BANCA D'ITALIA

EUROSISTEMA

Questioni di Economia e Finanza

(Occasional Papers)

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by L. Lavecchia, J. Appodia, P. Cantatore, R. Cappariello, S. Di Virgilio, A. Felettigh, A. Giustini, V. Guberti, D. Liberati, G. Meucci, S. Piermattei, F. Schimperna and K. Specchia

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DATA AND METHODS TO ASSESS CLIMATE-RELATED AND ENVIRONMENTAL RISKS IN ITALY

by L. Lavecchia, J. Appodia, P. Cantatore, R. Cappariello, S. Di Virgilio, A. Felettigh, A. Giustini, V. Guberti, D. Liberati, G. Meucci, S. Piermattei, F. Schimperna and K. Specchia[1]

Abstract

Monitoring climate-related (and environmental) financial risks requires high quality and highly granular data. However, these are scarcely available, except for little data on a small number of counterparty firms. This paper sheds light on the sustainable data gap in Italy, with a special focus on the climate and environmental components. First, we take stock of the data needs arising from firms' transition plans, commitments to net zero, and financial analyses, as well as those stemming from international, European and national regulations, and from supervisory requirements. Second, we map the existing and available data regarding climate, energy, greenhouse gas (GHG) emissions, climate-related financial risks, as well as existing but inaccessible data. Finally, we identify any missing data, highlighting the areas that are most affected by the data gap.

JEL Classification: C81, Q54, Q48.

Keywords: sustainable data gap, climate change, sustainable finance, physical risk, transition risk, GHG emissions, energy.

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Contents

[1] Banca d'Italia and IVASS (Specchia).

1. Introduction[1]

In God we trust. All others must bring data
(W. Edwards Deming)

In recent years, the demand for data about sustainable finance and climate change has surged. More and more firms have been integrating their climate and environmental risks into their risk management practices, setting targets to reduce their GHG emissions, in line with the Paris Agreement of 2015, following initiatives such as the Financial Stability Board's Task Force on Climate-related Financial Disclosures (TCFD) and, more recently, the IFRS' International Sustainability Standards Board (ISSB). Disclosure requirements and expectations are growing, especially in Europe, led by EU and national legislators and regulators.[2]

However, firms have made limited progress in this area, overall.[3] Some of this delay is likely due to persistent difficulties in finding data; what is more, the gap between the data needs and their availability shows no signs of abating. Both Italian and other European banks still have limited risk management tools for climate risks[4] and are working on plans to meet the supervisory expectations

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[2] As for European banks, in 2018 the EBA was charged by the European Commission with the task of evaluating how to integrate ESG risks into the three pillars of microprudential supervision. EBA published in 2019 an Action plan on sustainable finance to incorporate ESG risks into the regulatory and supervisory framework. The ECB has included climate and environmental risks among its supervision priorities and it follows closely the impact on larger Euro-area banks (see the Guide published in November 2020). As for the insurance sector, EIOPA published in 2019, on behalf of the European Commission, an opinion on sustainability within Solvency II (EIOPA 2019a), with a focus on climate risks. With the following opinion, EIOPA provided a direction to the national authorities supervising how insurers integrate climate change risks into their ORSAs (EIOPA 2021a).

[3] At the end of 2020 less than 6 per cent of all public firms listed on the S&P 500 and STOXX Europe 600 had in place credible targets to reduce GHG emissions. By capitalization, these firms accounted for less than 0.06 per cent of the total. Approximately 85 per cent of all the firms in the aforementioned stock indices disclosed information about their GHG emissions (BCE 2022a).

[4] Based on the Regional Bank Lending Survey (RBLS) conducted by Banca d'Italia, 'only a small share of banks (13 per cent of respondents) analyse the impact of climate risks (physical and transition) within their own remit, but a significant share of firms (80 per cent) will do so in the near future and all significant institutions are already actively carrying out these evaluations.' (Banca d'Italia 2022 and Angelico et al. 2022). These findings are consistent with those of the Climate risk stress test conducted recently by the ECB (2022b) and with a previous survey carried out in 2018 by Working group No. 3 of the Italian observatory on sustainable finance (OIFS 2019).

set by the SSM[5] (for the biggest banks, the 'significant institutions', SIs) and by Banca d'Italia[6] (for the smaller banks, the 'less significant institutions', LSIs, and for the other supervised financial firms).

Signs of progress within the insurance sector are still limited to the bigger insurance groups that are leaders in the non-life business, as proved by recent national surveys conducted by IVASS and EIOPA.[7] Insurance groups and companies specializing in the life business and medium-sized insurers, nonetheless, are increasingly integrating ESG (Environmental, Social and Governance) factors and risks into their evaluations and developing investment policies for adaptation to climate change, through new insurance coverages and innovative ancillary services.[8]

We refer to the deficiencies in the availability, usability, access and reliability of information for climate change and sustainable finance analysis (NGFS 2021) as the sustainable data gap. The lack of or limited access to granular information, such as energy performance certificates, or the energy consumption of households and firms, hinders effective climate and environmental risk management for individual firms and the financial system as a whole. Moreover, the lack of data risks undermining the targets of the European Green Deal, as it impairs the evaluation of climate policies (particularly in terms of redistributive impacts).

Recent initiatives, including legislative action – e.g. the harmonization of climate disclosure standards by the International Sustainability Standards Board (ISSB),[9] the extension of the scope of non-financial reporting requirements under the Corporate Sustainability Reporting Directive (CSRD), the new prudential rules on disclosure for financial firms, and the new classification of sustainable activities as defined in the Taxonomy Regulation (852/2020) – should help reduce the existing sustainable data gap within the EU and increase the quality, quantity and comparability of available information. The effects of these initiatives will be clearer in the medium or long term.

[5] For an overview of the ECB initiatives on climate change, see the Keynote speech by Frank Elderson, 10 June 2022, 'Good, bad and hopeful news: the latest on the supervision of climate risks.'

[6] Banca d'Italia extended the thematic review that the ECB carried out with the SIs to a sample of LSIs, to verify, keeping in mind the principle of proportionality, the alignment to the related SSM supervisory expectations; simultaneously, a significant sample of non-bank financial institutions were administered a self-evaluation survey, based on the Supervisory expectations recently published by Banca d'Italia for the supervised financial firms. Based on the results, the most frequent deficiencies are in the risk management area, also due to the lack of available and reliable data, which does not help in quantifying and monitoring exposure towards climate and environmental risks. Moreover, most of the clients are SMEs, from which it is hard to obtain information on climate and environmental factors.

[7] Please refer to the section Prudential Supervision - Climate change and sustainable finance in the Annual Reports for 2020 and 2021, in addition to EIOPA's Opinion on sustainable finance (2019a), which contains a description of the impact of climate-related risks on the life and non-life businesses. See also EIOPA's report on non-life underwriting and pricing in light of climate change (2021b).

[8] Compared with 2019, European insurance companies show a gradual integration of ESG factors and risks into their business models, within a rapidly evolving regulatory context//framework for sustainable finance (IVASS 2021). On the topic of the integration of sustainability risks into risk management and the future challenges for the insurance sector, see also Corinti (2022) and De Polis (2022 and 2021).

[9] The International Financial Reporting Standards (IFRS) Foundation, which has formerly set International Accounting Standards Board (IASB) standards, has been working on a new set of International Sustainability Standards Board (ISSB) standards. These standards will make comparisons of requirements across jurisdictions easier, including under the EU Corporate Sustainability Reporting Directive (CSRD). The group in charge of submitting an initial technical proposal has already published its recommendations, currently under discussion.

Meanwhile, the sustainable data gap has been narrowing thanks to commercial data providers. These firms supply additional information to complement the data released by corporations, though their estimates are based on proprietary algorithms and may lack evidence or transparency. Moreover, the quality and comparability of the information is usually quite low (Berg, Kolbel and Rigobon 2022), particularly in terms of GHG estimates, specifically within Scope 3[10] (Busch et al. 2022), which many regulators deem of fundamental importance to properly manage the transition risk.[11] There is also little consistency (and correlation) between ESG ratings and rankings that different data providers assign to the same firm (BCE 2022a). The European Banking Federation (EBF) has recently drawn ESMA's attention to the need for more transparency in the proprietary methodologies behind ESG ratings and urged data providers to increase their staff in order to improve the quality of their analysis.

Similarly, Eurosif (2022) has called for more transparency in ESG rating methodologies, in the disclosure of conflicts of interest and in ESG-rating fee structures. Subsequently, IOSCO and ESMA have launched other initiatives, including a survey by ESMA (currently underway) on the quality of ESG ratings, with a view to regulating data providers.

For the purposes of climate and environmental risk management, it is therefore fundamental that regulators and financial operators allocate resources to data harvesting, production and filing and to analysis and modelling, with a critical approach towards third-party data (Bank of England 2022). The use of advanced and well-documented techniques, such as machine learning, might reduce the sustainable data gap, but it requires granular databases to calibrate the algorithms that are usually not available (e.g. data on firms' energy use) (Nguyen et al. 2021). Moreover, even when data exist, they are usually harvested and disseminated inconsistently and with different standards a crucial problem that the future global standards by ISSB (and, at the European level, by EFRAG) will likely solve (see par. 3.2).

The dissemination of information about climate risks and sustainable finance, in terms of quality and consistency, is another crucial point. Initiatives such as the Global Climate Action Portal launched during the 26th Conference of the Parties (COP26), the directory proposed by the Network of Central Banks and Supervisors for Greening the Financial System (NGFS),[12] the future European Single Access Point (ESAP)[13], or the Climate Data Steering Committee recently proposed by the French Government, might all help in reducing the information fragmentation and increasing transparency, comparability and access, thus lowering the risk of greenwashing.[14]

[10] The Greenhouse Gas Protocol classifies the emissions into three categories: direct emissions, from the use of fossil fuels for heating, company fleets, etc. ('Scope 1 emissions'); indirect emissions from purchased electricity, steam, heat, and cooling ('Scope 2 emissions'); other indirect emissions from purchased goods and services (paper, IT, furniture, canteen services), waste production, transportation of goods, commuting, business trips, etc. ('Scope 3 emissions').

[11] For an extended definition of physical and transition risks please see Banca d'Italia's Annual report for 2020, chapter 15 or Bernardini et al. (2021).

[12] The directory proposed by the NGFS, which currently does not provide direct access to the data, shows a gap with reference to the analysis of the biophysical impact, GHG emissions and geolocalized data (NGFS 2022).

[13] A draft regulation is currently under discussion in the European Parliament and the Council of the European Union, and it entrusts ESMA with the task of creating and managing the ESAP by 31 December 2024, with a gradual set-up to be completed by 2026. The information that will be published cannot date back to before 1 January 2024. The ESAP will have several financial and non-financial data (to be defined) and it should include the information currently included in non-financial reports. Access will be direct, immediate (also through APIs) and free for all.

[14] A situation where investors fund activities that are sustainable only on paper.

In summary, enhancing the climate data architecture is a global priority (IMF 2022) that requires: 1) reliable, comparable and high-quality data; 2) harmonized information satisfying a set of disclosure standards on climate risks, as uniform as possible at the global level.

More specifically, to ensure the quality and comparability of climate data it will be fundamental to: 1) rapidly adopt shared disclosure practices at the global level; 2) develop a basic global taxonomy or adopt some classification principles for sustainable finance; 3) develop and use transparent metrics, certifications, labels and methodologies (NGFS 2021).

In this paper, we review the data needed to analyse sustainability risks, particularly climate and environmental ones (paragraph 2). We then list the data required of banks, insurance companies and other financial firms operating in Italy in compliance with transparency requirements under the current financial regulation (paragraph 3). Lastly, we provide a review of the existing data (paragraph 4), including those currently not available, which could significantly narrow the sustainable data gap in Italy. We end with a summary highlighting where the data gap is concentrated.

