ANNUAL REPORT ON THE BANKING SECTOR'S EXPOSURE TO CLIMATE RISK

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BANCO DE PORTUGAL
EUROSYSTEM

Lisboa, 2023 • www.bportugal.pt

Annual Report on the Banking Sector's Exposure to Climate Risk • Banco de Portugal Rua do Comércio, 148 | 1100-150 Lisboa • www.bportugal.pt • Edition Financial Stability Department • Design Communication and Museum Department | Design Unit • ISSN (online) 2975-9501

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Executive summary

Greenhouse gas (GHG) emissions are the main cause of climate change. In the presence of a negative externality, markets fail to provide an efficient allocation of resources and corrective measures are therefore necessary. In the first place and above all, addressing climate change falls to governments. They have the legitimacy and the most effective tools to target the causes of the problem.

The magnitude and cross-cutting nature of the process of adapting economies to climate change requires a global response, justifying the coordination of policies and mitigation measures at supranational level. At national level, society as a whole should contribute to this collective effort.

Climate change is a new source of risk to the economy. The role of the financial sector is crucial, because of the materiality of climate change risks and their potential effect on institutions' balance sheets and business models. Similarly, climate change influences the implementation of the mandates of central banks and supervisors, who, within the scope of their tasks, play a key role in preserving financial stability and the resilience of supervised institutions.

The Banco de Portugal, as entity responsible for preserving the stability of the Portuguese financial system, presents an exploratory analysis in this report of the potential impact of the physical and transition risks of climate change on the Portuguese banking system.

The banking sector's exposure to physical risks depends on the geospatial distribution of the areas affected by physical risk events and on assets located in those areas. The results point to a more significant exposure of the domestic banking sector – through credit granted – to firms vulnerable to water stress, heat stress and wildfires. The banking sector's exposure to events with the highest level of risk (severe) is quite limited and is only relevant in the case of heat stress. The interaction of the banking sector's exposure to the firms most vulnerable to the materialisation of physical risks with credit quality shows no sign of increased concentration risks.

Indicators reflecting the banking sector's exposure to transition risks, according to the activity sectors' GHG emissions, show a decreasing trend over the most recent period. These indicators place Portugal in an intermediate position in the euro area context.

The average credit risk of the sectors that, due to their activity, will tend to be negatively affected by the climate transition process is close to, but lower than, the credit risk of the NFCs loan portfolio. Thus, there is no concentration of loans with higher credit risk in the sectors likely to be negatively affected by the climate transition process.

The interaction of physical risks with transition risks points to a greater concentration in the highest credit risk class of firms affected by both transition risk and heat or water stress, relative to total credit to firms. However, the banking sector's credit exposure to these situations is low.

The climate transition can affect homeowners through higher energy prices and devaluation of less energy efficient properties. Such effects may imply risks to the banking system associated with the housing loan portfolio.

The analysis leads to the conclusion that the most vulnerable to higher energy prices are concentrated in the lowest income brackets, with lower levels of wealth and less ability to change the composition of their consumption coupled with higher share of energy expenditure in income.

The structure of the consumption basket suggests that Portuguese households may be less exposed to rising energy prices than euro area households on average.

Only a small portion of the riskier housing loans – identified by loan-to-value (LTV) ratios above 80% – are associated with less energy-efficient real estate, which will tend to mitigate the possible impact of devaluation of these properties on the banks' exposure.

For the first time, this report uses climate scenarios – Net-zero 2050, Delayed Transition and Current Policies – to carry out a risk analysis of the Portuguese banking system. The results of this scenario analysis are broadly consistent with those obtained by the ECB for the euro area, signaling the existence of benefits of swift action in reducing emissions from a banking system's perspective.

The climate transition scenarios used in this exercise are not forecasts of future evolution of the variables, but rather plausible projections of their evolution under certain assumptions over a very long time horizon. Thus, this exercise is a long-run cost-benefit analysis of different climate transition scenarios from the perspective of credit risk of the banking system's exposures to NFCs.

In line with the Network of Central Banks and Supervisors for Greening the Financial System (NGFS), this analysis considers three scenarios: Net-zero 2050, where the reduction of GHG emissions is immediate and consequential in achieving climate goals; Delayed Transition, where the climate transition only starts in 2030, reflecting an abrupt and unanticipated response, with disruptive effects but sufficient to achieve climate objectives; Current Policies, where no new measures are implemented to reduce GHG to levels that limit the acute materialisation of physical risks.

Scenarios are analysed with a high level of granularity at firm-level, differentiating them in terms of (i) GHG emissions, (ii) exposure to physical risk events, considering the geographical location, and (iii) the firm's financial situation.

The results of the scenario analysis suggest that, from the perspective of the banking system, there are benefits of acting swiftly to reduce emissions. Despite the up-front transition costs, there are gains over a projection horizon up to 2050 in the Net-zero 2050 scenario – compared with the Delayed Transition and Current Policies scenarios – in terms of probability of default, losses given default and, as a result, expected losses. In turn, the Current Policies scenario shows, also at the horizon of 2050, higher costs than the Delayed Transition scenario in these three variables. These results are broadly consistent with those obtained by the ECB for the euro area.

The analysis has a number of limitations, which are common to similar analyses for the EU. There are various possibilities for developing these exercises in the future, such as deepening the interaction between developments in the real economy and climate change, increasing granular information at firm level, taking into account the entry and exit dynamics of firms over the projection horizon, and incorporating dynamic adjustments into banks' balance sheets.

As a banking supervisor that participates in the Single Supervisory Mechanism (SSM), the Banco de Portugal is working to improve the prudential supervisory framework so that supervisory tools and policies foster the greater resilience of supervised institutions throughout the climate transition process.

The SSM is the banking supervision system that integrates the European Central Bank (ECB) and the national competent authorities (NCAs) of euro area countries, including the Banco de Portugal. The SSM aims to ensure the safety and soundness of the European banking system, to promote financial integration and stability in Europe, and to ensure consistent supervision, based on the sharing of expertise between the participating authorities and the ECB.

Credit institutions considered "significant" are subject to the ECB's prudential supervision, accounting for 76% of banking activity in Portugal. The prudential supervision of the credit institutions considered "less significant" is assigned to the Banco de Portugal, following a decentralised implementation approach to supervisory tasks, which ultimately belong to the ECB.

Climate-related and environmental risks are one of the SSM's three supervisory priorities for the period 2023-2025. In the context of SSM activities, the definition of supervisory expectations to promote an appropriate identification, quantification and mitigation of climate-related and environmental risks by banks is of relevance.

In November 2020, the ECB published a set of supervisory expectations addressed at significant institutions (SIs), covering four main areas: business models and strategy, governance and risk appetite, risk management and disclosures.

To ensure a common and consistent treatment of supervised institutions, in April 2021 the Banco de Portugal established that the ECB's supervisory expectations for managing climate-related and environmental risks should be extended to less significant institutions (LSIs) under its direct supervision, in proportion to the nature, scale and complexity of their activities.

Both the ECB, for SIs, and the Banco de Portugal, for LSIs, conducted assessment and monitoring exercises on practices to identify and manage climate-related and environmental risks, to assess the alignment of institutions' practices with the supervisory expectations.

The ECB concludes that SIs have made gradual progress to meet the aforementioned supervisory expectations over the past two years. As institutions' practices still require further alignment with supervisory expectations, the ECB has established that SIs' practices should be fully aligned with supervisory expectations by the end of 2024.

In 2021, the Banco de Portugal concluded – for a set of institutions representing around 95% of the assets of the 24 institutions under its direct supervision – that these institutions had also initiated the process of assessing the relevance of these risks and that initiatives to define an action strategy to comply with supervisory expectations were ongoing. However, significant gaps from supervisory expectations remain, which are more pronounced than those for SIs. The Banco de Portugal established that LSIs' practices should also materially converge with supervisory expectations by the end of 2024.

The ECB and the Banco de Portugal recognise that the current data-related limitations and the need to improve the framework for climate risk analysis pose a number of significant challenges (e.g., high uncertainty, long-term horizons, non-linearities and lack of historical evidence of losses). However, these challenges are expected to be progressively overcome by ongoing initiatives to enhance the regulatory framework and prudential supervisory policies.

Introduction

By releasing the *Annual Report on the Banking Sector's Exposure to Climate Risk*, the Banco de Portugal complies with Article 35(7) of the Climate Framework Law – Law No 98/2021 of 31 December 2021, which requires "regulatory and supervisory authorities to submit a report on the climate-related risk exposure of the respective sectors, particularly on the climate risk of the financial and insurance sector". This report analyses the Portuguese banking sector's exposure to climate-related risks with reference to calendar year 2022.

Within its mandate to preserve financial stability, the Banco de Portugal's activity is aligned with the following goals in order to address climate-related risks to the Portuguese banking system: (i) to understand the financial risks stemming from climate change, (ii) to assess the Portuguese banking system's exposure and resilience to these risks, and (iii) to tailor supervisory tools and activities to promote the banking sector's resilience throughout the climate transition process as part of the Bank's participation in the Single Supervisory Mechanism.

Chapter 1 in this report describes the role of Central Banks – for the purpose of preserving financial stability – in the face of climate-related risks and outlines the nature of these risks as well as the main challenges facing the financial system. It also introduces the main ongoing regulatory and supervisory initiatives at European and global levels to understand and mitigate the effects of climate-related risks on the financial sector.

The Banco de Portugal, as the entity responsible for preserving the stability of the Portuguese financial system, assesses the banking system's exposure, resilience, and efforts to adapt to climate-related risks.

Chapter 2 presents an overall assessment of climate-related risks to the Portuguese banking system. To this end, it identifies risks stemming from the banking system's exposure to non-financial corporations (NFCs) and housing loans, focusing on credit risk. The report presents indicators of the Portuguese banking system's exposure to physical and transition risks of climate change and the results of climate scenarios. As this is the first time such a report has been produced, this chapter also identifies the limitations and opportunities for further development of these exercises.

