 1, two main categories of climate risks are commonly acknowledged in the scholarly and policy domains: physical and transition risks. The former refers to the direct, tangible consequences of climate change manifested through acute weather events or through chronic environmental shifts, including prolonged heat waves and altered precipitation patterns. These phenomena expose firms to potentially severe economic losses by damaging assets, interrupting production processes, impairing infrastructure, and increasing operational and insurance costs. Particularly vulnerable are companies situated in high-risk geographies or those dependent on climate-sensitive supply chains. On the other hand, transition risks emerge from the multifaceted societal and regulatory shifts underway to curb GHG emissions and promote a low-carbon economy. These encompass regulatory changes (e.g., carbon pricing mechanisms), legal liabilities (e.g., climate-related litigation), technological evolution (e.g., the integration of clean technologies), market transformations (e.g.,

evolving consumer preferences), and reputational dynamics. Such transitions may engender financial repercussions for firms, including increased compliance costs, the obsolescence of carbon-intensive assets, and fluctuating investor confidence, ultimately affecting firm valuation and long-term viability (Dal Maso et al., 2024a, 2024b).

At the policy level, the EU has embarked on a robust regulatory trajectory to mitigate climate change through the advancement of carbon pricing and the codification of sustainability standards, as discussed in Chap. 2. This legislative framework establishes detailed criteria for determining the environmental sustainability of economic activities, serving as a cornerstone for aligning corporate behavior with the EU's climate neutrality target for 2050. While the regulation is not directly binding for SMEs, its cascading externalities and impacts through supply chains and investor expectations indirectly compel SMEs to conform to emerging sustainability norms. SMEs, in particular, encounter unique vulnerabilities in this context. Their frequent localization in single markets, limited access to diversified customer bases, and constrained financial and organizational capacities render them especially susceptible to both physical disruptions and transition-related adjustments. Consequently, a proactive orientation toward climate risk management is not merely advisable but imperative for SMEs striving for continuity and competitiveness in a rapidly transforming global economy.

As discussed in Chap. 1, the research aims to support this orientation by assessing the degree of readiness and proactivity of SMEs to climate risks through mapping strategic responses across territories, examining key determining factors of higher proactivity, and thus allowing companies for the integration of a double materiality perspective into the assessment of strategic outcomes.

The conceptual framework underpinning our research is portrayed in Fig. 3.1. It unfolds in three sequential stages. It begins with a set of internal determinants drawn from the literature, including senior management's perception of climate-change risk (Todaro et al., 2021), corporate governance mechanisms (Asad et al., 2025), ownership structure (Berrone et al., 2010), financial resources (Voss et al., 2008), legal form (Kim et al., 2017) and the degree of climate-related education within the organization (Audebrand, 2010). Together, these factors influence both the awareness of climate challenges and the firm's capacity to respond to these risks. Building on this foundation, four strategic profiles are identified along an increasing scale of engagement with climate change: "Wait-and-see,"

Fig. 3.1 Conceptual framework. (Source: Own elaboration)

"Planners," "Foresighted," and "Proactive" firms. Each profile produces outcomes that are best interpreted through the lens of double materiality. On the financial side, strategic choices affect such indicators as cost of capital, cash-flow volatility, and broader risk-return metrics. On the impact side, the same choices influence contributions to SDG 13, manifesting in reduced greenhouse-gas emissions, more efficient use of land and water, and lower waste generation. The framework, therefore, links organizational determinants to strategic posture and, in turn, to both economic and environmental performance, offering a coherent perspective for management research and practice. The next sections discuss these three elements in more detail.

3.2 Sustainability Drivers and Determinants in SMEs

A growing body of academic literature has examined the factors that drive or hinder corporate investments in climate mitigation and adaptation. One of the most significant determinants is the perception of risk (Todaro et al., 2021). Firms that recognize climate change as a material and imminent threat are more likely to invest in protective or transformative measures. This perception shapes how the costs and benefits of climate investments are assessed: higher risk salience correlates with greater willingness to absorb upfront costs in anticipation of long-term gains

(European Investment Bank (EIB), 2021; Hoffmann et al., 2009; Pinkse & Gasbarro, 2019).

However, the mere recognition of risk is insufficient. The availability of financial resources critically influences the feasibility of climate-related investments (Voss et al., 2008). For SMEs in particular, limited access to external finance, constrained internal capital, and short planning horizons can hinder the implementation of effective strategies (EIB, 2022). This underscores the importance of supportive financial instruments, policy incentives, and public–private partnerships to enable climate action in resource-constrained contexts, as discussed in Chap. 2.

Another salient factor is organizational capability, including access to technical expertise and climate literacy. While awareness of climate impacts may be growing, many SMEs still lack the knowledge base and human capital to translate concern into concrete action (Alam et al., 2022). In this regard, corporate governance constitutes a critical supporting pillar (Asad et al., 2025). Evidence suggests that firms equipped with dedicated sustainability managers (Peters et al., 2019), environmental management teams (Jabbour et al., 2013; Palea et al., 2024), or sustainability-linked compensation systems (Flammer et al., 2019; Velte, 2024) are better positioned to design and implement effective climate strategies. Moreover, reporting mechanisms can contribute to fostering climate engagement. Sustainability reporting serves as a tool for internal decision-making, accountability, and stakeholder communication, thereby reinforcing corporate commitment to environmental goals (Massa et al., 2015; Tang & Higgins, 2022). Additionally, participation in multi-stakeholder initiatives—e.g., the UN Global Compact or the Science Based Targets initiative (SBTi)—can further drive environmental improvements by embedding firms in networks of shared learning and performance benchmarking (Berliner & Prakash, 2015; Romito et al., 2024).

Finally, certain structural characteristics of firms also shape their climate responses. For example, firms with higher proportions of institutional ownership tend to exhibit lower emissions profiles (Benlemlih et al., 2023), while legal forms that embed social purpose, such as benefit corporations, may provide directors with a clearer mandate to pursue sustainability objectives (Kirst et al., 2021).

3.3 Climate Strategic Approaches

Effective economic value creation presupposes the systematic integration of risk management into corporate strategy. Research in this field (D'Onza, 2008; Zagaria, 2017) describes this integration as progressing through three phases: risk identification, evaluation, and mitigation.

In the identification phase, the organization monitors events that could compromise performance, analyzes the factors that precipitate those events and verifies the corresponding causal relationships. Once the risk landscape is delineated, each threat is evaluated by combining the probability of its occurrence with the potential scale of its consequences; exposure increases in step with the height of these two variables. The sequence concludes with mitigation, when management designs and implements measures intended to lessen overall vulnerability. The efficacy of such measures depends on cultivating an organizational "risk consciousness" that promotes their consistent application over time (Dal Maso, 2025).

In responding to climate-related challenges, firms typically deploy a combination of mitigation and adaptation strategies. Mitigation efforts are oriented toward reducing or offsetting emissions that contribute to global warming. Such interventions include investments in renewable energy, improvements in energy efficiency, carbon capture technologies, and participation in carbon offsetting schemes. These strategies help mitigate exposure to transition risks, particularly in regulatory environments where carbon pricing or emission ceilings are enforced.

Conversely, adaptation strategies are designed to strengthen organizational resilience against the physical manifestations of climate change. These may include diversifying product portfolios and geographical markets, enhancing operational flexibility, reinforcing infrastructure, and innovating in climate-resilient technologies or business models. As noted in the climate adaptation literature (Linnenluecke et al., 2013; Neil Adger et al., 2005), such measures aim to build firms' adaptive capacities and ensure business continuity under future climate scenarios.

The literature categorizes corporate responses based on their temporal orientation toward climate stimuli. Smit et al. (2000) conceptualize these responses as either reactive (implemented post-impact), concurrent (during impact), or anticipatory (pre-impact), while Gasbarro and Pinkse (2016) offer a parallel framework distinguishing between preemptive, reactive, continuous, and deferred adaptation behaviors. The degree of

	INVESTMENTS PLANNED (2024-26)	
INVESTMENTS MADE (2021-23)	NO	YES
NO	***Wait-and-see***	***Planners***
YES	***Foresighted***	***Proactive***

Fig. 3.2 Firms' climate change adaptation and mitigation strategies. (Source: Own elaboration)

organizational readiness and strategic foresight is critical in determining where firms fall within this spectrum (EIB, 2022).

Aligned with these taxonomies, this research project aims to assess the readiness levels of SMEs with respect to climate action. Drawing from empirical work, we propose, as shown in Fig. 3.2, a fourfold classification of SMEs based on their investment patterns in climate-related measures:

- "**Wait-and-See**" firms: These companies neither have a history of climate-related investment nor show intent to invest in the future. They represent a risk-averse posture, possibly due to low perceived exposure or limited resource availability.
- "**Planner**" firms: Businesses that have not yet invested but intend to do so are in a preparatory phase. They potentially signal growing awareness and the intention to incorporate climate objectives into corporate strategy.
- "**Foresighted**" firms: Firms that have previously undertaken climate investments but do not plan future initiatives. These organizations may lack long-term strategic commitment or face resource reallocation challenges.
- "**Proactive**" firms: Business organizations with a track record of investment and ongoing plans for climate action. These entities typically exhibit a long-term strategic vision and are more likely to integrate sustainability across multiple dimensions of operations.

This classification will underpin the empirical analysis developed in subsequent stages of the project, serving as a foundation for identifying barriers, enablers, and best practices across different sectors.

3.4 Strategic Outcomes: A Double Materiality Perspective

Materiality refers to identifying the issues that matter most to a company's business and stakeholders. It represents a key accounting and reporting principle, since focusing on material matters ensures companies report on the most crucial issues and communicate what is useful for stakeholders' decision-making processes. However, reporting is only the last step of a more complex path. Upstream, materiality is crucial in defining business strategies (Whitehead, 2017), identifying and managing business risks (Matsumura et al., 2024), stakeholder engagement (Gromis di Trana et al., 2024), and business planning and control activities (Eccles & Youmans, 2016).

In 2019, the EC formally introduced "double materiality" as the approach that organizations must adopt to disclose information on sustainability matters, including climate-related issues (EC, 2019). The double materiality concept acknowledges that sustainability risks and opportunities can be material from both a financial and non-financial perspective. Specifically, double materiality combines financial and impact materiality (Fig. 3.3). Based on this approach, a sustainability matter is

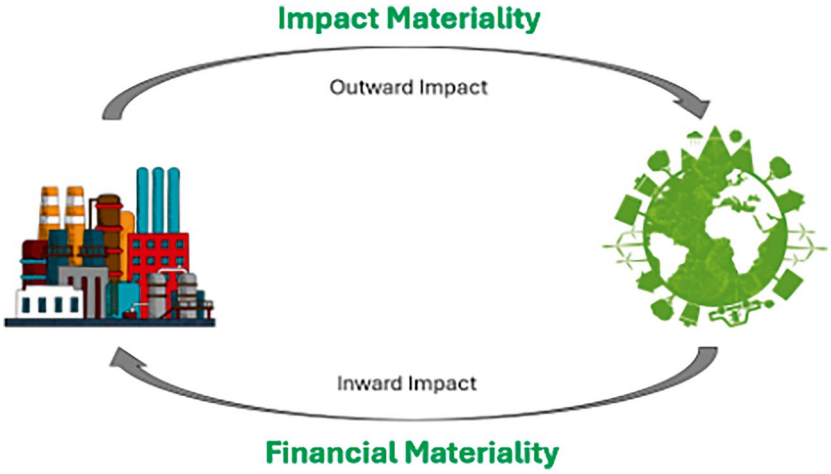

Fig. 3.3 The double materiality in climate change risks. (Source: Own elaboration)

material when it meets the criteria defined for financial materiality, impact materiality, or both (EFRAG—ESRS 1 (2022), par. 28).

Financial materiality reflects an outside-in perspective. Precisely, it focuses on the impact of sustainability factors (e.g., climate risks) on an entity's financial position, performance, or cash flow (EU, 2022). Hence, organizations must assess, measure, and report risks and opportunities that could substantially affect their operations, earnings, physical assets, and other aspects contributing to their enterprise value. Dependence of businesses on natural, human, and social resources may trigger effects in two possible ways (ESRS 1, par. 50). On the one hand, it may influence companies' ability to continue to use or obtain the resources in their business processes, as well as the quality and pricing of those resources. On the other hand, it may affect companies' ability to rely on relationships needed in their business processes on acceptable terms. Precisely regarding climate risk exposure, several studies provide evidence that it negatively affects firm financial performance in different ways, such as determining higher earnings volatility (Huang et al., 2018), higher cost of debt (Palea & Drogo, 2020), lower profitability (Palea & Santhià, 2022), and lower market evaluations (Palea & Santhià, 2022; Zhang, 2022). However, implementing specific corporate mitigation/adaptation strategies can attenuate negative impacts (Cadez et al., 2019; Palea & Drogo, 2020; Palea & Santhià, 2022). Considering the financial implications of climate risks is not only a prerequisite for companies to address broader social and environmental issues (Biondi et al., 2023) but also relevant to financial institutions for managing financial risks stemming from climate change (Mähönen & Palea, 2024).

Impact materiality represents an inside-out perspective. It entails assessing the impacts of business activities on sustainability factors (EC, 2022). Based on ESRS 1, a sustainability matter is material from an impact perspective when it pertains to a company's material actual or potential, positive or negative impacts on people or the environment over the short, medium, or long term. Impacts include those connected with a company's operations and its upstream and downstream value chain, including through its products, services, and business relationships. Business relationships include those in the company's upstream and downstream value chain and are not limited to direct contractual relationships. Hence, impact materiality is essential to inform corporate stakeholders on how a business entity comprehensively affects the environment and society (Global Reporting Initiative, 2022) and to evaluate its alignment with

planetary boundaries (Mähönen & Palea, 2024). For instance, business operations generate interrelated impacts on climate change and biodiversity, defined as "the variety of life in all its forms" (Dasgupta, 2021, p. 52). Biodiversity loss exacerbates climate vulnerability, while climate change accelerates the degradation of ecosystems and species extinction, thus generating a relevant relation to consider in business activities between impacts on, and dependences on, biodiversity (Cinquini et al., 2024). In this context, firms can play a dual role by contributing to climate change mitigation, for example through the reduction of carbon emissions, and by undertaking biodiversity-focused initiatives. Such measures may include employee training programs, the creation of protected areas such as ecological corridors, donations and sponsorships, restoration and site rehabilitation (Boiral & Heras-Saizarbitoria, 2017).

Considering both the financial and the impact perspectives together, corporate management of climate risks requires recognizing that the organization contributes to and is affected by climate change.

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CHAPTER 4

Research Methodology: A Survey of Italian Firms

Abstract This chapter presents the research methodology adopted to investigate Italian firms' responses to climate-related risks and sustainability challenges. It outlines the design and implementation of a large-scale survey, detailing the sampling strategy, regional coverage, and sectoral selection criteria. It describes the questionnaire structure, the key areas of investigation, the data-collection techniques employed, and the resulting dataset and sample characteristics.

Keywords Data sample • Italian firms • Survey method • Questionnaire design

To investigate firms' responses to climate risks and related factors (see Chap. 3), we developed and administered a survey to Italian companies. The characteristics and the methodology implemented to conduct the survey are presented below, from the sampling procedure[1] to the questionnaire structure and sample description.

[1]We gratefully acknowledge the support of Prof. Alessandro Rinaldi and Dr. Giacomo Giusti from Centro Studi delle Camere di Commercio G. Tagliacarne in conducting the sampling process and survey design.

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https://doi.org/10.1007/978-3-032-17454-3_4

4.1 Sample Selection

As a first step, we identified the population that represents the objective of the survey, its statistical units, their characteristics, and the relative classifications.

The population for this research is made up of active undertakings in the Italian register of enterprises (ASIA) of the Italian National Institute of Statistics (ISTAT), as of the end of the 31st December 2021. In particular, we selected corporations with a minimum of ten employees on average per year. Furthermore, all sectors of economic activity were included, except for *Agriculture forestry and fishing*, which was excluded due to the predominance of sole proprietorships in the sector, and *Financial and insurance activities*, because of their distinct profile, making them not comparable to other firms. Finally, we defined the geographical area of observation. Since the project involved five universities, each located in a different region, the study considered the firms operating within the respective regions of the participating universities. Therefore, each university was responsible for collecting and analyzing data about its regional context. Accordingly, sample companies were selected from enterprises located in the following Italian Regions (NUTS 2): Piemonte, Veneto, Emilia-Romagna, Toscana, and Lazio. Then, to complete the analysis and provide a picture of the entire Italian context, *Centro Studi Tagliacarne* has focused its research on Southern Italy (including Sicilia, Sardegna, Abruzzo, Molise, Campania, Puglia, Calabria, and Basilicata) and, specifically, on the food sector.

Subsequently, for every region subject to the survey, the undertakings operating in that territory (which together constitute the statistical universe) were divided into n-blocks, resulting from the combination of the following variables: province, class of employees (from 10 to 49 employees, from 50 to 249, or more than 250), and sector.[2] This methodology was implemented since it is able to guarantee, at the same time, homogeneity within every block and heterogeneity between different blocks, allowing for the capture of existing differences in the observed phenomena. Furthermore, every block was designed to achieve a predetermined sample size, ensuring statistical relevance for the variables of interest.[3]

[2] For example, in a region with five provinces, three classes of employees and six economic sectors, 5x3x6 blocks have been realized.

[3] Therefore, statistical relevance is not achieved for every single block, due to the predetermined number of interviews established for each region.

Concerning the sectors of economic activity, their identification resulted from a reclassification of the codes of classification ATECO 2007 based on the EU Taxonomy of sustainable activities.[4] This led to the identification of the following "eligible" sectors: *Food and beverages*; *Other manufacturing*; *Energy*; *Water supply, sewerage, waste management and remediation*; *Construction and real estate activities*; *Transport*; *Information and communication*; and *Professional, scientific and technical activities.* The other sectors were classified as "not-eligible."[5]

A questionnaire was administered to sample companies via a mix of CATI (Computer-Assisted Telephone Interviewing) and CAWI (Computer-Assisted Web Interviewing) methodologies, especially when requested by the interviewees.

4.2 Structure of Questionnaire

We chose to use a questionnaire as the primary data collection tool, because of its practicality and effectiveness for collecting large amounts of data within a short timeframe (Groves et al., 2011). Given the diverse and dispersed nature of the target group (enterprises located in the following Italian Regions: Piemonte, Veneto, Emilia-Romagna, Toscana, Lazio, and the Southern Italy, including Sicilia, Sardegna, Abruzzo, Molise, Campania, Puglia, Calabria, and Basilicata), the questionnaire format was ideal for reaching a broad audience while ensuring consistency across responses. Questionnaires offer significant advantages, including their efficiency in data collection and the ease with which respondents could complete them at their convenience (Chiper et al., 2024; Bryman, 2016). This reduced the burden on participants, potentially increasing the response rate. Moreover, the structure of closed-ended questions allowed for straightforward quantitative analysis, while open-ended questions provided richer qualitative insights (Fowler, 2013). However, the literature also points to potential drawbacks. One limitation is the risk of superficial responses (Dillman et al., 2014), particularly when addressing complex topics such as sustainability and climate change. To mitigate this, the

[4] Regulation (EU) 2020/852 of the European Parliament and of the Council on the establishment of a framework to facilitate sustainable investment and amending Regulation (EU) 2019/2088.

[5] These include, for example, *Retail trade*; *Activities of membership organizations*; *Accommodation and food service activities,* etc.

questionnaire was carefully designed to balance clarity with the depth of inquiry, ensuring that the questions were engaging and relevant to the target. Overall, a questionnaire provided an efficient and comprehensive method to explore corporate perspectives on sustainable development and climate risks, aligning with the study's objectives by capturing broad trends and individual insights.

The investigation spanned a broad range of dimensions, including past and planned climate investments, motivations and barriers, access to sustainable finance, internal governance mechanisms, and attitudes toward biodiversity. Thus, it offered a comprehensive perspective on how resilience, awareness, sustainability orientation, and adaptive behaviors are evolving across the Italian entrepreneurial landscape.

The survey was carefully designed to capture quantitative and qualitative data from Italian firms. It comprised a total of 29 questions (largely consisting of closed-ended questions), divided into nine core areas of investigation identified as relevant to gain information about the readiness level of companies: risk perception; green investment; emissions; reporting and workforce policies; green finance; environmental programs; corporate governance; expectations; biodiversity.[6]

Table 4.1 reports the correspondence between the areas of investigation and the questionnaire's associated questions (Appendix A). The areas of investigation are presented below.

In a preliminary section of the questionnaire, we collected basic structural and demographic information about the firms, including legal name, tax code, province, sector of activity, and employment class. These variables are essential to contextualize responses, enable firm-level segmentation, and support comparative analyses across geographic areas, economic sectors, and firm sizes.

The first area of investigation of the survey (Section A) contains two closed Likert-scale questions aimed at assessing how Italian firms perceive climate-related risks, both in general terms and across specific risk categories. The objective is to measure managerial awareness regarding the potential impact of extreme weather events, long-term environmental

[6] In addition to the 29 core questions, each participating University had the option to include up to five additional questions. These supplementary items were tailored to specific institutional interests and are not included in the present methodological overview or in the subsequent discussion of survey findings.

Table 4.1 Areas of investigation and associated questions

Areas of investigation	*Questions*
A.Risk perception	1), 2)
B.Green investment	3), 4), 5), 6), 7), 8), 9), 10)
C.Emissions	11), 12A), 12B), 13)
D.Sustainability reporting, committee and remuneration	14), 14A), 15), 15A), 16), 16A), 17)
E.Green finance	18), 18A), 19), 20)
F.Environmental programs	21), 22), 23)
G.Ownership and legal form	24), 25)
J.Expectations	26)
K.Biodiversity	27), 28), 29)

changes, and transition-related risks, to evaluate the firms' subjective level of alertness and preparedness.

The second area of investigation (Section B) focuses on firms' mitigation and adaptation strategies in response to climate risks, combining retrospective (2021–2023) and prospective (2024–2026) horizons. It includes a mix of dichotomous closed-ended questions (yes/no) and ranked multiple-response items. Firms report whether they undertook investments targeting acute, chronic, or transition risks and, if so, select up to three prioritized actions (e.g., insurance, water-saving, renewable energy). The same structure applies to future intentions. Follow-up items explore motivational drivers and investment barriers through ordinal multiple-choice questions.

The third area of investigation (Section C) focuses on corporate practices related to measuring, reducing, and strategically managing CO_2 emissions. The aim is to assess how Italian firms have integrated climate mitigation targets into their operational planning and reporting systems. Within the section, there are four closed-ended questions, structured to capture both the presence of formal climate objectives and the implementation of specific mitigation actions. It begins with a dichotomous question (yes/no), identifying whether the firm has formally adopted CO_2 reduction targets. Conditional on a positive response, two follow-up questions are presented in single-choice closed format, investigating (1) the stringency of the emissions reduction objectives set for 2030 or 2050, and (2) whether these commitments have been confirmed, strengthened, or revised for the upcoming period (2024–2026). A final single-choice

question collects information on the presence (or planned adoption) of internal measurement systems for CO_2 emissions, distinguishing between direct (Scope 1), indirect controllable (Scope 2), and other indirect (Scope 3) emissions, in line with international sustainability reporting frameworks.

The fourth area of investigation (Section D) explores the internal governance mechanisms and human resource strategies that support the environmental sustainability agenda of Italian firms. It examines whether firms have institutionalized environmental accountability through formal reporting, designated sustainability roles, and incentive systems linked to climate-related performance. This section consists of seven questions, combining single-choice closed-ended items, open-ended numerical entries, and a multiple-choice question. The first set of questions collects information on the presence of a sustainability report (with or without third-party assurance), the appointment of a dedicated sustainability officer, and the existence of climate-linked remuneration schemes, all captured via single-response closed-ended questions. For firms that answered affirmatively to these items, three open numerical questions follow, asking respondents to specify the year in which these practices were introduced. These data points allow for temporal analysis of the adoption of climate--related governance tools across the firm sample. The final question in this section employs a multiple-response closed-ended format, allowing respondents to indicate which professional categories (e.g., executives, middle managers, employees, interns) are covered by climate-related performance-based remuneration systems. This facilitates the mapping of incentive diffusion within organizational hierarchies and enables analysis of how sustainability priorities are embedded in HR policy.