2. The data necessary for the economic and financial analyses of climate risks

2.1 The analysis of climate risks for firms

Climate-related financial risks (CRFRs) are typically classified as physical risk and transition risk. Physical risk occurs when extreme weather events, both acute and chronic, damage the structures and capital of households and firms or affect their ability to produce income. The repercussions can impact the financial system directly or indirectly, through various channels, as extensively described by the Basel Committee in its analysis.[15] Transition risk is, instead, associated with a (more or less) sudden devaluation of the production and financial assets of firms operating in the fossil fuel industry. This risk can originate, first of all, from an unexpected implementation of policies that affect the use or price of fossil fuels; secondly, it can derive from disruptive technological innovations or changes in the preferences of investors and/or consumers that alter the energy scenario. Transition-oriented policies should be based on a change in the relative prices of energy inputs, making carbon-intensive inputs less affordable (*carbon intensive*).[16] In general, the transition entails, at least in the short and medium term, an increase in costs which affects households and firms arising from the need to finance new investments in green technologies, the possibility of implementing carbon pricing policies, and the costs of assets whose investment value cannot be recouped and must be written off (stranded assets)[17]

[15] E.g. if an entity suffered damages to one of its production units and had to interrupt the production or delivery of its products, it could struggle to repay its debts. Using insurance to cover these costs will limit the expected loss for intermediaries, while increasing insurers' exposure, especially if their portfolio is concentrated in the affected areas (or if the impacts are particularly extensive).

[16] See for example Signorini (2022).

[17] According to some evaluations, the assets linked to oil and gas activities, for a total value of $1,000 billion, are likely to be stranded; 60 per cent of these assets are from listed companies (more specifically, on the New York, Moscow, London and Toronto Stock Exchanges – Carbon Tracker, 2022).

The economic risk for an economic player or business linked to a climatic shock, either physical or transitional, can be calculated as the product of three factors: likelihood of an adverse event occurring (hazard), value of the exposed activities (exposure) and expected loss per unit exposed (vulnerability).[18]

Hazard is defined as the probability that an extreme natural phenomenon occurs, in the case of physical risk (e.g. flood), or that a certain regulation is introduced, in the case of transition risk. With regard to physical risk this requires maps that define the level of risk of the extreme weather events linked to climate change,[19] using data that are as granular as possible. Unfortunately, in Italy, most of the classifications currently available are aggregated at provincial or, at best, at municipal level. Assigning the same hazard level to all the areas of a territory is a considerable and limiting approximation; ideally, risk classification grids should be more granular, i.e. broken down by address or geographical coordinates, and information should be available on the geolocation of the production units of the companies (and estimates of their financial contribution) in the same grid to allow correct matching between the risks and the assets exposed to those risks. Finally, it should be taken into account that over time climate change increases the probability of certain events occurring. The use of forward-looking data is equally important, as using exclusively historical data could lead to a systematic underestimation of risk (FSB 2021). With regard to transition risk, in order to assess the likelihood of a company being subjected to unexpected changes in policies and regulations,[20] such as the introduction of a carbon pricing system,[21] or the prohibition/obligation to use a specific source of energy or technology, the focus is usually placed on the company's business sector.[22] Even in this case, however, the sectoral dimension, although available, is not sufficient; in fact, the use of sectoral data does not allow for discrimination between two companies operating in the same sector that adopt opposite approaches (e.g. with regard to energy efficiency). Moreover, the current system of

[18] For more details, see Chapter 5 in Bernardini et al., 2021. See also the technical description of the EIOPA Pilot Dashboard on insurance protection gap (2020) which, for the current estimate of the insurance protection gap relating to natural catastrophes, refers to the following algorithm: *Risk = Hazard*Exposure*Vulnerability* integrated with the level of insurance coverage of expected economic loss (so-called level of insurance penetration). This formula refers to the estimate of the expected loss in the banking sector (given by the iteration between the probability of default, the amount in default and the percentage of loss given the default).

[19] Event-based mapping should be distinguished from scenario-based mapping. In the first case, it is necessary to understand to what extent those events are exclusively attributable to climate change. This requires the use of attribution science, a discipline that studies how much climate change may be responsible for certain extreme weather events (for a review of the methodologies, see the work of the World Weather Attribution; for an example of the estimate of the effects of the emissions of one country on the other countries in the world, see Callahan and Mankin 2022).

[20] Estimating the probabilities of such events is crucial and requires dedicated analysis.

[21] Carbon pricing systems are based on the idea of incorporating into the price of fossil fuels the negative externalities associated with their use. There are two main types of carbon pricing: carbon taxes and emissions trading systems (ETS), also referred to as cap-and-trade systems, which cap emissions and leave price determination to the market where emission permits are traded. Worldwide, there are 68 carbon pricing schemes that cover approximately 23 per cent of global greenhouse gas emissions, with an average price of $7 per tonne of CO2 (World Bank 2022). In the European Union, the mechanism in place is of the second type, the EU ETS, on which the emission permits of large European energy-intensive plants are traded. These prices have recently risen too, helping to put pressure on the costs of electricity generation from coal and gas: in May 2022, the price of emissions had increased by 60 per cent compared to a year earlier, exceeding €85 per tonne.

[22] For example, vehicles with an internal combustion engine (ICE) will be banned from sale in the UK starting in 2030 (2035 for hybrid vehicles); similarly, the EU programme 'Fit for 55' is set to impose a ban on the sale of new ICE cars by 2035. From 2026, the Netherlands will make the use of heat pumps for domestic heating mandatory.

classification of economic activities by sector (NACE/ATECO) does not take into account some fundamental distinctions in the field of energy transition, such as electricity generation.[23]

The second type of data necessary to assess climate risks relates to the economic value of the activities exposed to the event, i.e. exposure. While it can be easy for banks to know the value and location of the property assets owned by the households to which mortgages are granted, in the case of firms it is impossible to make an exact estimate of the value added of the production units (plants, warehouses, etc.) without collecting ad hoc data. Often times, the only information available in the domestic business registry database is the address of the firm's administrative offices; even in the best case scenario, in which the position of the individual production units is also known, as rare as this may be, a criterion must be established to quantify value of capital, production capacity and generated turnover for the various units. One way to accomplish this is to use the number of people employed in each geographic area or production site (Meucci and Rinaldi 2022). For transition risk, exposure[24] varies according to the carbon intensity of the sector and technology, and to the choices made by the individual firm. In this case, it would be desirable to have access to details on GHG emissions at an individual firm level or, even better, to information on the energy mix used by the firm, to understand not only how a given amount of emissions is reached but also what the effects of an increase in the cost of a specific energy source would be on the economic and financial situation of the firm. However, the number of firms publishing such information is still very limited (see Paragraph 3). The attempts to estimate emissions at the individual firm level collide with the difficulty in finding data on energy consumption, on the quantities of raw materials processed and on the emission factors linked to the specific production processes, which are essential for calculating direct and indirect emissions.[25] It follows that, by comparing the different sources, the estimates can largely differ and therefore turn out to be unreliable; the problem is particularly severe in the case of Scope 3 emissions (Busch et al. 2020). The use of advanced statistical machine learning techniques to estimate ESG indicators, for instance, could mitigate these difficulties, at least for equity portfolios (Lanza et al., 2020), but it still requires detailed data sources on which to 'train' algorithms. Furthermore, well-designed surveys can accurately outperform Big data (Big Data Paradox; Bradley et al. 2022).

[23] Electricity generation is all classified under the same NACE/ATECO code (35.11.0) regardless of whether it is sourced from fossil fuels (coal, gas or oil) or renewable sources. This makes it extremely difficult to assess the impact of different policies, such as a cap on GHG emissions (which would apply to the former but not to the latter).

[24] According to some studies conducted by Banca d'Italia, at the end of 2019, 37 per cent of loans to non-financial corporations were exposed to transition risks, 15 per cent to physical risks and 13 per cent to both types of risk (Banca d'Italia 2021). Recent estimates for exposure to transition risk, extended to all financial intermediaries and total assets (loans, shares and bonds) indicate a greater concentration in the banking system compared with other sectors, particularly for loans (Faiella et al. 2022).

[25] Many production processes involve emissions of GHGs and other pollutants during the actual production phase (e.g. production of paper or ceramic, processing of ferrous and non-ferrous metals), as well as direct emissions from fossil and non-fossil fuels (including heating for the furnaces used for melting metals or sand for glassmaking, brick firing furnaces, heating systems, paper pulp making, etc.). Therefore, it is not enough to know the energy consumption in terms of direct combustion of natural gas, coke oven gas, fuel oils, refuse-derived fuel (RDF), biomass, electricity taken from the grid or, where existing, from power plants serving a production unit (to estimate indirect Scope 2 emissions); it is also necessary to know the quantities of raw materials processed and the emission factors linked to the specific production process, as well as the amount of heat/steam used – expressed in the correct and consistent units of measurement – produced by combustion or electrical heating or supplied by third parties. Therefore, there is a need to acquire information not only on the economic activity on which to calculate current emissions, but also on the processes and technologies associated with them.

The third type of data needed to assess climate risk is vulnerability, i.e. the expected loss per unit exposed. Once the value of the units exposed to risk and the probability of an adverse event have been estimated, the portion of the value that would actually be lost should be calculated, taking into account also any insurance coverage – a useful tool to reduce the expected loss. In this regard, it would be important to have information on the protection gap both at the firm level and at the macro level (sector or geographical aggregation) to assess potential risks also at a systemic level. Unfortunately, even this type of information is not normally available, particularly at the micro level.[26] Finally, a climatic event might not damage the entire housing and production units: e.g. a flood could affect only the lower floors of a building. Even this type of information, which is especially relevant for calculating vulnerability, is currently difficult to find.

2.2 Business transition plans and the use of climate scenarios

Many firms have begun to signal to the market that they are preparing to control and reduce climate risks; the standard practice is to set emission reduction targets and prepare transition plans that outline the strategies to achieve them. In formulating these plans, firms typically start from a long-term target, for example 2050; they subsequently define intermediate medium-term targets (e.g. 2025, 2030, 2040). Hereafter, strategic planning identifies the concrete initiatives to be undertaken from time to time to achieve medium-term objectives. Objectives are formulated in very heterogeneous ways, in terms of a percentage reduction either in carbon intensity or in emissions, defined in all-inclusive (Scope 1, 2 and 3) or partial terms. This heterogeneity exacerbates the difficulty, for investors and stakeholders in general, in comparing transition plans across firms and in analysing their robustness and consistency with the objectives stated. Firms' transition plans typically take as a reference for their long-term objective the zeroing of net emissions by 2050, or the trajectory of global emission reduction necessary to keep global warming within the limit of 1.5 °C; others rely on emission cutback trajectories coherent with a favourable climate scenario for the planet's climatic balance.

The effects associated with climate change depend on so many factors, all of which profoundly uncertain, that it is impossible to establish a probability distribution on which to rely for predictions; in this case, natural and social sciences typically rely on scenario analysis, which is useful to provide information on the type and order of magnitude of the social and economic costs that would emerge in unfavourable scenarios or to quantify the room for manoeuvre that would remain available in favourable scenarios.[27]

Following an established scientific practice, climate scenarios are based on mathematical models and combine the possible evolution of two sets of variables: on the one hand, socio-economic variables, such as population growth and the economic effect of climate change (e.g. on per capita GDP); on the other hand, climatic variables such as the concentration of greenhouse gases in the atmosphere. The infinite possible trajectories are summarized in a finite number of representative possibilities: for the

[26] In 2019, only 35 per cent of losses relating to catastrophic and climate-related events in Europe were covered by insurance (EIOPA); the EIOPA report on the insurance protection gap will be updated by the end of 2022; see also ESRB/ECB Report (2021) and the EIOPA Financial Stability Report (June 2022). Cesari and D'Aurizio (2019) examine the main sources of natural catastrophe risk in Italy (earthquakes and floods), the most discussed issues in the insurance literature and the fundamental aspects of natural catastrophes (nat-cat) risk insurance management systems in the main countries.