As a banking supervisor that participates in the Single Supervisory Mechanism, Banco de Portugal is working to improve the prudential supervisory framework to foster the greater resilience of supervised institutions throughout the climate transition process.

Chapter 3 presents the Single Supervisory Mechanism's supervisory strategy for climate-related risks, describing the main micro-prudential supervisory activities for significant institutions and less significant institutions. The micro-prudential definition and monitoring of the supervisory expectations set by the Single Supervisory Mechanism for identifying and managing climate-related risks by supervised institutions are particularly important.

1 Background

1.1 Preserving financial stability in the face of climate-related risks

GHG emissions are the main cause of climate change (International Panel on Climate Change – IPCC; 2023). It is a negative externality in that the GHG issuer subjects the remaining economic actors to its effects without incurring the total costs arising from the impacts generated by their activity (i.e. the private value of the production of the goods/services does not take into account the social and environmental costs caused by their production).

In the presence of a negative externality, markets fail to provide an efficient allocation of resources, and corrective measures are therefore necessary. First and foremost, addressing climate change therefore falls to governments since they have the legitimacy and the most effective tools (public policies) to address the root of the problem.

The scale and cross-cutting nature of the impacts and challenges inherent in this process to transform economies call for a global response – although impacts may vary widely across geographies – warranting the coordination of policies and mitigation measures at supranational level. At national level, society as a whole – public authorities, the scientific community, universities, firms, consumers, and the financial sector – should be part of the collective effort to adapt to climate change.

The role of the financial sector is crucial, both because of the materiality of risks stemming from climate change and their potential effect on the balance sheets and business models of the sector's institutions, and due to the significant amount of funding needed to ensure the transition to a low-carbon economy in line with the political commitments made.

Risks associated with climate change are a new source of risk for the economy at large, carry numerous specificities and influence the soundness and resilience of banks through micro- and macroeconomic transmission channels. More generally, environmental risks encompass those associated with climate change, but also other phenomena such as risks stemming from biodiversity loss (which affect the ecosystem's ability to provide services that are essential for human survival). This report refers predominantly to "climate-related risks" as they correspond to those incorporated in the analyses.

Acknowledging the impact of climate-related risks on the financial sector makes the case for adapting the regulatory framework at international level, which is complex as it requires a holistic approach based on accurate risk identification and reliable information.

Against that background, climate change influences the discharge of the mandates of Central Banks and supervisors, which, within the scope of their tasks, have a role to play in mitigating the consequences of that change, including in preserving financial stability and the resilience of supervised institutions.

The Banco de Portugal, as the entity responsible for preserving the stability of the Portuguese financial system, is undertaking initiatives to improve its understanding of the financial risks arising from climate change and to thus have a more comprehensive picture of the exposure, resilience and efforts of the banking system to adapt to those risks.

As a banking supervisor that participates in the SSM, the Banco de Portugal is working to improve the prudential supervisory model, so that supervisory tools and policies foster a greater resilience of supervised institutions throughout the climate transition process. Of particular importance in

this context is the publication of supervisory expectations to promote the appropriate identification, quantification and mitigation of climate-related and environmental risks by banks.

1.2 The financial nature of climate-related risks

Climate change is a new source of risk to the economy. The risks associated with climate change are of a highly mixed nature (NGFS (2019), Basel Committee on Banking Supervision (BCBS; 2021)): high uncertainty surrounding the effects of climate change, highly complex transmission mechanisms of these effects to the real economy, to the financial system and across geographies, direct dependence on the economic policies being adopted, extended time horizons for the materialisation of these effects over which risk may build up. Given the specificities of these risks, climate change is a potential source of systemic risk, with possible material consequences for banks and the financial system (ECB/ESRB (European Systemic Risk Board; 2022), BCBS (2021a)).

Financial risks stemming from climate change are usually associated with two broad categories (NGFS (2019)):

- Physical risks: associated with the occurrence of more frequent and intense natural disasters (known as acute risks such as heatwaves, wildfires, storms) or the long-term effects gradually induced by climate change (known as chronic risks such as changes in rainfall patterns, ocean acidification and sea level rise); these risks are likely to generate varied economic costs affecting the financial system (e.g. compensation payments by insurance companies; reduction in the value of collateral received as part of banking operations; reduced ability of bank customers to service their debt if their income decreases or they suffer property losses).

  According to the methodology employed by the IPCC, the information used to assess impacts should take into account three main aspects: (i) the likelihood of the risk event that could cause loss of life and/or other hazards, (ii) exposure, i.e. the geospatial distribution of the population and of the natural and economic resources that may be adversely affected, and (iii) vulnerability, which depends on the characteristics of the population and resources in a given territorial unit, as well as their resilience, adaptability and recovery from the impact of the physical risk event, for instance through mitigation strategies.
- Transition risks: related to uncertainty regarding the adjustment path and the speed of transition ('orderly' vs 'disorderly transition') towards a sustainable low-carbon economy, including (i) the adoption of regulatory or tax changes with respect to carbon levies and the setting of CO_2 emission limits, (ii) technological changes translated into the transition to less polluting energy sources with an impact on prices of different energy sources and (iii) changing consumer preferences with an impact on demand. To varying degrees, these changes may affect the viability of certain activities/counterparties, lead to abrupt changes in the value of assets also giving rise to stranded assets, with material implications for the financial system, which will be greater the more disruptive the process is.

Financial risks associated with physical and transition risks can be exacerbated by litigation risks (NGFS (2021a)), i.e. by lawsuits relating to climate factors. The transmission of these risks to the financial system may occur directly should banks themselves be subject to lawsuits (e.g. due to possible omissions or inaccuracies in disclosing information related to climate-related risks in the financial products marketed, the failure to align their activity with the Paris Agreement goals, breach of fiduciary duty, or because they are considered 'indirect polluters' by financing certain projects with high GHG emissions). Transmission to the financial system may also occur indirectly through exposure to counterparties that are subject to lawsuits arising from their alleged liability if they fail to prevent or duly mitigate risks resulting from an extreme event that climate change has made more likely.

Climate change influences banks' soundness and resilience through micro (e.g. impact on counterparties' profitability, devaluation of assets, legal and compliance costs) and macroeconomic transmission channels (e.g. impact on productivity, GDP, unemployment rate), materialising in the 'traditional' prudential risk categories (e.g. credit, market, operational and liquidity risk) (NGFS (2020)).

The likelihood and magnitude of an institution's exposure to each of these transmission channels – and therefore to financial risks associated with climate change – are affected by various factors (BCBS (2021)):

- Geographical reasons, reflecting heterogeneity in exposure to climate-related risks (depending on geographical location and topographic features, certain regions/countries are likely to be more affected, e.g. by severe storms, more frequent droughts or more intense rainfall);
- Characteristics of the financial system in which the institution operates, including aspects such as size, business model and level of sophistication of the business, which may influence the level and type of exposure to assets/activities most vulnerable to climate change risks;
- Potential amplification of the risks to which banks are exposed, arising inter alia from (i) interdependencies/interactions between different physical risks and between different transition risks and/or between both (e.g. the more delayed the transition period, the more significant the materialisation of both physical and transition risks will tend to be, due to a more abrupt adaptation) and (ii) 'traditional' amplification mechanisms (e.g. self-imposed reductions/restrictions of lending on certain entities or sectors of activity that may hamper the transition process and the viability of certain counterparties; reduced insurance coverage by insurers, or application of significant adjustments to insurance premiums to certain regions/events/activities that may lead to a higher level of risks becoming uninsurable, leaving firms and households more vulnerable to losses from the materialisation of extreme events); the feedback loop between the credit risk of banks and their sovereigns;
- Mitigation measures that can be taken by banks to decrease or offset exposure to climate-related financial risks (e.g. diversification, transfer/hedging instruments, pricing and collateralisation policies, disposal of assets).

1.3 Challenges for the banking sector and regulatory and supervisory initiatives

1.3.1 Paradigm shift

The scale and intensity of the transformations and impacts associated with climate change and the transition to a low-carbon economy represent a paradigm shift in the financial system, challenging the methodologies and practices "traditionally" used to identify, measure and manage risks. The specificities of this (new) source of financial risks also require a paradigm shift in the approach of regulators and supervisors to assess banks' soundness and resilience given the risks to which they are, or might be, exposed.

At the heart of this adaptation process affecting the financial sector are, to a large extent, the understanding and incorporation of financial risk dimensions typically associated with climate science phenomena. In particular, the incorporation of the forward-looking dimension to capture the specificities of climate-related risks (e.g. high uncertainty, non-linearity, and long-term horizons of possible materialisation) both by institutions when drawing up their strategies/policies and when adapting their business model, by regulators when reviewing the current prudential framework and by supervisors when monitoring and following up on institutions' activities.

Against this background, the European framework for prudential regulation and supervision applicable to banks with a view to incorporating climate-related and environmental risks is under discussion. The complexity and magnitude of the challenges at stake call for a **holistic, sequential, and prudent approach of regulators and supervisors** across all strands of that framework, **focusing on risks** to banks and the banking system.

Given the comprehensive nature of climate-related risks, some systemic dimensions go beyond banks' idiosyncratic risks and may not be adequately safeguarded by micro-prudential regulation. In this context, the potential contribution of macroprudential policy to preserving the resilience of the financial system is also under discussion, namely in mitigating potential adverse effects that may arise from longer-term exogenous shocks. This requires **close alignment between micro- and macroprudential policies in order to ensure consistent and effective action in the face of new challenges**.