The fifth area of investigation (Section E) investigates the degree of awareness, engagement, and access of Italian firms concerning sustainable finance instruments and regulatory developments. The objective is to assess cognitive familiarity with EU sustainability frameworks and the concrete use of financial products to support green investment strategies. This section includes four questions. The first two are closed-ended dichotomous items (yes/no) that inquire whether the firm is aware of recent legislative developments in sustainable finance (e.g., CSRD, European Taxonomy, CSDDD), and whether it has participated in relevant training or capacity-building activities. A subsequent multiple-choice closed-ended question gathers information on the use of specific sustainable financial instruments over the past three years (2021–2023), including green loans, bonds, or other forms of green credit. Respondents can indicate multiple

applicable options, including the type of climate risk the financing was intended to mitigate (physical, transition-related, or other). Finally, a further dichotomous question investigates whether the interest rate applied to such green financing was perceived as advantageous compared to conventional lending, allowing for an initial assessment of the economic accessibility and perceived value of sustainable financial mechanisms. This section supports both descriptive profiling of firms' financial behavior and analytical linkage with investment patterns (Section B) and institutional maturity (Section D), contributing to an integrated understanding of the enabling financial environment for climate action.

The sixth area of investigation (Section F) aims to explore the level of formal engagement of Italian firms in voluntary environmental initiatives and certifications. This dimension serves as a proxy for proactive organizational alignment with international sustainability standards and climate leadership practices. Two closed-ended single-response questions assess whether the firm has joined prominent global environmental frameworks, specifically, the UN Global Compact and the SBTi, captured through closed-ended single-choice questions, which also record (where applicable) the year of enrollment via a follow-up field. The final question of this section adopts a multiple-choice closed-ended format and examines the presence of formal environmental certifications within the firm. These include ISO 14001 (environmental management), ISO 50001 (energy management), and other relevant standards. Respondents may select multiple certifications and are asked to indicate the year of adoption, allowing for temporal and categorical analysis of certification uptake.

The seventh area (Section I) of the survey collects basic structural information on the ownership and legal form of the responding firms, serving as control variables for the analysis of heterogeneity in climate-related behavior among Italian firms. This block consists of two questions. The first is a closed-ended dichotomous item (yes/no), which asks whether the firm is legally constituted as a Benefit Corporation. This status may indicate a formal commitment to social and environmental objectives alongside profit. The second item is a closed-ended multiple-choice question regarding the firm's ownership structure. Respondents are asked to select all relevant ownership categories exceeding a 20% participation threshold, including family members, private investors, venture capital funds, corporations, public entities, or multinational groups. An open "Other" option is included for unlisted ownership types.

The penultimate area of investigation (Section J) includes a Likert-scale question aimed at capturing firms' retrospective evaluation of their financial performance in light of recent macroeconomic pressures. Respondents are asked to assess their revenues in 2023 compared to 2022, choosing from a set of ordered response options that range from "extremely negative" (threatening business survival) to "extremely positive." Although limited to one item, this measure serves as a proxy for perceived business vulnerability or resilience in a volatile energy and climate context.

The final thematic section (Section K) investigates the degree of awareness, integration, and strategic consideration of biodiversity issues. Although more limited in scope, this section provides an initial indication of how environmental concerns beyond climate change, specifically the loss of biodiversity, are entering into business practices and sustainability agendas of the surveyed companies. It includes three closed-ended questions. The first is a single-choice question that gauges the firm's level of familiarity with the concept of biodiversity, offering a graduated response scale from full awareness to complete unfamiliarity. This allows for basic segmentation of respondents based on cognitive exposure to the issue. The following question is a closed-ended dichotomous item (yes/no), asked only of those who reported at least some awareness. It investigates whether biodiversity is formally included in corporate sustainability policies or reports. The second, a closed-ended dichotomous item with two levels of decisions, explores whether the firm has developed specific strategic lines or investment plans to mitigate impacts on biodiversity or leverage it as a business opportunity (e.g., through innovation or diversification).

4.3 Sample Description

The survey process yielded an extensive sample of 10,381 responses, collected between June and December 2024, across the six regions considered (see Table 4.2). The distribution of the firms based on their dimension is illustrated in Fig. 4.1. Only 2% of the firms interviewed have 250 employees or more; 20% of them have between 50 and 249 employees; 78% of them have between 10 and 49 employees.

Regarding the distribution of the sampled firms based on their sector of economic activity, according to the EU Taxonomy of sustainable activities, 73% of them operate in eligible sectors, particularly in *Manufacturing* (44%), *Construction and real estate* (25%), *Food and beverage*, and *Information and communication* (both 9%). Instead, 27% of the interviewed firms belong to sectors considered not eligible (Fig. 4.2).

Table 4.2 Distribution of firms by regions

Region	*Number of firms interviewed*	*Share of firms*
Piedmont	2,121	20.4%
Lazio	1,076	10.4%
Tuscany	2,200	21.2%
Veneto	2,032	19.6%
Emilia-Romagna	2,200	21.2%
Southern Italy	752	7.2%
Total	**10,381**	**100%**

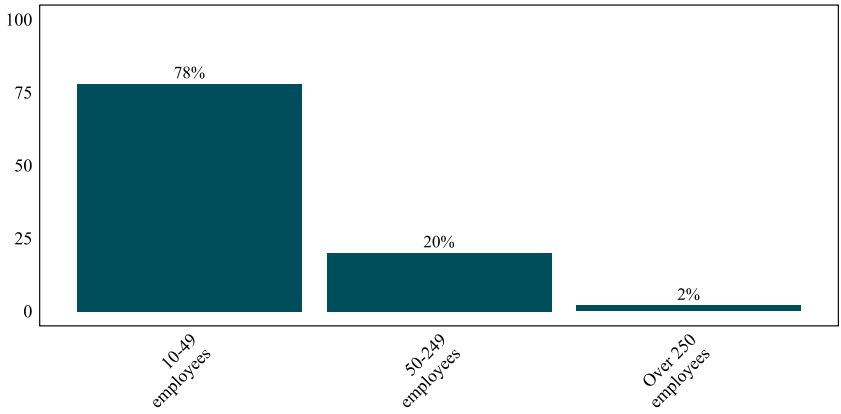

Fig. 4.1 Distribution of firms by class of employees. (Source: Own elaboration)

4.4 Data Analysis

4.4.1 Data Preprocessing Phase

The data preparation phase involved a structured and manual coding process to convert raw survey responses into a structured format suitable for statistical analysis. This step was essential to ensure consistency, preserve data quality, and enable quantitative analysis.

A total of 88 analytical variables were generated from survey questions ranging from D1 to D29, in addition to 5 structural variables capturing firm-level information (such as legal name, tax code, location, sector, and

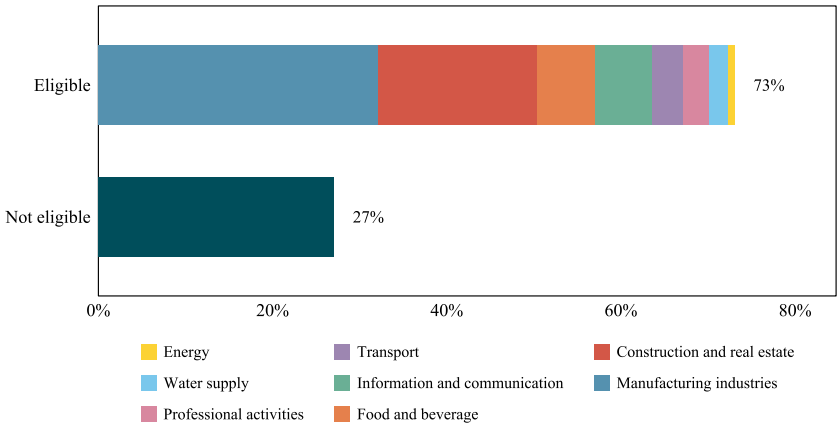

Fig. 4.2 Distribution of firms by sectors. (Source: Own elaboration)

size). The coding followed a clear and systematic approach, with distinctions based on the type of variable:

1. *Binary variables*: Questions requiring yes/no answers (including D3[0.1,0.2,0.3], D6[0.1,0.2,0.3], D11, D17[.I1-.I6], D18, D18A, D19[.I1-.I4], D20, D23[.I1,.I2,.I3,.I4], D24, D25[.I1-.I8], D28, D29[0.1,0.2]) were encoded using dummy coding:

- 1 = Yes
- 0 = No

This format was applied to both standalone dichotomous questions and multiple-response questions, where each selectable item was transformed into an individual binary variable.

2. *Ordinal variables*: Likert-scale or graded questions measuring perception or intensity (to which types correspond D1, D2[0.1,0.2,0.3], D26) were encoded using ordinal coding:

- 1 = Not at all
- 2 = Slightly
- 3 = Fairly
- 4 = Very much

3. *Nominal variables*: For unordered categorical questions (containing the items D12A, D12B, D13[0.1,0.2,0.3], D14, D15, D16, D21, D22, D27, iii, iv, v), responses were encoded using numeric labels with no inherent order. Coding schemes typically ranged from 1–3 or 1–4.

4. *Ranked categorical variables* (implicit order): For questions asking respondents to select and rank multiple options, typically up to three choices (including D4[.S1,.S2,.S3], D5[.S1,.S2,.S3], D7[.S1,.S2,.S3], D8[.S1,.S2,.S3], D9[.S1,.S2,.S3], D10[.S1,.S2,.S3]), each ranking position was transformed into a separate variable:

- Variable_1 = 4 (e.g., option 4 ranked first)
- Variable_2 = 2 (e.g., option 2 ranked second)
- Variable_3 = 6 (e.g., option 6 ranked third)

This structure preserved the ordinal nature of the ranking and was applied across several thematic blocks of the questionnaire. Where an "Other (please specify)" option (D4_other, D5_other, D7_other, D8_other, D9_other, D10_other) was available and selected, a dedicated open-text variable was included to capture the additional information, regardless of its position in the ranking.

5. *Textual and numeric variables*: Open-ended responses were preserved as text variables, and numeric entries (D14A, D15A, D16A, D21.A, D22.A, D23[.1Y,.2Y,.3Y], i, ii) were retained as continuous numeric variables, enabling both qualitative and quantitative analysis. The variables D12_other, D19_other, and D23_other were also coded as textual, as they were linked to the "Other" option, which allows respondents to provide an open-ended answer.

This coding strategy ensured the data could support a wide range of descriptive and inferential statistical analyses. For a complete overview of the variables, coding scheme, and survey structure, please consult Appendix B.

4.4.2 Analytical Approach

The dataset obtained through the questionnaire was structured into a matrix, with each row representing a respondent Italian firm and each column corresponding to a coded variable. The analytical work was conducted using STATA, a statistical software widely used in the social sciences for its robust data handling, graphical tools, and modeling capabilities (Acock, 2018; Long & Freese, 2014). The first stage of the analysis

involved univariate exploration, aimed at summarizing individual variables and outlining the characteristics of the respondent firms. Frequency distributions and central tendency measures were calculated for categorical and numeric variables, offering an overview of firms' size, location, sector, climate risk perception, and sustainability practices. These distributions were visualized (as shown in Chapter 5) using bar charts and frequency tables, enabling an intuitive representation of trends and dominant patterns across the sample. This approach allowed for a structured interpretation of variable distributions (Montgomery & Runger, 2010), serving as a foundation for further exploration (Fowler, 2013; Agresti, 2010). Descriptive statistics are essential in survey research to detect anomalies and capture the diversity of response behaviors (Bryman, 2016; Moore et al., 2017). In addition, building on this, bivariate analyses were conducted descriptively, focusing on relationships between key categorical variables. In fact, in line with the study's exploratory nature, the bivariate comparisons were conducted using descriptive visualizations and cross-tabulations to preserve interpretive flexibility and highlight observable patterns (Bryman, 2016; Fowler, 2013). The final step involved the construction of strategic profiles, based on the temporal investment behavior of firms. Specifically, a logical segmentation of firms was produced by cross-tabulating two binary variables: past green investments (2021–2023) and planned investments (2024–2026). This yielded four groups (see Chap. 3). Business strategy literature has proposed similar visual frameworks to support managerial analysis and policy communication (Hill & Brown, 2007). In the present study, clustered bar charts and comparative visuals were used to represent the distribution of these profiles, offering a clear view of strategic postures within the firms' landscape.

Taken together, the survey sections form a comprehensive analytical framework that captures the multifaceted ways in which Italian SMEs engage with sustainability and climate risks. This structure aligns with the study's conceptual goals and enables the identification of emerging patterns, behavioral profiles, and critical gaps, which are examined in detail in the following results chapter.

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CHAPTER 5

Evidence on Climate Strategies and Their Determinants Among Italian SMEs

Abstract This chapter presents the empirical findings of the survey, focusing on firms' readiness to address climate-related risks. It analyzes patterns of climate risk perception, investment behavior, and strategic responses, identifying different profiles of corporate proactivity. It also examines the key organizational, financial, and governance-related factors associated with more advanced climate strategies.

Keywords Climate strategies • Climate investments • Climate proactivity • Climate risk perception • Sustainability governance • Green finance

The chapter presents the empirical results of the survey conducted on Italian SMEs to examine the readiness of companies to address climate risks and the factors promoting higher levels of proactivity. Results are presented in the following sections.

5.1 Climate Risk Perception

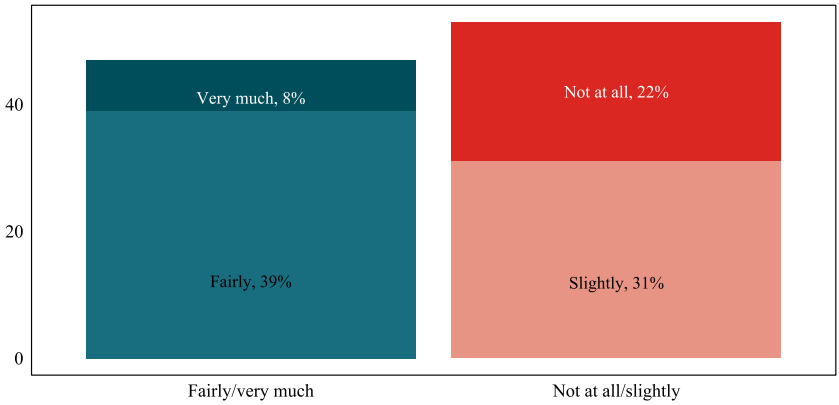
This section presents descriptive statistics on how firms assess climate risks and how perceptions differ across space and sectors. Findings reveal distinct patterns, offering insights into the private sector's prioritization of

V. Palea et al., *Climate Strategies and Sustainability Pathways of Italian Small and Medium-Sized Enterprises*, Palgrave Studies in Climate Resilient Societies,
https://doi.org/10.1007/978-3-032-17454-3_5

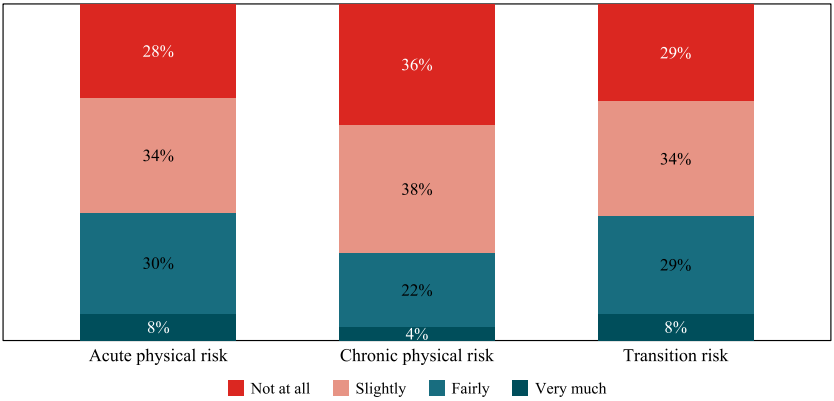
climate threats, both from catastrophic events and transition scenarios, and related investments to attenuate them.

Graph 5.1 presents firms' responses to the question regarding their general perception of climate risks, specifically the extent to which they perceive climate risks are or will be impacting their business activity (see Appendix A, question no. 1). Data collected from respondents show that a moderate level of risk perception is the most widespread, with nearly 40% of firms placing themselves in the "fairly" concerned category. Around this group, a clear tendency to underrate climate risks can be observed: 31% are "slightly" concerned and 22% are "not at all" concerned, while only 8% report being "very much" concerned. This indicates that detachment or skepticism toward climate issues (22%) is more than twice as common as intense concern (8%). Furthermore, when grouping responses into two main clusters, namely *high* ("fairly" and "very much") and *low* ("not at all" and "slightly") risk perception, it can be noted that most firms (53%) show a low perception of climate threats. Overall, findings suggest that the under-prioritization of climate threats outweighs perceived urgency to address climate change.

In Graph 5.2, firms' perception of different types of climate risks—i.e., *acute*, *chronic*, and *transition* risks—is reported. First, in relation to physical climate risks, it can be noted that firms dismiss chronic risks more than acute ones (36% vs. 28%). This suggests that businesses may tend to view



Graph 5.1 Climate risk perception. (Source: Own elaboration)



Graph 5.2 Risk perception distribution by type of risk. (Source: Own elaboration)

slow-onset climate phenomena (e.g., gradual temperature changes or shifts in precipitation patterns) with greater detachment compared to more immediate and tangible physical risks like extreme weather events (e.g., floods, wildfires). On the other hand, firms' perception of acute physical risks and transition risks (e.g., new regulations or changes in consumer preferences) follow a similar pattern. This outlines that businesses may be more responsive to acute physical risks and those arising from the transition toward a net-zero economy.

Furthermore, the results of our analysis highlight that climate risk perception is impacted by geographical factors. In particular, it emerges that physical risks, especially acute threats, elicit more geographically differentiated responses compared to transition risks, which display a much more uniform pattern nationwide (see Fig. 5.1). This supports that while perceptions of physical risks are meaningfully shaped by local environmental exposures and traumatic events, widespread concerns related to policy and market transitions reflect the broader applicability of regulatory frameworks and energy market dynamics across the country. Detailed statistics and commentary on regional differences are provided in Appendix C. Additionally, further analysis suggests that climate risk perception increases with firm size but is not influenced by a company's sector eligibility. However, among eligible sectors, the energy sector demonstrates the highest climate awareness, followed by food and beverage.

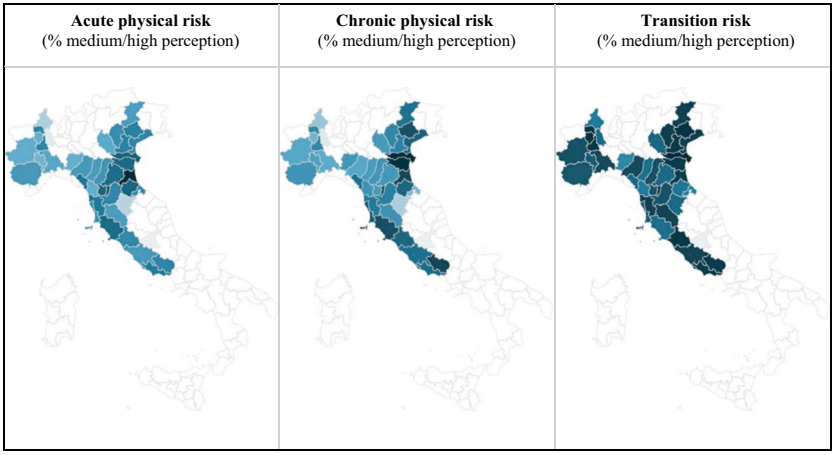
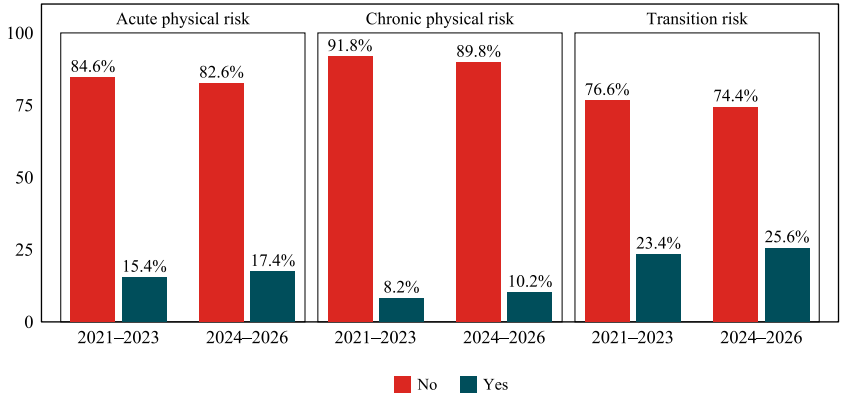


Fig. 5.1 Climate risk perception by province (The gradient mapping of provinces from light to dark green indicates medium to high perceived risk). (Source: Own elaboration)

5.2 Climate Investments and Strategies

In this section, we provide an overview of investments carried out by firms to attenuate climate risks, along with the different strategies underpinning climate investment decisions.

Graph 5.3 compares the portion of firms who have made investments in the period 2021–2023 with the share of firms planning investments for the period 2024–2026, across the three types of climate risks (acute, chronic, transition). Focusing on the 2021–2023 investments, it emerges a prioritization in climate risk management, where emphasis is placed more heavily on transition risks than on physical risks, particularly chronic ones. Indeed, transition risk accounts for the largest share of firms that have undertaken investments (23%), reflecting the growing awareness of systemic shifts driven by the transition to a low-carbon economy. Acute risks motivated investments for 15% of these firms, while chronic risks did so for only 8%. This could point again to firms' perception that these impacts are less immediate or harder to quantify, making them a lower priority despite their potential to cause deep, structural damage over time.

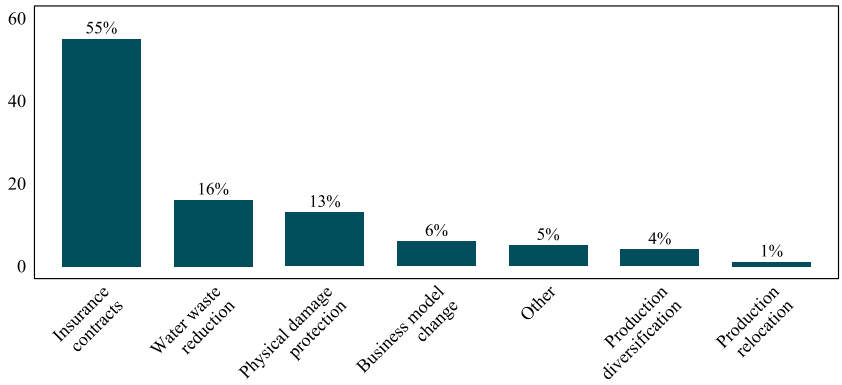


Graph 5.3 Climate investments made and planned by type of risk. (Source: Own elaboration)

Overall, the data support that firms tend to prioritize near- and medium-term economic and regulatory changes over long-term environmental degradation.

This is reflected also for 2024–2026. Looking at the investment plans, a 9-percentage-point overall increase in climate-related investments can be observed. This growth appears to be evenly distributed across all three risk categories—with transition risks increasing by 3%, and both acute and chronic risks increasing by 2% each. This confirms the investment trend observed during 2021–2023, indicating that firms are continuing to prioritize transition risks while gradually expanding their attention to physical climate risks as well.