[27] Politecnico di Milano has launched the EUNICE project, which aims to correct misspecification and biases of ensembles of climate-energy-economy models studying climate stabilization and develop ways to validate and confirm scenarios' insights and quantify their uncertainties.

socio-economic variables, the five trajectories defined by the Shared Socioeconomic Pathways (SSP; Riahi, K. et al. 2017), numbered from SSP1 to SSP5,[28] are typically used. For the GHG concentration, instead, the trajectories called Representative Concentration Pathway (RCP) are used; in the sixth version of the IPCC assessment report (AR6), they are numbered from 1.9 to 8.5, where the number indicates the intensity of the effects of climate change.[29] Finally, for a given mathematical model and each SSP-RCP couple, it is possible to construct a climatic scenario. In the IPCC AR6, five combinations were chosen between SSPs and RCPs (SSP1-1.9, SSP1-2.6, SSP2-4.5, SSP3-7.0 and SSP5-8.5), spurring the analysis of over 2,500 climate scenarios.

In the analyses conducted by the supervisors of insurance companies and banking and financial intermediaries, a set of climate scenarios is emerging which, while remaining firmly anchored to scientific bases, offer a more intuitive and therefore more understandable narrative[30] even for non-experts: these are the climate scenarios developed by the Network for Greening the Financial System (NGFS).[31] More details on these scenarios are available in Bernardini et al. (2021) and on the dedicated NGFS website.

Initiatives have been launched at an international level to facilitate firms in the preparation of transition plans and to define the standards with which a good transition plan must comply in order to be realistic, comparable and consistent with one of the climate scenarios considered in the scientific literature. An example is the Science-Based Targets initiative (SBTi), a private global initiative[32] aimed at facilitating the preparation, adoption and verification of transition plans consistent with the actions necessary to achieve climate neutrality by 2050. To this end, SBTi has prepared a standard (SBTi's Net-Zero Standard), which provides companies with guidance and analytical tools that enable them to define science-based net-zero targets independently evaluated by SBTi. At the end of 2021, over 2,000 large firms (among these only a few dozen are Italian), accounting for over one third of the capitalization of the world stock market, were involved in SBTi's initiatives; for 1,082 of them, SBTi formally validated the transition plans and targets.

In addition to the initiatives aimed at assisting firms in the preparation of transition plans, a number of projects are underway to evaluate them.[33] Noteworthy among these is the Corporate Climate Responsibility Monitor conducted by the New Climate Institute in collaboration with Carbon Market

[28] SSP1 - Sustainability (Taking the Green Road); SSP2 - Middle of the Road; SSP3: Regional Rivalry (A Rocky Road); SSP4 - Inequality (A Road divided); SSP5 - Fossil-fueled Development (Taking the Highway).

[29] The number is the measure of a physical quantity known as radiative forcing; the higher the number, the greater the effects of climate change on our planet.

[30] The scenarios are classified into four combinations based on the likelihood of physical or transition risks. Scenarios with less stringent climate policies see a higher probability of adverse climatic events ('hot house world' scenarios), whereas when limited and belated policies are adopted, both physical and transition risks arise ('Too little, too late' scenarios). Conversely, when stringent policies are adopted in an orderly manner, both types of risks will be mitigated ('orderly' transition scenarios); if, instead, policies are hesitant or implemented too late, or if they are reversed, there will be a 'disorderly' transition.

[31] NGFS is a global network of central banks and supervisory authorities founded in 2017 that coordinates the analyses to strengthen the role of the financial system in managing climate risks and in mobilizing financial flows towards green investment. As at June 14, 2022, the network had 116 members and 19 observers. Banca d'Italia participates in NGFS activities and has been a part of the Steering Committee since 2022.

[32] SBTI is a partnership between the Carbon Disclosure Project (CDP), the UN Global Compact, the World Resource Institute (WRI) and the World Wildlife Fund (WWF).

[33] For example, SBTi has announced that it intends to expand its transition plans certification and validation activities to the ex-post verification of firms' performance in achieving the targets, through the development of a measurement, reporting and verification framework (MRV).

Watch, two non-profit associations, to assess the transparency and integrity of transition plans. Their actual verification is a valid defence against greenwashing, which is also being discussed at the EU level; for example, the European Parliament has recently proposed that green bonds compliant with the EU Green Bond Standard (EU-GBS) under discussion may be issued only by firms whose transition plans have been properly verified by a third party.

3. The data necessary for financial intermediaries to respond to requests from supervisors

3.1 The general framework

The role of the financial system in the ongoing transition process is crucial, both to channel financial flows towards a more sustainable economic system and to prevent and mitigate the related risks. The different authorities involved in the various aspects of climate risk and sustainability regulation are making considerable efforts to align legislation and requests to intermediaries wherever possible.

The ECB has included climate and environmental risks among its supervisory priorities and monitors their impacts on significant banks in the euro area. In January 2022, it launched a thematic review of the banking system with a focus on the integration of climate and corporate risks, the results of which were published in November 2022.[34] In addition, in its 2020 Guide to significant banks, the ECB set out its expectations for sound and prudent management of climate and environmental risks, providing non-prescriptive guidance on how to incorporate such risks into the *business* model, strategic, *governance* and risk management processes, as well as in the required disclosures to the public. The Guide provides practical examples of how to use the existing regulatory framework to integrate climate risks into intermediaries' management processes but leaves ample leeway on how to use it based on the specific risk profile and business model of each intermediary. Sustainable finance is a strategic priority area in EIOPA's action plan for the coming years, aimed, in particular, at: i) integrating ESG risks into the prudential framework of Solvency II; ii) supporting the supervision of ESG risks in micro and macroprudential analyses with a view to financial stability and the convergence of supervisory approaches in the EU;[35] iii) promoting disclosure and sustainable business models; iv) addressing the climate risk insurance protection gap in Europe; v) promoting the use of open source models and data concerning the risks associated with climate change.

Entities subject to authorization and supervision by Banca d'Italia are required to comply with the supervisory expectations on climate and environmental risks, published by Banca d'Italia on 8 April 2022, regarding the integration of climate and environmental risks into their business strategies,

[34] This document provides useful references to a number of good practices including: the creation of climate databases and the use of appropriate proxies in case of lack of reliable information; the methodologies used for assessing the materiality of climate risks; the indicators adopted as KPIs for the strategic monitoring of climate objectives; the metrics set out in the risk appetite statement (key risk indicator, limits and thresholds).

[35] See the recent publications of EIOPA (Opinion of 2021 and Application guidance on how to reflect climate change in ORSA aimed mainly at small and medium-sized insurers, published in July 2022) on the analysis of the climate change scenarios that insurance companies should carry out to identify material exposure to climate change risks and their short-, medium- and long-term impact on business (in ORSA). They provide specific guidelines in qualitative and quantitative terms (e.g. the data to be considered in the assessments) and on best practices.

governance, control and risk management systems, as well as market disclosures. These expectations are quite general, and the formalization of the underlying principles at the operational level is deferred to individual intermediaries, who are therefore required to conduct in-depth analyses and assessments to determine the materiality of their risk exposure. Based on these analyses, intermediaries will be able to apply the principle of proportionality, taking into account their complexity.

3.2 Disclosure requirements[36]

Filling the sustainable data gap requires not only an improvement in the statistical coverage of phenomena affecting sustainability and climate risks, but also common and well-defined reporting standards. This requires improving transparency and reporting (disclosure), i.e. the dissemination by companies of basic information about the potential risks they face and the effects of their activities (the 'double materiality'). In terms of improved transparency, the international financial community 'institutionalized' the topic of climate risks by establishing the Task Force on Climate-related Financial Disclosures (TCFD)[37] in December 2015. Since then, reporting requirements for non-financial and financial companies have become increasingly stringent. To complicate things further, the enforcement of these requirements varies according to the scope of the regulatory framework (see Figure 1), including the transparency of financial investments.

In Europe, the regulation of non-financial reporting has been innovated with the publication of a proposal for a Corporate Sustainability Reporting Directive (CSRD)[38]. The CSRD aims to achieve a high level of alignment and integration between the European sustainability standards and the overall European sustainability framework (e.g. Pillar 3, SFDR), as well as with other initiatives launched at the international level (e.g. the recommendations of the TCFD and the forthcoming sustainability standards of the ISSB).
The CSRD envisages: i) the inclusion of all large undertakings[39] in the scope of the regulation – including unlisted undertakings from 2025 and listed SMEs from 2026 (with the option to move this obligation to 2028); ii) the use of specific standards provided by the European Financial Reporting Advisory Group (EFRAG);[40] (iii) the requirement of an external auditor; (iv) the inclusion of the non-financial report within the management report; (v) the adoption of the single electronic reporting format, to improve the dissemination of information.

The extension of the scope will mean that almost 50,000 companies in the EU will have to publish a non-financial report, compared with 11,700 under the current regime. In Italy, it is estimated that the

[36] For further details, see Loizzo and Schimperna (2022).
[37] For a summary of the TCFD recommendations, see Chapter 5 of the WG 3 Report of the Sustainable Finance Observatory.
[38] A preliminary political agreement between the EU Council and Parliament was reached on 21 June 2022.
[39] Large undertakings are undertakings that exceed at least two of the three following criteria on their balance sheet dates: i) balance sheet total: €20,000,000; ii) net turnover: €40,000,000; iii) average number of employees during the financial year: 250.
[40] The new EFRAG standards will be progressively adopted by the Commission and will also require the reporting of certain information about the reporting entity's value chain (e.g. Scope 3 emissions). Thus, companies that will be required to report this information will have to obtain it from the non-financial reports of the companies in their value chain (if available) or request it on a bilateral basis, or use proxies. For further details, see Loizzo and Schimperna (2022).

scope will be extended from the current 210 companies to around 4-5,000.[41] Together with the implementation of the SFDR, this extension will increase disclosures by large unlisted undertakings, which are the object of increasing market attention.[42]

Concerning transparency in financial investments, the Sustainable Finance Disclosure Regulation (SFDR; 2019/2088), in force since 10 March 2021, aims to increase and standardize the reporting requirements of ESG investment processes for financial market participants both at entity and product level. At the entity level, the regulation sets some basic requirements for all financial market participants and other specific requirements based on their size. At the product level, it defines sustainable investment. It then classifies investments as sustainable investments (Article 9 SFDR), investments that reward certain environmental or social characteristics (Article 8 SFDR) and the residual category of unsustainable investments (Article 6 SFDR). For each category, there are different disclosure requirements[43] regarding pre-contractual disclosures, periodic reports and communication on corporate websites.[44]

3.3 The European taxonomy of sustainable investments

To foster market confidence and reduce the risk of greenwashing, the Taxonomy Regulation (2020/852), which entered into force on 12 July 2020, introduces a classification system that defines an economic activity that meets specific requirements as environmentally sustainable;[45] furthermore, it sets precise reporting requirements[46] in the context of pre-contractual information and periodic reports.

More specifically, undertakings within the scope of the CSRD are required to provide the following disclosures (as part of their non-financial reports):

- Non-financial undertakings are required to report, from 1 January to 31 December 2022, three key performance indicators (KPIs), namely the proportion of turnover, capital expenditure (CapEx) and total operational expenditure (OpEx) relating to eligible activities;[47] from 1 January 2023, the KPIs will also relate to aligned activities;

[41] OIBR, 'Innovazioni nella Direttiva UE su Reporting di Sostenibilità', 4 July 2022.

[42] 'Scrutiny of ESG claims for private investments grows', Financial Times, 3 July 2022 and NGFS (2022).

[43] These obligations are specified in: Articles 6, 8 and 9 with regard to pre-contractual disclosures; Articles 7 and 10 for communication on websites; Article 11 for periodic reports.

[44] The application of this classification is not exempt from controversy. At the end of 2021, 39 per cent of investments which promote environmental or social characteristics (Article 8 SFDR) and 33 per cent of sustainable investments (Article 9 SFDR) had an exposure to fossil fuel companies greater than 5 per cent. In addition, around 22 per cent of sustainable investments (Article 9 SFDR) derived more than 5 per cent of their revenues from coal (Eurosif, 2022).

[45] An activity is environmentally sustainable if: i) it contributes substantially to at least one of the six environmental objectives defined in the Regulation; ii) it does not significantly harm (DNSH) any of the other environmental objectives; iii) it is carried out in compliance with the minimum safeguards, i.e. human and labour rights as defined in the Guiding Principles and UN International Conventions; iv) it complies with the technical screening criteria (TSC) published by the European Commission for each target. For further details, see the Commission's website.

[46] Art. 8 of the Regulation, as supplemented by Delegated Regulation (EU) 2021/2178.