It is important to ensure consistency in the adaptations applied across the various dimensions, bearing in mind international developments in this area, as well as to ensure that the measures to be taken do not lead to the transfer (and/or build-up) of climate-related risks to other areas of the financial system outside the banking supervisory perimeter.

The sustainability and sustainable finance agenda has thus made progress on multiple fronts and through a patchwork of initiatives under sequential and gradual Action Plans, such as those established, inter alia, by the European Commission, the European Banking Authority (EBA), the Financial Stability Board (FSB), the BCBS, the NGFS and the ECB.

1.3.2 Key regulatory and supervisory initiatives

In fulfilling their mandates, regulators and supervisors face several challenges in adapting to climate change and its possible consequences. The main challenges grouped into seven categories are set out below and mapped together with the initiatives undertaken at global level to address them.

Taxonomy

To achieve the objectives of the European Green Deal, it is crucial that investments are directed towards environmentally sustainable projects and activities, which requires a clear and consistent understanding of what is considered 'sustainable'. **A unified EU classification system - or taxonomy - that provides clarity on the activities that can be considered environmentally 'sustainable' was enshrined by the European Commission in its "Action Plan: Financing Sustainable Growth" (March 2018) as "the most important and urgent action", providing a basis for the further development of other central initiatives** (COM(2018) 97 final).

The Taxonomy Regulation[1] – a tool for transparency and not a risk assessment tool – entered into force on 12 July 2020 and (i) introduced changes to sustainability-related disclosures in the financial services sector, (ii) set six environmental objectives and conditions that an economic activity must meet to be considered environmentally sustainable, and (iii) imposed new disclosure requirements on entities subject to an obligation to publish non-financial information for environmentally sustainable economic activities. Its operationalisation is based on Delegated Regulations aimed at further developing specific matters which are implemented sequentially.

[1] Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088.

The first European Commission Delegated Regulation issued under the Taxonomy Regulation[2] has been in force since January 2022. This legal instrument sets out the technical screening criteria for defining the activities that contribute substantially to climate change mitigation and climate change adaptation, which are the first two environmental goals out of the six set in the Taxonomy Regulation.

In March 2022, the Commission adopted a Taxonomy Complementary Climate Delegated Act,[3] applicable from January 2023, setting out (i) the inclusion, subject to very specific conditions, of nuclear power generation activities and fossil gas energy production activities in the list of economic activities covered by the EU Taxonomy and thus considered environmentally sustainable, and (ii) specific disclosure requirements in relation to those economic activities.

The expected extension of the scope of the Taxonomy Regulation to cover activities that cause significant harm to the environment (taxonomy for 'brown' activities) could be a relevant contribution to clearer concepts and risk assessment by the financial system.

Data

Having data in place that make it possible to measure these risks is key to address the challenges posed by climate change. Reliable, granular, comparable and relevant information on environmental sustainability is crucial across multiple dimensions: to (i) correctly identify, assess and quantify risks (including quantifying any risk differentials between "green" and "non-green" exposures); (ii) move from initial diagnostic analyses of exposures to more comprehensive risk assessments; (iii) understand the interaction between climate change and the economy; (iv) support policy-making; (v) fulfil the mandates of authorities (including Central Banks); and (vi) prevent greenwashing practices.

Several initiatives have been taken in this respect at international level in order to (i) identify sustainability information deemed relevant for the purpose of financial stability, supervisory and reporting analyses, (ii) identify data gaps in view of data that may already be available, largely based on market disclosure practices; (iii) enhance the quality and granularity of information, and (iv) establish forward-looking financial risk indicators, underpinned by accurate science-based information to effectively monitor compliance with European sustainability goals.

Examples include the report published by the NGFS in July 2022 on identifying and bridging data gaps on climate change (NGFS (2022)). The document includes a 'directory' which systematises the various types of climate-related data sources that are deemed necessary for different economic and financial purposes by different users and also facilitates the identification of possible gaps (where raw data items needed to construct a metric are not available). For the purpose of this inventory, which is intended to be a 'living catalogue' of available climate-related data sources, 1,262 raw data items have been identified (grouped into ten categories: 'accounting', 'asset', 'climate', 'general statistics', 'geospatial data', 'reference data', 'biophysical impact', 'technology', 'emissions', and 'other'), 329 unique metric/methodology contributions and 748 links to potentially useful data sources. The findings of this Report indicate that the largest data gaps stem from "biophysical impact", "emissions", and "geospatial data", which limits the use of metrics related to vulnerability to physical and transition risks.

[2] Commission Delegated Regulation (EU) 2021/2139 of 4 June 2021 supplementing Regulation (EU) 2020/852 of the European Parliament and of the Council by establishing the technical screening criteria for determining the conditions under which an economic activity qualifies as contributing substantially to climate change mitigation or climate change adaptation and for determining whether that economic activity causes no significant harm to any of the other environmental objectives.

[3] Commission Delegated Regulation (EU) 2022/1214 of 9 March 2022 amending Delegated Regulation (EU) 2021/2139 as regards economic activities in certain energy sectors and Delegated Regulation (EU) 2021/2178 as regards specific public disclosures for those economic activities.

At European level, the ECB published in January 2023 a first set of climate-related statistical indicators – experimental indicators and analytical indicators – which also includes information on transition risks and physical risks for Portugal. This initiative, which is part of the ECB's July 2021 action plan to include climate change considerations in its monetary policy strategy, is presented as a work in progress and is intended to facilitate a better assessment of the impact of climate-related risks on the financial sector and also to help monitor developments in the sustainable finance market. The ECB's report emphasises that a very careful approach must be adopted when viewing and interpreting these indicators, as they still have several shortcomings.

Disclosures

The need for reliable sustainability data – as mentioned above – to address this paradigm shift in the financial system is directly linked to another complementary challenge: the dissemination of information by economic agents. It is not enough that data be 'merely' relevant and of high quality: it is also important to increase the disclosed information and ensure that it is easily accessible and disseminated to its potential users.

In order to provide more and better information on environmental sustainability, it is key to move from a voluntary framework (grounded on market recommendations and practices) to a regime of minimum mandatory disclosure requirements based on harmonised reporting standards. Among the set of initiatives relevant for this purpose are:

- The Corporate Sustainability Reporting Directive (CSRD), published on 16 December 2022,[4] which (i) revises and strengthens sustainability reporting rules in their three dimensions – environmental, social and governance (ESG) – putting sustainability information on an equal footing with financial information in the management report (i.e. sustainability as a new pillar of corporate performance); (ii) aims to improve the quality, granularity and comparability of public information to be reported in order to meet the (growing) needs of investors; (iii) extends the scope of reporting entities by establishing mandatory disclosure requirements to all large listed and unlisted enterprises and to all listed SMEs (including banks) within the meaning of the Accounting Directive, subject to proportionality criteria; (iv) establishes the double materiality principle in the information to be reported; (v) provides a long-term approach in the transition plans that will have to be drawn up by firms; (vi) mandates the European Financial Reporting Advisory Group (EFRAG) to develop European Sustainability Reporting Standards (ESRS). The Directive must be transposed by Member States by 6 July 2024.
- The EBA's specification, through draft implementing technical standards (ITS) submitted to the European Commission in January 2022 and endorsed in November 2022,[5] of ESG risk disclosure requirements for large banks with securities admitted to trading on a regulated market in any Member State within Pillar 3. The determination of mandatory disclosure requirements (e.g. CO_2 levels, energy efficiency, exposure to sectors and counterparties that are most vulnerable to climate-related risks, green asset ratio) is an important incentive to foster market discipline and gradual convergence towards sustainability goals – provided that it relies on the disclosure of science-based, reliable information. The first releases are expected to be made in 2023 (with reference to information as of 31 December 2022), and in stages depending on the type of information.

[4] Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting.

[5] Commission Implementing Regulation (EU) 2022/2453 of 30 November 2022 amending the implementing technical standards laid down in Implementing Regulation (EU) 2021/637 as regards the disclosure of environmental, social and governance risks.

To ensure access to and dissemination of information, promoting the creation of data repositories in consistent formats, a relevant initiative in this area – even if originating from the Capital Markets Union – is the proposal for a Regulation establishing a European Single Access Point (ESAP), adopted by the European Commission on 25 November 2021. Its main aims are to: (i) set up a centralised platform for access to public financial and sustainability information on EU firms and EU investment products; (ii) facilitate the access, research and dissemination of relevant public information; (iii) provide public access to information in digital format; (iv) contribute to the greater visibility of firms to investors while expanding their sources of funding; (v) support investors in making informed investment decisions; and (vi) improve risk assessment.

Climate scenarios

Anticipating the potential implications of climate change for supervised institutions and financial stability requires the use of modelling techniques to project the impact on the financial situation of banks and their counterparties under different scenarios, which presents a number of challenges.

In addition to the aforementioned issues related to the poor quality and lack of information available (e.g. levels of CO_2 emissions by sector and entity) and its taxonomy, the integration of climate factors in the traditional models of economic projections and scenario analyses entail practical difficulties, not least due to the characteristics of those factors themselves (e.g. associated with very long time horizons, the non-linearity of impacts and the lack of relevant historical experience).

The main challenges in scenario analysis and stress tests are: (i) the need to use longer-term scenarios that highlight the trade-off between transition risks, incurred in the short to medium term, and physical risks, which tend to materialise over longer horizons; and (ii) the need to use very granular firm-level information to capture heterogeneity in the impact of transition risks, and regarding the specific location of firms' physical assets (establishments or physical units of production), to capture the materialisation of physical risks. Moreover, since there have been no similar adjustments in the past, it is particularly difficult to make assumptions on (i) the progressive reconversion of selected activity sectors to a low-carbon economy, (ii) transition speeds conditioned either by technological developments or by economic policy decisions, and (iii) balance sheet developments in the banking sector (size and composition) in view of the investment associated with the transition (as opposed to the static balance sheet assumption).