We delved deeper into the typologies of investments made and planned. Graph 5.4 presents the first preference (out of three options) in the types of investment made for adaptation. Insurance contracts emerge as the primary choice, cited by 55% of firms, underscoring a prevailing preference for risk transfer over operational reorganization. Following insurance, a smaller but notable share of firms reports investments in water and waste reduction measures (16%), and physical damage protection (13%). Only a limited portion of firms prioritize more transformative measures, such as business model innovation (6%), production diversification (4%), or

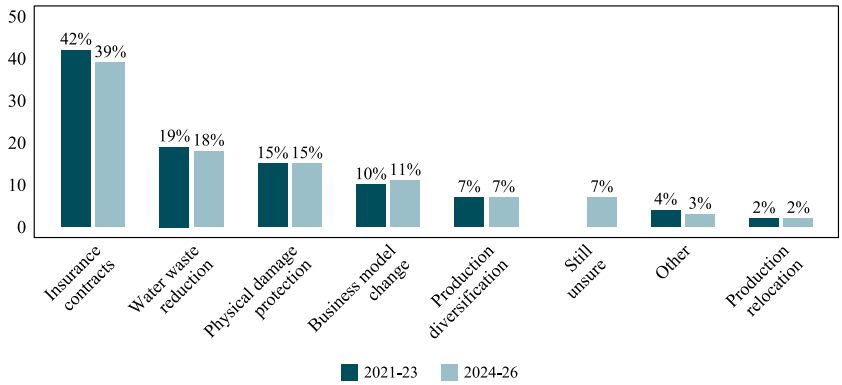


Graph 5.4 Adaptation investments made in 2021–2023 (1st preference). (Source: Own elaboration)

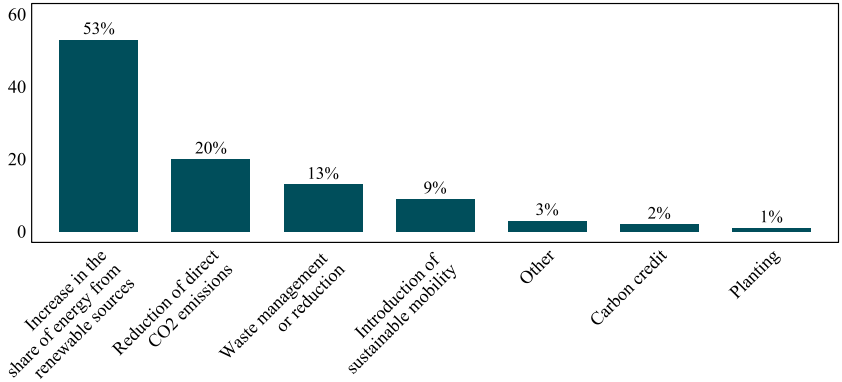
production relocation (1%). This pattern reflects a strong preference for risk protection over structural adaptation. The temporal evolution of adaptation investments confirms this trend. The composition of planned investment for 2024–2026 remains broadly consistent with past allocations. Variations in aggregate investment preferences are primarily driven by the share of firms that are still uncertain about how to allocate their green investment resources (see Graph 5.5).

Graph 5.6 presents firms' first preference for mitigation investments. The most common type of investment is the increase in the use of renewable energy (53% of firms), followed by investments oriented toward direct emission reduction (20%) and waste management (13%). Fewer companies report investments in sustainable mobility (9%), while a very limited portion of firms indicates carbon credit and planting as their preferred investments. This hierarchy mirrors the EU's policy priorities, suggesting that firms are strategically aligning with them. Again, the breakdown of planned investments for 2024–2026 largely aligns with previous investment decisions, with most changes reflecting the proportion of firms that are still unsure about the future (see Graph 5.7).

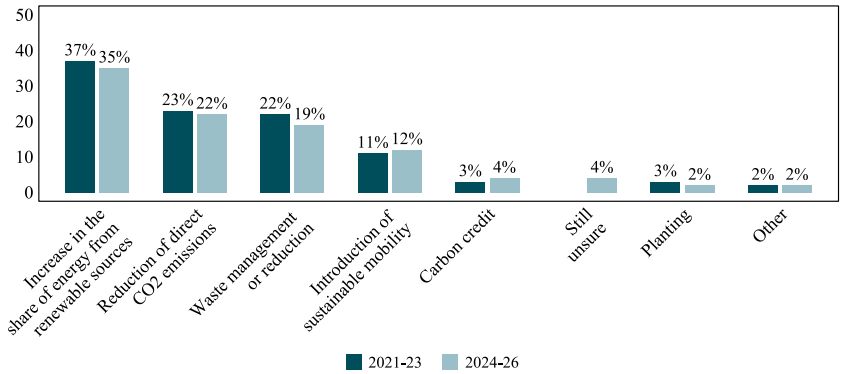
Drawing on both past and planned investments, we present descriptive statistics on the climate strategic profiles as defined in Chap. 3 (Sect. 3.3). Graph 5.8 displays the prevalence of the four strategic postures across the



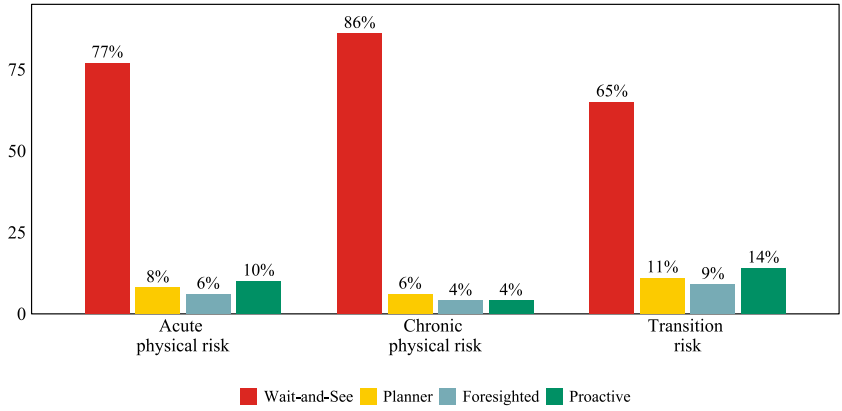
Graph 5.5 Adaptation investments 2021–2023 vs. 2024–2026 (aggregated preferences). (Source: Own elaboration)



Graph 5.6 Mitigation investments made in 2021–2023 (1st preference). (Source: Own elaboration)



Graph 5.7 Mitigation investments 2021–2023 vs. 2024–2026 (aggregate preferences). (Source: Own elaboration)



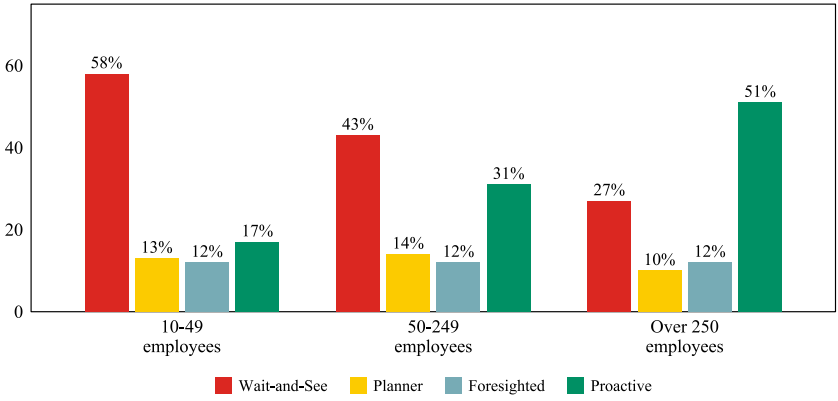
Graph 5.8 Climate strategies by type of risk. (Source: Own elaboration)

three risk categories. The findings show that most companies adopt a wait--and-see approach to climate risks, especially physical risks. Consistent with evidence on the prioritization of transition risks, the share of proactive firms is higher in mitigation (14%) compared to acute (10%) and chronic risks (4%).

5.3 Determinants of Climate Proactivity

5.3.1 Organizational Factors and Risk Perception

A key factor influencing firms' proactivity on climate change is their *size*. As shown in Graph 5.9, proactive strategies are significantly more widespread among medium-sized and large companies compared to small businesses. Smaller firms, which dominate the Italian economic fabric as well as the European economy, tend to adopt a wait-and-see stance (58%). This suggests structural barriers, such as limited resources and lack of expertise, that constrain smaller businesses. Nonetheless, these firms face comparable, if not greater, climate threats.

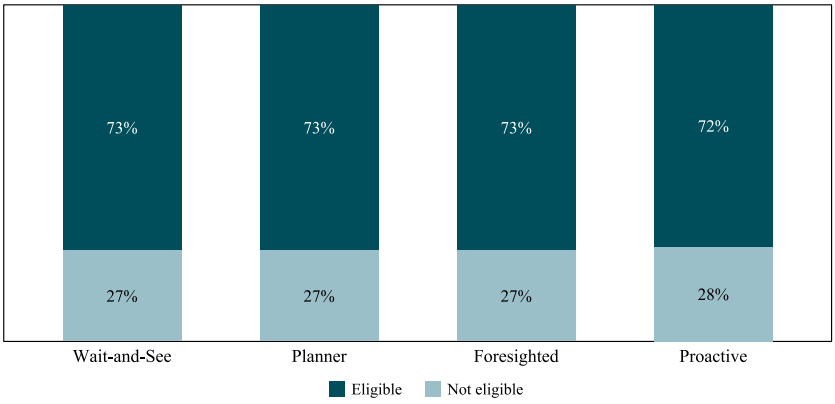


Graph 5.9 Climate strategies by size. (Source: Own elaboration)

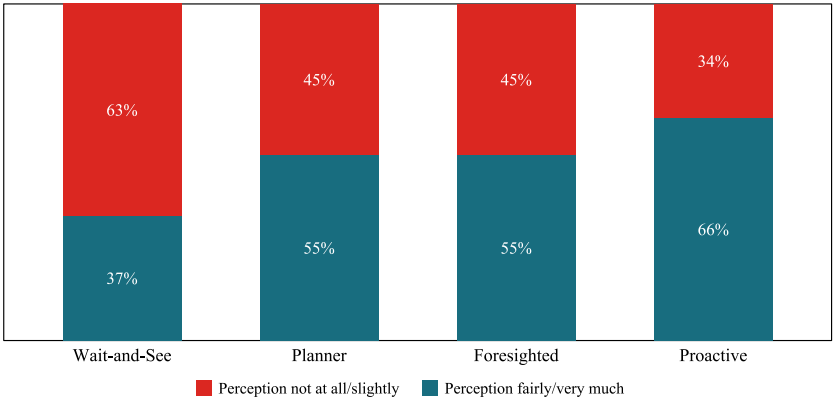
Furthermore, the firm's *sector* is examined in relation to mitigation strategies. Given that the EU Taxonomy places greater expectations on firms engaged in taxonomy-eligible economic activities, a higher level of proactivity in climate management can be anticipated among these firms. Surprisingly, our analysis does not reveal any meaningful differences between firms in eligible and non-eligible sectors (see Graph 5.10), indicating that eligibility does not necessarily translate into more proactive mitigation behavior. However, within the group of eligible sectors, certain industries show a higher commitment to climate change, most notably the energy sector.

By contrast, a firm's *location* significantly influences its level of proactivity in adaptation. This aligns with the fact that physical risks are closely tied to the specific climate vulnerabilities of the geographical area in which a firm operates. In our analysis, we find, for instance, that firms operating in Veneto, which is a region particularly exposed and vulnerable to physical risks, are more likely to show a proactive attitude compared to firms in other regions. A more detailed discussion on regional differences is provided in Appendix C.

Alongside structural organizational factors, *risk perception* appears to be a core element of climate proactivity. Two-thirds of proactive firms rank



Graph 5.10 Mitigation strategies by sector. (Source: Own elaboration)



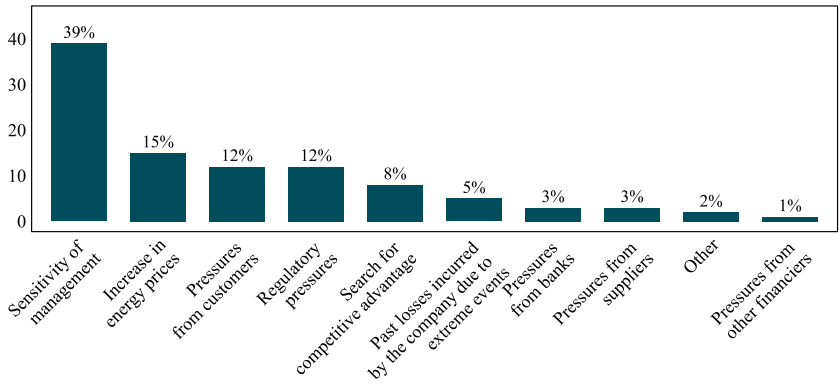
Graph 5.11 Climate strategies by risk perception. (Source: Own elaboration)

high in climate concern, while low-perception firms account for 63% of the wait-and-see group (see Graph 5.11). This indicates that, in line with expectations, companies with a medium/high risk perception are significantly more likely to show a higher proactivity.

5.3.2 Motivations and Barriers

Corporate investment in climate measures hinges on a complex interplay of internal motivations and external constraints. We provide some insights into the motives and obstacles to climate investments.

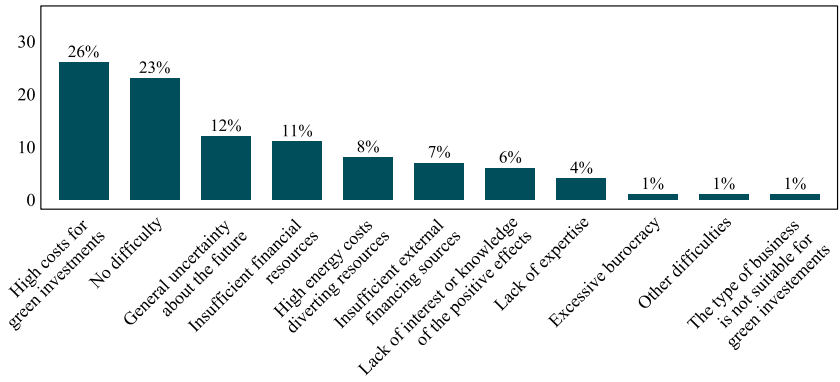
The most commonly reported motivation for climate investments among firms is management's sensitivity to sustainability issues, cited by around 40% of investing companies (see Graph 5.12). This intrinsic driver outweighs external pressures such as energy price volatility (15%), regulatory requirements (12%), customer demand for greener products (12%), and requests from suppliers (3%) and financial institutions (3%). Nonetheless, we also assess that drivers differ significantly between proactive and non-proactive firms, with external drivers



Graph 5.12 Drivers of climate investments (1st preference). (Source: Own elaboration)

showing a higher association with firms' proactivity. This provides evidence in support of the role of institutional pressures in fostering more forward-looking climate strategies. While SMEs may be more inclined to address climate issues based on their internal organizational values, external pressures can be crucial in prompting companies to take stronger action and providing them with clearer guidance on how to do it effectively.

On the barriers side, firms most frequently cite economic and financial constraints as the main obstacles to climate investments (see Graph 5.13). In particular, the high investment costs are the primary cited obstacle (26%), followed by difficulties in planning (12%), financial constraints (11%), the high energy costs diverting resources from investments (8%), and insufficient or unknown external financing sources. Furthermore, a consistent portion of firms (23%) report no difficulties at all, which is consistent with the share of firms having no concerns about climate risks (see Graph 5.1). Interestingly, the analysis also points out that obstacles differ significantly between wait-and-see and investing firms. More specifically, wait-and-see firms perceive



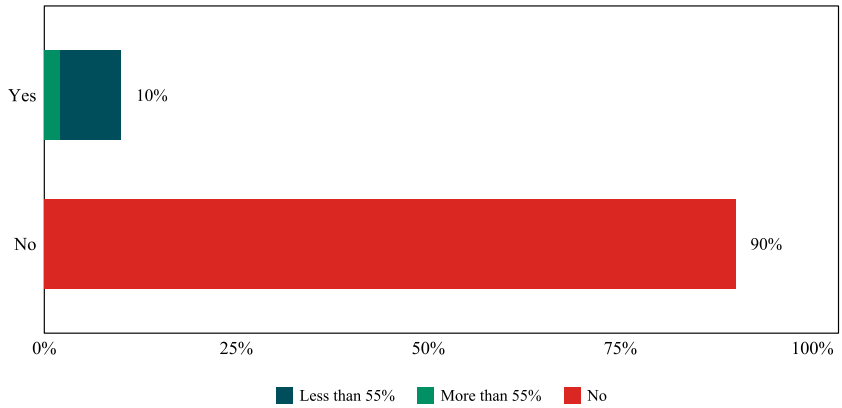
Graph 5.13 Obstacles to climate investments (1st preference). (Source: Own elaboration)

investment barriers to a significantly lesser extent, reflecting a low level of awareness. These firms also tend to show limited interest in climate issues and a lack of expertise, whether internal or external. This highlights the importance of fostering climate education and promoting capacity-building, i.e., the development of adequate skills and competencies.

5.3.3 Emission Reduction Targets

The establishment of specific CO_2 emission reduction targets by firms is explored in relation to proactivity behaviors. Setting clear, measurable objectives may signal not only an awareness of climate-related risks but also a commitment to long-term strategic planning aligned with sustainability goals and international agreements (e.g., the Paris Agreement).

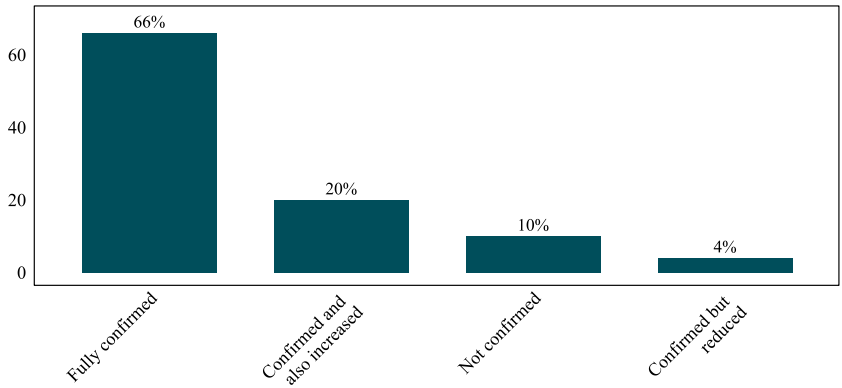
Our findings reveal that 90% of companies did not establish any such targets for the period 2021–2024 (see Graph 5.14). Notably, the vast



Graph 5.14 CO_2 emission reduction targets. (Source: Own elaboration)

majority of these firms show a wait-and-see approach to climate change. This pattern suggests that the absence of emission reduction targets may be both a symptom and a cause of low levels of climate investment. First, the absence of emission reduction targets in strategic planning may help explain the limited investment by firms in adaptation and mitigation measures: without clear goals, firms may lack the internal momentum or justification needed to allocate resources toward adaptation and mitigation. This, in turn, has detrimental effects on corporate contributions to emissions reduction: the more firms delay in formalizing commitments, the less likely they are to invest in climate change attenuation, and thus, to meaningfully contribute to emission reduction.

Moreover, we observe that among the firms that have formally set emission reduction targets, most companies have adopted plans aimed at cutting emissions by less than 55% by 2030 (see Graph 5.14). This indicates a level of target ambition below what would be required to meet the objectives of the Green Deal, transposed by the Member States through the European Climate Law. Examining the investment plans for emission reduction scheduled for 2024–2026 (see Graph 5.15), it becomes evident that most companies (approximately 65%) have reaffirmed their investment strategies from the previous three-year period, whilst one out of five companies has increased investments and/or

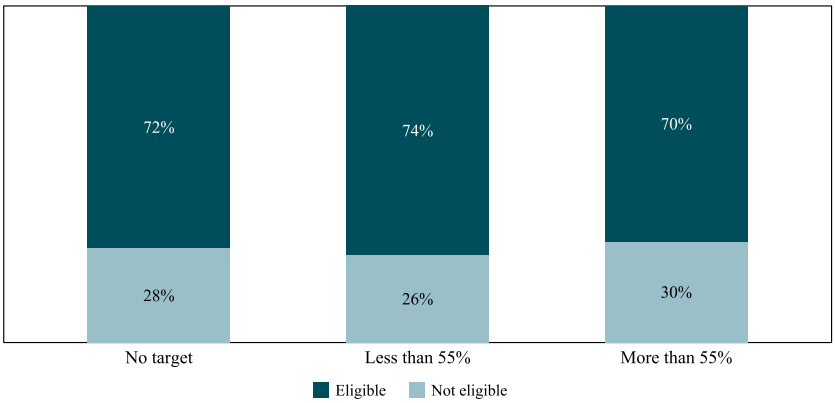


Graph 5.15 CO_2 emission reduction targets confirmation. (Source: Own elaboration)

raised reduction targets. However, about 10% of firms have chosen not to confirm their plans, abandoning both their investments and emission reduction goals.

Additionally, among firms that have established more ambitious targets, it is the proactive companies that have taken the lead, setting goals for full emission reduction by 2050 in line with long-term climate neutrality commitments. These firms thus demonstrate a greater alignment with the European decarbonization pathway and a stronger integration of climate objectives into their strategic vision. Surprisingly, however, the largest contribution to emission reduction does not originate from eligible sectors, and no significant differences in target setting emerge between eligible and not-eligible sectors, as illustrated in Graph 5.16.

These findings carry important implications not only for firms' resilience but also for the broader collective effort to reduce emissions. In this context, raising awareness of the strategic and economic value of early action becomes essential, especially in eligible sectors. Encouraging firms to move beyond a reactive stance and toward proactive planning is critical to accelerating the transition to a low-carbon economy and achieving meaningful progress in reducing CO_2 emissions.

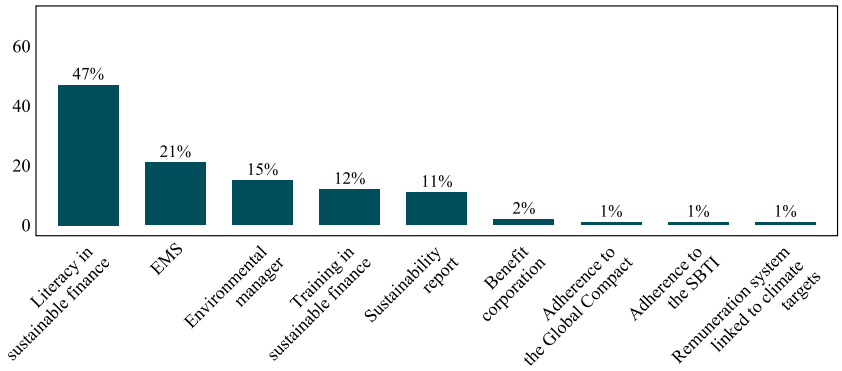


Graph 5.16 CO_2 emission reduction targets by eligible sectors. (Source: Own elaboration)

5.3.4 Corporate Governance Mechanisms

Based on the literature, in this research we consider the role of corporate governance (CG) in promoting a proactive approach to climate-related risks. Recognizing the importance of the governance *of* sustainability and *for* sustainability, we analyze the relationship between climate strategies and different operational governance mechanisms aimed at facilitating the integration of climate risks into strategic planning and business operations (see Chap. 3, Sect. 3.2).