[47] An activity is defined as eligible if it is included in the delegated acts of the European Commission issued under Articles 10(3), 11(3), 12(2), 13(2), 14(2), and 15(2) of the Taxonomy Regulation. If it meets all the technical screening criteria envisaged in these delegated acts it is an aligned activity.

- financial undertakings[48] are required to disclose, from 1 January 2022 to 31 December 2023, the proportion of their total exposures to i) eligible activities; ii) central governments, central banks and supranational issuers and derivatives; and iii) undertakings excluded from the scope of the non-financial report.

Moreover, financial undertakings have additional and different requirements based on their nature:

- Banks shall disclose, from 1 January 2022 to 31 December 2023, the proportion of their trading book and interbank loans on demand; from 1 January 2024, banks shall publish the Green Asset Ratio[49] (GAR), with reference to the credit institution's assets that finance taxonomy-aligned economic activities or are invested in such activities; the proportion of financial guarantees supporting debt instruments financing taxonomy-aligned economic activities compared to all financial guarantees supporting debt securities to undertakings; the proportion of assets under management (equity and debt instruments) from undertakings financing taxonomy-aligned economic activities, compared to total assets under management (equity and debt instruments); additionally, from 1 January 2026, they shall disclose the proportion of their fee and commission income from undertakings, derived from products or services other than lending associated with taxonomy-aligned economic activities, and the GAR for the trading portfolio;
- Insurance and reinsurance undertakings shall disclose, from 1 January 2022 to 31 December 2023, the proportion of taxonomy-eligible and taxonomy-non-eligible non-life insurance economic activities;[50] from 1 January 2024, on the other hand, they shall disclose the weighted average of those investments that are directed at funding or are associated with taxonomy-aligned economic activities (as a percentage of 'total investments' and in absolute terms, in monetary units) as well as the KPI relating to the proportion of gross written premiums for the non-life (or reinsurance) business that cover taxonomy-aligned activities;
- Asset managers shall publish, from 1 January 2024, the Green Investment Ratio (GIR)[51] while investment firms shall disclose different KPIs according to their business.[52]

[48] The exposures to central governments, central banks and supranational issuers are excluded from the calculation of the numerator and denominator of KPIs, while derivatives are excluded from the numerator. Exposures to companies not subject to the non-financial report requirement are also excluded from the calculation of the numerator.

[49] The GAR is calculated as the proportion of credit assets financing taxonomy-aligned economic activities (numerator) to total assets (denominator). Only loans and advances, debt securities and equity instruments not held for trading to entities included in the scope of the NFRD are considered in the numerator and the following exposures are excluded from both the numerator and the denominator: i) sovereigns; ii) central banks; and iii) trading book.

[50] The KPI must be expressed as a percentage of total gross non-life written premiums; information on reinsurance layers must be included. For more details (e.g. on the reinsurance business), please refer to Annex IX to Regulation (EU)2021/2178 (see EIOPA 2021).

[51] The GIR is calculated as the ratio of the weighted average of the value of taxonomy-aligned investments made by investee companies to the value of all financial assets under management, net of exposures to central governments, central banks and supranational issuers.

[52] Investment firms trading on their own accounts will have to report KPIs relating to their assets in the form of: (I) assets associated with taxonomy-eligible economic activities as a share of total assets; (II) assets associated with taxonomy-aligned economic activities as a share of assets associated with taxonomy-eligible economic activities; (III) assets associated with taxonomy-aligned economic activities as a share of assets. Investment firms that do not trade on their own accounts will have to report KPIs for revenue, including fees, commissions and other monetary benefits as follows: (I) revenue from investment services and activities associated with taxonomy-eligible economic activities as a share of the total revenue from investment services and activities; (II) revenue from investment services and activities associated with taxonomy-aligned economic activities as a share

3.4 Pillar 3 disclosure requirements

As part of the prudential regulation of the banking system, the European Banking Authority (EBA) set harmonized disclosure standards in January 2022 (Implementing Technical Standards - ITS - P3 ESG ITS). ESG risks should be communicated through:

i. tables for qualitative disclosure of environmental, social and governance risks;
ii. templates for quantitative disclosure of the climate change-related transition risk;
iii. a template for quantitative disclosure of the climate change-related physical risk;
iv. templates reporting quantitative information and some KPIs on climate change mitigation actions, including the Green Asset Ratio (GAR) and the Banking Book Taxonomy Alignment Ratio (BTAR),[53] and other mitigation actions.

Despite several common elements between Pillar 3 and DNF requirements, their scope is different (narrower in the case of P3 ESG ITS),[54] as is the timing with which the regulations will come into force (from 2024, in the case of the CSRD; already in force, in the case of P3 ESG ITS). Indeed, the Pillar 3 disclosure for the financial years 2022 and 2023 will not be able to use the information required under the CSRD, which will only come into force as of 2024 and, in any case, will have a lower degree of detail than that required by banks (e.g. on the energy efficiency of collateral properties).[55] Therefore, at an early stage, the data can be obtained essentially based on information collected as part of the credit granting and monitoring processes and/or from the data providers mentioned above.
As of 2024, banks will need even more detailed non-financial information on entrusted counterparties to calculate indicators such as the GAR (provided for both in Pillar 3 and the non-financial report) and BTAR (required only by Pillar 3). In that regard, the European legislature provided for non-financial companies subject to the non-financial report requirement to publish data necessary for intermediaries to comply with these obligations. However, this will not completely eliminate the problems, in particular with regard to future Pillar 3 obligations for smaller banks and data from unlisted SMEs and micro-enterprises: from 2025, Pillar 3 obligations will apply to all banks, not only large banks, while the non-financial report will be mandatory only for large firms and listed SMEs.

In addition to the previous three initiatives (CSRD, SFDR and the Taxonomy Regulation), there is a proposal for a Corporate Sustainability Due Diligence Directive (CSDDD), whose scope partially overlaps with the CSRD Directive. The CSDDD aims to increase the promotion of sustainable and responsible corporate behaviour along the global value chain.[56]

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of the revenue from investment services and activities associated with taxonomy-eligible economic activities; (III) revenue from investment services and activities associated with taxonomy-aligned economic activities as a share of the total revenue from investment services and activities.

[53] The BTAR differs from the GAR because its numerator also includes taxonomy-aligned exposures to companies not subject to the non-financial report requirement (i.e. SMEs).

[54] The P3 ESG ITS is applicable from 28 June 2022 to large institutions with traded instruments (see ITS, point 20), which, in the case of Italy, essentially correspond to significant institutions; from 2025 it will apply to all banks.

[55] Pillar 3 information covers, for example, the amount of exposure to sectors that highly contribute to climate change and to the top 20 carbon-intensive counterparties in the world, the degree of energy efficiency of properties obtained as collateral, and the amount of exposure to counterparties in geographical areas subject to physical risk.

[56] The draft directive presented by the Commission on 23 February 2022 includes mandatory monitoring of respect for human rights and environmental sustainability (through the adoption of a plan consistent with the Paris targets) for companies with more than 500 employees and €150 million turnover (250 employees and €40 million turnover if belonging to certain 'high-impact' sectors).

3.5 Insurance-specific surveys

The insurance undertakings supervised by IVASS are required to comply with the provisions issued by IVASS regarding the integration of environmental and social risks into the governance system,[57] as well as the control and governance requirements for insurance products qualified as 'ethical' or 'sustainable'.[58] With the letter to the market of 27 July 2022, IVASS has launched a qualitative[59] and quantitative[60] survey of all companies established in Italy on natural catastrophes and the risks of transitioning to a sustainable low-carbon economy, as at 31 December 2021. Monitoring is aimed at collecting hard evidence (by October 2022), in line with objective no. 2 of IVASS' Strategic Plan for 2021-2023 and with the commitments undertaken on the COP 26 Finance Day, for the purposes of: i) analysing, at micro and macroprudential level, the possible impacts of transition risks and physical risks on insurance undertakings; ii) identifying potential material elements of vulnerability in terms of system and financial market stability; iii) monitoring the level of insurance penetration at national level; iv) assessing the alignment of national regulations with European legislation; v) effectively guiding sustainable finance work in a national and international context. In this regard, the following evidence will be relevant: the impact of climate change and environmental risks on the assets and liabilities of Italian insurance undertakings; the related strategies and behaviours regarding financial sustainability, taking into account the specificities and size of the insurance business, in the short, medium and long term; the peculiarities of the insurance coverage (e.g. policy conditions, limits/deductibles, sum insured) of the risks in question, its geographic distribution and potential changes under discussion.

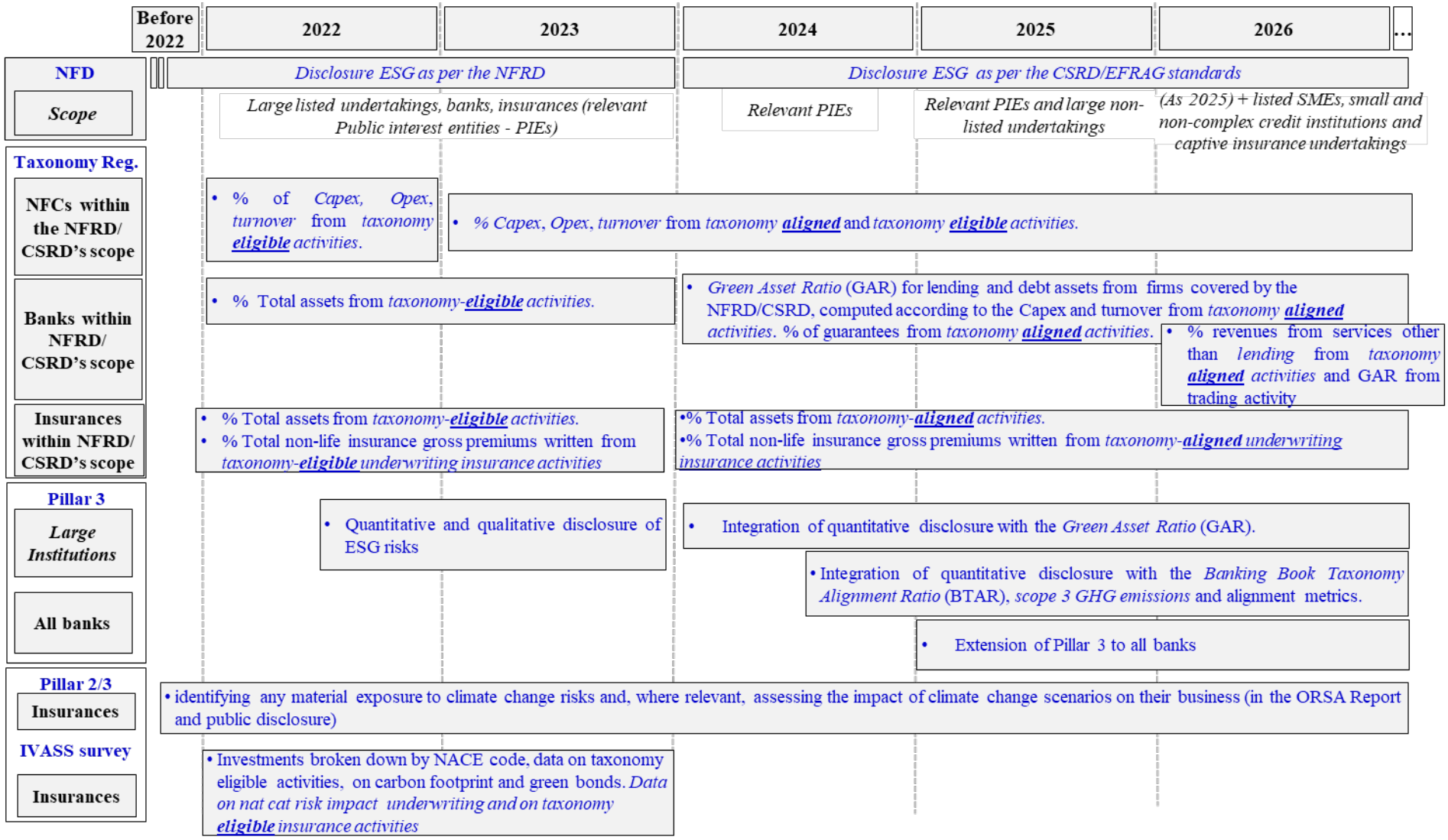
[57] See IVASS Regulation no. 38/2018 laying down provisions on the system of governance, according to which the governance controls cover all types of business risks, including those of an environmental and social nature. New measures are being taken to comply with Delegated Regulation (EU) 2021/1256, in force since 2 August 2022, which provides for the consideration of sustainability risks in the context of: 1) risk management policies, also for assessing overall solvency needs; 2) the underwriting policy; 3) remuneration policies; 4) the prudent person principle at the core of the investment policy; 5) the duties of the functions involved.