Despite these difficulties, important work has already been undertaken to quantify the impact of various energy transition scenarios on the financial sector, with particular emphasis on the climate scenarios developed by the NGFS since 2019. These scenarios have been subject to major annual developments and updates, providing a common benchmark to both regulators and supervisors and to banks.

The NGFS first reported macro-financial and climate scenarios for large geographical blocks in Phase I (June 2020). With Phase II (June 2021), information was released for a wide range of countries, including each EU country. In September 2022, the NGFS released the latest update on these climate scenarios – Phase III – which deepens, expands and enriches the previous version and presents, compared to the previous phase, (i) greater geographical granularity, (ii) more detailed sectoral aspects of scenarios, incorporating greater sectoral differentiation of climate-related transition risks, and (iii) the inclusion of acute physical risks.

Risk and vulnerability analysis

Greater knowledge on climate change topics – based on reliable, comparable and science-based data – requires the identification and assessment of the materiality of the different risk factors with a potential impact on the financial system as a whole, on individual banks and on supervisory practices.

It is crucial to map the transmission channels and intensity of risks to the economy as a whole and the financial system in particular. Given the specificities of these risks, diagnostic and quantification analyses of risk exposures should be developed further and the assessment of institutions' long-term resilience against alternative scenarios of physical and transition risk combinations should be expanded.

In this respect, at European level, there were some notable initiatives by the ECB in terms of stress tests and climate scenario analyses. In 2021, the ECB conducted a stress test to assess the impact of the climate-related transition and physical risks on the economy and the banking system as a whole, with a 30-year horizon, from a macro-prudential perspective, and with a top-down approach. In 2021 and 2022, it carried out a series of supervisory climate stress tests, with a bottom-up approach (as described in Chapter 3 of this Report).

At national level, the Banco de Portugal presented the first assessment of the exposure of the Portuguese banking system to non-financial corporations vulnerable to climate transition risks in June 2021 in an Occasional Paper (Marques and Carvalho (2021)) and in the June 2022 issue of the *Financial Stability Report*. An exploratory analysis of the banking system's exposure to climate-related transition risks inherent in the housing loan portfolio was published in the November 2022 issue of the *Financial Stability Report*. The May 2023 issue of the *Financial Stability Report* presented the preliminary results of the assessment of the banking system's exposure to firms located in areas vulnerable to the materialisation of physical risks, the analysis of which is further elaborated in Sections 2.1.1 and 2.1.3 of this Report.

Integrating climate considerations into the regulatory and supervisory framework

The challenges of adapting the prudential framework to climate considerations are very significant. First, because they involve a process of (i) 'interpretation' and integration into the prudential taxonomy of risks related to climate change, and (ii) the identification of channels of transmission of such risks to the financial system, namely how such risks translate into the risk classes set out in the prudential framework and supervisory activities (e.g. credit risk, liquidity risk, market risk and operational risk).

Moreover, three key questions need to be addressed as regards the role of prudential policies in the global action to transition to a low-carbon economy : (i) to what extent the current rules already capture financial risks stemming from climate-related risks, (ii) what are the possible shortcomings of the current regulatory framework, and (iii) which changes need to be implemented, and at what levels, to improve the integration of climate-related risks into the resilience of banks and the preservation of financial stability.

A number of initiatives have been developed at European level and others are underway in these areas, mainly under the European Commission's Action Plan (COM (2018) 97 final) under "Action 8: Incorporating sustainability in prudential requirements", with particular emphasis on:

- At EBA level, the relevant and sequential developments in the three pillars of prudential regulation, as mandated mainly in the Capital Requirements Directive (CRD)[6] and the Capital Requirements Regulation (CRR)[7] and described in its Action Plan on Sustainability and Sustainable Finance (released in December 2019 and updated in December 2022) including, in addition to the above-mentioned ITS within Pillar 3: (i) at Pillar 2 level, the publication in June 2021 of the Report on management and supervision of ESG risks for credit institutions and their inclusion in the review and evaluation performed by competent authorities (SREP); (ii) for Pillar 1, the opening for public consultation between May and August 2022 of a Discussion Paper (EBA (2022)) with an initial reflection on the extent to which a dedicated prudential treatment of exposures related to assets or activities substantially associated with

[6] Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013 on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC.

[7] Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012.

environmental and/or social objectives and those subject to environmental and/or social impacts would be justified.

- The proposal to revise the EU Banking Package (CRD and CRR), adopted by the European Commission on 27 October 2021 and for which the EU Council's general approach was approved on 8 November 2022, which, among other matters, regulates prudential rules for banks. The new rules, which essentially aim to finalise the implementation of the BCBS reforms in the EU, will help EU banks become more resilient to potential economic shocks while seeking to contribute to the transition to climate neutrality. With regard to sustainability, the proposed revision includes a broad integration of ESG considerations into the prudential requirements for banks across their areas of business (e.g. internal governance, internal capital, risk management strategies and policies), as well as specific provisions addressed to regulators and supervisors.

At international level, also important is the ongoing work in the BCBS, focusing on assessing possible shortcomings in the current prudential framework, in order to allow for consideration of improvements to be adopted. The BCBS will carry out further work on the three main dimensions, covering prudential standards, supervision and market disclosures. As part of that holistic approach, in June 2022 the BCBS published 18 general principles (BCBS (2022)) to improve banks' risk management and supervisors' practices regarding climate-related financial risks.

Internalisation of environmental considerations by institutions

Regulators and supervisors have intensified the message that institutions should incorporate climate-related and environmental risks into the management and development of their business, and cannot wait until the formal update of the prudential regulatory framework is completed. A longer-term vision should prevail (as referred to, for example, in the December 2019 EBA Action Plan (EBA (2019)).

In this context, mention should be made to the publication in November 2020 of the ECB Guide on climate-related and environmental risks (ECB (2020)) setting out supervisory expectations for the identification and management of climate-related and environmental risks, for significant institutions under the SSM, which is further discussed in Chapter 3 of this Report.

As such, while challenges remain, in particular in terms of data and methodologies, institutions should make the best possible use of available information and, where necessary, proxies, using all relevant information collected as part of their interaction with counterparties, to assess the strategic resilience of their business to different climate change and energy transition scenarios.

Despite progress on various fronts, awareness of the financial risks associated with climate change and the policy initiatives needed to address them are still at an early, albeit rapidly developing stage.

2 Assessment of climate-related financial risks to the banking system

2.1 Banking system's exposure to climate-related risks

2.1.1 Physical climate risks: exposure to non-financial corporations

From a financial stability perspective, it is important to assess the direct and indirect impact of losses resulting from physical risk materialisation on banks and how such an impact can be systemic in nature. Physical risks refer to the economic and financial impact stemming from the increased frequency and intensity of natural hazards associated with climate change.

Such risks can be subdivided into acute risks, which refer to the impacts of extreme weather events, e.g. fires, heat waves, floods and storms such as hurricanes, **or chronic risks**, associated with gradual climate changes, such as changes in temperature, rainfall, drought periods, sea level rise and coastal erosion.

Estimating the impact of physical risks on the economy and the financial system is complex and its outcome is the subject of great uncertainty. In particular, note should be taken of the non-linearity of the relationship between global average temperature rise and physical risk events (e.g. tipping points) or the possibility that the same location is exposed to various physical risk phenomena, as well as the interaction between those risks and economic activity (e.g. impact on labour productivity). Using very long horizons (e.g. several decades) also contributes to complexity in estimating the effects stemming from physical risk materialisation. The need for high spatial resolution data to assess the impact of physical risks also results in increased challenges to collect information.

The geospatial distribution of physical risks is heterogeneous globally. In the case of the Portuguese territory, the main impacts associated with climate change identified under the *Programa de Ação para a Adaptação às Alterações Climáticas* (P-3AC, the Portuguese action programme for climate adaptation) were considered.[8] The work carried out in the development of the P-3AC identified as main impacts and vulnerabilities the increase in maximum temperature and susceptibility to desertification, sea level rise, as well as the increased frequency and intensity of extreme events such as wildfires in rural areas, heatwaves, droughts and water scarcity, extreme rainfall, coastal overtopping and erosion.

This section therefore focuses on the analysis of the banking sector's exposure to physical risks associated with the exposure to NFCs, taking into account the potential materialisation of six climate events or phenomena. Of these, three are chronic risks – heat stress, water stress and sea level rise – and three are extreme climate events or acute risks – floods, wildfires and hurricanes

[8] Endorsed by Resolution of the Council of Ministers No 130/2019 of 2 August 2019. This programme aims to implement adaptation measures on Portuguese territory and establishes both direct and cross-cutting lines of action on the territory and infrastructure. Further details are available at: https://apambiente.pt/clima/programa-de-acao-para-adaptacao-alteracoes-climaticas-p-3ac and https://apambiente.pt/clima/projetos-em-adaptacao.

and typhoons.[9] The banking sector's exposure is assessed through credit granted to firms by means of loans and debt securities.

Transmission mechanisms of physical risks to the banking sector

Physical risk materialisation can entail significant economic and financial costs. The impact resulting from extreme events (acute risks) may result in the destruction of firms' physical assets, such as buildings and infrastructure, disruption of supply chains and in the markets where they trade, causing partial or total disruption of their business. Gradual changes arising from chronic risks are also reflected in deteriorating living conditions and the population's health and tend to lead to a loss in labour productivity. The need to cope with these effects, for example by rebuilding or replacing destroyed assets, may also be reflected in an increase in firms' liabilities.