The data presented in the chart (Graph 5.17) offer a snapshot of the current state of sustainability-related CG mechanisms across organizations. The CG mechanism showing the highest frequency is *literacy in sustainable finance*, reported by 47% of organizations. This reflects that recognition of the critical role of sustainability-related themes is still limited, and that most companies ignore new regulations in the sustainable finance field, which is key for planning investments. Increasing knowledge and awareness in this area equips decision-makers to better align investments with environmental goals. About 21% of firms adopt *environmental management systems* (EMS), which provide a formalized framework for organizations to manage their environmental impacts and comply with relevant regulations. The figure indicates that nearly four



Graph 5.17 Distribution of corporate governance mechanisms. (Source: Own elaboration)

out of five organizations have yet to implement such a system, highlighting a need for greater institutionalization of environmental governance. Only 15% of organizations have designated an *environmental* or *sustainability manager*. The absence of dedicated officers may hinder the effectiveness of sustainability efforts, lacking accountability and strategic direction. Furthermore, just 11% of firms produce a *sustainability report*. In the face of the growing pressures and demands from a variety of stakeholders for increased transparency, this figure is notably low. In the light of the CSRD, these data highlight that many firms are unprepared for the shift toward a mandatory sustainability disclosure regime. The bottom four categories—*benefit corporation* status (2%), *remuneration linked to climate targets* (1%), *adherence to the UN Global Compact* (1%), and *SBTi* (1%)—reflect a strikingly low level of commitment to more ambitious sustainability governance practices, involving changes in the legal structure, remuneration scheme, and participation in multi-stakeholder initiatives.

Table 5.1 presents a comparative overview of the presence of the above CG mechanisms across strategic clusters as identified in Chap. 3 (Sect. 3.3). Overall findings suggest that a more proactive approach is positively related to the integration of sustainability governance mechanisms. For instance, the percentage of organizations that publish a *sustainability*

Table 5.1 Distribution of corporate governance mechanisms by strategies

	Wait and see	*Planner*	*Foresighted*	*Proactive*
Sustainability report	6.0%	12.4%	12.9%	23.1%
Environmental manager	7.5%	17.2%	16.3%	30.1%
Climate-linked remuneration	0.4%	1.0%	1.4%	3.1%
Sustainable finance literacy	38.0%	51.0%	53.0%	62.2%
Sustainable finance training	17.8%	27.2%	24.1%	39.8%
Adherence to UN Global Compact	0.3%	0.4%	0.3%	2.2%
Adherence to Science Based Targets Initiative	0.3%	0.6%	0.4%	1.2%
Benefit corporation	1.0%	1.5%	2.1%	3.5%

Source: Own elaboration

report rises steadily from 6.0% in the wait-and-see group to 23.1% among proactive actors. This suggests that sustainability reporting is potentially conducive to proactivity in climate change management. Similarly, the presence of an *environmental manager* increases significantly across the spectrum—from just 7.5% in the inactive group to 30.1% among proactive organizations. This highlights the importance of dedicated roles in embedding sustainability into governance structures. Notably, *literacy* in sustainable finance is relatively high across all organizational profiles but especially among proactive companies. This indicates that understanding financial implications and opportunities tied to sustainability is a foundational element for strategic action. This supports that higher awareness of sustainability issues and knowledge about regulatory interventions in the sustainability field can promote corporate climate engagement by facilitating the adoption of a planner, foresighted, or proactive approach. Complementary to this, *training* in sustainable finance also follows an upward trend, with proactive organizations almost doubling the investment seen in the wait-and-see category (39.8% vs. 17.8%), thus suggesting its importance in translating knowledge into actions.

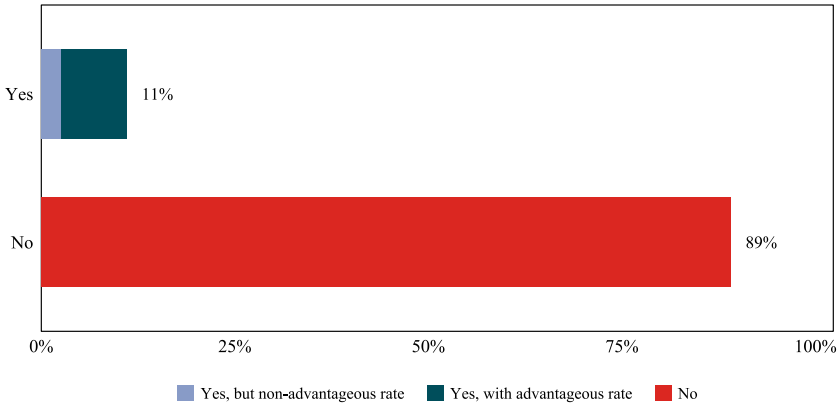
By contrast, the other sustainability initiatives—adherence to the UN Global Compact, SBTi, and Benefit Corporation status—show consistently low adoption among all categories, indicating limited uptake regardless of the organization's strategic approach to climate issues.

5.3.5 Green Financing

Besides the organizational structure, the research also investigates the forms of financing underlying the climate investments by firms. In particular, we asked companies that had made investments in the period 2021–2023 whether they had financed those investments using green financing measures, such as green loans or green bonds. From this question, it emerges that most companies did not benefit from green financing; only 11% used some form of green financing (see Graph 5.18).

In relation to this portion of firms, we further examined the economic convenience of interests applied. It turns out that the interest rate is considered economically beneficial by almost 80% of firms, compared to the rate that would have been applied to an equivalent non-green financing. This suggests that green financing, although not yet widely adopted among SMEs, can serve as a direct economic incentive for sustainable investment, encouraging companies to pursue low environmental impact projects, as this also results in financial benefits through lower debt costs.

Nonetheless, data analysis also highlights that the majority (70%) of companies that accessed green financing did not produce a sustainability report. Since sustainability reports are an essential part of companies' disclosure about their environmental and social impacts, the lack of this requirement raises concerns about the credibility of green financial instruments, whose effectiveness may be compromised by weak eligibility and monitoring standards set by financial institutions.



Graph 5.18 Green financing. (Source: Own elaboration)

5.4 Biodiversity

Biodiversity is the variety of life in all its forms, which is why it is not uncommon to regard biodiversity as the number of species of organisms that inhabit Earth. Economic development is closely linked to environmental issues, as it relies on the consumption of natural resources. Unfortunately, this has serious consequences, leading to an irreversible loss of biodiversity and the collapse of ecosystems.

In this research, we provide a brief overview of how companies perceive and address biodiversity. In particular, the analysis is structured around two levels of investigation. First, we draw on some general questions featuring firms' views on biodiversity, which were administered to companies across all sample regions. Second, we summarize findings from a set of more detailed questions that were specifically administered to firms located in Tuscany, by virtue of its strong industrial presence as well as its geographical position along the belt of Apennine chains, an area with high landscape conservation status. For these companies, the topic of biodiversity is explored in greater depth by analyzing corporate policies related to the issue, relationships with suppliers, and, finally, corporate responsibility regarding biodiversity impact.

Table 5.2 shows that most companies (55%) in the overall sample are not aware of biodiversity issues. About 31% demonstrate some awareness, while only 14% are actively deepening their understanding. This points to a widespread low level of biodiversity literacy among firms.

Moreover, findings suggest that, among companies that are familiar with the topic, biodiversity is poorly integrated into corporate sustainability policies, with only 16% of firms including it. Among these, approximately 35% of respondents indicate that biodiversity is addressed through strategic guidelines and investment plans aimed at reducing the company's impact on biodiversity and mitigating the risks associated with its degradation. Meanwhile, around 30% view biodiversity as a growth opportunity

Table 5.2 Literacy in biodiversity

Literacy in biodiversity	*Answers*	*Percentage*
No, we are not familiar with the topic	5265	55%
Yes, we are familiar with it	3003	31%
Yes, we are further exploring the topic	1362	14%
Total	**9630**	**100%**

for their business, and 35% have integrated biodiversity into their sustainability policies with both objectives in mind (see Table 5.3).

Diving deeper into the sample of firms located in Tuscany, Table 5.4 further shows the type of sustainability policies implemented in relation to biodiversity. We observe that among the companies that formally integrate biodiversity into their sustainability policies, a consistent share of firms have implemented training activities on the topic (41.54%); they have opted for unconventional communication methods, including social media (40%), or disclosed information through sustainability reports (31.54%). However, fewer companies (24.62%) have undertaken concrete initiatives aimed at ecosystem regeneration, going beyond communication and education on biodiversity. As for cooperation policies with other organizations, 18 out of 130 companies have established partnerships to raise awareness on the issue, while ten companies have chosen to directly support environmental associations through financial contributions.

By asking companies familiar with the topic of biodiversity to share their perception of its impact in relation to their suppliers, we assess their awareness of the issue from a supply chain perspective. Graph 5.19 shows that most companies do not consider biodiversity a factor in supplier selection (75%) or a topic discussed in supplier relations (72%). Furthermore, responsibility for biodiversity impacts is rarely attributed to suppliers (78%), and even less so to the company itself (87%). This suggests that companies struggle to recognize themselves and their supply chain as the main parties responsible for the impact on biodiversity, highlighting a broader lack of ownership and accountability in managing biodiversity within supply chain practices.

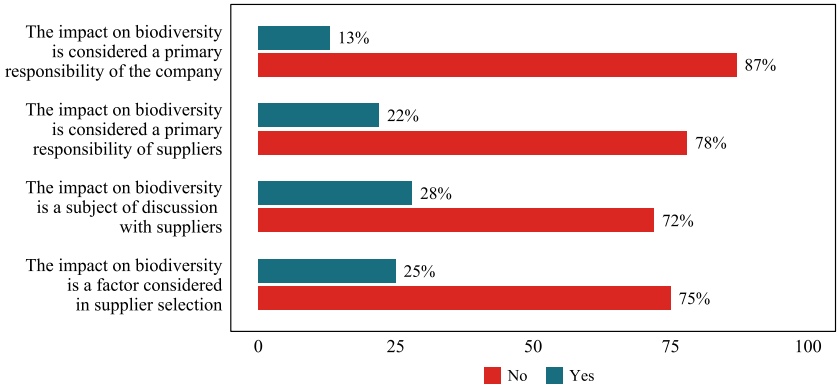
Table 5.3 Biodiversity and corporate sustainability policies

Biodiversity and corporate sustainability policies	*Number*	*Percentage*
Biodiversity is addressed through strategic guidelines and investment plans aimed at reducing the company's impact on biodiversity and mitigating the risks associated with its degradation	237	35.5%
Biodiversity is addressed through strategic guidelines and investment plans aimed at pursuing new opportunities for the business growth	208	30.2%
Both answers	243	35.3%
Total respondents	**688**	**100%**

Table 5.4 Corporate sustainability policies related to biodiversity of Tuscan companies

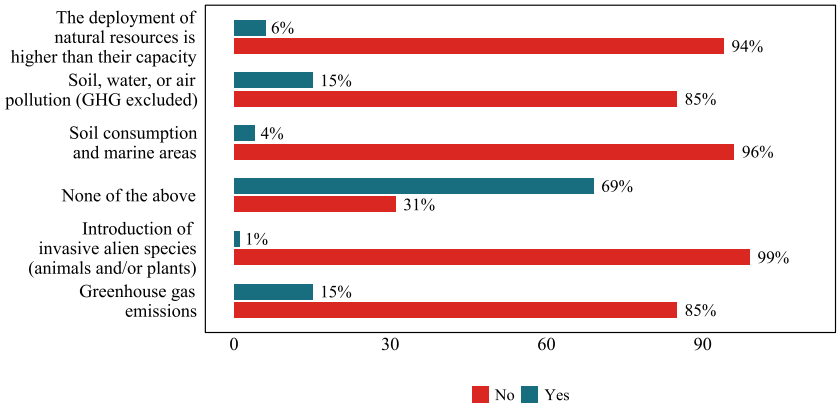
Corporate sustainability policies related to biodiversity	*Number*	*Percentage*
Corporate training on the topic	54	42%
Other forms of communication (e.g., press releases, social media, website)	52	40%
Sustainability report	41	32%
Environmental projects aimed at ecosystem restoration	32	25%
Partnerships aimed at awareness-raising and/or initiatives on the topic	18	14%
Donations to environmental associations working on the issue	10	8%
Other	4	3%
Total respondents	**130**	**100%**

Note. Multiple choices allowed. Total respondents: 130 companies



Graph 5.19 Biodiversity from a supply chain perspective. (Source: Own elaboration)

To further explore the issue of responsibility, respondents were asked to identify the biodiversity impact categories for which their company recognizes primary responsibility. As shown in Graph 5.20, 69% of companies report that they do not acknowledge significant responsibility in any of the listed impact categories. This finding may reflect either a genuinely limited environmental pressure exerted by business activities or, more likely, a low



Graph 5.20 Biodiversity impacts identified as most relevant to the company's responsibility. (Source: Own elaboration)

level of awareness or difficulty in understanding their influence on ecological systems. Among the remaining respondents, two main areas of responsibility emerge: soil pollution and greenhouse gas emissions, each cited by 15% of the companies. These aspects are generally more visible, due both to increased media attention and to growing regulatory pressure, which pushes companies toward greater awareness. Conversely, the role played by businesses in other environmental issues is perceived as marginal, such as the introduction of invasive alien species (recognized by only 1%) and land or marine area consumption (only 4%). These types of impacts, although ecologically significant, may be less understood or perceived as relevant by the companies themselves, possibly due to limited institutional communication, low cultural awareness, or differing sector-specific perceptions.

Overall, this result suggests the need to raise awareness and inform companies about the concept and implications of biodiversity, to encourage more responsible practices and business strategies that are more closely aligned with environmental sustainability.

CHAPTER 6

The Role of Climate Risk in Driving Green Business Model Transformation: Evidence from the Agrifood Sector in Southern Italy

Abstract This chapter examines the role of climate risk in driving green business model transformation, with a focus on agrifood SMEs in Southern Italy. Using survey data on food enterprises, it analyzes the relationship among green investments, business model change, and economic performance in a sector highly exposed to both transition and physical risks.

Keywords Green investments • Green business model • Business model innovation • Financial performance • Agrifood

This chapter analyzes the impact of green investments on firms' economic performance, by distinguishing between different types of green investments according to the degree of business model transformation (simple-green vs. deep-green investments). The results show how deep-green investments alone don't have a direct positive influence on economic performance; however, since they impact the business model, they can have an indirect positive effect on it. Moreover, the chapter investigates which risk factors influence the most firms' decisions to invest in green, within the category of risks associated with climate change, showing how transition risk is the key driver of deep-green investments, in contrast to physical risks.

V. Palea et al., *Climate Strategies and Sustainability Pathways of Italian Small and Medium-Sized Enterprises*, Palgrave Studies in Climate Resilient Societies,
https://doi.org/10.1007/978-3-032-17454-3_6

6.1 Introduction

Investing in green initiatives has become increasingly important for firms, not only to comply with environmental regulations and pressures from stakeholders and investors (e.g., Ahmed & Halil, 2023; Tamasiga et al., 2024), but also to adapt and/or mitigate climate risks (Li, 2025). Indeed, green investments are fundamental to counteracting both the negative effects of climate change on business activity and the harmful environmental externalities caused by firms. They represent the first step toward achieving environmental sustainability.

Previous research on the topic suggests that undertaking green investments can have a positive impact on firms' economic performance, for example in terms of output, employment, and turnover, thus representing a lever of competitive advantage (i.e., Siedschlag & Yan, 2023). More broadly, studies have provided evidence that CSR-related investments positively affect the financial and sustainable performance of firms (Indriastuti & Chariri, 2021). However, to the best of our knowledge, there are still gaps in the literature regarding the effects of different types of green investments on economic growth and the impact of climate risks on investment decisions. Filling this void is crucial to identify which green investments can have a greater impact on economic performance, in order to maximize the benefits stemming from the green transition. Moreover, studying the channels through which these effects materialize can provide a deeper understanding of the relationships between green investments and economic growth. Similarly, uncovering the nexus between climate risks and green investments is fundamental to understanding the drivers of investment decisions and designing optimal environmental policies.

To fill the identified research gaps, this chapter employs a mediation analysis to explore the nexus between climate risks, different types of green investments, green business model transformation, and turnover expectations. The analysis is conducted on a sample of 750 food enterprises located in the South of Italy with at least four employees; thus, it represents a valuable contribution to the GRINS project and its data platform AMELIA. Indeed, it provides novel data on climate risks and green investment decisions with a greater level of granularity.

The chapter begins by testing several determinants of green investment decisions, i.e., safeguarding against acute physical risk, chronic physical risk, and transition risk, to explore which type of climate risk influences investment decisions the most. Next, the analysis is extended to analyze

the impact of green investments on firm economic performance (measured in terms of turnover expectations), not only directly but also through the changes in the business model they produce. The peculiarity of the analysis lies in the fact that the impact of different types of green investments is examined by distinguishing between simple-green investments and deep-green investments, as to identify which category is conducive to the best economic results.

The findings shed light on the potential benefits of investing in deep-green, i.e., in technologies and production processes that change the business model, since these types of investments lead to higher turnover expectations compared to simple-green investments (i.e., investments aimed at compensating for the negative environmental externalities caused by the business activity). Furthermore, by quantifying the impact of climate risks on investment decisions, this chapter provides policymakers with recommendations on how to create a conducive environment for sustainable business practices.

Therefore, these results can contribute to a more comprehensive understanding of the drivers of green investment decisions and the mechanisms behind their impact on economic performance, enabling more informed decision-making and the development of effective strategies for promoting sustainable business practices.

6.2 Hypothesis Development

6.2.1 Climate Risks and Investment Decisions

Climate risks and their implications for investment decisions are gaining increasing relevance for corporate strategy and environmental policy (Pata et al., 2024). Although accurate quantification of both transition and physical risks remains a substantial challenge for the industry and policymakers (Rising J et al., 2022), a substantial body of literature has investigated the influence of climate risks on corporate investment behavior (Engle et al., 2020) and on the initiatives undertaken by firms to mitigate carbon emissions (Rodriguez Lopez et al., 2017). For instance, Li et al. (2024) quantify firms' exposure to both physical and transition climate risks, demonstrating that firms facing elevated levels of climate risk tend to respond through increased investment, the development of green innovations, and adjustments in employment strategies. The attention devoted to the topic is largely driven by the increasing recognition of the

multifaceted risks associated with the physical impacts of climate change and the evolving regulatory landscape aimed at facilitating the transition to a net-zero economy, which has led researchers to explore how firms respond to climate-related pressures exerted by investors and other stakeholders (van Benthem et al., 2022). Furthermore, recent evidence has supported that physical risks and transition risks can exacerbate financial systemic risks, even though limited to the occurrence of the most adverse climate scenarios (Migliorelli, 2023). Additional studies have focused on the relationship between climate risk and the performance of green energy assets, revealing that heightened climate risk may act as a catalyst for investment in alternative energy sources (Dutta et al., 2023).

Based on this, we posit that higher climate risk exposure positively affects a firm's propensity to undertake green investments, especially those aimed at the transformation of its business model (i.e., deep-green investments). Therefore, we propose the following hypothesis:

Hp1 : Climate risk influences firms' decisions to invest in deep-green.

6.2.2 Green Investments, Green Business Model, and Firm Economic Performance

Ever since the green transition of businesses has become a matter of interest and competitiveness concerns have risen, the relationship between green investments and economic performance has gained attention in the literature. In a recent paper by Siedschlag and Yan (2023), for instance, the authors investigate the impact of firms' green investments on a wide range of performance outcomes, such as output growth, employment, productivity, export intensity, and energy intensity, to find out that, on average, in the medium term, green investments have positive effects on firms' performance. Similarly, Ahmed and Halil (2023) find that firms adopting proactive environmental strategies tend to achieve long-term competitive advantage through enhanced reputation, cost savings, and improved stakeholder relations. Indriastuti and Chariri (2021) examine the relationship between green investment, CSR investment, and sustainability to conclude that green investments and CSR investments positively affect the financial performance and sustainable performance of firms. More recently, D'Angelo et al. (2023) have explored the impact of green manufacturing practices, disentangled into green activities and green

investments, to show how green activities have a positive effect on economic performance, while green manufacturing investments have an inverted U-shaped relationship with economic performance.

Additionally, the characteristics of enterprises that realize green investments have also been analyzed in the literature. In this respect, it is worth mentioning the work of Siedschlag and Yan (2021), who have discovered that green investments are more likely to be realized by larger firms, importers, and firms that are part of an enterprise group.

However, extant studies have mainly focused on green innovations, which can be adopted to enhance efficiency in the use of natural capital and foster new economic opportunities (Authority & Allé, 2012). Green or eco-innovations are essential to decouple economic growth from environmental impacts and are of particular importance to enable a long-term transition and transformation toward a greener economy (Authority & Allé, 2012). For instance, Liu (2024) examines the correlation between green corporate innovation and its potential effects on firm performance and risk reduction, to find out that implementing green innovation leads to a reduction in firm volatility and credit risk, while also enhancing firm value and emission performance. A similar conclusion is reached by Tang et al. (2018), who observe that green process and product innovation have a positive and significant impact on firm performance. Analogously, Khalil and Nimmanunta (2023) underline that investments in green innovation are beneficial for firms' value.

Green investments can also lay the foundation for the development of green business models (GBM). According to the framework proposed by Sommer (2012), GBMs are characterized by five key elements: the green value proposition, the target group, key activities, key resources, and financial logic. Building on this, Trapp and Kanbach (2021) identify the following three elements as constitutive of every green business model: (1) a green value proposition, which provides a combination of ecological value and economic value to firms' customers and other stakeholders; (2) value creation and delivery, which describe how a firm and its partners create and deliver ecological and economic value for all stakeholders; (3) value capture, which describes how a firm captures a combination of environmental value and economic value from the provision of a product and/or service. More specifically, the authors distinguish 12 distinctive green business model archetypes, such as the Energy Efficinnovator, Efficiency Energizer, and the Green Technolooper. Quintás et al. (2018) analyze the components of GBMs in SMEs from the point of view of decarbonization,

identifying nine voluntary practices able to transform a traditional BM into one oriented toward environmental sustainability, namely energy and environmental audits; product life cycle; ecological design; eco-labeling; best available techniques for attaining lower consumption of resources and/or environmental impact; recycling, reuse, and/or valorization of sub-products and waste products; waste and recycled materials for generating energy; cogeneration and trigeneration. Furthermore, Müller and Pfleger (2014) propose a "sustainability maturity cube" to help organizations define the set of actions needed to transform their business activity toward greater sustainability, with the aim of integrating ecological, social, and economic objectives in their decision model.

With regard to the Italian context, the relationship between firms' eco-innovation and business performance has been studied by Cassetta et al. (2023), who have explored this issue by focusing on the role played by external collaborations with supply chain and quadruple helix actors as factors explaining the economic effects of eco-innovation. A topic that has been investigated earlier in time by Ghisetti et al. (2015), who already recognized the economic importance of environmental innovations and their "win–win" effect on firms' competitiveness and environmental sustainability.

Based on the literature, we propose the existence of a positive relationship between green investments and economic performance, which can be explained by the transformation of the business model toward greater environmental sustainability. In particular, since we are interested in testing the impact of different types of green investments on economic performance, we formulate the following hypotheses:

Hp2 : Deep-green investments have a positive direct effect on firms' economic performance.

Hp3 : Deep-green investments have a positive indirect effect on the firms' economic performance via *green business model transformation.*

6.3 Conceptual Framework

Based on the hypotheses presented in Sect. 6.2, we have developed the conceptual framework represented in Fig. 6.1.

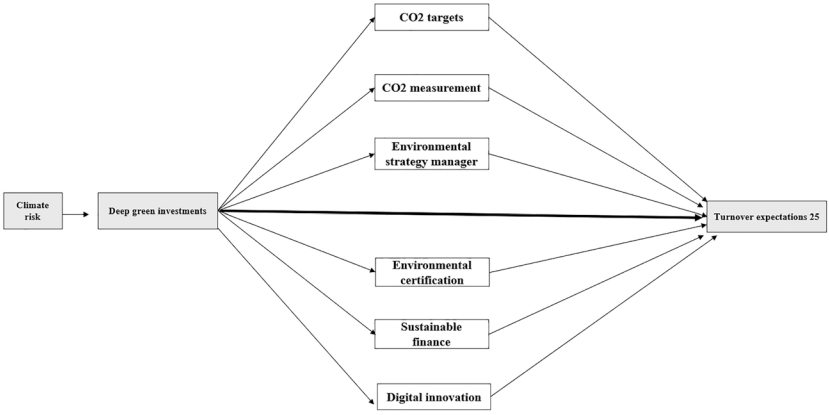


Fig. 6.1 Conceptual framework. (Source: Own elaboration)

The purpose of the analysis is twofold. First, to understand if climate risks play a role in influencing firms' decisions to invest in green, particularly in deep-green investments, and which category of climate risk exerts the greater influence on this choice (i.e., physical risks or transition risk).