[58] See IVASS Regulation no. 41/2018 on transparency, disclosure and design of insurance products, which requires insurance companies to provide specific information on their websites for insurance products qualified as 'ethical' or 'sustainable'. The Regulation will be updated with the provisions of Delegated Regulation (EU) 2021/1257. Changes are expected in the product design phase; in its testing phase; in the monitoring and review process; in the data flows between manufacturers and distributors; in the distribution phase.

[59] The qualitative survey includes two sections. The first section requires information on organizational, governance and risk management profiles; on current and forward-looking investment policies; on the ESG criteria adopted for the selection and evaluation of existing investments. The second section is devoted to underwriting policies, climate mitigation and adaptation measures, the characteristics of insurance coverage and pricing models.

[60] In particular, as indicated in the technical annexes to the letter to the market, the following data will be collected: i) investment portfolio at market values, disaggregated based on the NACE code; ii) degree of alignment of the investment portfolio with the EU taxonomy; iii) carbon footprint of the investment portfolio, in absolute and relative terms; iv) amount of investments in green bonds certified by external entities. The survey monitors, in particular, premiums, claims, expenses and sums insured gross and net of reinsurance, as well as the number of contracts issued for each of the twelve non-life lines of business (LoB), potentially affected by physical risks. They include the eight non-life LoBs specifically indicated by the taxonomy as 'enabling' economic activities, i.e. those allowing other activities to make a substantial contribution to climate change adaptation measures. The data required refer to the risks associated with climate change as a whole and in particular, the climate risks associated with water (flood and hail) and wind (storm) as well as risks from seismic events. For the latter two risks, the Solvency II regulatory system provides for a specific survey on the capital requirement (Solvency Capital Requirement - Non-life and Health catastrophe risk).

The following figure summarises the disclosure requirements for banks and insurance companies under the different regulations, which will be implemented over the next four years.


Before 2022
2022
2023
2024
2025
2026
...
NFD
Scope
Disclosure ESG as per the NFRD
Disclosure ESG as per the CSRD/EFRAG standards
Large listed undertakings, banks, insurances (relevant Public interest entities - PIEs)
Relevant PIEs
Relevant PIEs and large non-listed undertakings
(As 2025) + listed SMEs, small and non-complex credit institutions and captive insurance undertakings
Taxonomy Reg.
NFCs within the NFRD/ CSRD's scope
• % of Capex, Opex, turnover from taxonomy eligible activities.
• % Capex, Opex, turnover from taxonomy aligned and taxonomy eligible activities.
Banks within NFRD/ CSRD's scope
• % Total assets from taxonomy-eligible activities.
• Green Asset Ratio (GAR) for lending and debt assets from firms covered by the NFRD/CSRD, computed according to the Capex and turnover from taxonomy aligned activities. % of guarantees from taxonomy aligned activities.
• % revenues from services other than lending from taxonomy aligned activities and GAR from trading activity
Insurances within NFRD/ CSRD's scope
• % Total assets from taxonomy-eligible activities.
• % Total non-life insurance gross premiums written from taxonomy-eligible underwriting insurance activities
•% Total assets from taxonomy-aligned activities.
•% Total non-life insurance gross premiums written from taxonomy-aligned underwriting insurance activities
Pillar 3
Large Institutions
• Quantitative and qualitative disclosure of ESG risks
• Integration of quantitative disclosure with the Green Asset Ratio (GAR).
• Integration of quantitative disclosure with the Banking Book Taxonomy Alignment Ratio (BTAR), scope 3 GHG emissions and alignment metrics.
All banks
• Extension of Pillar 3 to all banks
Pillar 2/3
Insurances
• identifying any material exposure to climate change risks and, where relevant, assessing the impact of climate change scenarios on their business (in the ORSA Report and public disclosure)
IVASS survey
Insurances
• Investments broken down by NACE code, data on taxonomy eligible activities, on carbon footprint and green bonds. Data on nat cat risk impact underwriting and on taxonomy eligible insurance activities

4. Available data

A quantitative assessment of the impact of climate and environmental risks on the financial system requires accessible and available data. National and international organizations play a pivotal role in collecting the information and making it available for monitoring both physical and transition risks relating to the financial system and the micro and macroeconomic impacts of climate change, as well as to the transition to a new sustainable economy. This is a prerequisite to identifying and understanding climate and environmental risks.

4.1 Statistical sources on environmental phenomena

International sources - In the context of official statistical production, the economic and environmental accounts represent the most important source of information. This data system describes the links between the economy and the environment in a way that is fully compatible with national accounts[122] and offers a means of monitoring the pressures exerted by the economy on the environment[123] and of evaluating the policies and economic resources that could abate these pressures.

In Europe, the environmental economic accounts, used also to design the EU policies, are organized in six modules made available by Eurostat on its website in collaboration with the national statistical agencies and the European Environment Agency (EEA).

The first module relates to direct emissions (Scope 1) of greenhouse gases and air pollutants (Air Emissions Accounts). In particular, emissions into the atmosphere of greenhouse gases,[124] including CO_2, and seven other air pollutants are recorded. Air emissions are presented from three complementary perspectives:

1. Emissions from the EU economy with a production perspective ('accounts');
2. Emissions from the EU territory ('inventories');
3. Emissions from the EU economy with a consumption perspective ('footprints').

The Environmental Accounts report emissions originating from the EU's domestic production of goods and services, including those caused by the international transport of passengers and goods. The data for the European Union and individual countries are broken down by economic activity (64 in total)

[122] The international standard is the UN System of Environmental Economic Accounting 2012 - Central Framework (SEEA 2012 CF) whereas Regulation (EU) 691/2011 provides the legal framework of the European Union for the harmonized collection of comparable data from all Member States and EFTA countries.

[123] The pressures of the anthropic system on the natural environment – for example in terms of emissions of pollutants – can cause damage if they exceed the regenerative capacity of the ecosystems. Environmental accounting tools can be usefully placed within the framework of the most internationally widespread conceptual model for the representation of the links between the anthropic system and the natural environment: the DPSIR model (determinants, pressures, states, impacts, responses). The scheme is adopted by the main statistical agencies as an integrated approach to environmental reporting processes.

[124] The greenhouse gases detected are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), fluorinated gases (PFC), hydrofluorocarbons (HFC) and nitrogen trifluoride (NF_3). Since each greenhouse gas has specific characteristics (and permanence in the atmosphere), the estimates are normalized in tonnes of CO_2 equivalent using the 100-year Global Warming Potential (GWP), as estimated by the fourth IPCC report (AR4).

according to the NACE Rev. 2 classification;[125] these statistics are published annually with a 12-month lag. Eurostat also publishes quarterly data on emissions with a 5-month lag; however, data broken down by sector are available only for the EU as a whole.

Territorial accounts ('inventories'), produced by the EEA, refer to emissions within the borders of the EU Member States and are used to follow the development of emissions in relation to climate change goals. Finally, annual data on 'footprints' estimate emissions 'embedded' in goods and services that are finally consumed in the EU economy. For example, the carbon footprint is a measure of how much CO_2 was emitted along the entire production chain of a product consumed or invested in, regardless of the sector or country in which the emission occurred. These data are available broken down by final product according to the CPA08 classification.

A second set of statistics are the Physical energy flow accounts[126] (PEFA), which provide information on estimated energy flows compatibly with the concepts, principles and classifications of national accounts, enabling integrated analyses of economic, environmental and energy issues. The dataset contains data on the supply and use of energy (for intermediate and final consumption and uses relevant to emissions) classified by economic activity (NACE Rev.2), specifically for 21 sections. This information, published annually, complements traditional energy statistics, balances and derived indicators, which are the main source of information for EU energy policies. Information on energy consumption by household and sector of economic activity is available in the statistics of the Energy Balances, also compiled by Eurostat.

As part of the economic and environmental accounts, Eurostat publishes four more modules:

1. economy-wide material flow accounts (EW-MFA), which provide data on physical inputs into the economy, on the accumulation of materials within the economy and on outputs to other economies or environments;
2. environmental taxes in the following areas: energy, transport, pollution and resource;
3. environmental goods and services sector accounts (EGSS), which provide information on an economic sector that generates environmental products, i.e. goods and services produced for environmental protection or resource management.
4. environmental protection expenditure accounts (EPEA), which provide information on the resources dedicated to protecting the natural environment, with particular reference to waste treatment services and wastewater.

In addition to producing data on direct emissions of pollutants and greenhouse gases and making them available, the European Environment Agency processes and publishes annual data, available since 2008, on the quotas that give the right to emit harmful gas emissions (so-called "allowances")

[125] A strong limitation of the current NACE / ATECO classification is the fact that it does not disaggregate the production of electricity between renewable and non-renewable sources. This breakdown could be provided, along with others, starting in 2025.

[126] The PEFA data published on the Eurostat website and those on the ISTAT website differ from 2017: the former include an estimate of the environmental heat (heat pumps), which has been calculated in Italy only since 2017. Therefore, there is a series discontinuity on the Eurostat website starting from 2017 but not in the ISTAT series (which continues not to include this estimate in the publication). The difference is around 0.2 per cent in the case of households.

issued under the EU emissions trading system (EU ETS), the EU's main carbon pricing tool.[127] The quota exchange system is based on administrative microdata collected through the European Union Transaction Log (EUTL), the system that controls, records and authorizes transactions between the accounts of market participants. The list of operators in the EU ETS market and the allowances (verified and traded) are available at the single operator level within a timeframe of 16/17 months.

Another European register with granular data on industrial emissions is the European Pollutant Release and Transfer Register (E-PRTR), which contains data on emissions and transfers of pollutants reported by about 34,000 industrial facilities covering 65 economic activities and located in EU Member States, Iceland, Liechtenstein, Norway, Serbia, Switzerland and the United Kingdom. The data transmitted by the industrial facilities to the Member States are published on the European Emission Industrial Portal by the European Commission with the support of the European Environment Agency.

Starting in 1952, British Petroleum (BP) has published, once a year, a key compilation of statistics (the *Statistical Review of World Energy*) of data on energy production, consumption and prices, broken down by source and country. In recent years, the Review has included data on emissions of CO_2 and methane caused by and deriving from the use of fossil fuels. This harmonized and freely accessible collection of data is a key point of reference for the world energy community.

The IMF Climate Change Indicators Dashboard is a large collection of climate-related indicators. The statistics are collected in five groups: economic activity indicators (greenhouse gas emissions, national inventories and targets, and CO_2 emissions, intensities and multipliers), cross-border indicators (both trade-related and direct investment-related), financial and risk indicators (including financial, physical and transition risks), government policy indicators (environmental taxes, environmental protection expenditures, fossil fuel subsidies) and climate change data (including annual surface temperature change and change in mean sea levels).

The NGFS Dashboard on scaling up green finance collects a series of useful indicators to monitor and analyse the ecological transition of national financial systems. Information is grouped into 6 categories: a) real economy, useful for assessing the impact of green finance developments; b) reporting, to examine companies' transparency on environmental and sustainability issues; c) risk, for identifying and managing climate-related financial, transition and physical risks; d) mobilisation, which measures capital flows for the financing of green projects including, in particular, information on green bonds; e) regulation, which describes the state of national and regional regulation on green finance; and f) global initiatives, for mapping the adoption of commitments and voluntary principles. The dashboard provides links to the websites of the primary sources from which available data can be acquired and is accompanied by an explanatory note.