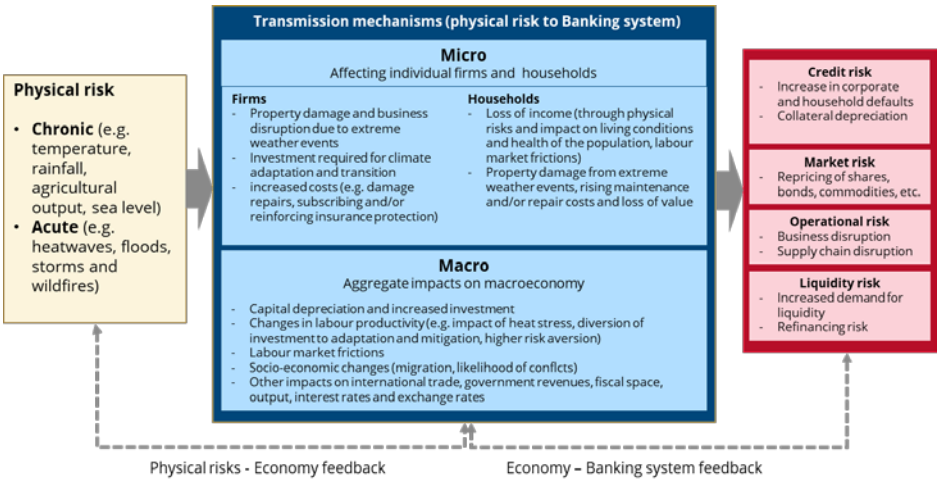
At the same time, strategies for adapting to climate change result in investment and increased costs for economic agents. The investment needed to adapt and mitigate the impacts of climate change, as well as to acquire or strengthen insurance to mitigate losses have an impact on business costs and may result in increased financing needs of economic agents.

These effects are passed on to the banking sector, as they affect households' and firms' financial position and their debt servicing capacity, as well as the value of assets pledged as collateral in loans (Chart 2.1).

In addition to the impact on credit risk, physical risk materialisation may also be reflected in all other categories of prudential risks, such as the banking sector's market, liquidity and operational risks (BCBS (2021a) and Chapter 1). For market risk, losses resulting from physical risk events may lead to abrupt asset price corrections or valuation adjustments of the most exposed firms, leading to the devaluation of banks' portfolios. For liquidity risk, the possibility of firms and households making significant withdrawals from their deposits and credit lines to meet losses is of particular note. Operational risk may arise from banks' exposure to physical risks, either through their branch network or through the location of their own decision-making centres and data centres or their suppliers. In the latter case, the risk may be of a systemic nature, in so far as there is a concentration of the location of the equipment, common to several institutions in the banking sector, which undermines the continuity of their operations. In addition, it may also have an impact in terms of reputational and litigation risks.

[9] Hurricanes and typhoons are part of the set of storms known as tropical cyclones. They are known as hurricanes when they occur in the North Atlantic or in the central and eastern North Pacific. If they occur in the western North Pacific, they are known as typhoons.

Chart 2.1 • Physical risk transmission channels to the banking sector



Sources: Banco de Portugal and NGFS (adapted).

Data

The use of sufficiently granular data to capture territorial differences in the exposure to physical risks is crucial for a proper assessment of their impact. Identifying the geospatial distribution of both the areas affected by the materialisation of physical risk events and assets located in these areas is a necessary condition for this analysis. The geographical distribution of the firms' production units or assets allows for a better assessment of the potential impact of physical risks. However, since obtaining the location of business activity is particularly challenging, most of the analyses have considered only the location of the firm's head office, thus limiting the validity of the findings (see, for example, ECB/ESRB (2021) and Alogoskoufis et al. (2021)).

This section analyses the banking sector's exposure to physical risks through credit granted to firms. The locations – based on the head office address – of the 50,000 firms ranking higher in terms of outstanding loans on the Banco de Portugal's Central Credit Register (CCR) in December 2021 (hereafter referred to as "firms") were used.[10] Loans were added to the amount of debt securities issued by firms and held by the banking sector, obtained through the Banco de Portugal's Securities Statistics Integrated System (*Sistema Integrado de Estatísticas de Títulos* – SIET) for the same period. For firms belonging to economic groups, the credit amount was computed using a consolidated group logic and distributed to each of the constituent firms taking into account the importance of their turnover for the total.[11]

The credit taken into account to assess the banking sector's exposure to physical risks amounts to €63 billion for the outstanding amount of the CCR loans (around 81% of total loans to NFCs) and €11 billion for debt securities held by the banking sector (approximately 74% of the total NFC debt securities reported in the SIET). It should be noted that for these firms as a whole, around 90%

[10] Information on the head office's address was obtained using the Moody's Orbis Bureau Van Dijk database. For a very residual set of firms (0.6% of the total) it was not possible to obtain information on a valid address and therefore the post-code was considered for location purposes. This set of firms is also used in the analysis in Section 2.2.

[11] As the CCR is reported on an individual basis, it is assumed that financing in these cases is managed at the economic group level, seeking to capture credit granted to firms specialised in obtaining financing for the group. Information from SIET also includes issues by non-resident firms belonging to the economic group, with the amounts of debt securities allocated following the same logic as for loans from the CCR.

(accounting for 73% of total credit analysed) have only one establishment (head office), therefore the location hypothesis should not be limitative to the findings.

The geographical location of the firms' head offices (latitude and longitude) made it possible to relate information on physical risks. This is based on the indicators or scores of Moody's Climate on Demand (Moody's COD, former Four Twenty Seven),[12] a database which assesses the exposure potential of firms' location to physical risks such as heat stress, water stress, wildfires, floods, sea level rise, hurricanes and typhoons (tropical cyclones) (Table 2.1). These indicators combine various types of information – from climate models, climate databases (in some cases used in addition) and simulations using historical data. In the case of information from climate models, Moody's COD considers the Representative Concentration Pathway (RCP) 8.5 scenario, which is the worst emissions scenario and where it is assumed that no effort is made to limit greenhouse gas emissions.[13] The information is summarised in the form of scores on a scale of 0 to 100 and incorporates the level of exposure to physical risk in relation to its distribution within a global territory.

The analysis considers the risk indicators integrating the information, including climate model projections, up to 2050. It should be noted that the use of the distribution of past events in assessing exposure to physical risks is not necessarily the best representation of their present or future materialisation, making the use of forward-looking information, albeit subject to high uncertainty, crucial in this type of analysis. Only the assessment of hurricanes and typhoons (tropical cyclones) is based solely on historical information, taking into account the unavailability of projections in this case. Other indicators combine historical data with projections, such as flood risk. Choosing a long horizon makes it possible to analyse the effects of physical risk materialisation, especially where there is an accumulation of chronic risks. The choice of this period also ensures consistency with other exercises included in this report (section 2.2).

Physical risk scores are ranked by Moody's COD under five risk levels, depending on the impact of physical risk on a particular location. Areas that are not exposed to a given risk or whose exposure to physical risks is not material are categorised as "no risk" or "low risk" respectively. For the whole range of events analysed, the "medium risk" level broadly reflects some possibility of the location or area concerned being affected by physical risk materialisation. In the case of the "high risk" level, some exposure to physical risk is already observed, with a tendency to increase in the future. The "severe risk" level reflects on the one hand, significant exposure to physical risk, and on the other, considerable intensification, indicating a high potential for materialisation of the negative impact on the firms located in that location (Table 2.2). The latter two levels (high and severe) thus represent greater vulnerability to risk materialisation.

[12] Moody's COD (former Four Twenty Seven) is a database providing physical risk indicators for a set of physical risk events. Further details available at: https://www.moodysanalytics.com/microsites/climate%20on%20demand?utm_medium=cpc&utm_campaign=climateondemand&utm_source=google&utm_term=europe. For a further description of this information, see also ECB/ESRB Report Climate-related risk and financial stability – Data Supplement:
https://www.esrb.europa.eu/pub/pdf/recommendations/2021/esrb.climateriskfinancialstability202107_annex~35e1822ff7.en.pdf?fe8cacf5c2844527a9c43678bde76442.

[13] The RCPs describe different pathways for greenhouse gas emissions and concentration, air pollutant emissions and land cover by 2100. Further details can be found in the IPCC report (2014). It should be noted that the RCP 8.5 is more severe than that considered in the "Current Policies" scenario of the NGFS, the latter being close to RCP 6.0 at the end of 2100.

Quantification of the banking sector's physical risk exposure is obtained from the combination of the information on physical risks associated with the location of firms and credit granted (loans and debt securities). The banking sector's exposure to the physical risk level through credit granted to firms is calculated on the basis of the following formula:

$$Exposure\ to\ credit\ to\ firms_{f,s} = \frac{\sum_{50.000}^{i=1} Credit\ to\ firm_{i,f,s}}{\sum_{50.000}^{i=1} Credit\ to\ firm_{i}} (1)$$

Where $i - firm$, $f - physical\ risk$ and $s - physical\ risk\ level$.

This exercise aims to obtain an estimation of the banking sector's exposure to physical risk for a wide range of climate events, as well as to identify potential concentration of risk exposure, taking into account its relevance to firms. Note that the validity of the findings is conditional on the physical risk data considered in the analysis, and developments at this level will tend to ensure greater robustness of the quantification presented. Therefore, the results should be seen as preliminary. This analysis is an important contribution to the discussion and identification of the needs for adapting the banking sector's balance sheet, with a view to mitigating the negative impacts associated with the materialisation of these risks.