Second, to understand if deep-green investments have a positive direct impact on firms' economic performance or if their impact is exerted indirectly by the mediating role of the business model. The underlying hypothesis, here, is that deep-green investments may not have a direct impact on economic performance. However, if their adoption is positively correlated with the introduction of other measures that have the potential to transform the business model toward greater sustainability, they can have an indirect positive impact on economic performance through the changes in the business model they generate.

For the purpose of the analysis, we have measured positive economic performances in terms of positive turnover expectations, while, to measure the change in the business model, we have considered the following initiatives: the definition of CO_2 targets; CO_2 measurement; the appointment of an environmental strategy manager; the achievement of environmental certifications; access to sustainable finance; investments in digital innovation (see the following Sect. 6.4.2. for more details).

6.4 Methodology

6.4.1 Sample

The data derive from a survey carried out between July and September 2024 by Centro Studi Tagliacarne—Unioncamere (Italian Union of Chambers of Commerce) as part of the GRINS project. The survey was conducted on a sample of 752 firms having at least 4 employees, operating in the food sector and located in Southern Italy (whose frame population counts 6.500 units). The sample was selected through a stratified simple random sampling design with strata given by class size in terms of employees (4–9, 10–49, 50 and over), industry (one sector of the section C manufacturing sector of the Nace Rev.2 classification: Food), and geographical location (Campania, other regions of Southern Italy). The survey was administered via a mix of CATI and CAWI techniques.

6.4.2 Econometric Model

We conducted a mediation analysis (Hayes, 2018) to test if: (1) deep-green investments are related to the turnover expectations growth, by estimating the direct effects; (2) all factors of business model transformation mediate the influence of deep-green investments on turnover expectations growth, by estimating the indirect effects. In other words, we simultaneously estimate the direct effect of deep-green investments on the turnover expectations growth, and the indirect effect of deep-green investments on turnover expectations via business model transformation (mediation effect). To do so, we applied structural equation modeling. The path explained in Fig. 6.1 is estimated through the following equations:

$$M_{1i} = i_{M_1} + a_1 X_i + \varepsilon_{M_1} \tag{6.1}$$

$$M_{2i} = i_{M_2} + a_1 X_i + \varepsilon_{M_2} \tag{6.2}$$

$$M_{3i} = i_{M_3} + a_1 X_i + \varepsilon_{M_3} \tag{6.3}$$

$$M_{4i} = i_{M_4} + a_1 X_i + \varepsilon_{M_4} \tag{6.4}$$

$$M_{5i} = i_{M_5} + a_1 X_i + \varepsilon_{M_5} \tag{6.5}$$

$$M_{6i} = i_{M_6} + a_1 X_i + \varepsilon_{M_6} \tag{6.6}$$

$$Y_i = i_Y + c'X_i + b_1M_{1i} + b_2M_{2i} + b_3M_{3i} + b_4M_{4i} + b_5M_{5i} + b_6M_{6i} + \varepsilon_Y \quad (6.7)$$

where M_1, M_2, M_3, M_4, M_5, M_6 are the mediators (*CO_2 targets, CO_2 measurement, environmental strategy manager, certify_amb01, sustainable finance, digital innovation*), Υ is the response variable *Export growth*, X is the key variable related to the *Deep-green investments*. Finally, ε is the random error term.

In Eqs. 6.1-6.2, the coefficients a_1, a_2, a_3, a_4, a_5, a_6 are the effects of the corresponding key variable (X) on the mediators (M_1, M_2, M_3, M_4, M_5, M_6). In Eq. 6.7, the coefficient c' is the direct effect (that is, unmediated) of the key variable (X) on the response variable Υ; coefficient b_1 is the effect of the mediator M_1 on Υ.

The indirect effect measures the effects of X on Υ, as well as Z on Υ, that are explained (mediated) by the mediator. Specifically, we have six indirect effects: one for each mediator (a_1b_1, a_2b_2, a_3b_3, a_4b_4, a_5b_5, a_6b_6); the sum of these six effects constitutes the total indirect effect. The sum of these two effects (direct and indirect) constitutes the total indirect effect. Thus, the total effect (c) of X on Υ corresponds to the sum of the direct effect (c') and the indirect effects.

Dependent variable. We measured expected turnover using a dummy variable (*turnover expectations 25*) equal to 1 if the firm has positive turnover expectations in 2025.

Key independent variables. To identify firms that undertake deep-green investments (*deep-green investments*), we considered the type and number of investments that they realized. In particular, we regarded as deep-green investors all those enterprises that realized at least two investments with a transformative effect on the business model, in contrast with simple-green investments (which represent our benchmark), put in place by firms that realized at most one transformative investment. To measure the risk of transition, we used a dummy variable (*transition risk*) equal to 1 if the firm is impacted by this type of risk.

Mediators. To identify the effects induced by a change in the business model, we considered a series of initiatives that have the potential to impact the business organization in the direction of greater environmental sustainability, according to the different dimensions of GBM defined by Abuzeinab et al. (2018) and Quintas et al. (2018), related to value capture and proposition, key resources and processes, and financial logic.

Table 6.1 Description of variables employed in the econometric analysis

Variables	*Type*	*Description*
Dependent variable		
Turnover expectations 25	Dummy	1 = if the firm expects positive turnover in 2025
Key independent variables		
Deep-green investments	Dummy	1= if the firm realizes deep-green investments
Transition risk	Dummy	1= if the firm is impacted by transition risk
Mediators		
CO_2 targets	Dummy	1 = if the firm sets targets of CO_2 emissions reduction
CO_2 measurement	Dummy	1 = if the firm measures CO_2 emission's reduction
Environmental strategy manager	Dummy	1 = if the firm has an environmental strategy manager
Environmental certification	Dummy	1= if the firm has environmental certifications
Sustainable finance	Dummy	1= if the firm has benefitted from sustainable finance
Digital innovation	Dummy	1= if the firm has invested in digital innovation

First, we considered the firm's involvement in reducing CO_2 emissions, by setting targets for emissions reduction (*CO_2 targets*) and systems to measure direct emissions (*CO_2 measurement*). Then, we looked for the presence of an environmental strategy manager (*environmental strategy manager*) and the achievement of environmental certifications (*environmental certification*) to prove the firm's ambition to reduce its environmental impact. Finally, we regarded the access to sustainable finance instruments (*sustainable finance*) and the decision to invest in digital innovations (*digital innovation*) as two other factors contributing to the greening of the business model. We regarded all these mediator variables as dummies equal to 1 if the firm is engaged in the activity, as reported in Table 6.1.

6.4.3 Descriptive Statistics of Variables

Table 6.2 displays summary statistics of the variables used. The share of firms that have positive turnover expectations in 2025 is equal to 41,8% (*turnover expectations 25)*, while one firm out of two is impacted by transition risk (*transition risk:* 50,5%). Overall, only a small proportion of firms undertake deep-green investments (*deep-green investments*:7,7%), while

Table 6.2 Summary statistics of variables

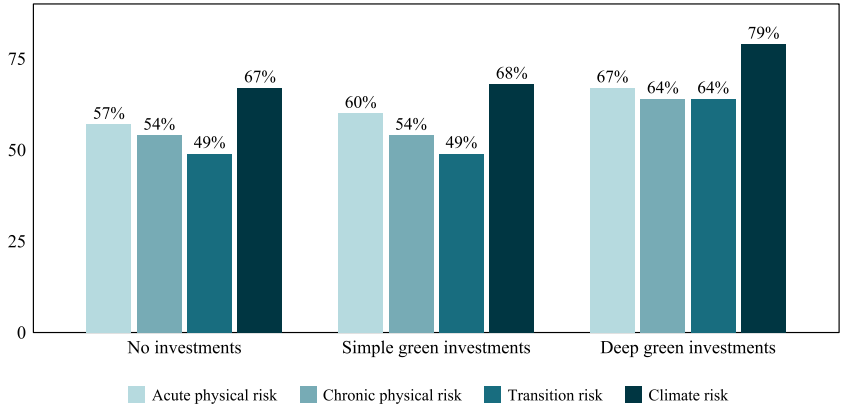
Variables	*Mean*	*Std. Dev.*	*Min*	*Max*
Turnover expectations 25	0.418	0.493	0	1
Transition risk	0.505	0.500	0	1
Deep-green investments	0.077	0.266	0	1
Simple-green investments	0.538	0.498	0	1
CO_2 targets	0.114	0.318	0	1
CO_2 measurement	0.131	0.338	0	1
Environmental strategy manager	0.121	0.326	0	1
Environmental certification	0.159	0.366	0	1
Sustainable finance	0.057	0232	0	1
Digital innovation	0.517	0.500	0	1

simple-green investments are more frequent (*simple-green investments*: 53,8%). More than one firm out of ten has set the objective of reducing CO_2 emissions (*CO_2 targets*: 11,4%) and has put in place a system to measure CO_2 emissions (*CO_2 measurement*: 13,1%). Regarding the organizational structure, only 12,1% of the firms have appointed an environmental strategy manager responsible for implementing the green transition of business activity. Furthermore, 15,9% of firms have obtained an environmental certification and 5,7% have had access to sustainable finance instruments, such as green bonds and green loans. Under the digitalization profile, more than half of the enterprises have invested in digital innovations (*digital innovation*: 51,7%).

6.5 Results and Discussion

6.5.1 Descriptive Statistics of Investing Firms

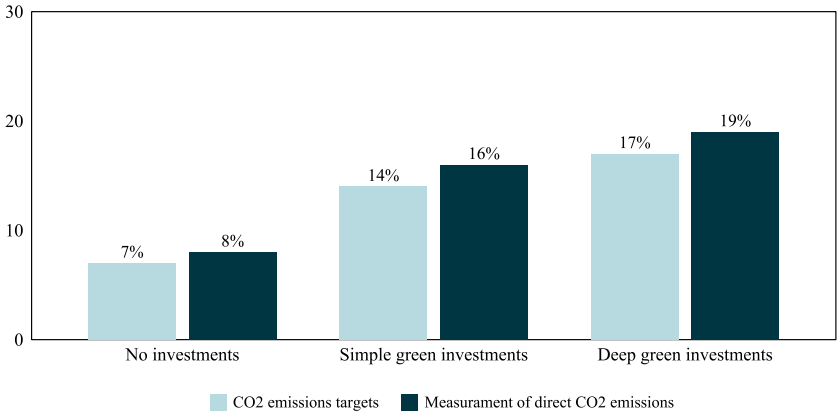
In this section, we present the descriptive statistics of sample firms, divided into three clusters based on their green investment decisions (i.e., no investments, simple-green investments, deep-green investments). To this aim, a variable called *types of green investments* has been defined, which takes the following three values: 0 = if the firm doesn't undertake green investments; 1 = if the firm undertakes at most one green investment with a transformative impact on the business model (*simple-green investments*); 2 = if the firm undertakes at least two investments with a transformative impact on the business model (*deep-green investments*). In what follows the main findings are illustrated.



Graph 6.1 Share of enterprises impacted by climate risks divided by type of green investments. (Source: Own elaborations based on a survey conducted by Centro Studi Tagliacarne, 2024)

First, firms that invest in green are more exposed to climate risks (Graph 6.1). Almost eight firms out of ten (79%) which undertake deep-green investments are impacted by climate risks (vs. 68% of those that realize simple-green investments and 67% of those that don't invest), suggesting that climate risks are a major driver of green investments. Among the different types of climate risks, acute physical risk is the one affecting most firms realizing deep-green investments (67%), although transition risk is the type of risk that differentiates most firms that realize deep-green investments from those that realize only simple-green investments (15 p.p. of difference: 64% vs 49%). Thus, firms that invest in deep-green are more sensitive to environmental and climate policies compared to the rest, since they react more quickly to legislative changes and market sentiments.

Second, there is a correlation between firms' decisions to invest in green and the adoption of other initiatives aimed at greening the business model. For example, when comparing the propensity of enterprises to set targets to reduce CO_2 emissions and measure CO_2 emissions reduction, data show how firms that realize deep-green investments are more likely to intervene to reduce their direct carbon emissions compared to the rest, by setting targets and measuring results. On average, 17% of enterprises that undertake deep-green investments set targets to reduce CO_2

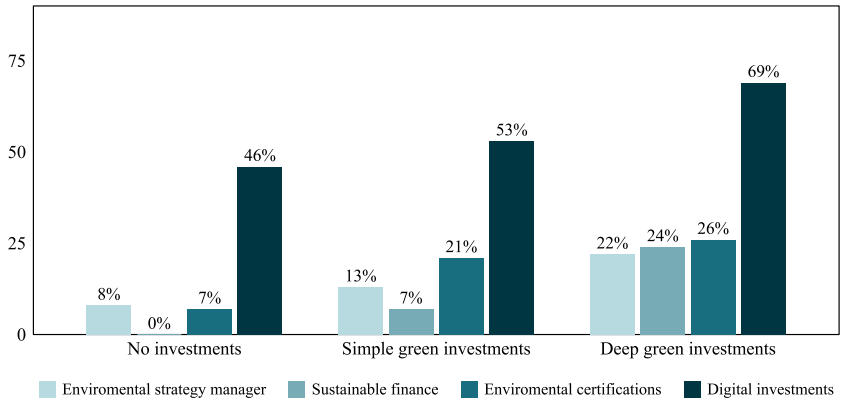


Graph 6.2 Share of enterprises that have CO_2 emissions policies divided by type of green investments. (Source: Own elaborations based on a survey conducted by Centro Studi Tagliacarne, 2024)

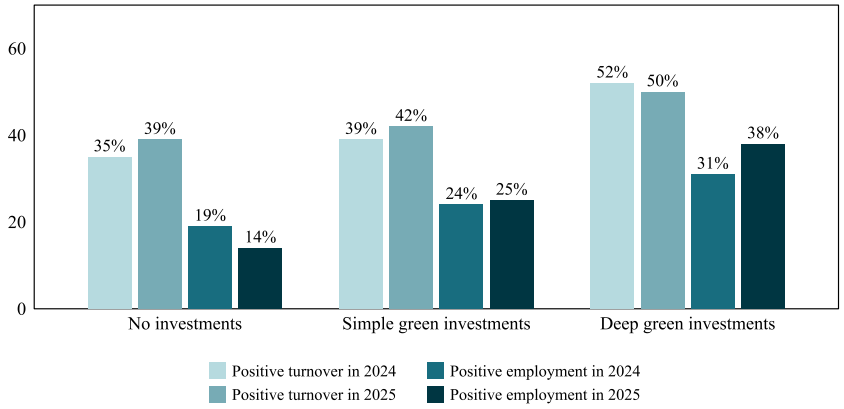
emissions (vs. 14% of those that realize simple-green investments and 7% of those that don't invest in green), and 19% of them measure their direct emissions (against 16% of those that realize simple-green investments and 8% of those that don't invest in green) (Graph 6.2).

Additionally, firms that realize deep-green investments are more likely to appoint an environmental strategy manager (22% vs. 13% of those that undertake simple-green investments), access more frequently to sustainable finance instruments (24% vs. 7% of those that undertake simple-green investments), are more likely to obtain environmental certifications (26% vs. 21% of those that undertake simple-green investments), and invest more in digital innovations (69% vs. 53% of those that undertake simple-green investments) (Graph 6.3). Therefore, the decision to realize deep-green investments seems correlated with the decision to adopt a series of other measures aimed at changing the business model toward greater environmental sustainability, an observation that raises several questions regarding the role played by deep-green investments in incentivizing an overall transformation of the business model.

Finally, it is interesting to notice the presence of a correlation between firms' investment decisions and their future economic expectations. Again, data show how firms that invest in deep-green are more likely to have better economic expectations for the future, expressed both in terms of



Graph 6.3 Share of enterprises that employ an environmental strategy manager, have access to sustainable finance, obtain environmental certifications, and invest in digital innovations divided by type of green investments. (Source: Own elaborations based on a survey conducted by Centro Studi Tagliacarne, 2024)



Graph 6.4 Positive employment and turnover expectations for 2024 and 2025, divided by type of green investments. (Source: Own elaborations based on a survey conducted by Centro Studi Tagliacarne, 2024)

turnover and employment, compared to firms that realize simple-green investments or don't invest at all. Indeed, as can be seen from Graph 6.4 below, deep-green investors tend to expect an increase in turnover and employment for 2024 and 2025.

6.6 Results of the Econometric Model

6.6.1 The Nexus Between Climate Risks and Deep-Green Investments

In this section, we analyze what types of climate risks drive deep-green investments. To address this issue, we run a probit regression by setting as dependent variable deep-green investments and as independent variables the different types of climate risks. The results are shown in Fig. 6.2: within the three categories of climate risk considered, only transition risk (*transition risk*) has a positive and statistically significant effect on the decision to realize deep-green investments (*deep-green investments*, $p<0.1$). Thus, transition risk is the only driver of investment decisions and *Hp1* is accepted, while physical risks don't influence firms' decisions to invest in deep-green. These results are summarized in Table 6.3, which shows how transition risk has an impact on investment decisions when considered in conjunction with other climate risks.

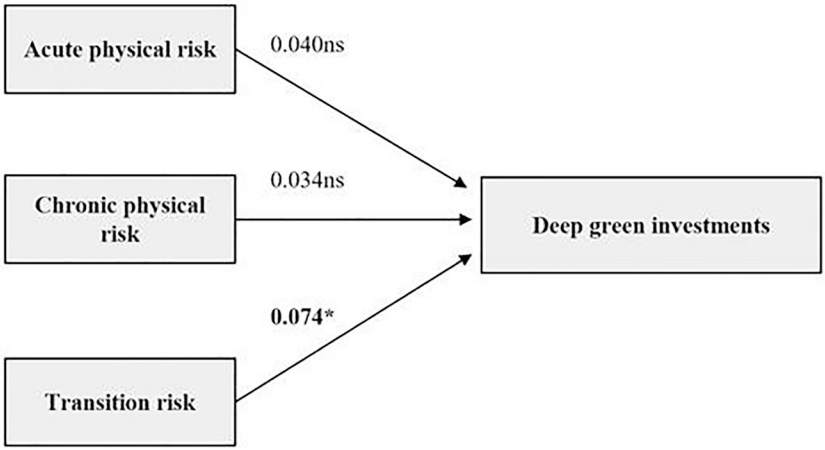


Fig. 6.2 Effects of transition risk, acute physical risk, and chronic physical risk on deep-green investments. (Note: The figure reports the coefficients of the structural equation model (see Table 6.3). *** $p<0.01$; ** $p<0.05$; * $p<0.1$; ns: not significant)

Table 6.3 Effects of climate risks on deep-green investments

Variables	*Coefficient*	*Std error*
Transition risk	0.074*	0.044
Acute physical risk	0.040	0.050
Chronic physical risk	0.034	0.050
Observations	464	

Note: Dependent variable: *deep-green investments*. Table displays average marginal effects. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

6.6.2 The Relationship Between Deep-Green Investments and Green Business Model Change

To study the effects of deep-green investments on turnover expectations, we included a series of variables related to the business model (mediator variables), to test if deep-green investments have a direct impact on turnover expectations or an indirect effect through the changes in the business model they promote (see Fig. 6.3). Indeed, as appears evident from Fig. 6.3, the direct effect of deep-green investments (*deep-green investments*) on economic performance (*turnover expectations 25*) is not statistically significant ($p>0.1$); thus, *Hp2* is rejected and the indirect effect should be evaluated (*Hp. 3*). To do so, we check if deep-green investments impact business model decisions and have a positive effect on turnover expectations via the changes in the business model they produce. The results show how deep-green investments (*deep-green investments*) have a positive and statistically significant impact on firm's decisions to set CO_2 emissions reduction targets ($p < 0.1$), measure direct CO_2 emissions ($p < 0.01$), appoint an environmental strategy manager (*environmental strategy manager*, $p < 0.05$), access to sustainable finance instruments (*sustainable finance*, $p < 0.01$), and invest in digital innovations (*digital innovation*, $p < 0.01$). However, deep-green investments don't have a significant impact on a firm's likelihood of obtaining environmental certifications (*environmental certification*).

6.6.3 The Effect of Deep-Green Investments on Economic Performance: The Mediating Role of Green Business Model Transformation

The observations delineated in the previous paragraph are summarized in Table 6.4, where the effects of deep-green investments on firms' expectations of positive turnover are broken down. Indeed, according to our

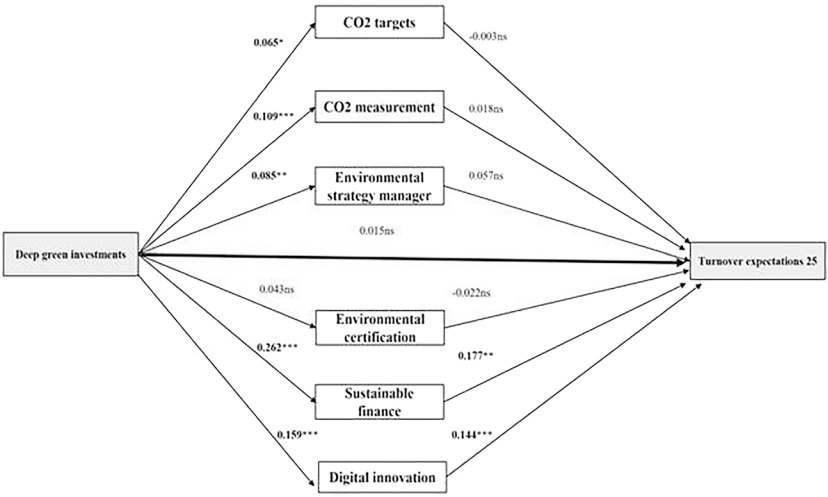


Fig. 6.3 Effects of transition risk, deep-green investments and other business model factors on turnover expectations. (Note: The figure reports the coefficients of the structural equation model. *** p<0.01; ** p<0.05; p<0.1; ns: not significant)

Table 6.4 Direct, indirect, and total effects of deep-green investments on positive expected turnover

Effects	*Coefficient*	*Std error*
Direct effect Deep-green investments ➔ turnover expectations 25	0.015	0.055
Indirect effect Deep-green investments ➔ turnover expectations 25	0.075***	0.026
Total effect Deep-green investments ➔ turnover expectations 25	0.090*	0.050

Note: *** p<0.01; ** p<0.05; * p<0.1

framework analysis (Fig. 6.1), deep-green investments can influence firms' expected turnover in two ways, both: (1) directly; and (2) indirectly through the changes in the business model they promote, which are expressed by the mediator variables (*CO_2 targets, CO_2 measurement, environmental strategy manager, environmental certification, sustainable*

finance, digital innovation). Thus, the total effect of deep-green investments is the sum of direct and indirect effects. By exploring this issue, we discover that *deep-green investments* exert a significant effect on firms' expected turnover only indirectly (indirect effect: 0.075, $p<0.01$, Table 6.4), while the direct and total effects are positive but not statistically significant. In particular, the total effect is almost totally explained by the indirect effect, which accounts for 83% (0.075) of the total effect (0.090) (Table 6.4). This confirms the key role played by the green business model transformation in influencing the likelihood of having a future positive turnover, while deep-green investments by themselves are not sufficient to explain positive turnover expectations (*Hp9* is accepted).

6.6.4 The Relationship Between Transition Risk and Economic Performance

Since transition risk drives investment decisions, which in turn influence economic performance, we decided to test if transition risk has an impact on turnover expectations (Fig. 6.4). The results of our analysis show how the total effect of transition risk on economic performance is negative but not statistically significant ($p>0.1$), which means that transition risk doesn't exert a significant effect on turnover expectations either directly or indirectly ($p>0.1$) (Table 6.5).