[127] The market is characterized by a cap on harmful emissions and by a system for trading emission allowances (quotas) among companies in the sectors that must fulfil the ETS requirements in compliance with Directive 2003/87/EC of 13 October 2003. One of the main allowances allocation methods is auctioning through dedicated IT platforms such as the common European Energy Exchange AG (EEX). Thanks to the predefinition and reduction over time of the cap on emissions and to the sanctioning system relating to the surrendering of allowances from the previous year, the carbon price set increases over time, thus discouraging emissions: the goal for 2030 is to reduce emissions from the ETS-regulated sectors by 43 per cent compared with 2005 levels.

As part of the initiatives promoted by research centres and universities, Carbon Monitor[128] provides regularly updated estimates of CO_2 emissions of the main world economies by macro-sector, as well as data on electricity production by energy source. Carbon Monitor has also created the GRACED platform to provide users with near-real-time estimates of daily CO_2 emissions from fossil fuel and cement production with high spatial resolution, responding to the need for timely and fine-grained information necessary to monitor emissions reduction.

Among the international initiatives aimed at increasing the transparency and accessibility of data, the Open Data for Resilience Initiative (OpenDri) was launched in 2011 by the Global Facility for Disaster Reduction and Recovery (GFDRR). This initiative promotes a variety of projects, including OpenStreetMap, a database that collects detailed information on buildings and their characteristics that can be accessed and fed by individuals citizens and public institutions on an open basis through official maps. These data are controlled through satellite images and the tags in the dataset can be used to improve the classification of the buildings. This information could be useful to create physical risk indicators for the residential estate sector. The coverage and statistical significance of some information details vary between countries. For Italy, where coverage is not very extensive, the data can be accessed with customized queries via the Real Estate Market Observatory (OMI) of the Italian Revenue Agency, which provides details at the municipal micro-area level.

The European Storm Forecast Experiment (ESTOFEX) initiative, launched by a group of European meteorologists and meteorology students, serves as a platform that allows the exchange of information on forecasting of severe weather events (storms, tornadoes) in Europe and other areas. Bulletins are published daily on the platform with forecasts of hail, strong gusts of severe wind gusts, tornadoes and excessive rainfall are published on the platform. ESTOFEX also provides access to the European Severe Weather Database (ESWD) which collects and provides detailed information on these weather phenomena. The data are collected by national weather service institutes with the cooperation of a network of volunteer observers.

National data sources – In Italy, Law no. 132 entrusts the Italian Institute for Environmental Protection and Research (ISPRA) and the National Network for the Environmental Protection (SNPA) with a strategic role in the organization and distribution of locally based environmental information; the data are collected in a consistent way by the various national, regional and provincial agencies.[129] There are many areas of expertise for which data and indicators are available, i.e.: inland waters, physical agents, air quality and soil.[130] Special interest[131] is devoted to the historical series on national emissions[132] (the same that are disclosed to the European Environment Agency) –broken down by

[128] The participants to the initiative are: the University of Tsinghua, the University of California, the Laboratory of Climate and Environmental Sciences (Laboratoire des Sciences du Climat et de l'Environnement, LSCE) and the Institute of Geographical Sciences and Research on Natural Resources - Chinese Academy of Sciences.

[129] Within the regulatory framework of the Italian digital agenda (*Agenda Digitale Italiana* – ADI), the agency for digital Italy (*Agenzia per l'Italia digitale* – AgID), established by the Italian Government with Decree Law 83/2012, is tasked with promoting open access to public administration data. In this context, ISPRA launched 'Linked ISPRA', a pilot project for the production and publication of Linked Open Data in compliance with the World Wide Web Consortium (W3C) standards.

[130] For a complete overview see https://www.isprambiente.gov.it/en/databases?set_language=en.

[131] The Report on the climate change impact indicators (2021) (available only in Italian) catalogues the climate change impact indicators available at national and regional level consistently with the SNPA.

[132] ISPRA is responsible for the collection of data from the Italian Greenhouse Gas Inventory, an air pollution monitoring programme. The so-called 'National System' consists of the collection and harmonization of

region, province and municipality or by industry and type of pollutant and micropollutant–, as well as to the risk indicators for landslides and floods related to geographic areas, population, households, buildings, firms, and cultural heritage at the municipal level,[133] which are useful to design national maps. Detailed information on hydrogeological risk (floods and landslides) and on the national landslide inventory is made available by ISPRA through the IdroGEO portal.[134] ISPRA also disseminates a dataset on climate, weather and climate change that collects data, including historical ones, and indicators relating to climate status, variations and trends in Italy.

The Institute of atmospheric sciences and climate (ISAC), within Italy's National Research Council (CNR), publishes monthly maps of mean, minimum and maximum temperatures, as well as of the deviations from the 1991-2020 mean, with highly spatially disaggregated since as far back as 2002.

The Ministry of Environment and Energy Security publishes various databases on the average prices of fuels (petrol, diesel oil, LPG, heating oil and fuel oils) and on oil consumption, as well as data from the Oil Bulletin and the Coal Bulletin, and the natural gas balance sheet with data on its regional and provincial consumption. The statistics on the heating and motor fuels, calculated and collected at the EU level from oil companies operating in Italy, are published with weekly frequency and refer to the week preceding the day of the release. To increase transparency in the fuel market and contribute to consumer protection, the Ministry of Enterprises and Made in Italy has created the website Osservaprezzi carburanti (fuel price observatory), which allows users to check the selling prices charged by the distribution plants located in Italy in real time.

institutional data sources from different operators, such as industrial associations or individual producers, and of the estimation of emissions in accordance with the IPCC guidelines. The dataset is subsequently transmitted to European agencies, e.g. EUROSTAT, EMEP, and EEA. The Italian Greenhouse Gas Inventory is submitted annually for review by international experts of the IPCC on behalf of the Secretariat of the United Nations Framework Convention on Climate Change (UNFCCC). The National Inventory Report (NIR) officially represents the state of GHG emissions in Italy. It is produced by ISPRA experts and published on the UNFCCC website; it reports data about emission producing activities in Italy and their emission factors from 1990 to the present day. Similarly, every year ISPRA communicates to the United Nations the national inventory of cross-border pollutant emissions, via the 'Informative Inventory Report 2020 - Annual Report for submission under the UNECE Convention on Long-range Transboundary Air Pollution', which illustrates the trends of Italian polluting emissions into the atmosphere from 1990 to 2020 and analyses the key sources, calculation methodologies and emission factors and activities. The purpose of the document is to help understand the calculation of atmospheric pollutant emissions in Italy, by providing a tool to compare the relative contribution of different emission sources and facilitate the identification of policies to reduce polluting emissions.

[133] See the report 'Landslides and floods in Italy: hazard and risk indicators – 2021 Edition'. The hydrogeological risk indicators are computed by ISPRA on the basis of the national maps of landslides and floods and data relating to population, households, buildings, industries and services (Census on population and firms, ISTAT 2011) and cultural heritage (see the project Vincoli In Rete of the ISCR, Italy's Conservation and Restoration Institute). ISPRA creates national maps that harmonize the classification of the areas at risk of landslides in 5 categories based on the Hydrogeological Layout Plans: from AA to P4, with increasing risk. For floods, the 3 flood probability scenarios set out in the EC Floods Directive 2007/60 are used: high probability with return period between 20 and 50 years; medium probability with return period between 100 and 200 years; low probability with return period > 200 years. The hazard areas used for the calculations are mapped using data from the River Basin District Authorities in Italy and from the Autonomous Provinces of Trento and Bolzano.

[134] From a historical perspective, both total and per-event deaths//fatalities due to landslides have exceeded those caused by floods (Faiella 2013). Generally, the flood risk affects a higher share of the Italian population than landslides (6.8 and 1.3 million inhabitants, respectively; Trigila et al. 2021) although, as previously mentioned, in the past it has been characterized by a lower frequency and fewer victims per event (Faiella and Natoli 2018). Looking ahead, flood events are expected to increase and double by 2050 (Alfieri et al. 2015).

The Italian Regulatory Authority for Energy, Networks and Environment (ARERA) carries out annual supervisory activities in the sectors of electricity and natural gas. The data are gathered from energy producers, suppliers and retailers. They contain information on the quantity of energy produced and sold in a given year, the number of points of delivery, average prices and supply costs. It is a relevant database, though it contains information broken down only by energy operator, geographic region[135] and type of user (household or firm) and, sometimes, also by energy usage.[136] While these data are not public, they are processed by ARERA and the results are made available in its Annual Report.

Data and information useful to monitor the environmental impact of Italian firms and their climate risks management policies are made available by the Observatory on Non-Financial Disclosures (NFDs) and Sustainable Practices.[137] The Observatory provides access to the NFDs produced by Italian firms[138] via a digital platform and collects information available to users through Excel sheets. As for environment-related aspects, data on direct emissions (Scope 1), indirect emissions from energy consumption (Scope 2) and/or other indirect emissions (Scope 3), as well as the intensity of greenhouse gas emissions, are available for the sample.

Assessing the distributive impact of climate policies is crucial because the fairer ecological transition is perceived as a process (i.e. Just Transition), especially by energy-poor households, the faster it will be (Faiella and Lavecchia 2021). To this end, it is important to acquire data on households' appliances and systems and energy consumptions. In 2020, the Italian National Institute of Statistics (ISTAT) launched a survey on the energy consumption of households in line with the one conducted in 2013. As part of the National Statistical Program, the survey took place in the first part of 2021 and the results, published in June 2022, provide an up-to-date energy profile of the residential sector, useful for public institutions to design actions aimed at protecting the quality of the environment and meet national and EU climate change mitigation objectives.[139]

Useful information and data on the progress of public policies for ecological transition in Italy are presented in the 'Progress report on the implementation of the Ecological Transition Plan (ETP)' published last May. The Report illustrates the main indicators in the ETP, updated based on the most recent data available, i.e.: percentage of population exposed to flood risk (with a view to contrasting land consumption), percentage of marine protected areas (for sea protection and development) or the circular material use rate (within the framework of circular economy), calculated on data from

[135] Some of the data are also available at city level, for a small number of cities chosen by ARERA.

[136] Natural gas supply data are grouped into the following usage categories: heating; cooking and domestic hot water; air conditioning; technological use. Gas sales data are grouped into the following categories: domestic; apartment buildings; public services; trade and services; industry; electricity generation. With regard to electricity, information on street lights is available.

[137] The NFD Observatory is fruit of the partnership between the Department of Business and Law of the University of Siena and Sustainability Makers, an association of Italian market operators working on sustainability strategies and projects.

[138] The NFDs are filed by CONSOB which annually publishes a list of the entities that are compliant with the disclosure requirements (210 in 2022).

[139] The purpose of the survey is to produce statistics (representative both at the national and regional levels on households' energy consumption, i.e. energy-consuming appliances and systems in dwellings and their daily lifestyle uses. The survey collects information about the characteristics of the dwelling; heating, cooling and hot water systems; consumption of wood, pellets and other types of biomass; lighting systems and household appliances; as well as the costs incurred for electricity and heating fuels. However, there is a lack of precise information on the consumption of electricity and gas. Microdata are not available yet.

different sources. The report also documents the NRRP's main measures, targets and financial resources available. The overview is subject to periodic updates based on regional, national and European actions that have either already been or are in the process of being designed.

4.2 Risk indicators

Measuring climate and environmental risks requires comparable data based on standard rules and classifications among countries. Directive 2007/2/EC constitutes the regulatory and technological framework underlying the establishment, in 2017, of the Disaster Risk Management Knowledge Center (DRMKC) Risk Data Hub (RDH) developed by the European Commission's Joint Research Center (JRC). RDH is a web platform with an EU-wide geolocation information system that consists of two modules. The first module collects information on the location and impact (in terms of economic damages and human losses) of past natural disasters such as floods, earthquakes, wildfires, landslides, droughts, storms, eruptions and tsunamis; some 19,000 events from 1870 to 2019 are recorded. The second module presents an analysis of the potential risk of natural disasters; it takes into account the severity of the impact on different resolution grids and reference categories (buildings, population, etc.) and the occurrence probability of the events.

Among the resources of the JRC, there is the Agri4Cast portal, a tool dedicated to the publication of climate change databases useful for the agricultural sector. In particular, the database *Monthly Heating and Cooling Degree Days in the European Union* reports monthly time series since 1979 on the daily maximum and minimum temperatures with a NUTS 3 level of spatial resolution for the geographical area.