Table 2.1 • Summary of physical risks and potential impacts on business activity

Hazard	Description	Potential impact on business activity
Water stress (WS)	Changes in water demand and supply	– Reduced water supply – Increased water costs – Erosion of the "social license to operate" and/or reputation[(a)]
Heat stress (HS)	Increase in temperature	– Increased energy costs – Heightened risk of brownouts/power outages – Stress on human health/labour force
Wildfires (WF)	Change in wildfire potential	– Permanent loss of property value – Human health deterioration (air quality) – Deterioration in ecosystem services – Business interruptions – Rise in insurance costs or loss of insurance coverage
Floods (FL)	Changes in rainfall conditions and in the scale and intensity of floods	– Damage to property and buildings – Infrastructure compromised – Business interruption
Sea level rise (SLR)	Heightened storm surge, augmented by sea level rise	– Damage to property and buildings – Permanent loss of property value – Relocation costs
Hurricanes and typhoons – tropical cyclones (HT)	Exposure to past cyclones	– Severe damage to property and buildings – Permanent loss in property value – Relocation costs

Source: Moody's COD. | Note: (a) The "social licence to operate" refers to the idea that firms need support of the society and the community where they operate to maintain their activity, also reducing their reputational risk. This concept is relevant in some activities, such as the mining industry or the intensive agriculture.

Table 2.2 • Characterisation of the highest levels of physical risk (medium, high and severe)

Physical risk levels/Physical risk categories	**Medium risk** Exposed to some risks based on historical information or projected future risks	**High risk** Exposure to risk and increasing level of exposure	**Severe risk** Significantly exposed to past and/or projected future risks, indicating a high potential for negative impact
Water stress (WS)	Changes in the demand for and supply of water resources will tend to lead to competition for these resources in the future.	Water stress may already be high in the period and water resources are already decreasing.	Competition for water resources is already very high and there may be a failure in water supply in the future.
Heat stress (HS)	Heating observed; changes in maximum temperatures in line with the global average.	Changes in maximum temperatures above the global average.	Locations exposed to some of the greatest variations in global maximum temperatures.
Wildfires (WF)	Moderate wildfire potential, with some degree of variation in future severity.	High and/or major wildfire potential; existence of fire fuel; significant variation in future severity of wildfire potential and high-risk days.	High wildfire potential and high existence of fire fuel; several-week increase with high-risk days.
Floods (FL)	Some vulnerability to floods based on historical records or intensified rainfall in the future.	Vulnerable to some degree of flooding during rainfall or river flooding events.	Vulnerable to high frequency and/or higher severity of rainfall or river flooding events at least once over a period of 100 years.
Sea level rise (SLR)	Coastal and ocean-connected location; possible flooding.	Vulnerable to some degree of coastal flooding, although there is little variation in the frequency of flooding.	Flooding has not historically been observed in this location, but it is vulnerable to coastal flooding.
Hurricanes and typhoons (HT)	Location exposed to frequent and/or severe tropical cyclones based on historical observations.	Location situated in regular tropical cyclone trajectories.	Location situated in regular tropical cyclone trajectories; severe events are common.

Source: Moody's COD (adapted). | Notes: Levels of physical risk also include the 'no risk' and 'low risk' classes.

Banking sector's exposure through credit granted to firms most affected by physical risks

The banking sector's exposure to firms most affected by physical risks largely depends on the territorial distribution of physical risks, the location of firms and their assets. Most of the firms considered in this analysis are located in the northern and central coastal areas of Portugal, with the (head offices of the) large firms located mainly in the Lisbon and Porto Metropolitan Areas (maps in the Annex).

The distribution of physical risks associated with the location of firms is rather heterogeneous in view of the six climate events analysed. Considering the firms located in areas with exposure to

physical risk, classified as having medium, high and severe risk levels according to Moody's COD (maps in the Annex), the conclusion is that:

- The risk of water stress is more acute in firms located in the centre and south of Portugal, with some relevance also on the island of Madeira.
- Exposure to heat stress extends throughout the territory of mainland Portugal and the archipelagos of the Azores and Madeira with various degrees of intensity. The medium level is mainly concentrated in the region Lisboa e Vale do Tejo, the south coast of the mainland and islands. High and severe levels can be found mainly in northern and central areas and inland Alentejo.
- In relation to fires, the medium risk level has a greater impact on the region Lisboa e Vale do Tejo, Porto and Braga districts and the archipelagos of the Azores and Madeira. The high level is dispersed across Portuguese territory, with residual significance in the areas identified above. There is no firm classified as having a severe risk exposure.
- For flooding, the medium and high levels show greater significance in the northern coastal area of the mainland and in the archipelago of Madeira (medium level). In the case of the severe level, there is only a very residual exposure in the Minho region.
- The risk of sea level rise points to high vulnerability (severe risk) in firms located in some parts of the country's coast.
- For hurricanes and typhoons, a residual exposure is observed for firms located in medium level areas in the Viana do Castelo district and the archipelago of the Azores.

Chart 2.2 • Banking sector's exposure to firms affected by physical risks | Percentage of total credit to firms

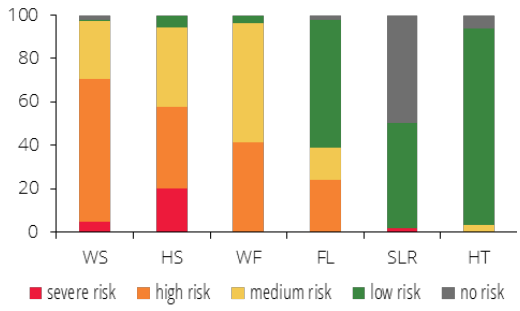


Table 2.3 • Banking sector's exposure to firms affected by physical risks | Percentage of total credit to firms

	WS	HS	WF	FL	SLR	HT
No risk	2	0	0	2	50	6
Low risk	0	6	4	59	48	91
Medium risk	27	37	55	15	0	3
High risk	66	37	41	23	0	0
Severe risk	5	20	0	0	2	0
Total	100	100	100	100	100	100

Sources: Banco de Portugal and Moody's COD. | Notes: Total credit includes the outstanding amount of loans reported in the CCR, as well as debt securities held by banks from the SIET for all 50,000 firms under review. The risk events considered are water stress (WS), heat stress (HS), wildfires (WF), floods (FL), sea level rise (SLR) and hurricanes and typhoons (HT). The sum of the percentages may not total 100% due to rounding.

The banking sector's exposure, as assessed through the credit granted to firms, shows some concentration in firms located in areas with physical risk potential, with predominance at the medium and high levels (Chart 2.2 and Table 2.3).[14] Exposure to physical risk is determined on the basis of the importance of credit granted to firms associated with medium, high and severe risk categories. This exposure is particularly significant in water stress, heat stress and wildfire events, with a share of credit to firms exceeding 90% of the total. Although there are different compositions between the different risk levels, note should be taken of the medium and high-risk concentration and, consequently, the higher credit share associated with firms located in areas vulnerable to physical risk materialisation. Risk exposure of firms located in areas prone to flooding is also somewhat significant, accounting for 38% of total credit granted to firms. Exposure to physical risks related to sea level rise or hurricanes and typhoons is low, reflecting the more specific nature associated with such events.

When considering only the highest risk category (severe level), the banking system's exposure to the events included in the analysis are rather limited, with the exception of heat stress. In this case, around 20% of total credit belongs to firms located in areas where the maximum temperature change is expected to be among the highest at the global level (Table 2.3). The share is rather small for the severe level associated with water stress and sea level rise, with approximately 5% and 2% of total credit granted to firms respectively, and immaterial in the remaining situations.

Table 2.4 • Bank credit to firms with exposure to physical risk (medium, high and severe levels (A)) and to firms most vulnerable to physical risk materialisation (high and severe levels (B)) by sector of activity | Percentage of credit to firms

	Total	WS		HS		WF		FL		SLR		HT	
		(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)	(A)	(B)
Manufacturing	25	26	19	27	43	26	25	28	24	13	14	18	0
Wholesale and retail trade	20	20	17	20	18	19	18	21	22	18	16	22	0
Const. and Real estate activities	12	12	16	12	8	12	14	10	11	12	13	10	75
Accommodation and food services activities	8	8	5	7	3	8	10	7	8	28	26	6	25
Other	35	35	42	35	28	35	33	34	35	29	31	43	0
Total	100	96	70	94	58	97	41	39	24	2	2	3	0

Source: Banco de Portugal and Moody's Climate on Demand. | Notes: The risk events considered are water stress (WS), heat stress (HS), wildfires (WF), floods (FL), sea level rise (SLR) and hurricanes and typhoons (HT). (A) corresponds to the sum of exposure associated with the medium, high and severe levels and (B) the sum of exposure at the high and severe levels, the latter related to firms that are most vulnerable to physical risk materialisation. The figures are shaded in grey when the share of credit granted to firms in a given risk event and sector of activity is higher than the total share of the sector in the portfolio of credit granted to firms. Identification of activity sectors: Manufacturing, Trade, Construction and real estate activities (Constr. and RE activities), Accommodation and food services (Accomm. and food services) and the remaining category of Others.

[14] Note that there are differences in the sources of information and/or horizons used, as well as in the methodology adopted and scope considered in Alogoskoufis et al. (2021), ECB/ESRB (2021) and ECB (2023), which prevent a direct comparison with the results obtained in this section.

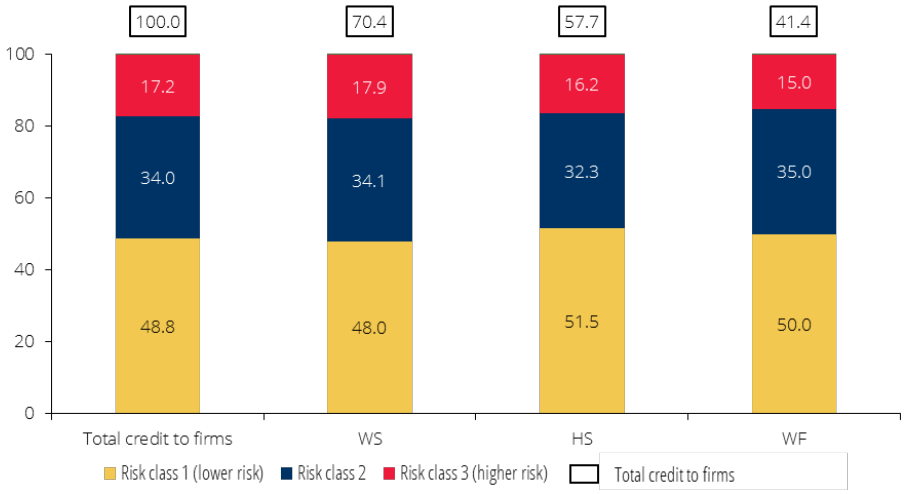
The impact of physical risks materialisation on different activity sectors reflects their dependence on resources, such as energy or water, and on working conditions (with an effect on productivity). For example, some sectors – e.g. the construction sector –, as they often include outdoor activities, are particularly subject to atmospheric conditions and available water resources. Other activities – e.g. manufacturing and trade – depend on their ability to maintain suitable climate conditions in facilities, leading to an increase in energy consumption where there is a rise (or fall) in temperature.