6.7 Conclusion

Research on the impact of green investments on economic performance has now become mainstream. Many studies (see, for example, Siedschlag & Yan, 2023) suggest that there is a positive correlation between firms' decisions to invest in green and economic growth, expressed in terms of output, employment, productivity, or exported intensity. However, to the best of our knowledge, there is little literature focused on the impact that different types of green investments have on economic performance, along with the role played by green business model innovation in enhancing the competitiveness of green practices. Moreover, few studies investigate the influence of climate risks on investments decisions and the role played by transition risk in driving transformative green investments (such as *deep-green investments*).

Building on a survey conducted by Centro Studi Tagliacarne—Unioncamere in 2024 on a representative sample of 750 food enterprises located in the South of Italy, this chapter tries to fill this gap by

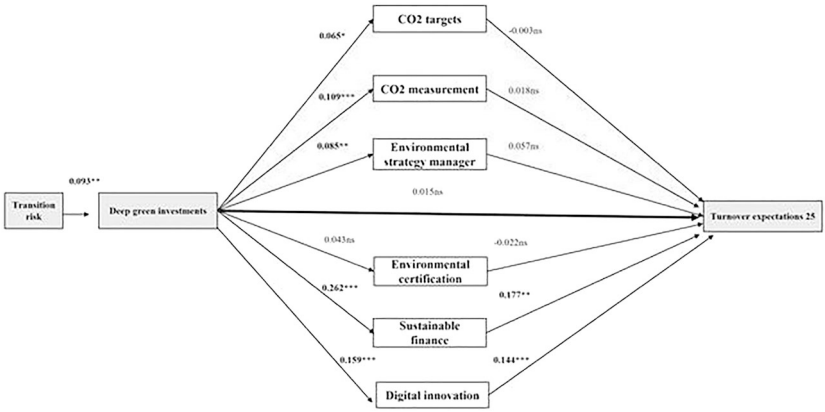


Fig. 6.4 Effects of transition risk, deep-green investments, and other business model factors on turnover expectations. (Note: The figure reports the coefficients of the structural equation model. *** p<0.01; ** p<0.05; p<0.1; ns: not significant. The coefficient related to *Transition risk* on *deep-green investments* is different from that displayed in Table 6.3 because the regression does not take into account the other two types of risks)

Table 6.5 Direct, indirect, and total effects of transition risk on positive expected turnover

Effects	*Coefficient*	*Std error*
Direct effect Transition risk ➔ turnover expectations 25	−0.037	0.046
Indirect effect Transition risk ➔ turnover expectations 25	0.008	0.006
Total effect Transition risk ➔ turnover expectations 25	−0.028	0.045

Note: *** p<0.01; ** p<0.05; * p<0.1

investigating which type of climate risk influences green investment decisions the most, and which category of green investments has the greater impact on economic growth. To do so, we identified two categories of green investments: *deep-green*, which have the potential to change the business model, and *simple-green*, which are aimed at compensating for the negative environmental externalities caused by business activity. First,

we analyzed which types of climate risks influence investment decisions the most, finding that transition risks are the main drivers of deep-green investments. Second, we studied whether and to what extent deep-green investments have a positive effect on turnover expectations, discovering that these types of investments have a positive impact on economic performance (higher compared to simple-green investments), mediated by the change in the business model they produce. Therefore, deep-green investments don't promote economic growth per se, but through the channel of the business model change they provoke.

Several policy implications can be drawn from our results. To start with, the decision to realize deep-green investments is motivated by the impact of transition risk, which has a positive and significant effect on deep-green investment decisions, whereas the other types of climate risks, i.e., acute and chronic physical risks, are not drivers of deep-green investments. Thus, firms that realize these investments are more sensitive to new legislative initiatives and environmental policies than to climate changes when they plan their investment strategies. This is important information for policymakers, who have the potential to incentivize deep-green investments by acting on policy instruments, before acute and chronic physical risks materialize. Another policy implication that can be drawn is that not all green investments are the same. Indeed, investing in technologies and production processes that have the potential to change the business model is different from investing in end-of-pipe technologies. The results of our analysis show that deep-green investments have a greater effect on economic growth compared to simple-green investments. Thus, to balance environmental sustainability with economic sustainability, firms should privilege deep-green investments.

Beyond these policy implications, this work represents an important contribution to the GRINS project and its data platform AMELIA, since it provides novel data on climate risks and green investment decisions for enterprises located in the South of Italy with at least four employees. Thus, it enriches the knowledge of these topics by focusing on a territorial area and on an enterprise dimension that is often overlooked.

This work presents some limitations that can be tackled by future research. First, the analysis has been conducted on a sample of enterprises that is geographically and sectorally circumscribed, therefore it would be interesting to repeat the investigation on a more representative sample to generalize the results. Second, cross-sectional analysis impedes more in-depth investigation of the cause-effect mechanism. Third, we didn't

consider the intensity of green investments, since the variables related to green investments have been modeled as binary.

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CHAPTER 7

Implications and Guidelines for Stakeholders

Abstract Building on the empirical evidence of limited climate-risk awareness and preparedness among Italian SMEs, this chapter outlines contributions to the literature on corporate sustainability and climate strategy. It also develops targeted recommendations for policymakers, firm managers, and financial institutions, with a focus on governance mechanisms, capability building, and access to sustainable finance.

Keywords Climate proactivity • Climate awareness • Capacity-building • Stakeholder guidelines

The chapter discusses the implications of the research project. Based on the limited awareness and preparedness to climate risks emerging from the empirical analysis, we outline theoretical contributions alongside targeted policy and managerial recommendations, with a focus on overcoming structural barriers, enhancing governance, and promoting climate-resilient business models.

V. Palea et al., *Climate Strategies and Sustainability Pathways of Italian Small and Medium-Sized Enterprises*, Palgrave Studies in Climate Resilient Societies,
https://doi.org/10.1007/978-3-032-17454-3_7

7.1 Discussion of Findings

The empirical evidence described in the previous sections reveals a strikingly moderate perception of climate risk among Italian firms, with 53% of the sample falling into the low-perception cluster. This aligns with prior studies indicating that businesses, especially in non-financial sectors, often underestimate climate-related risks unless they face immediate regulatory or reputational pressures (Abhayawansa & Adams, 2021). The finding that only 8% of firms are "very much concerned" about climate risks points to a latent skepticism toward climate change, a pattern that continues to hinder corporate engagement in sustainability transitions. Such skepticism is troubling, especially considering the growing scientific consensus that climate risks, both physical and transitional, are increasingly material to firm performance, resilience, and survival (Fard et al., 2020; Li, 2024).

The breakdown of perceptions by risk type offers further granularity. Chronic risks, such as gradual temperature increases or shifts in precipitation, are perceived as less concerning than acute risks or transition risks, suggesting a cognitive and strategic tendency to address threats with immediate visibility or tangible manifestations. This mirrors the "saliency bias" identified by behavioral research also in corporate performance management settings, where firms prioritize problems that are temporally and spatially proximate (Cristofaro et al., 2023). As a result, organizations may underestimate the urgency or importance of addressing these slow-moving climate risks, which could lead to insufficient preparation and greater vulnerability over time.

Geographic variability in risk perception further reinforces the importance of local context and organizational learning. The slightly higher sensitivity to acute physical risks in areas prone to environmental hazards, such as floods, droughts, and landslides, aligns with the theory of experiential learning in risk management (Cook et al., 2022). Localized traumatic experiences appear to function as catalysts for risk awareness, especially among firms in environmentally vulnerable regions like Veneto. This suggests the idea that lived experience may serve as a powerful driver of climate salience in corporate decision-making. Conversely, the uniform perception of transition risks across regions reflects the national scope of regulatory frameworks and market mechanisms, which influence firms regardless of their location.

Interestingly, firm size emerged as a more robust determinant of risk perception than sector eligibility under the EU taxonomy. While large

firms generally exhibited higher levels of climate awareness, no significant differences were observed between eligible and non-eligible sectors. This finding contrasts with assumptions embedded in the EU Green Deal and related frameworks, which posit that regulatory classification will act as a lever for climate leadership within targeted sectors. In line with authoritative literature on the topic (e.g., Chowdhury et al., 2022), internal organizational factors, such as top management commitment, resource availability, and absorptive capacity, may override sectoral characteristics in shaping sustainability engagement. This finding suggests the importance of capacity-building and firm-specific engagement strategies in driving corporate changes toward sustainability (Bhatia et al., 2024).

Investment patterns offer a meaningful narrative about the strategic posture of firms toward climate risks. The prioritization of insurance (55%) over more structural or transformational investments, like innovation, diversification, or relocation, suggests a predominant reliance on risk transfer mechanisms. This preference reflects a defensive attitude where the focus is on minimizing short-term financial exposure rather than proactively adapting to or mitigating systemic risks. While such strategies may appear rational from a cost-benefit perspective in the near term, they do little to enhance long-term resilience and may delay the adoption of more sustainable business models. As Surminski and Oramas-Dorta (2014) caution, excessive reliance on insurance can act as a substitute for adaptation investments, thereby perpetuating organizational inertia and vulnerability.

The empirical classification of firms into "Wait-and-see," "Planners," "Foresighted," and "Proactive" categories offers a nuanced and multidimensional perspective on corporate climate engagement. This typology allows us to move beyond simplistic binary distinctions between leaders and laggards and to examine the interplay between perception, investment, and organizational characteristics. The predominance of the wait-and-see strategy, especially in response to acute and chronic risks, is consistent with behavioral patterns observed under high uncertainty and low perceived self-efficacy (Zayadin et al., 2022). Only 14% of firms adopt a proactive stance for transition risks, with even fewer doing so for physical risks (10% acute, 4% chronic), underscoring a widespread reluctance to invest in resilience-oriented strategies that typically offer delayed or uncertain returns.

Firm size again emerges as a critical differentiator in strategic posture. Larger firms show a markedly higher tendency toward proactive or

foresighted behavior, reinforcing the resource-based view of the firm (Barney et al., 2021), which holds that access to financial, human, and informational resources enhances a firm's capacity to innovate and adapt under uncertainty. These firms are more likely to possess dedicated sustainability units, participate in voluntary disclosure initiatives, and integrate climate-related metrics into corporate governance. Moreover, they tend to be subject to greater scrutiny from institutional investors, regulators, and civil society actors, all of whom demand credible and transparent climate action (Eccles et al., 2014). By contrast, SMEs, often resource-constrained and more focused on short-term survival, report structural and cognitive barriers to engagement, including lack of expertise, risk assessment tools, and climate-related financial data. These findings echo earlier work by Noci and Verganti (1999), who identified firm capabilities and absorptive capacity as core determinants of environmental innovation.

Our findings further elucidate the motivational architecture and perceived barriers that shape corporate engagement with climate-related investments. Managerial values and personal environmental commitment emerged as the primary internal motivators, cited by 40% of firms. This underscores the continued relevance of leadership in fostering environmental stewardship and driving sustainability initiatives (Egri & Herman, 2000). In line with transformational leadership theory, firms where top managers exhibit a strong commitment to environmental values tend to demonstrate greater strategic alignment with sustainability goals, including more proactive risk management, integrated reporting, and employee engagement (Pellegrini et al., 2018; Ullah et al., 2019; Wenzig et al., 2022). However, among firms categorized as "proactive," external factors, particularly regulatory requirements, customer expectations, and energy price volatility, appear to gain salience, suggesting that internal motivations are necessary but not sufficient for scaling and institutionalizing climate action (Nielsen, 2017).

The interplay between internal and external drivers aligns with Oliver's (1991) typology of strategic responses to institutional pressures, which posits that organizations navigate institutional complexity through strategies of acquiescence, compromise, avoidance, or manipulation. Our data suggest that many firms, especially those in transition from "planner" to "foresighted," are situated in an intermediate state, combining normative commitment with instrumental responsiveness to stakeholder expectations. This hybrid logic is particularly visible in firms facing dual pressures

from investors seeking ESG performance and regulators enforcing compliance.

On the barrier side, financial constraints remain paramount. High upfront costs, long payback periods, planning uncertainties, and limited access to green finance were consistently reported as major deterrents. These findings reaffirm the view that market failures, particularly the inadequate internalization of environmental externalities, continue to hinder private-sector adaptation and mitigation (Cohen & Winn, 2007; Stern, 2008). The paradox is that firms most vulnerable to climate risks, such as SMEs located in hazard-prone areas, are often the least equipped to invest in resilience-enhancing measures. This points to an urgent need for differentiated policy instruments, such as concessional financing, credit guarantees, and capacity-building programs tailored to firm size and sectoral exposure (Lamperti et al., 2021).

Encouragingly, proactive firms are more likely to adopt long-term climate goals, including net-zero targets for 2050. This reflects a more strategic and integrated approach to sustainability, one that transcends compliance and seeks to anticipate regulatory, technological, and societal shifts (e.g., Hahn et al., 2014). Yet even among these firms, sectoral differences remain muted, and taxonomy eligibility appears unrelated to target-setting. This raises important questions about the motivational efficacy of existing classification systems and underscores the need to embed climate targets into broader governance structures, such as strategic planning cycles, capital allocation frameworks, and executive remuneration policies (Kovacs et al., 2025).

7.2 Theoretical Implications

This research has several theoretical implications. First, based on the analysis of existing literature on management perception of climate change risk (Kolk & Pinkse, 2005; Todaro et al., 2021), corporate governance mechanisms (Asad et al., 2025), ownership structure (Berrone et al., 2010), financial resources (Voss et al., 2008), legal form (Kim et al., 2017), and the level of climate education within organizations (Audebrand, 2010), we refined and described four possible main approaches of firms to climate risks, which enrich the theory of bounded rationality (Gigerenzer & Selten, 2002; Simon, 1990) and gradual commitment to sustainability (Szekely & Strebel, 2013), and provide a valuable basis for future empirical analyses of corporate sustainability strategies and practices.

Second, research findings support the neo-institutional theory (Hwang, 2023) by demonstrating that firms' propensity to address climate issues is strongly influenced by some institutional factors, mainly regulatory or normative. On the external hand, these factors primarily concern the current regulation and its evolution over time, the volatility of energy prices, and the pressure from suppliers, customers, and financial institutions. Furthermore, results confirm the behavioral model of sustainability: from an internal perspective, cultural awareness of climate impacts (Todaro et al., 2021), managers' perception of climate-change risk (Todaro et al., 2021), and climate-related education (Audebrand, 2010) are the key drivers leading firms' sustainability strategies and practices. Precisely, higher awareness of climate impacts and higher risk perception foster the implementation of specific sustainability governance mechanisms (Arnell & Delaney, 2006), essential to adapting business models to climate challenges through implementing policies and practices appropriate to each firm's particular characteristics.

Third, this research provides empirical support for the theoretical significance of financial materiality and impact materiality as dual and complementary drivers of corporate sustainability strategies. Within the double materiality perspective, our analysis highlights both enabling factors and barriers. Moreover, our firm classification framework enables a systematic examination of impacts through the lens of double materiality. Precisely, the framework we outlined and adopted can be valuably implemented also by future studies to enlarge the analysis of the outcomes of different climate strategies in terms of both financial materiality (e.g., profitability, resilience to shocks, access to capital) and impact materiality (e.g., GHG emissions reduction, circularity, biodiversity protection). Indeed, this dual perspective allows scholars to explore whether and how corporate sustainable practices translate into measurable performance improvements and resilience outcomes.

Finally, this study offers some insights regarding regional and contextual specificities as well. On the one hand, results show preliminary evidence that more radical sustainability investments, particularly in the agri-food sector in Southern regions, may yield positive effects on economic performance. On the other hand, local vulnerabilities and contexts are demonstrated to shape SMEs' readiness and responses to climate challenges. This latter evidence aligns with contingency theory (Mahmud et al., 2021). Climate change introduces multiple contingencies, such as regulatory changes or supply chain disruptions, which require firms to adapt their strategies, organizational sets, and operational practices. To approach climate-related challenges, no single solution exists: each firm's

approach strictly depends on the economic environment in which it operates, which in turn is shaped by several institutional factors, including the industry and the geographical location.

7.3 Policy and Practical Implications

7.3.1 For Policymakers

This research has also different practical implications for policymakers. More specifically, our analysis suggests that many Italian SMEs underestimate climate-related threats, especially with the chronic risks, despite mounting evidence of their materiality and the severity of the impacts generated (Pinkse & Gasbarro, 2016). This gap in the perception of climate-change-related exposure underscores the importance of (systematic) training programs related to the effects of climate change on firms' operations and vice versa. In particular, territorial business associations and chambers of commerce, as already trusted intermediaries, could deliver modular courses that combine basic risk-assessment techniques with case studies drawn from recent local disasters. Evidence from Veneto and Emilia-Romagna, where repeated floods have revealed the impact of such acute events, further strengthens the case for prevention and underscores the urgency of adopting adaptation measures. These extreme events, which are related to the climate change effects on local bio-ecosystems, and the correlated production systems, also highlight that wait-and-see strategies are ineffective, while also isolated firm-level initiatives are insufficient to ensure the ecological transition. Our project shows that what is required is large-scale, forward-looking interventions launched well before emergencies arise. These programs should be coupled with sustained capacity-building programs that equip local authorities, businesses, and communities with the skills and resources needed to anticipate risks and implement resilient solutions.

Moreover, according to our results, regional differentiation emerges as an equally critical lever. Embedding granular exposure data into policy interventions can help policymakers move beyond the conventional "one-size-fits-all" approach, enabling them to target resources more effectively toward firms genuinely exposed to physical and transition risks (Martínez-Ferrero & García-Meca, 2020; Lamperti et al., 2021). However, detailed risk data generates tangible benefits only when firms have the capacity and knowledge to interpret and integrate this information into their

decision-making processes. GRINS tackles this by combining place-based drivers and barriers to climate resilience adaptation with continuous capacity building. Accordingly, specific initiatives such as joint training courses run with trade associations, chambers of commerce, and local universities translate regional exposure maps into firm-level day-by-day decisions. The same logic drives the AMELIA portal in the GRINS Project, which potentially may let companies test their own exposure and compare results with peers on climate strategies. A growing body of evidence—confirmed by the results of the GRINS Project—shows that management sensitivity to climate issues is the single strongest predictor of whether a firm moves from intention to actual investment (Egri & Herman, 2000; Audebrand, 2010; Todaro et al., 2021). Firms led by managers with high climate risk awareness invest more in adaptation and mitigation than similar companies (Todaro et al., 2021; Cristofaro et al., 2023). This finding further underlines the strategic value of targeted training; by raising executives' and middle managers' awareness, these capacity-building programs can unlock investment even when financial incentives are already in place. Embedding training programs would therefore magnify the impact of public support and accelerate the diffusion of resilient business practices. Moreover, this territorial analysis stresses that these initiatives foster social and entrepreneurial engagement in these public research interventions.

Secondly, governance and organizational shortcomings remain a second-order but pervasive constraint. In fact, fewer than one SME in six has appointed a sustainability manager or issued any structured ESG report. This evidence is relevant for the understanding of the status quo of the sensibilization for sustainability and ESG-related managerial practices. Moreover, prior studies show that governance structure, and the formalization of responsibility for sustainability, strongly predict subsequent investment in mitigation and resilience (Sullivan & Gouldson, 2016; Termeer et al., 2016). In this regard, the presence of minimal governance safeguards—such as board oversight of climate targets or annual disclosure aligned with CSRD requirements—could convert voluntary good practice into a widespread managerial norm, preparing firms for the trickle-down effects of European regulation without adding disproportionate red tape (Accountancy Europe, 2024).

Thirdly, another element that emerges from the GRINS findings is the role of energy costs as a driver for climate-related investments. On one hand, volatility and rising prices for fossil-based energy sources have motivated many firms to consider renewable energy adoption or efficiency

measures, as they seek to stabilize operational expenses and hedge against future shocks (Wang & Sueyoshi, 2018). On the other hand, high current energy costs drain liquidity and reduce SMEs' capacity to allocate financial resources to other long-term investments, especially among firms with limited access to external financing. This effect is particularly acute in energy-intensive sectors and for smaller firms, which face higher relative energy costs but often lack the capital or scale to benefit from energy transition incentives (International Energy Agency, 2023). Therefore, this reinforces the importance of designing policies that simultaneously relieve short-term cost pressures—i.e., through targeted subsidies or tax relief on energy-saving investments—and promote structural shifts toward renewable energy sources and efficiency upgrades of production plants. Without coordinated support addressing both the immediate and structural dimensions of energy costs, there is a risk that firms will defer necessary investments, locking themselves into outdated, carbon-intensive technologies (Pinkse & Kolk, 2012).

Fourthly, experience shows that (financial) incentives are most effective when firms commit to clear, time-bound emission-reduction goals that look beyond the year-by-year budgeting cycle. Yet only 10% of the businesses surveyed have set quantitative targets, and most plan simply to repeat past actions, thus adopting a mimetic strategic approach, while a slight increment is registered with references to future planned investments. Studies on the adoption of specific goal-setting measurement systems demonstrate that even voluntary targets, once announced and monitored, create a self-reinforcing drive for improvement (Hale et al., 2021). Evidence from "Foresighted" and "Proactive" firms further indicates that medium- and long-term milestones, typically framed around 2030 and 2050 horizons, help managers redesign production processes, redirect capital toward renewable energy and spur stakeholder engagement (Wang & Sueyoshi, 2018).

Moreover, the uptake of green finance remains modest since only 11% of the SMEs we surveyed have accessed dedicated instruments. In line with this reasoning and results, the recent work by the Italian Sustainable Finance Roundtable[1] (2024) has sought to close this gap: the "Sustainability

[1] For more information on this initiative, you can visit the Ministry of the Economy and Finance webpage at the following link: https://www.dt.mef.gov.it/en/attivita_istituzionali/sistema_bancario_finanziario/finanza_sostenibile/dialogo_sostenibilita/index.html?__element=head

Dialogue between SMEs and Banks" sets out a common set of climate-risk and performance indicators to guide credit discussions and reduce the information asymmetries that Berg et al. (2022) identify. The GRINS Project team may act as a potential flagship partner in these future initiatives for institutions like the MEF and the Bank of Italy, providing the underlying data architecture, training capability and scientific-advisory support. In practical terms, the project has already built a public dashboard within the AMELIA platform where both lenders and firms can view regional risk maps, find ESG-related indicators, and download the information provided by the surveys. Linking streamlined loan applications and partial public guarantees to those shared metrics and information would lower transaction costs for banks and borrowers alike, while climate-related information delivered through AMELIA would ensure that finance is coupled with the capacity-building needed to turn credit into more credible transition plans (Christensen et al., 2021).

Finally, because the GRINS survey can be rerun at regular intervals, the dashboard could also become a living observatory of territorial resilience, tracking how industrial districts evolve in response to new shocks and policy incentives. Finally, as a further proposal for the research agenda, extending the same (or an adapted) questionnaire and data collection model to other European institutions would make it possible to build an EU-wide map of SME readiness, potentially offering the Commission a powerful tool for aligning sustainable-finance policies across member states.

7.3.2 For SME Managers

Beyond the practical policy implications, this study also offers managerial implications. From a managerial standpoint, the results point to the decisive role of internal capabilities. "Proactive" and "F" firms, according to our classification, are characterized by twice the presence of staff with explicit responsibility for climate strategy, confirming the resource-based view that specialized knowledge underpins superior adaptive performance (e.g., Li, 2024). According to our results, the presence of sustainability managers, cross-functional teams, and sustainability-oriented entrepreneurs can deliver a coherent implementation of sustainability strategies, provided they receive targeted training and clear operating mandates. Empirical evidence from the GRINS survey shows that SMEs which have put in place sustainability-oriented organizational assets—i.e.,

integrated performance-measurement dashboards, formal planning and control routines, sustainability accounting tools, structured stakeholder engagement, externally assured disclosure, and certification—are the firms most likely to belong to the "proactive" cluster, confirming the link between robust management-control architectures and advanced sustainability behavior already noted by prior literature (Hsiao et al., 2022). This view has been reinforced by a recent assessment of the adequacy of administrative-accounting systems in light of the CSRD Directive (EU, 2022) and the Omnibus package (e.g., CNDCEC & FNC, 2023; CNDCEC, 2025). More specifically, the firms best positioned to meet the new disclosure demands—and higher expectations with reference to climate resilience—are those whose owners show a strong sustainability orientation, who recognize that forward-looking planning is a source of competitive advantage, and who can close the significant information gap that still affects decision-making processes (Mattei & Caccialanza, 2025).