The Centre for Research on the Epidemiology of Disasters (CRED) manages the Emergency Events Database (EM-DAT), created with the initial support of the World Health Organization (WHO) and the Belgian government. The database collects data on the main natural (geophysical, meteorological, hydrological, climatic, biological and extraterrestrial) and technological (mainly industrial and transport accidents) risks of more than 22,000 mass disasters that occurred in the world from 1900 to the present day, based on public and private sources.

Another database has been developed, the MEteorological Reanalysis Italian DAtaset (MERIDA), to analyse disruptions on the electricity grid and correlate them with the increasingly frequent extreme weather conditions of the past 20 years that have caused those disruptions. The project has been developed following the recommendations of the 'Working table for resilience' established by the Regulatory Authority for Energy Networks and the Environment (ARERA). The dataset provides energy stakeholders with reliable meteorological data to increase the resilience of electricity distribution networks and allows them to implement measures aimed at restoring energy supply in the areas that are more prone to extreme weather events and which have a major impact on the national electricity system the implement effective adaptation strategies for safely operating the electricity system.

4.3 Green Finance

Over the last 50 years, the UNEP (United Nations Environment Program) has set the environmental and sustainable development agenda within the United Nations. Many initiatives and programmes have been launched: in 1991 the UNEP Finance Initiative (UNEP FI) was launched, a partnership

between UNEP and the main actors in the private financial sector (banks, insurance companies, etc.) with the aim of steering capital towards sustainable projects to protect the planet and improve the quality of life of present and future generations, in an attempt to close the so-called green finance gap. UNEP FI provides various tools to perform impact analyses and identify transition and physical risks with respect to financial portfolios.

UNEP FI is a supporter and partner of the Sustainable Stock Exchange Initiative (SSEI), a global platform where stock exchanges, issuers, policy-makers and investors promote the knowledge of ESG securities issues. By browsing the platform, users can select the stock exchanges with dedicated ESG bond segments on their websites; in many cases, these stock exchanges are accessible and provide the identification details of the debt security as well as the related green certification documents. The partner stock exchanges (currently 116 for a total of over 61,000 issuers) include Borsa Italiana and other European stock exchanges.

4.4 Climate scenarios

In June 2021, the NGFS published a new version of the climate scenarios (The NGFS Scenario data - see paragraph 2) providing information useful to assess the physical and transitional risk. Each scenario was selected to allow for a broad risk interval, from the lowest to the highest.

High-resolution scenario analyses and climate simulations, which have proven useful also to draft the National Plan for Adaptation to Climate Change (NPACC), are conducted by the Euro-Mediterranean Center on Climate Change (CMCC) which classifies Italian provinces based on a two-dimensional risk index for classes of potential impact and adaptability. The CMCC provides access to interactive maps for different types of indicators (average daily temperature, days of intense rainfall, days of intense cold, etc.), emission scenarios (RCP 4.5 or RCP 8.5) and periods (2021-2050, 2041-2070 and 2071-2100) based on the information available for the years 1981-2010.

Table 1 – Data available

Dataset name	Reference institute	Unit	Description
Statistical sources on environmental phenomena			
Air Emissions Accounts on greenhouse gas emissions and polluting emissions into the atmosphere.	Eurostat	**Geographical area:** European Union **Spatial unit:** Country **Period:** 2010 – 2022 **Further disaggregations:** Sector (NACE Rev. 2); for footprints: CPA08	The database provides statistics on direct emissions (Scope 1) deriving from production and consumption ("Environmental accounts", "Inventories" "and "Footprints"). Annual data are available since 2010 and cover all the EU countries. Quarterly details are available only for specific statistics and for some non-EU countries (UK, Iceland, Liechtenstein, Norway, Switzerland and Turkey).
Physical energy flow accounts, PEFA	Eurostat/Istat	**Geographical area:** European Union **Spatial unit:** Country **Period:** 2010 – 2020 **Further disaggregations:** Sector (NACE Rev. 2)	The database provides access to statistics on energy flows from the environment into the economy (inputs), within the economy (products), and from the economy back into the environment (residues). Data are annual starting from 2011 and cover all EU countries and some non-EU countries.
Other statistics on European economic and environmental accounts	Eurostat	**Geographical area:** European Union **Spatial unit:** Country **Period:** 1990 – 2021 (for some countries) **Further disaggregations:** Country and, for some statistics, sector (NACE Rev. 2)	Other statistics: Material flows and resource productivity, Taxes, Environmental sector, Environmental protection.
European Union Transaction Log (EUTL)	EU (European Environment Agency)	**Geographical area:** European Union **Spatial unit:** Country and individual firm **Period:** 2008 – 2022 **Further disaggregations:** Sector (NACE Rev. 2)	The dataset provides information on direct emissions and on the rights to emit harmful gases (so-called “allowances”). Data are annual, available since 2008 and cover the EU Member States, Iceland, Liechtenstein and Norway.
European Emission Industrial Portal	EU (European Environment Agency)	**Geographical area:** European Union **Spatial unit:** Country **Period:** 2007 – 2020	The portal contains data from the European Pollutant Release and Transfer Register (E-PRTR) on emissions and transfers of pollutants reported

		Further disaggregations: Sector (NACE Rev.2); Industrial plants	by about 34,000 industrial facilities located in the EU, Iceland, Liechtenstein, Norway, United Kingdom, Serbia and Switzerland.
Climate Change Indicators Dashboard	IMF	**Geographical area:** World **Spatial unit:** Country **Period:** 1990 – 2021 for some statistics **Further disaggregations:** Sector (NACE Rev. 2) for some statistics	The database provides a very large set of information on climate and economic variables including indicators on greenhouse gas emissions, financial indicators, risk indicators (including financial, physical and transition risks), economic indicators (e.g. on the countries' environmental policies), as well as data on climate change. Data are annual and available by country. Quarterly emissions data are also available for key global regions.
Dashboard on scaling up green finance	NGFS	**Geographical area:** World **Spatial unit:** Country **Period:** 1970 – 2021 for some indicators **Further disaggregations:** based on the indicator	The dashboard provides links to websites with 21 annual ecological transition indicators in member countries, including, greenhouse gas emissions, national policies, green and social bond issues.
Carbon Monitor and GRACED estimates	Carbon Monitor	**Geographical area:** World **Spatial unit:** Country **Period:** 2019 – 2022 **Further disaggregations:** Sector (NACE Rev. 2);	The Carbon Monitor website provides daily estimates of CO_2 emissions by macro-sector of the main world economies as well as data on electricity production by energy source. The GRACED platform provides near-real-time estimates of daily CO_2 emissions from fossil fuels and cement production.
OSM - OpenStreetMap	OpenDri	**Geographical area:** World **Spatial unit:** Country and individual property **Period:** continuously updated **Further disaggregations:** classification variables on properties; LAU (different levels)	Data and variables on real estate

***European Storm Forecast Experiment* (ESTOFEX) and *European Severe Weather Database* (ESWD)**	ESTOFEX	**Geographical area:** Europe **Spatial unit:** Municipality **Period:** 2007 – 2022 **Further disaggregations:** type of natural event;	The ESTOFEX platform publishes daily bulletins with forecasts of hail, strong gusts of wind, tornadoes and excessive rainfall in Europe and other areas. The European Database on Local and Violent Meteorological Phenomena collects data on these phenomena in Europe.
ISPRA/SNPA data and indicators	ISPRA/SNPA	**Geographical area:** Italy **Spatial unit:** Municipality (for some indicators) **Period:** different time ranges based on the indicator **Further disaggregations:** different disaggregations based on the indicator	Inland waters, physical agents, air, climate, weather, climate change, sea and coasts, nature and biodiversity, waste, sustainable development, pollen and fungal spores, radioactivity, and geology, reclaimed and contaminated sites.
Energy and mining analysis and statistics	The Ministry of Environment and Energy Security	**Geographical area:** Italy **Spatial unit:** Country **Period:** 1996-2022 (monthly); 2005-2022 (weekly) **Further disaggregations:** type of motor/heating fuel	The database provides datasets on mean prices of fuel; oil consumption; consumption and imports of coal and natural gas. Generally, data are provided with a monthly frequency; data on fuel prices are available also with a weekly frequency.
Osservaprezzi carburanti	The Ministry of Enterprises and Made in Italy	**Geographical area:** Italy **Spatial unit:** Country **Period:** 2008-2022 **Further disaggregations:** type of motor/heating fuel; fuel distribution plants	The tool provides access to real-time information on the selling prices of fuels charged at the distribution plants.
Annual report	ARERA	**Geographical area:** Italy **Spatial unit:** Country **Tempo:** 1997-2022 **Further disaggregations:** type of energy source; Households and firms	This database contains data collected from electricity and natural gas producers, suppliers and retailers. In particular, it contains data on the energy consumption of households and firms and on average energy prices. However, data are grouped by energy operator, geographical region and type of user.

Observatory on Non-Financial Disclosures (NFDs) and Sustainable Practices	University of Siena and Sustainability Makers	**Geographical area:** Italy **Spatial unit:** Region **Period:** 2017-2020 **Further disaggregations:** Main Italian firms	The database collects data on Non-Financial Disclosures of the main Italian firms. Data on direct and indirect emissions are included.
Survey on the energy consumption of households	Istat	**Geographical area:** Italy **Spatial unit:** Region **Period:** 2013 and 2021 **Further disaggregations:** households	The 2021 survey provides information on the energy profile of the residential sector.
Risk Indicators			
Disaster Risk Management Knowledge Center (DRMKC) Risk Data Hub (RDH)	European Commission	**Geographical area:** Europe **Spatial unit:** different disaggregations based on the indicator **Period:** 1870-2019 (historical events) **Further disaggregations:** type of risk and potential loss; LAU (different levels)	The database collects information on damages associated with historical events and potential impact analyses with respect to different physical hazards. It features two main modules: historical events and risk analysis.
Agri4Cast	European Commission	**Geographical area:** European Union **Spatial unit:** Country, region and province based on the indicator **Period:** 1979-2022 for some statistics **Further disaggregations:** different disaggregations; LAU (different levels)	Agricultural and meteorological grids, irrigation grids, indices on low- and high-temperature days, and crop statistics.
EM-DAT	Centre for Research on the Epidemiology of Disasters (CRED)	**Geographical area:** World **Spatial unit:** Country **Period:** 1900-2022 (historical events) **Further disaggregations:** different disaggregations	The database collects information on the main natural (geophysical, meteorological, hydrological, climatic, biological and extraterrestrial) and technological (mainly industrial and transport accidents) risks.
MERIDA MEteorological Reanalysis Italian DAtaset	Regulatory Authority for Energy	**Geographical area:** Italy **Spatial unit:** Country **Period:** 1990-2021 **Further disaggregations:** meteorological variables	The database collects information on the measures used to restore the energy supply service in the areas that are most prone to extreme weather events and which have a major impact on the national electricity system

Green Finance			
Online Tools for the Financial Sector	UNEP FI	**Geographical area:** World **Spatial unit:** Country **Period:** real time **Further disaggregations:** type of asset	Useful tools for financial operators
ESG bond segments	SSEI and Stock Exchange (Borsa Italiana, LSE, Euronext)	**Geographical area:** World **Spatial unit:** Country **Period:** real time **Further disaggregations:** type of ESG bond;	ESG assets: green and sustainable bonds
Climate scenarios			
The NGFS Scenario data	NGFS	**Geographical area:** World **Spatial unit:** Country **Period:** different periods based in the type of scenario **Further disaggregations:** different disaggregations	The database provides information on physical and transition risks in four different scenarios based on the timing, methods and policies for climate change.
CMCC **Euro-Mediterranean Center on Climate Change**	CMCC Foundation	**Geographical area:** Italy (high resolution) and world **Spatial unit:** Country **Period:** 2021-2050, 2041-2070 and 2071-2100 **Further disaggregations:** emission scenario (RCP 4.5 or RCP 8.5	High-resolution climate scenarios are available in Italy for various emission scenarios (RCP 4.5 or RCP 8.5) and periods (2021-2050, 2041-2070 and 2071-2100). Global data are available at lower resolution. Climate variables (average daily temperature, days of intense rainfall, days of intense cold, etc.).