The distribution of credit to firms located in areas more vulnerable to physical risk materialisation does not differ significantly from the structure of total credit granted to firms (Table 2.4). Thus, taking into account total exposure at the medium to severe levels, sectors such as 'manufacturing', 'trade' and 'construction and real estate activities' show a higher share in credit granted, as they can be particularly affected should physical risks materialise. For sea level rise, there is a higher incidence of credit to the 'accommodation and food services' sector, although exposure associated with this climate event is low. However, when only credit granted to firms located in the areas more vulnerable to physical risk materialisation is considered (high and severe levels), note should be taken of the concentration of exposure to the 'manufacturing' sector in heat stress and the 'construction and other real estate activities' and 'accommodation and food services' sectors in hurricanes and typhoons, although the banking sector's exposure is residual in the latter.

Interaction of the banking sector's exposure to physical risks with credit risk

It is also important to assess the interaction between the exposure to physical risks and firms' credit quality based on the probability of default of the firm, according to the credit ratings available in the Banco de Portugal's In-house Credit Assessment System (ICAS) with reference to the figures from the Simplified Corporate Information (*Informação Empresarial Simplificada* – IES) for 2020. In its current version, the ICAS model does not incorporate climate change risks in the calculation of probabilities of default. This analysis focuses on the events for which a significant banking sector's credit exposure was identified in relation to firms most vulnerable to physical risk materialisation (high and severe risk levels), i.e. water stress, heat stress and wildfires.

Chart 2.3 • Exposure of bank credit to firms located in areas more vulnerable to physical risks materialisation (high and severe levels) by risk class | Percentage of credit to firms



Sources: Banco de Portugal and Moody's Climate on Demand. | Notes: Risk events considered are water stress (WS), heat stress (HS) and wildfires (WF), in line with the identification of the largest banking sector exposures to physical risk events under review. The figures at the top of each bar correspond to the share of total credit granted to firms in each of the physical risk categories identified, while the figures inside the bars are related to the share of each exposure class in total credit associated with the physical risk category under review. Credit risk, as measured by the probability of default (PD), is based on credit ratings available in the In-house Credit Assessment System (ICAS) of the Banco de Portugal. The lower risk class (risk class 1) corresponds to firms with a one-year PD below or equal to 1%; risk class 2 corresponds to firms with a one-year PD above 1% and below or equal to 5% and the higher risk class (risk class 3) corresponds to firms with a one-year PD above 5%. This indicator does not include the impact of climate change.

The interaction of the banking sector's credit exposure to the firms most vulnerable to the materialisation of physical risks (associated with water stress, heat stress and wildfires) with credit quality shows no sign of increased concentration risks. The share of credit to firms with the highest probabilities of default (class 3) is in line with the figure for the total portfolio across all physical risk categories, being slightly higher in the water stress event and lower in all other situations (Chart 2.3).

Limitations of the analysis and future developments

These results should be interpreted as initial estimates of the banking system's exposure to physical risks through credit granted to firms. The use of Moody's COD information enabled an assessment of the banking system's exposure to a wide range of physical risks. However, estimating the effects of physical risks on the economy and the financial system is complex. The incorporation of other sources of information, including the climate component using data and strengthening the methodologies adopted, may have an impact on the conclusions identified here.

Location is a key factor in analysing the impact of physical risks. In this analysis, the address of the head office was used as a proxy for the location of all the firms under review. In Portugal, the vast majority of firms have only one establishment, in line with the prevalence of micro and small firms. Nevertheless, the location of the firms' establishments – a factor that is more relevant for larger firms – is essential for the assessment of their exposure and, consequently, of the banking sector's exposure to physical risks. This will be developed and incorporated into future analyses of the Banco de Portugal.

The use of static balance sheets of banks and firms in this physical risk projection horizon (2050) could result in an overestimation of risk exposures, as banks are expected to adapt their credit policy to firms, reflecting in particular the materialisation of climate change, notably transition and physical risks and the adaptation or mitigation processes implemented by firms.

The Banco de Portugal will continue to monitor this issue using other sources of information, notably taking into account the NGFS scenarios. In this analysis, the assessment focused only on direct exposure to physical risks. However, the impact of second-round effects, such as the destruction of vital infrastructure (e.g. transport networks) or the supply chain, may also have a material impact on firms' business and their debt servicing capacity. In addition, the interaction between physical risks should also be considered, as the simultaneous occurrence of several events could amplify the impact of climate change.

Finally, information on the existence of insurance coverage[15] of the assets provided as collateral in loans, or other adaptation and risk mitigation strategies, should be incorporated. For real estate assets, it is also necessary to assess the correlation of their location with the location of the establishments and their exposure to physical risk. The availability of sufficiently granular information is essential in this case.

2.1.2 Climate-related transition risks: exposure to non-financial corporations

As mentioned in Section 1.2, transition risks are associated with the impact of structural changes to the economy from reducing GHG emissions. This could weaken economic activity in some sectors, such as those linked to the extraction and use of fossil fuels, and could be a source of risk to financial institutions more exposed to these sectors. The extended time horizon associated with

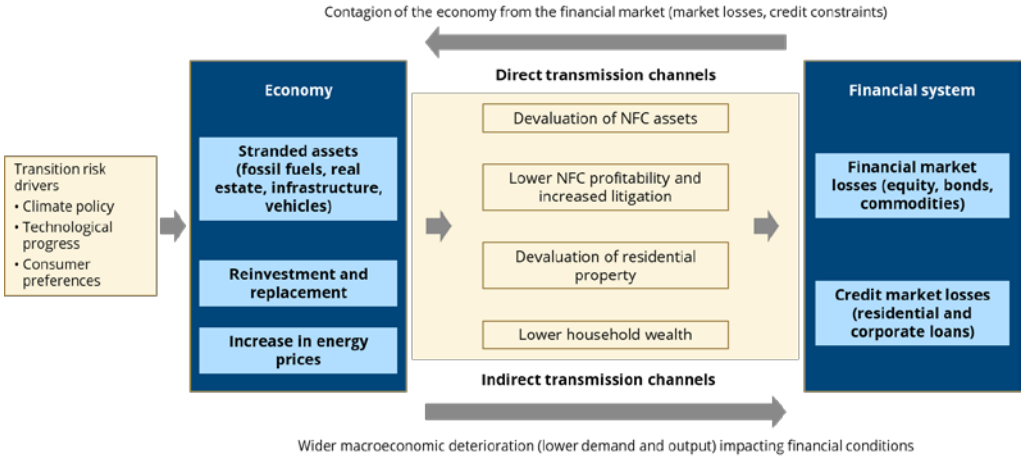
[15] Note that for Portugal, EIOPA's information on the protection gap shows relatively low rates, in European terms, of penetration of insurance in Portugal for this type of risk. Insured losses, based on historical information, amount to 4% for floods, 5% for wildfires and 62% for storms, considering EMDAT information (2%, 5% and 8% respectively for the CatDat information source). For further details see EIOPA (2023).

the transition process to a low-carbon economy suggests that regular analyses of its impact on NFCs should be carried out, particularly in the sectors identified as climate-policy-relevant-sectors (CPRS).

The climate transition process passes on directly to the economy via three channels (Chart 2.4): (i) tax and regulatory changes (e.g. taxes and limits on GHG emissions) with a view to internalising the social cost of carbon by economic agents; (ii) technological progress leading to greater energy efficiency, the use of renewables and the reduction of emissions; and (iii) change in consumer preferences by excluding products whose production or consumption is associated with a high level of emissions.

These three factors could translate into economic impacts, such as asset stranding and associated conversion costs to less polluting technologies, and significant changes in energy prices. The effects of the transition process are likely to spill over to the financial system through, inter alia, an increase in borrowers' credit and market risk, with possible distributional effects owing to interlinkages between economic agents.

Chart 2.4 • Transmission channels between climate-related transition risks and financial stability



Sources: Banco de Portugal and NGFS (2019), "A call for action: Climate change as a source of financial risk" (adapted).

The monitoring of climate-related risks to financial stability requires quantification of climate-related factors and their impact on productive activities and the banking system. This section presents two complementary perspectives to assess the banking system's exposure to climate-related transition risks via loans to non-financial corporations (NFCs).

First, it presents two indicators which assess the banking system's exposure to transition risks according to the sectors' GHG emissions from different perspectives. Information on direct GHG emissions[16] is available in the Air Emissions Accounts database by sector of activity, compiled by

[16] A firm's GHG emissions are divided into three categories by the Greenhouse Gas Protocol (WBCSD/WRI, 2004): direct emissions, or scope 1 emissions, caused by sources owned or controlled by the firm (e.g. emissions from burning fossil fuels during the production process); scope 2 indirect emissions, associated with electricity purchased and consumed by the firm, but whose emissions were originated by third-party controlled sources; and scope 3 indirect emissions, corresponding to all other indirect emissions, such as those attributable to the final consumption of goods and services produced (e.g. emissions generated by the use of cars). For further information, see https://ghgprotocol.org/corporate-standard.