Secondly, setting explicit emission-reduction or energy-efficiency targets offers a low-cost catalyst for such organizational learning. Firms that articulate even modest goals report higher levels of investment planning and easier dialogue with lenders (Ameli et al., 2019) and customers (Goettsche et al., 2016). Managers should therefore embed quantifiable, time-bound, and climate-related objectives into strategic plans, using them to steer this commitment and provide positive spillover effects on firms' value (Eccles et al., 2014). More specifically, a growing empirical literature shows that strong environmental performance and climate resilience are more than a reputational asset for firms, since they are also a measurable driver of cheaper capital and higher operating returns (Asad et al., 2023; Othman et al., 2011; Chowdhury et al., 2022). In fact, eurozone firms with lower carbon footprints pay smaller credit spreads, an effect that intensifies when climate-related disclosures are transparent and governance structures are robust (Palea & Drogo, 2020). Moreover, translating climate-risk exposure into an explicit, forward-looking estimate of enterprise value is arguably the most difficult stage of any sustainability assessment (Dal Maso et al., 2024). As Dal Maso (2025) shows, valuation models can incorporate physical and transition risks through several techniques, if the availability of data allows this implementation. However, SMEs are structurally more vulnerable from this perspective, since their limited scale and financial slack reduce their ability to absorb climate shocks and to finance costly adaptation measures (Voss et al., 2008). On one hand, ignoring climate-related risks and these dynamics

leads to a systematic undervaluation of (climate) risk exposure and, by extension, of the long-term financial damage that unmitigated exposure can inflict. On the other hand, incorporating climate metrics into standard valuation practice is therefore not an academic add-on but a prerequisite for realistic capital allocation and for safeguarding the long-term viability of Italian and Europe's competitiveness (Dal Maso, 2025; Perdichizzi et al., 2024). Consequently, anticipating formal EU disclosure requirements offers an additional strategic advantage: it prompts managers to map their critical supply relationships, open channels to discuss climate exposures, and explore appropriate responses and investments that will support the sustainable transition of their business models (Cristofaro et al., 2023). These approaches not only reduce costs in the long term but also strengthen business ties, enhancing competitiveness in increasingly sustainability-oriented markets (Vachon & Klassen, 2008; Mattei & Caccialanza, 2025).

Together, these insights depict an intertwined agenda: public authorities can tilt the playing field through targeted incentives, regulatory foresight, and accessible finance; however, the decisive momentum must come from firms that invest in skills, set measurable objectives, and cultivate resilient networks. This project demonstrates that, when these elements converge, SMEs shift from reactive postures to strategic engagement, laying the groundwork for a more climate-resilient and competitive Italian economy. This perspective also suggests the direction for the further development of this study in order to guarantee the higher comparability of climate-resilience measures. Developing a targeted and specific tool could provide access to a benchmarking system that compares each firm's climate strategy, green-investment effort, and organizational set-up with peers in the same region (or industry) and would give managers a clear snapshot of their competitive position and highlight managerial practices to implement and information gaps to close. To meet this need, future development of this research may develop a benchmarking module that could be integrated into the AMELIA platform realized at the end of the project. Drawing on the survey database and publicly available disclosures, the tool could therefore generate dashboards showing how a company scores against sector medians and best-in-class performers on key metrics such as emission-reduction targets, carbon intensity, governance mechanisms, and access to sustainable finance. These expectations suggest that comparability of this kind may accelerate the diffusion of good practices by turning abstract standards into tangible performance differentials.

Consequently, based on the GRINS Project's evidence and by embedding this module in AMELIA, the proposed research agenda will offer SMEs and local stakeholders an up-to-date, evidence-based reference point for setting priorities and tracking progress over time.

7.3.3 For the Banking and Financial System

The double materiality principle introduced in the previous chapters applies to the banking and financial system as well (Gourdel et al., 2022). The collapse of certain ecosystems and the changes in environmental patterns pose a threat to entire value chains across the globe and, therefore, could generate a cascade effect on a significant portion of a financial institution's assets (i.e., financial materiality). Mundaca and Heintze (2024), for example, estimate that for every euro of banks' equity holding, 26 cents are potentially highly dependent on—and therefore exposed to—ecosystem services. This exposure, ultimately, is not a problem only for a single institution, but for the financial and banking system at large (Wu et al., 2024; Wang et al., 2024). However, the banking and financial sector, through their capital allocation choices, can move their counterparts toward a greener economy (i.e., the impact materiality). Green securities, green investments, climate finance, carbon finance, green insurance, green credit, and green infrastructural bonds are all examples of green products that the banking and financial system can implement to steer the economy toward sustainable development (Akomea-Frimpong et al., 2021).

In the past few years, we have been observing an increasing regulatory effort to push the financial and banking system to account for such new risks (ECB, 2020; OECD, 2021; EBA, 2025; NGFS, 2022; Galletta & Mazzù, 2023), and the sector is indeed showing progress in materiality assessments, risk management, and stress testing (Elderson, 2025). In fact, it is essential for financial institutions to adopt forward-looking climate and environmental scenarios and sectoral risk assessments to evaluate portfolio exposure and guide capital allocation. Moreover, banks need to consider incorporating physical climate risks into their credit risk models to keep up with the Basel III developments (Pozdyshev et al., 2025) and the ECB requirements (Elderson, 2025). Furthermore, central banks and supervisory authorities must push for the integration of climate and environmental risks into prudential frameworks, stress testing, and macro-financial surveillance (Roncoroni et al., 2021).

The EBA's (2025) guidelines on ESG risk management in banking authorities introduce several new and expanded requirements. By taking its premises from the EU Commission's renewed Directive 2013/36/EU (Capital Requirements Directive, CRD) and Regulation (EU) No 575/2013 (Capital Requirements Regulation, CRR), the EBA's guidelines aim at enhancing the identification, measurement, management, and monitoring of ESG risks by institutions to support their safety and soundness against the short-, medium-, and long-term impact of ESG factors. For what concern environmental risks, "institutions should consider a sufficiently large scope of environmental factors that includes at least climate-related factors, degradation of ecosystems and biodiversity loss" (EBA, 2025, p. 19).

According to the EBA's guidelines, institutions shall undertake a materiality assessment of ESG risks, returning a view on the financial materiality of ESG risks for its business model and risk profile, supported by a mapping of ESG factors and transmission channels to traditional financial risk categories. Moreover, ESG factors shall be integrated into the internal capital adequacy assessment process (ICAAP) materiality assessment. Institutions shall further ensure that "the scope of their materiality assessment sufficiently reflects the nature, size and complexity of their activities, portfolios, services, and products. Institutions should consider the impact of ESG risks on all traditional financial risk categories to which they are exposed, including credit, market, liquidity, operational (including litigation), reputational, business model and concentration risks" (EBA, 2025, p. 18).

To comply with the EBA's Guidelines, Italian banks will need to gather and use the information necessary to assess, manage, and monitor both current and forward-looking ESG risks to which they may be exposed through their counterparties. Accordingly, they will have to collect client- and asset-level data at an appropriately granular level (EBA, 2025, p. 21). Considering that SME-level ESG data are scarce and fragmented (OECD, 2021), and that the financial literacy of SMEs is still limited (cfr. The GRINS survey), this is likely to pose a significant challenge for the Italian financial and banking system. Banks are making notable strides forward on these issues, but a lot more effort is still needed (Elderson, 2025).

Although the OECD (2021) and the EBA (2025) emphasize the importance of financial innovation in supporting SME sustainability and ESG management, the results of our survey underscore the limited uptake of green finance among Italian SMEs, with only 11% accessing green financial instruments between 2021 and 2023. This might be a consequence of the scarce green finance literacy of SMEs or a persistent misalignment of the

banking sector with decarbonization objectives (ECB, 2024; Lu et al., 2020). Given the scarcity of SME-level ESG data, in fact, banks find it troublesome to integrate climate risks into cost-of-debt considerations. Therefore, if a bank cannot delineate the climate profile of a specific SME, it may find it difficult to offer a green financial product under favorable financial conditions (Ge et al., 2025; Ding et al., 2025; Martinez-Meyers et al., 2024; OECD, 2024; Reghezza et al., 2022).

At both the EU-level and the Italian-level, we are seeing important initiatives that go in the direction of creating a simple, coherent, and replicable set of ESG indicators that SME could produce for external reporting and engagement with financial institutions. For example, the EU Voluntary Small and Medium Enterprise European Sustainability Reporting Standard (VSME ESRS) is a simplified sustainability reporting standard that could be used as a basis point in the bank-SME interaction. Moreover, in 2024 the Italian Sustainable Finance Roundtable[2] issued the document "Sustainability Dialogue between SMEs and banks,"[3] containing a set of indicators on physical and transition risks, energy and emissions, pollution, water management, and biodiversity and ecosystems useful for banks and SMEs to reach a coherent and trustworthy set of information to use for improving the SMEs' competitiveness and access to financial capital (EU, 2024). While most Italian SMEs will remain formally exempt from CSRD for several years, preparing data flows now—i.e., using (simplified) ESRS-linked indicators—can avert last-minute compliance costs and position firms as reliable partners for larger customers and financial institutions. Even performance-led indicators or essential dashboards tracking greenhouse-gas intensity, water use, or waste generation create a foundation for continuous improvement and facilitate participation in public green-finance schemes (Flammer, 2021).

Nonetheless, our survey reveals alarming gaps in SMEs' knowledge and perception of climate risks, sustainability regulations, ESG practices, and environmental accountability requirements. Only 47% of firms report literacy in sustainable finance, and just 15% have an environmental manager. There is urgency for financial institutions to expand their advisory and supporting role, helping SMEs navigate complex frameworks such as the CSRD, VSME ESRS, and EU Taxonomy. For example, banks and financial intermediaries can collaborate with public institutions, chambers of commerce, and

[2] In Italian language: Tavolo per la Finanza Sostenibile.

[3] In Italian language: Il Dialogo di Sostenibilità tra PMI e Banche.

research networks (e.g., the GRINS Foundation) to offer capacity-building programs, ESG toolkits, and digital platforms that support SMEs in developing sustainability strategies and reporting mechanisms. Moreover, the integration of advisory services into financial products (e.g., green loans bundled with ESG consulting), coupled with internal training for the workforce of financial institutions, could enhance both uptake and effectiveness of sustainable, climate-resilient practices in SMEs.

Finally, the systemic nature of climate and environmental risks challenges traditional financial risk models. These risks involve the existence of tipping points, the irreversibility of some environmental impacts, and the nonlinearity of climate scenarios and biodiversity loss that conventional models are ill-equipped to capture (TCFD, 2020; TNFD, 2022). Also,

Table 7.1 Policy recommendations by stakeholder level

Stakeholder	*Barriers identified*	*Recommended policies/ guidelines*	*Expected impact*
EU and national policymakers	Low perception of chronic climate risks; limited access to green finance	Gradual extension of disclosure obligations (CSRD, taxonomy); fiscal incentives and dedicated funds for SME green investments; public–private partnerships	Stronger resilience of SMEs; alignment with EU green Deal targets
Financial institutions	Lack of SME climate literacy; difficulty in assessing risks	Development of green credit scoring; training programs for banks and SMEs; conditionality of credit on ESG performance	Improved access to sustainable finance; reduced credit risk
Business associations and chambers of commerce	Limited awareness and managerial competences	Capacity-building initiatives; regional sustainability observatories; knowledge--sharing platforms (geo--referenced maps, benchmarking)	Territorial ecosystems strengthened; diffusion of best practices
SMEs (firms and managers)	Cultural resistance; scarcity of resources; weak governance	Appointment of environmental/sustainability officers; integration of climate risk into governance and remuneration; adoption of net-zero targets; use of risk management tools	Increased competitiveness, resilience, and supply-chain integration

climate and environmental risks compound one another and are intertwined. The fact that only one out of two SMEs report either a "fair" or a "high" concern should ring a bell not only for banks and financial institutions but also for central banks and supervisory authorities.

The following Table 7.1 provides a structured synthesis of policy guidelines and summarizes the proposed measures by stakeholder level.

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Appendix

Appendix A: Questionnaire

A. RISK PERCEPTION

1) To what extent do you believe that climate change is overall making business activities more complex (e.g., increased workload, regulatory challenges, etc.)?

1) Not at all □
2) A little □
3) Quite a bit □
4) A lot □

2) How much do the following types of risk impact your company's activities? *(One response per row)*

		Not at all	A little	Quite a bit	A lot
1)	**Acute physical risk** (caused by extreme events such as droughts, floods, heatwaves)	□	□	□	□
2)	**Chronic physical risk** (caused by gradual changes such as rising temperatures, sea level rise, loss of biodiversity, etc.)	□	□	□	□

V. Palea et al., *Climate Strategies and Sustainability Pathways of Italian Small and Medium-Sized Enterprises*, Palgrave Studies in Climate Resilient Societies,
https://doi.org/10.1007/978-3-032-17454-3

3)	**Transition risk** (economic loss that a company may incur as a result of the adjustment process of the economy toward low carbon emissions and greater environmental sustainability. For example, due to the adoption of climate and environmental policies, changing market preferences, etc.)	□	□	□	□

B. GREEN INVESTMENT

3) In the three-year period 2021–2023, has your company made investments to reduce any of the following risks?

1)	**Acute physical risk** (caused by extreme events such as droughts, floods, heatwaves)	☐ Yes ☐ No
2)	**Chronic physical risk** (caused by gradual changes such as rising temperatures, sea level rise, loss of biodiversity, etc.)	☐ Yes ☐ No
3)	**Transition risk** (economic loss that a company may incur as a result of the adjustment process of the economy toward low carbon emissions and greater environmental sustainability. For example, due to the adoption of climate and environmental policies, changing market preferences, etc.)	☐ Yes ☐ No

(If you answered "Yes" to Q3.1 or Q3.2)

4) What types of investments has your company made in the three-year period 2021–2023 to reduce acute and/or chronic physical risks?
(Max 3 responses in order of importance)

		First	Second	Third
1)	Insurance contracts (to cover risks from extreme events like droughts, floods, etc.)	□	□	□
2)	Protection against physical damage (e.g., flood barriers, hail nets)	□	□	□
3)	Water waste reduction (e.g., through the installation of water-saving devices, reuse and recycling of wastewater, optimization of irrigation, etc.)	□	□	□
4)	Relocation of production (to other geographical areas)	□	□	□
5)	Diversification of production (different types of products)	□	□	□
6)	Change in business model (redefining strategies, operations, business processes, methods of engaging with customers and suppliers)	□	□	□
7)	Other (please specify_____)	□	□	□

(If you answered "Yes" to Q3.3)

5) **hat types of investments has your company made in the three-year period 2021–2023 to reduce transition risk?** *(Max 3 responses in order of importance)*

		First	Second	Third
1)	Increase in the share of energy consumed from renewable sources	□	□	□
2)	Reduction of direct CO2 emissions	□	□	□
3)	Waste reduction/management	□	□	□
4)	Introduction or strengthening of sustainable mobility	□	□	□
5)	Tree planting (commitment to reforestation projects or tree planting to mitigate climate impact or restore degraded ecosystems)	□	□	□
6)	Carbon credits (purchase of certificates related to projects that contribute to reducing greenhouse gas emissions or absorbing CO2)	□	□	□
7)	Other (please specify_____)	□	□	□

6) **In the three-year period 2024–2026, will your company make investments to reduce any of the following risks?**

1)	**Acute physical risk** (caused by extreme events such as droughts, floods, heatwaves)	☐ Yes	☐ No
2)	**Chronic physical risk** (caused by gradual changes such as rising temperatures, sea level rise, loss of biodiversity, etc.)	☐ Yes	☐ No
3)	**Transition risk** (economic loss that a company may incur as a result of the adjustment process of the economy toward low carbon emissions and greater environmental sustainability. For example, due to the adoption of climate and environmental policies, changing market preferences, etc.)	☐ Yes	☐ No

(If you answered "Yes" to Q6.1 or to Q6.2)

7) **What types of investments does your company intend to make in the three-year period 2024–2026 to reduce acute and/or chronic physical risks?**
(Max 3 responses in order of importance)

		First	Second	Third
1)	Insurance contracts (to cover risks from extreme events like droughts, floods, etc.)	□	□	□
2)	Protection against physical damage (e.g., flood barriers, hail nets)	□	□	□
3)	Water waste reduction (e.g., through the installation of water-saving devices, reuse and recycling of wastewater, optimization of irrigation, etc.)	□	□	□
4)	Relocation of production (to other geographical areas)	□	□	□

5)	Diversification of production (different types of products)	□	□	□
6)	Change in business model (redefining strategies, operations, business processes, methods of engaging with customers and suppliers)	□	□	□
7)	Other (Please specify_____)	□	□	□
8)	Still uncertain (EXCLUSIVE)	□		

(If you answered "Yes" to Q6.3)

8) What types of investments does your company intend to make in the three-year period 2024–2026 to reduce transition risks?
(Max 3 responses in order of importance)

		First	Second	Third
1)	Increase in the share of energy consumed from renewable sources	□	□	□
2)	Reduction of direct CO2 emissions	□	□	□
3)	Waste reduction/management	□	□	□
4)	Introduction or strengthening of sustainable mobility	□	□	□
5)	Tree planting (commitment to reforestation projects or tree planting to mitigate climate impact or restore degraded ecosystems)	□	□	□
6)	Carbon credits (purchase of certificates related to projects that contribute to reducing greenhouse gas emissions or absorbing CO2)	□	□	□
7)	Other (please specify_____)	□	□	□
8)	Still uncertain (EXCLUSIVE)	□		

(If you answered at least one code 1 "Yes" to Q3 or Q6)

9) The decision of your company to invest in reducing exposure to climate risk (physical or transition) is due to:
(Max 3 responses in order of importance)

		First	Second	Third
1)	Request from financing banks	□	□	□
2)	Pressure from other financiers (shareholders, bondholders)	□	□	□
3)	Pressure from suppliers to be more green	□	□	□
4)	Pressure from customers to be more green	□	□	□
5)	Regulatory pressure (e.g., standards, regulations, etc.)	□	□	□
6)	Individual sensitivity of the company/management to the issue	□	□	□

7)	Previous experience of losses suffered by the company (or other companies in the same sector) due to extreme events	□	□	□
8)	Increase in energy prices	□	□	□
9)	Pursuit of competitive advantage	□	□	□
10)	Other (please specify_____)	□	□	□

10) What do you consider to be the main obstacles to green ("sustainable") investments in your company?
(Max 3 responses in order of importance)

		First	Second	Third
1)	Insufficient financial resources within the company	□	□	□
2)	High costs of green investments	□	□	□
3)	Current energy costs are too high	□	□	□
4)	Insufficient or absent external financing or lack of knowledge about it	□	□	□
5)	General uncertainty about the future/difficulty in planning	□	□	□
6)	Lack of internal or external expertise (e.g., employees, consultants, etc.)	□	□	□
7)	Lack of interest in the issue/limited knowledge of the positive effects of environmental sustainability investments	□	□	□
8)	Other difficulty (please specify_____)	□	□	□
9)	No difficulty (EXCLUSIVE)	□		

C. EMISSIONS

11) Has your company formally set specific objectives for reducing CO2 emissions?

1)	Yes	□
2)	No	□

(If you answered "Yes" to Q11)

12A) In the last three-year period 2021–2023, which of the following measures has your company implemented?

1)	An investment plan for mitigation toward a target of reducing net CO2 emissions by less than 55% by 2030	□
2)	An investment plan for mitigation toward a target of reducing net CO2 emissions by between 55% and 75% by 2030	□
3)	An investment plan for mitigation toward a target of reducing net CO2 emissions by more than 75% but not total reduction by 2030	□

4)	An investment plan for total (100%) reduction of net CO2 emissions by 2050	□
5)	Other (please specify _____ _____)	□

(If you answered "Yes" to Q11)

12B) In the upcoming three-year period 2024–2026, is the investment plan for reducing net CO2 emissions implemented between 2021 and 2023 confirmed?

1)	Yes, and it has also been increased (for investments and/or CO2 reduction targets) *(NOT VISIBLE IF D12A=4)*	□
2)	Yes, it has been fully confirmed (for investments and/or CO2 reduction targets)	□
3)	Yes, but it has been decreased (for investments and/or CO2 reduction targets)	□
4)	No, it has not been confirmed (investments and CO2 reduction targets have been zeroed out)	□

13) Does your company have a CO2 emissions measurement system?
(*ONE RESPONSE PER ROW)*

		Yes	No, but intends to adopt it in the next three-year period 2024–2026	No / Will possibly do it after 2026
1)	**Direct emissions** (Scope 1 - i.e., from resources owned or directly controlled by the company, such as emissions from industrial processes and production)	□	□	□
2)	**Indirect emissions,** but controllable by the company (Scope 2 - i.e., emissions from purchased energy, typically electricity from renewable sources)	□	□	□
3)	**Indirect emissions** and not controllable by the company (Scope 3 - i.e., all indirect emissions that occur in the value chain of the company, such as during the transportation and distribution or disposal of goods or services after they have reached the consumer, the end-use of sold products and services, etc.)	□	□	□

D. SUSTAINABILITY REPORTING, COMMITTEE AND REMUNERATION

14) **Does your company prepare a sustainability report?** (*SINGLE RESPONSE)*

1) Yes, subject to assurance (compliance check by external auditors) □
2) Yes, not subject to assurance □
3) No □

(If you answered 1) or 2) to Q14)

14A) **Specifically, since which year has your company been preparing the sustainability report?**

|__|__|__|__| Year

15) **Does your company have a person or body responsible for the environmental/sustainability strategy?**

1) Yes □
2) No, but intends to introduce one □
3) No, and does not intend to introduce one □

(If you answered 1 to Q15)

15A) **Specifically, since which year has your company had a person or body responsible for the environmental/sustainability strategy?**

|__|__|__|__| Year

16) **Does your company have a remuneration system for employees linked to achieving climate targets?**

1) Yes □
2) No, but intends to introduce one □
3) No, and does not intend to introduce one □

(If you answered 1 to Q16)

16A) **Specifically, since which year has your company had a remuneration system for employees linked to achieving climate targets?**

|__|__|__|__| YEAR

(If you answered 1 or 2 to Q16)

17) **For which professional levels has your company implemented or plans to implement a remuneration system linked to climate targets?** (*POSSIBLE MULTIPLE RESPONSES)*

1) Executives □

2) Managers □
3) Employees □
4) Workers □
5) Interns/Apprentices □
6) Still uncertain (VISIBLE IF D16=2) (EXCLUSIVE) □

E. GREEN FINANCE

18) Is your company aware of the recent legislative developments in sustainable finance (i.e., considering environmental, social, and governance factors in investment decisions) adopted by the European Union (CSRD, CSDDD, European Taxonomy, etc.)?

1) Yes □
2) No □

18A) And, specifically, have you participated in training activities related to sustainable finance?

1) Yes □
2) No □

(If you answered 1 to Q18)
If you answered at least one "Yes" to Q3, meaning you made investments in the three-year period 2021–2023.

19) Has your company benefited in the last three years (2021–2023) from green financing measures (e.g., green loans, green bonds, green loans, etc.)?
(*POSSIBLE MULTIPLE RESPONSES)*

1) Yes, to reduce physical risk □
2) Yes, to reduce transition risk □
3) Yes, for other purposes (please specify_____) □
4) No (EXCLUSIVE) □

(If you answered 1) or 2) or 3) to Q19)

20) Was the interest rate applied advantageous compared to an equivalent conventional (non-green) loan?