5. Available but not accessible data

The possibility of using existing databases that are currently not accessible, in compliance with the laws on privacy and data protection in force, would improve the evaluation of climate-related and environmental risks. In particular, granular data on households and non-financial corporations' energy consumption, as well as data on the energy performance of buildings, could be used to monitor the progress of the transition process at the macroeconomic level, and to improve the measurement of firms' financial risks at the microeconomic level. Energy consumption levels, and the resulting greenhouse gas emissions, are one of the most direct measures of exposure to transition risks. In this respect, granular data on energy consumption would make it possible to measure these risks not only at the aggregated level but also for specific categories, for instance, groups of households or firms located in different geographical areas or belonging to different economic sectors. These data would also help to monitor the evolution of consumption and expenditure in real-time, as well as the measurement of Scope 2 emissions.

An interesting database is the integrated information system (*Sistema Informativo Integrato* - SII) managed by Acquirente Unico, which contains granular data on the electricity and natural gas consumption of Italian households and firms. According to Law 129/2010, Acquirente Unico has created an integrated informative system to manage the information flows between electricity and natural gas market players. In the beginning, the main aims of SII were the standardization and simplification of procedures, as well as the improvement of both the efficiency and the reliability of the information exchange process between different market operators. Moreover, Law 27/2012 established that SII should also collect data on the electricity and natural gas consumption of all Italian households and firms.

One of the most important features of SII is the fact that it contains the list of the points of delivery and contractual data for all Italian customers (including households and firms); the information contained in this database makes it possible to link the points of delivery, customers, energy sellers and suppliers. Moreover, SII contains periodic meter readings for all Italian electricity and natural gas customers, even with a daily frequency when it is possible for the type of meter installed. Furthermore, INPS (the Italian national institute of social security) transmits to SII the data of the households that are entitled to social bonuses for electricity and natural gas (according to Law 21/2022), so that SII can forward this information to the competent operators, which will automatically apply a discount on the energy bill. Since it contains census data, SII could represent an essential tool for monitoring – in compliance with the laws on privacy and data protection in force – the energy transition process at the sectoral and geographical levels, as well as the progress of the Just Transition Mechanism.[158] These data could help monitor, for specific categories, the channels through which the decarbonization process progresses, that is, the reduction of energy intensity (energy per unit of product), or the reduction of carbon intensity (greenhouse gas emissions per unit of energy) or, though not advisable, the reduction of total production (see Faiella et al. 2021). Third

[158] The Just Transition Mechanism (JTM) is a tool that ensures a fair energy transition. It consists of economic interventions worth around €55 billion to ease the socio-economic impact of the transition in the European Union. In this respect, the availability of granular data on households' energy consumption would help to improve the selectivity of the economic measures against energy poverty.

parties cannot access the database contained in SII. However, final customers can access information on their supplies through an online portal (Portale Consumi).

Concerning the energy efficiency of the building stock, in 2002 the European Union adopted the Energy Performance of Buildings Directive (EPBD 2002/91/EC), revised in 2010 (2010/31/EU) and 2018 (2018/844/EU), and transposed into Italian legislation with Laws 192/2005 and 48/2020. The Directive requires that, when buildings are constructed, sold or rented out,[159] an energy performance certificate (EPC)[160] be made available to the owner or by the owner to the prospective buyer or tenant. In Italy, EPCs are collected by the 21 regional cadasters. The availability of granular data on the energy performance of buildings would be very relevant for statistical purposes, both for macroeconomic and microeconomic analysis. From a macroeconomic perspective, given that EPCs are issued for every new construction, sale or rent, a database containing these data would provide relevant information to monitor the progress of the energy efficiency of the national building stock over time, and consequently, the progress of the energy transition itself. At the microeconomic level, granular data on the energy efficiency of residential and non-residential buildings could be employed to evaluate the exposure of mortgage loans to transition risks. This is based on the idea that loans granted to purchase less energy-efficient buildings or properties make the borrower more exposed to risks deriving from either environmental taxes or costly renovation works that can be made compulsory by law in the future in order to improve energy efficiency. Granular data on energy performance certificates could be used by banks and financial corporations to select the projects to be financed in a more efficient way, as well as by authorities to evaluate the risk exposure of the intermediaries' loan portfolio.

The use of energy performance certificates is envisaged, for example, in the Climate risk stress test launched by the ECB in 2022 and the ITS on prudential disclosures on ESG risks published by EBA on 24 January 2022 (EBA 2022 – par. 2.3). EPCs are also required by the Technical Screening Criteria for the climate change mitigation and adaptation objectives of the EU Taxonomy regarding the categories of activity 7.1 ('Construction of new buildings') and 7.7 ('Acquisition and ownership of buildings'). Nonetheless, the potential of using these data is limited. First, the methodology for producing energy performance certificates is not yet standardized across European countries. This implies that the measurement of the riskiness of loans to counterparties located in different countries could not be harmonized. Second, the possibility of using EPCs for the evaluation of risks faced by intermediaries is currently limited by the impossibility of linking the EPCs with the information provided by other databases, for instance, credit registers.

For the time being, the EPBD does not establish any obligation regarding national EPC databases. In Italy, ENEA created in 2016 *Sistema Informativo sugli Attestati di Prestazione Energetica* (SIAPE), the national tool for the collection of EPCs and the monitoring of the energy performance of buildings and real estate units. The portal includes a section in which some aggregated indicators are publicly accessible. SIAPE collects the energy performance certificates transmitted by almost all the Italian

[159] The energy performance certificate must be issued also for buildings where a total useful floor area over 250 m^2 is occupied by a public authority and frequently visited by the public.
[160] The EPC gives a rating of energy efficiency to buildings, from A4 to G, in decreasing order of efficiency. It also provides recommendations for the cost-effective improvement of energy performance.

regions and autonomous provinces (currently, certificates from Basilicata, Campania and Sardinia are missing, while those from Tuscany are being updated), with a total of 3 million of EPCs in the database as at 31 January 2022. In the portal, however, there is not all the information that is available in the regional energy cadasters.[161] The portal provides aggregated data on different aspects of the energy performance of buildings, such as the efficiency classes or the emissions differentiated with respect to the various parameters reported in the certificate, for instance, year of issuance, geographic area, climatic zone, building size. Access to granular data is allowed only to Regions, Autonomous Provinces and Municipalities.

The recast of the European Energy Performance of Buildings Directive will contribute to getting over some current limitations in terms of accessibility and usage of data on the energy performance of buildings. The proposed recast of the EPBD requires a harmonized scale of energy performance classes at the European level, the setting up of national databases for gathering the energy performance certificates of the building stock, the accessibility of national databases to the public in compliance with data protection rules, the integration with other administrative databases containing information on buildings.

[161] Just to give an example, in the energy cadaster of Sicily, in 2022 there are more than 690,000 EPCs, whereas in SIAPE the certificates referring to Sicily are less than 46,000. For Veneto, there are 618,000 certificates in the regional cadaster in 2022, while in SIAPE there are only 21,000 certificates.

Table 2 - Available but not accessible data

Database	Affiliation	Units	Description
Sistema informativo integrato (SII)	Acquirente Unico	Households and firms	The database contains granular data on electricity and natural gas consumption of Italian households and firms. The reading frequency depends on the type of meter installed
Sistema informativo sugli attestati di prestazione energetica (SIAPE)	ENEA	Real estate units and buildings	Energy efficiency classes of national real estate units and buildings. Accessible only to Regions, autonomous Provinces and Municipalities

6. Conclusions

As highlighted by an increasing number of initiatives (e.g. the report prepared by the FSB under the Italian presidency of the G20 and the final document of the NGFS workstream on data gaps) and confirmed by this paper, the sustainable data gap to be bridged by financial intermediaries is especially wide. Data provided by third parties are granular but broadly limited to large public corporations; moreover, the information provided is of lower quality and is less comparable than that produced by the official statistical authorities.

However, despite the plethora of financial regulations introduced at EU level (see below), the signs of progress from the official statistics have been limited. Sharper action by the official data producers is needed, i.e.: improving the processing and dissemination of the data already available, harvesting more data from the existing work, and designing new ways to collect data, with an eye to SMEs. This type of action, which will be described in future work, is necessary in order to strengthen/integrate sustainability data released by existing data providers and, especially in the case of analyses and assessments carried out by public institutions, to evaluate their reliability.

As for **energy**, there is a need for additional information on its usage, prices and expenditure, for both households and firms, at the highest possible level of detail (e.g. broken down by type of household or firm, and energy service; with higher frequency); these pieces of information are fundamental both for policymakers – especially in such delicate time for Italy – and for the estimation of GHG emissions. Furthermore, firms need forward-looking indicators and understandable climate scenarios to outline their transition plans (especially SMEs) and manage their exposure to physical risks.

As for the existing **non-financial reporting requirements** for intermediaries, ESG disclosure mandates have increased over the past few years, with regard to both accounting legislation (non-financial reporting, as amended and supplemented by the Corporate sustainability reporting directive, CSRD) and prudential legislation (so-called Pillar 3 - P3). Moreover, art. 8 of the Taxonomy Regulation (2020/852) dictates that firms subject to NFD requirements disclose specific information.[83]

There are some synergies between the Taxonomy, CSRD and P3. In particular, some of the data required by the implementing standards on P3 disclosures, as provided by the EBA (P3 ESG ITS), can be found in the NFDs, though the number of firms involved, even after the enlargement subsequent to the CSRD, is still limited.[84]

Furthermore, there is a differentiated timeline for the entry into force of the various requirements (in 2024, in the case of the CSRD; already in force, in the case of P3 ESG ITS for large institutions and in 2025 for all banks), as well as a lower level of detail of non-financial reports than what is required for

[83] The disclosure requirements specified in art. 8 of the Taxonomy regulation (2020/852) apply to all undertakings required to publish a non-financial report, which will contain these pieces of information. In the case of financial firms, the information required is or will be, for the most part, at their disposal: the temporary regime, in place from 1 January 2022 until 1 January 2024, requires information that is already available, while since 1 January 2024 the required KPIs (e.g. the GAR for banks) can be estimated using the non-financial reports submitted by non-financial firms since 1 January 2022.

[84] In Italy, the number of entities involved is estimated to increase from the current 210 firms to about 4-5,000 when the Directive will be fully enforced (OIBR 2022).

P3 disclosures[85] (e.g. on the energy efficiency of the property pledged as collateral).[86] Finally, in order to obtain some of the information requested to fill out the non-financial reports, ad-hoc surveys will need to be conducted.[87]

This work provides a first review of the data needs and a selected collection of the public resources available, to partially meet such needs. It is also a first attempt at identifying the existing sustainable data gap, leaving to future works the identification of specific proposals to reduce the data gap.

[85] P3 ESG ITS have been applied since 1 January 2022 to large institutions with traded instruments (see point 17 of the ITS) which, in the case of Italy, broadly correspond to significant institutions; since 2025, instead, the standards will apply to all banks.

[86] P3 information relates to: exposures towards the sectors that contribute the most to climate change and towards the world top 20 carbon-intensive counterparties; level of energy efficiency of the properties obtained as collateral; exposures towards counterparties in geographical areas exposed to physical risk.

[87] There are five draft EFRAG schemes relating to the environmental component (E1-E5). Based on the analysis of the latest drafts available, the following potential data gaps are identified: companies are required to find an estimate of GHG Scope 3 emissions (E1-9), total GHG emissions (E1-10) and GHG removals in the value chain (E1-12); an estimate of exposure to physical and transition risks is required (E1-15 and E1-16); requirements E2-7, E3-7, E4-10 and E5-9 require an estimate of the company's financial exposure to risks deriving from: pollution, management of water and marine resources, loss of biodiversity and circular economy. Requirement E4-1, on the other hand, provides for the publication of a transition plan that gives high-level indications on the corporate strategy to achieve the objectives of no net loss by 2030, net gain by 2030 and full recovery by 2050, which require numerous ad hoc data collections, such as in the case of metrics to detect pressures on biodiversity (E4-5).

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