1) Yes □
2) No □

F. ENVIRONMENTAL PROGRAMS

21) Has your company joined the UN Global Compact? (If yes) Since which year?

1) Yes ☐_____ Year
2) No, but plans to join ☐
3) No, although aware of it ☐
4) No, not aware of it ☐

22) Has your company joined the Science Based Targets Initiative (SBTi) (the scientifically supported emissions reduction program)? (If yes) Since which year?

1) Yes ☐_____ Year
2) No, but plans to join ☐
3) No, although aware of it ☐
4) No, not aware of it ☐

23) Does your company hold any of the following environmental certifications?
(If yes) Since which year?
(POSSIBLE MULTIPLE RESPONSES)

1) UNI EN ISO 14001 Environmental Management ☐ Year |__|__|__|__|
2) ISO 50001 Energy Management Systems ☐ Year |__|__|__|__|
3) Other (Please specify_____) ☐ Year |__|__|__|__|
4) No, none (EXCLUSIVE) ☐

G. OWNERSHIP AND LEGAL FORM

24) Is your company legally constituted as a Benefit Corporation?

1) Yes ☐
2) No ☐

25) Who are the shareholders holding more than 20% of the company?
(POSSIBLE MULTIPLE RESPONSES)

1) Family members, including through companies ☐
2) Private investors (individuals) not from the same family ☐
3) Investment funds (including Venture Capital, Private Equity, etc.) ☐
4) Corporations, other than those potentially linked to a family owner ☐
5) Multinationals ☐
6) Publicly controlled companies (e.g., municipalities, public entities, other territorial entities, etc.)
7) Other (please specify_____) ☐

H. EXPECTATIONS

26) **In light of the rising energy costs, how do you evaluate the performance of your revenues in 2023 compared to 2022?**

1) Extremely negative, jeopardizing the survival of the company □
2) Moderately negative □
3) Unchanged □
4) Moderately positive □
5) Extremely positive □

I. BIODIVERSITY

27) **Is the topic of biodiversity known within your company?** *(SINGLE RESPONSE)*

1) Yes, we are aware of it □
2) Yes, we are exploring the topic further □
3) No, we are not familiar with it □

(If you answered 1 or 2 to Q27)

28) **Is biodiversity formally included in your company's sustainability policies (e.g., mentioned in the sustainability report)?**

1) Yes □
2) No □

(If you answered 1 to Q28)

29) **And specifically, is the topic of biodiversity a specific subject of…**

1) Strategic guidelines and/or investment plans aimed at limiting impacts on biodiversity and risks from its deterioration? ☐ Yes ☐ No
2) Strategic guidelines and/or investment plans aimed at pursuing new business growth opportunities (e.g., differentiation and innovation)? ☐ Yes ☐ No

Appendix B: Codification of Variables

N. variables	*Variables Details*	*Codification*
i	Di	Textual: text
ii	Dii	Textual: alphanumeric
iii	Diii	1: Torino, 2: Vercelli, 3: Novara, 4: Cuneo, 5: Asti, 6: Alessandria, 96: Biella, 103: Verbano-Cusio-Ossola, 7: Belluno, 8: Padova, 9: Rovigo, 10: Treviso, 11: Venezia, 12: Verona, 13: Vicenza, 14: Massa-Carrara, 15: Lucca, 16: Pistoia, 17: Firenze, 18: Livorno, 19: Pisa, 20: Arezzo, 21: Siena, 22: Grosseto, 23: Prato, 24: Piacenza, 25: Parma, 26: Reggio Emilia, 27: Modena, 28: Bologna, 29: Ferrara, 30: Ravenna, 31: Forlì-Cesena, 32: Rimini, 33: Agrigento, 34: L'Aquila, 35: Viterbo, 36: Rieti, 37: Roma, 38: Latina, 39: Frosinone, 40: Avellino, 41: Bari, 42: Benevento, 43: Brindisi, 44: Barletta-Andria-Trani, 45: Cagliari, 46: Campobasso, 47: Caserta, 48: Chieti, 49: Caltanissetta, 50: Cosenza, 51: Catania, 52: Catanzaro, 53: Enna, 54: Foggia, 55: Isernia, 56: Crotone, 57: Lecce, 58: Messina, 59: Matera, 60: Napoli, 61: Nuoro, 62: Oristano, 63: Palermo, 64: Pescara, 65: Potenza, 66: Reggio Calabria, 67: Ragusa, 68: Salerno, 69: Siracusa, 70: Sassari, 71: Sud Sardegna, 72: Taranto, 73: Teramo, 74: Trapani, 75: Vibo Valentia
iv	Div	1: Food and beverages 2: Other manufacturing 3: Energy 4: Water supply, sewerage, waste management and remediation 5: Construction and real estate activities 6: Transport 7: Information and communication 8: Professional, scientific and technical activities 9: Not eligible
v	Dv	1: 10–49 employees 2: 50–249 employees 3: 250 employees or more
1	D1	1: Not at all 2: A little 3: Quite a bit 4: A lot
2	D2.1	1: Not at all 2: A little 3: Quite a bit 4: A lot

(*continued*)

(continued)

N. variables	*Variables Details*	*Codification*
3	D2.2	1: Not at all 2: A little 3: Quite a bit 4: A lot
4	D2.3	1: Not at all 2: A little 3: Quite a bit 4: A lot
5	D3.1	1: Yes 0: No
6	D3.2	1: Yes 0: No
7	D3.3	1: Yes 0: No
8	D4S1	1: Insurance contracts 2: Protection against physical damage 3: Water waste reduction 4: Relocation of production 5: Diversification of production 6: Change in business model 7: Other (please specify)
9	D4S2	1: Insurance contracts 2: Protection against physical damage 3: Water waste reduction 4: Relocation of production 5: Diversification of production 6: Change in business model 7: Other (please specify)
10	D4S3	1: Insurance contracts 2: Protection against physical damage 3: Water waste reduction 4: Relocation of production 5: Diversification of production 6: Change in business model 7: Other (please specify)
11	D4_ other	Textual: text

(*continued*)

(continued)

N. variables	*Variables Details*	*Codification*
12	D5S1	1: Increase in the share of energy consumed from renewable sources 2: Reduction of direct CO2 emissions 3: Waste reduction/management 4: Introduction or strengthening of sustainable mobility 5: Tree planting 6: Carbon credits 7: Other (please specify)
13	D5S2	1: Increase in the share of energy consumed from renewable sources 2: Reduction of direct CO2 emissions 3: Waste reduction/management 4: Introduction or strengthening of sustainable mobility 5: Tree planting 6: Carbon credits 7: Other (please specify)
14	D5S3	1: Increase in the share of energy consumed from renewable sources 2: Reduction of direct CO2 emissions 3: Waste reduction/management 4: Introduction or strengthening of sustainable mobility 5: Tree planting 6: Carbon credits 7: Other (please specify)
15	D5_ other	Textual: text
16	D6.1	1: Yes 0: No
17	D6.2	1: Yes 0: No
18	D6.3	1: Yes 0: No
19	D7S1	1: Insurance contracts 2: Protection against physical damage 3: Water waste reduction 4: Relocation of production 5: Diversification of production 6: Change in business model 7: Other (please specify) 8: Still uncertain

(*continued*)

(continued)

N. variables	*Variables Details*	*Codification*
20	D7S2	1: Insurance contracts 2: Protection against physical damage 3: Water waste reduction 4: Relocation of production 5: Diversification of production 6: Change in business model 7: Other (please specify)
21	D7S3	1: Insurance contracts 2: Protection against physical damage 3: Water waste reduction 4: Relocation of production 5: Diversification of production 6: Change in business model 7: Other (please specify)
22	D7_ other	Textual: text
23	D8S1	1: Increase in the share of energy consumed from renewable sources 2: Reduction of direct CO2 emissions 3: Waste reduction/management 4: Introduction or strengthening of sustainable mobility 5: Tree planting 6: Carbon credits 7: Other (please specify) 8: Still uncertain
24	D8S2	1: Increase in the share of energy consumed from renewable sources 2: Reduction of direct CO2 emissions 3: Waste reduction/management 4: Introduction or strengthening of sustainable mobility 5: Tree planting 6: Carbon credits 7: Other (please specify)
25	D8S3	1: Increase in the share of energy consumed from renewable sources 2: Reduction of direct CO2 emissions 3: Waste reduction/management 4: Introduction or strengthening of sustainable mobility 5: Tree planting 6: Carbon credits 7: Other (please specify)

(*continued*)

(continued)

N. variables	*Variables Details*	*Codification*
26	D8_ other	Textual: text
27	D9S1	1: Request from financing banks 2: Pressure from other financiers (shareholders, bondholders) 3: Pressure from suppliers to be more green 4: Pressure from customers to be more green 5: Regulatory pressure (e.g., standards, regulations, etc.) 6: Individual sensitivity of the company/management to the issue 7: Previous experience of losses suffered by the company due to extreme events 8: Increase in energy prices 9: Pursuit of competitive advantage 10: Other (please specify)
28	D9S2	1: Request from financing banks 2: Pressure from other financiers (shareholders, bondholders) 3: Pressure from suppliers to be more green 4: Pressure from customers to be more green 5: Regulatory pressure (e.g., standards, regulations, etc.) 6: Individual sensitivity of the company/management to the issue 7: Previous experience of losses suffered by the company due to extreme events 8: Increase in energy prices 9: Pursuit of competitive advantage 10: Other (please specify)
29	D9S3	1: Request from financing banks 2: Pressure from other financiers (shareholders, bondholders) 3: Pressure from suppliers to be more green 4: Pressure from customers to be more green 5: Regulatory pressure (e.g., standards, regulations, etc.) 6: Individual sensitivity of the company/management to the issue 7: Previous experience of losses suffered by the company due to extreme events 8: Increase in energy prices 9: Pursuit of competitive advantage 10: Other (please specify)
30	D9_ other	Textual: text

(*continued*)

(continued)

N. variables	*Variables Details*	*Codification*
31	D10S1	1: Insufficient financial resources within the company 2: High costs of green investments 3: Current energy costs are too high 4: Insufficient or absent external financing or lack of knowledge about it 5: General uncertainty about the future/difficulty in planning 6: Lack of internal or external expertise (e.g., employees, consultants, etc.) 7: Lack of interest in the issue/limited knowledge of the positive effects of environmental sustainability investments 8: Other difficulty (please specify) 9: No difficulty
32	D10S2	1: Insufficient financial resources within the company 2: High costs of green investments 3: Current energy costs are too high 4: Insufficient or absent external financing or lack of knowledge about it 5: General uncertainty about the future/difficulty in planning 6: Lack of internal or external expertise (e.g., employees, consultants, etc.) 7: Lack of interest in the issue/limited knowledge of the positive effects of environmental sustainability investments 8: Other difficulty (please specify)
33	D10S3	1: Insufficient financial resources within the company 2: High costs of green investments 3: Current energy costs are too high 4: Insufficient or absent external financing or lack of knowledge about it 5: General uncertainty about the future/difficulty in planning 6: Lack of internal or external expertise (e.g., employees, consultants, etc.) 7: Lack of interest in the issue/limited knowledge of the positive effects of environmental sustainability investments 8: Other difficulty (please specify)
34	D10_ other	Textual: text
35	D11	1: Yes 0: No

(*continued*)

(continued)

N. variables	*Variables Details*	*Codification*
36	D12A	1: An investment plan for mitigation towards a target of reducing net CO2 emissions by less than 55% by 2030 2: An investment plan for mitigation towards a target of reducing net CO2 emissions by between 55% and 75% by 2030 3: An investment plan for mitigation towards a target of reducing net CO2 emissions by more than 75% but not total reduction by 2030 4: An investment plan for total (100%) reduction of net CO2 emissions by 2050 5: Other (please specify)
37	D12A_ other	Textual: text
38	D12B	1: Yes, and it has also been increased (for investments and/or CO2 reduction targets) 2: Yes, it has been fully confirmed (for investments and/or CO2 reduction targets) 3: Yes, but it has been decreased (for investments and/or CO2 reduction targets) 4: No, it has not been confirmed (investments and CO2 reduction targets have been zeroed out)
39	D13.1	1: Yes 2: No, but intends to adopt it in the next three-year period 2024–2026 3: No / Will possibly do it after 2026
40	D13.2	1: Yes 2: No, but intends to adopt it in the next three-year period 2024–2026 3: No / Will possibly do it after 2026
41	D13.3	1: Yes 2: No, but intends to adopt it in the next three-year period 2024–2026 3: No / Will possibly do it after 2026
42	D14	1: Yes, subject to assurance (compliance check by external auditors) 2: Yes, not subject to assurance 3: No
43	D14A	Numeric: year
44	D15	1: Yes 2: No, but intends to introduce one 3: No, and does not intend to introduce one
45	D15A	Numeric: year

(*continued*)

(continued)

N. variables	*Variables Details*	*Codification*
46	D16	1: Yes 2: No, but intends to introduce one 3: No, and does not intend to introduce one
47	D16A	Numeric: year
48	D17I1	1: Yes 0: No
49	D17I2	1: Yes 0: No
50	D17I3	1: Yes 0: No
51	D17I4	1: Yes 0: No
52	D17I5	1: Yes 0: No
53	D17I6	1: Yes 0: No
54	D18	1: Yes 0: No
55	D18A	1: Yes 0: No
56	D19I1	1: Yes 0: No
57	D19I2	1: Yes 0: No
58	D19I3	1: Yes 0: No
59	D19I4	1: Yes 0: No
60	D19_ other	Textual: text
61	D20	1: Yes 0: No
62	D21	1: Yes 2: No, but plans to join 3: No, although aware of it 4: No, not aware of it
63	D21A	Numeric: year
64	D22	1: Yes 2: No, but plans to join 3: No, although aware of it 4: No, not aware of it

(continued)

N. variables	*Variables Details*	*Codification*
65	D22A	Numeric: year
66	D23I1	1: Yes 0: No
67	D23.1Y	Numeric: year
68	D23I2	1: Yes 0: No
69	D23.2Y	Numeric: year
70	D23I3	1: Yes 0: No
71	D23.3Y	Numeric: year
72	D23I4	1: Yes 0: No
73	D23_ other	Textual: text
74	D24	1: Yes 0: No
75	D25I1	1: Yes 0: No
76	D25I2	1: Yes 0: No
77	D25I3	1: Yes 0: No
78	D25I4	1: Yes 0: No
79	D25I5	1: Yes 0: No
80	D25I6	1: Yes 0: No
81	D25I7	1: Yes 0: No
82	D25I8	1: Yes 0: No
83	D25_ other	Textual: text
84	D26	1: Extremely negative, jeopardizing the survival of the company 2: Moderately negative 3: Unchanged 4: Moderately positive 5: Extremely positive

(*continued*)

(continued)

N. variables	*Variables Details*	*Codification*
85	D27	1: Yes, we are aware of it 2: Yes, we are exploring the topic further 3: No, we are not familiar with it
86	D28	1: Yes 0: No
87	D29.1	1: Yes 0: No
88	D29.2	1: Yes 0: No

Appendix C: Climate Risk Perception by Geographical Distribution

As illustrated in Table C1, results from the Pearson's χ^2 test[1] indicate that regional differences in risk perception are statistically significant across all risk categories ($p<0.01$ for all χ^2 tests). However, they explain only a small portion of the overall variance in risk perceptions. The effect size, measured by Cramer's V, ranges from 0.0427 for transition risks—indicating minimal regional variation—to 0.0743 for aggregate physical risks, suggesting a stronger geographical influence. Although statistically significant, these regional effects account for just 0.18% to 0.55% of the variance, highlighting the limited role of companies' geographical location compared to other factors.

Table C2 displays percentage deviations from expected values in risk perception across Italian sample regions.[2] Lazio shows above-average concern across multiple sources of risk (+8.54% for overall climate risk,

[1] The Pearson χ^2 test evaluates whether observed frequency distributions deviate significantly from expected distributions under the assumption of independence. Cramer's V (ranging from 0 to 1) quantifies the degree of association strength between categorical variables, with higher values indicating stronger dependence. The squared value (V^2) represents the proportion of variance in one variable explainable by the other, analogous to R^2 in linear regression.

[2] The percentage deviations represent firm response rates relative to expected frequencies under regional homogeneity (null hypothesis). Positive values (e.g., Lazio's +13.11% for chronic risks) indicate higher-than-expected concern prevalence, while negative values (e.g., Piedmont's −15.90% for acute risks) reflect lower-than-expected prevalence. These normalized measures enable cross-risk comparison by accounting for regional sample size variations.

Table C1 Regional variation in climate risk perception statistics

Risk type	χ^2	*df*	*p-value*	*Cramer's V*	V^2
Overall Climate	27.757	4	0.000	0.0537	0.29%
Acute Physical	47.377	4	0.001	0.0701	0.49%
Chronic Physical	41.804	4	0.002	0.0659	0.43%
Physical (Aggregate)	53.177	4	0.003	0.0743	0.55%
Transition	17.541	4	0.002	0.0427	0.18%

Table C2 Regional deviation in medium-high concern

Region	*Overall climate risk*	*Acute physical risk*	*Chronic physical risk*	*Physical (Aggregate) risk*	*Transition risk*
Piedmont	−4.39%	−15.90%	−15.22%	−7.99%	+2.19%
Veneto	+6.22%	+3.64%	+9.21%	+5.54%	−4.17%
Tuscany	+1.17%	+3.74%	−0.17%	+1.76%	−1.76%
Emilia-Romagna	−6.95%	+9.07%	−3.68%	+4.44%	−7.37%
Lazio	+8.54%	−1.76%	+13.11%	+0.42%	+12.38%

+13.11% for chronic physical risks, and +12.38% for transition risks), likely reflecting its combination of coastal vulnerabilities and policy-aware economic sectors. Veneto records the highest perception of physical risks (+5.54% aggregate physical), especially chronic risks (+9.21%), consistent with its exposure to physical threats. In contrast, firms located in Emilia-Romagna exhibit a higher perception of acute risks (+9.07%), which may be linked to the traumatic experience of the catastrophic floods that occurred in May 2023. These floods severely affected the region, particularly the provinces of Bologna, Cesena, Forlì, Faenza, Ravenna and Rimini, where two initial flooding in early May were followed by even more devastating floods in mid-May, resulting in 15 fatalities and the displacement of 50,000 residents. The disproportionate impact of these extreme weather events appears to have heightened local sensitivity to acute physical climate threats. Piedmont, on the other hand, shows below-average concern, particularly regarding acute risks (−15.90%), which may be attributed to its industrial profile and the presence of established flood protection infrastructure.

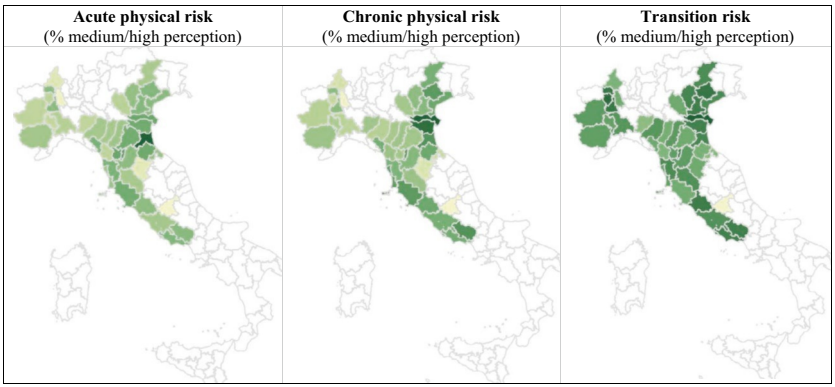

Fig. C1 Climate risk perception by province. (Source: Own elaboration)

Figure C1 portrays the spatial distribution of risk perception across Italian provinces, revealing the interplay between environmental exposure, historical memory, and socioeconomic factors in shaping the climate risk perception of firms. The gradient mapping, from light to dark green indicating medium to high perceived risk, shows that *acute* physical risks concentrate most intensely in Ravenna, followed by a cluster of provinces in Emilia-Romagna (Forlì-Cesena, Bologna, Ferrara), and extending to Rovigo in Veneto and Grosseto in Tuscany. This pattern mirrors Italy's hydrogeological fragility, particularly along the Po river basin and its deltaic extensions, where catastrophic flooding events have left a lasting imprint on collective memory. The prominence of Ravenna and its neighboring provinces likely reflects the lingering trauma of the 2023 Emilia-Romagna floods, which turned abstract climate risks into lived experience through human losses and significant economic disruption. *Chronic* risks, by contrast, are most strongly perceived in Ferrara and Rovigo, which underscores the vulnerabilities of the Po river delta. Here, gradual environmental damage, like land sinking and saltwater harming farmland, seems to have raised more awareness of risk than the more dramatic but occasional disasters experienced elsewhere. Beyond this epicenter, however, the perception of chronic risk extends to other provinces, including Grosseto, Frosinone, and Treviso, albeit shaped by distinct regional dynamics. In Grosseto, heightened sensitivity likely stems from its coastal and agrarian exposure, where rising sea levels threaten the lands of the Maremma while saline intrusion jeopardizes viticulture. Frosinone is affected by Apennine watershed vulnerabilities, as its valleys face

increasing drought stress and soil erosion, compounded by the Liri river's erratic flow regimes. Similarly, Treviso's fragility may be linked to the Piave river basin, where glacial retreat and altered precipitation patterns disrupt a once-stable hydrological system. Differently from physical risks, *transition* risks present a notably more homogeneous spatial distribution, suggesting that policy-driven threats transcend local particularities.

Climate Strategies by Geographical Distribution

The level of firms' proactivity varies across regions and provinces (see Fig. C2). Across all three types of risk, the Veneto region consistently leads in climate efforts. Regarding *acute* physical risks, firms demonstrate heightened responsiveness in the Po River basin and along the Tyrrhenian coast, particularly within Emilia-Romagna's provinces of Ravenna, Parma, and Piacenza. These areas have a history of severe weather events, implying that past flood experiences are motivating current mitigation efforts. In Veneto, the provinces of Belluno and Padua stand out, while Grosseto in Tuscany also emerges as particularly proactive, highlighting coastal vulnerability as a shared underlying factor. For *chronic* risks, the map is more scattered. In Veneto, the provinces of Belluno, Padua, and Treviso can be pointed out. In Lazio, Frosinone and Latina show a stronger commitment, which may reflect growing concern over slow-onset risks such as drought and soil degradation. In Tuscany, we highlight the province of Grosseto and Vercelli in Piedmont, likely due to the sensitivity of its rice cultivation to changing climatic conditions. Finally, concerning *transition* risks, northern Italy shows stronger engagement, especially Belluno and Venezia. Biella also stands out, likely due to its textile industry and need to adapt to decarbonization pressures.

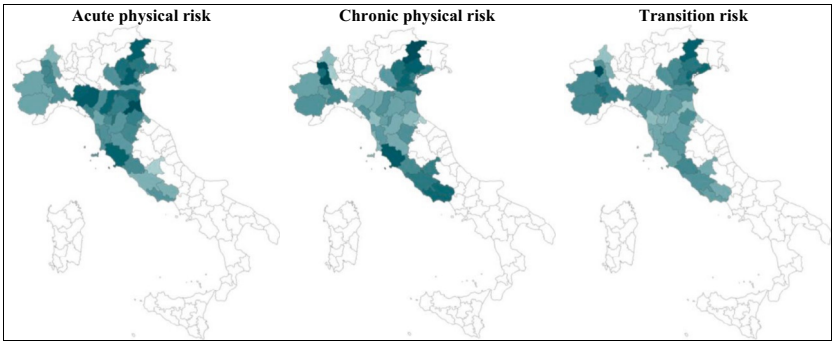

Fig. C2 Climate strategies—proactivity by province. (Source: Own elaboration)