Eurostat.[17] Bank loans to NFCs are available in the ECB's Consolidated Banking Data,[18] thus making it possible to compare the situation of the Portuguese banking system with that of the euro area.

Second, it presents a joint analysis of the banking system's exposure to the most relevant sectors in terms of climate policy and its credit risk rating. The banking system's exposure is measured by on-balance-sheet bank loans to NFCs at the end of December 2021, as reported to the Central Credit Register (CCR). The economic and financial information of NFCs is derived from the reporting of the Simplified Corporate Information *(Informação Empresarial Simplificada* – IES) and credit risk rating is based on information from the In-house Credit Assessment System (ICAS) of the Banco de Portugal in 2019.[19]

Indicator 1 – Carbon intensity weighted by bank loans to NFCs (CFALTL)

This indicator[20] corresponds to the sum of the carbon intensity of each sector of activity weighted by its share in the portfolio[21] of bank loans to NFCs:

$$CFALTL_t = \sum_s IC_{s,t} \times \frac{L_{s,t}}{L_t}$$

In the equation above, carbon intensity $IC_{s,t}$ corresponds to the ratio of direct GHG emissions (in kilograms of CO_2 equivalent – kg CO_2e) to gross value added (GVA) of sector *s* in year *t*.[22] The $L_{s,t}/L_t$ ratio corresponds to the share of sector *s* in period *t* in the portfolio of bank loans to NFCs.

The CFALTL over the period 2014-21 followed a downward path from 2018 onwards (Chart 2.5). In 2018, the reduction was particularly significant as a result of a decline in the carbon intensity of the economy (reflecting a decrease in GHG emissions and an increase in the GVA of NFCs) and a shift in the bank loan portfolio to less carbon-intensive sectors. This downward trend continued until 2021, when the banking system's portfolio composition effect was close to zero.

[17] The Air Emissions Accounts published by Eurostat cover direct GHG emissions.

[18] The information used for these two indicators comes from the Consolidated Banking Data (CBD) and is available at https://sdw.ecb.europa.eu/browse.do?node=9691144. Bank loans to NFCs in the CBD have a sectoral granularity broken down at one-digit level of NACE and are disclosed every year.

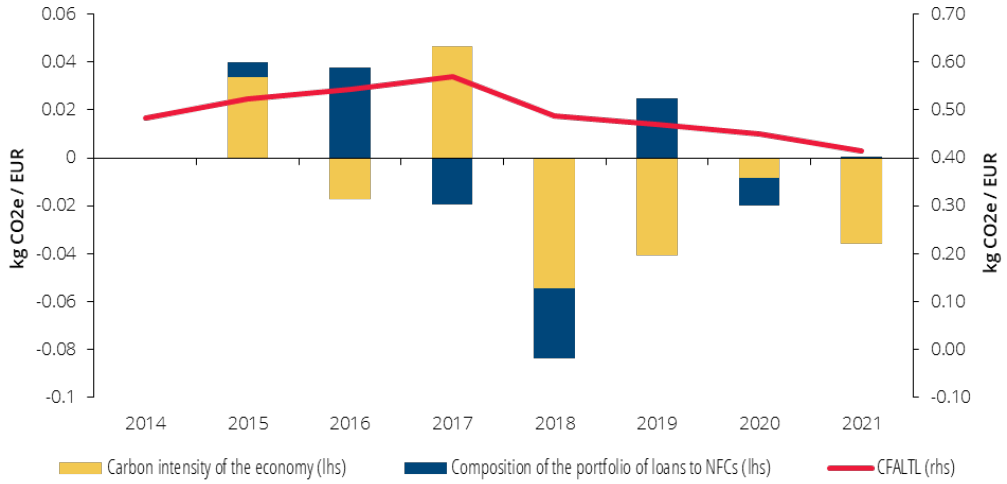
[19] Credit risk, as measured by probability of default, is based on credit ratings available in the In-house Credit Assessment System (ICAS) of the Banco de Portugal. For the calculation of firms' probabilities of default, see Antunes *et al.* (2016).

[20] Also referred to as "loan-weighted carbon intensity" in ECB/ESRB (2021). This report uses the IMF's expression "Carbon footprint-adjusted loans to total loans for deposit takers" (CFALTL) at the Climate Change Indicators Dashboard, available at https://climatedata.imf.org/.

[21] Exposure may also include NFC debt securities held by the banking system.

[22] The sectors of activity are classified according to the Statistical Classification of Economic Activities (NACE; CAE in Portugal). In this exercise, sectors broken down at one-digit level of NACE were considered in such a way as to be compatible with the level of granularity of bank loans (see footnote 18). Direct GHG emissions and carbon intensity by sector of activity are available at https://ec.europa.eu/eurostat/web/environment/air-emissions. GVA across sectors of activity is available at https://ec.europa.eu/eurostat/web/national-accounts/database.

Chart 2.5 • Carbon intensity weighted by bank loans (CFALTL) – Portugal, 2014-21
| In kg of CO2 equivalent per euro

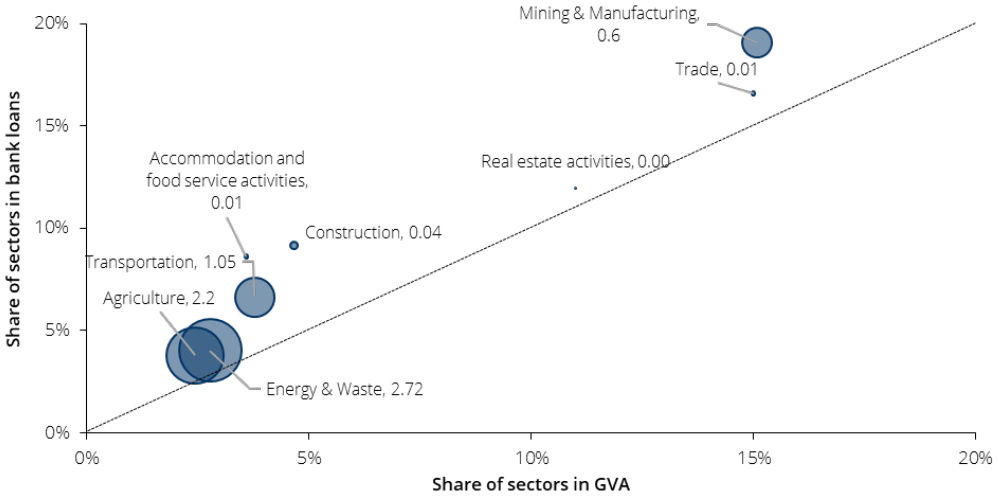


Sources: European Central Bank (Consolidated Banking Data), Eurostat and Banco de Portugal calculations. | Note: The carbon intensity indicator corresponds to the ratio of GHG emissions to GVA.

The CFALTL indicator should be interpreted in conjunction with the carbon intensity of the economy, i.e. the GVA-weighted carbon intensity (i.e. total direct emissions of the NFC institutional sector over its aggregate GVA). A banking system with a CFALTL higher than the carbon intensity of the economy shows, in its portfolio of loans to NFCs, a weight of the most carbon-intensive sectors exceeding the share of those sectors in the GVA of the economy.

In 2021, the carbon intensity of the Portuguese economy weighted by bank loans to NFCs was higher than GVA-weighted carbon intensity (0.42 kg of CO_2e and 0.38 kg of CO_2e respectively). This difference reflects a higher weight of sectors more intensive in GHG emissions (Agriculture, Manufacturing, Transportation, Energy and Waste) in the Portuguese banking system's portfolio, when compared with the sectoral composition of the economy's GVA (Chart 2.6).

Chart 2.6 • Share of sectors of activity in bank loans and in GVA and carbon intensity (Portugal, 2021) | Per cent and kg of CO2 equivalent per euro



Sources: European Central Bank (Consolidated Banking Data), Eurostat and Banco de Portugal calculations. | Notes: The area of the circles is proportional to the carbon intensity of the sectors of activity in 2020. Loans by sector of activity refer to end-2021. The perimeter of the sectors of activity corresponds to the aggregation by sections of the CAE: Agriculture – A; Mining & Manufacturing – B and C; Energy and waste – D and E; Construction – F; Trade – G; Transportation – H; Accommodation and food service activities – I; other sectors (J to S excluding Section L) accounted for 42% of GVA and 20% of bank loans in 2021.

Chart 2.7 makes it possible to place the indicators obtained for Portugal into context at euro area level. The GVA-weighted carbon intensity of the Portuguese economy, calculated by Eurostat, is close to, but higher than, the euro area average[23] as a whole. In terms of ranking, Portugal is in an intermediate position, the eighth country out of 19.[24]

For the period 1990-2019, Amador (2022) provided an analysis of several aggregate energy indicators[25] for Portugal and the euro area taking the year 2019 as a reference, and concluded that: the degree of energy dependency, as measured by the share of energy an economy needs to import, is approximately 10 p.p. higher in Portugal (80% and 70% respectively); the degree of energy intensity, as measured by energy consumption per unit of value added, was approximately 25% higher in Portugal; in terms of energy contribution, a higher contribution of renewables was observed in Portugal, by around 10 p.p. (contributions of 27% and 16% respectively).

In the euro area, in 2021 most countries had a higher carbon intensity weighted by the portfolio of loans to NFCs than when weighted by GVA, including Portugal (Chart 2.7). The CFALTL for Portugal exceeds the euro area average. In terms of ranking, Portugal is in an intermediate position, but in this case below the median (thirteenth out of 19 countries). For Portugal, this reflects a greater proximity between the portfolio composition of loans to NFCs and the structure of gross value added of the economy, which can be measured as the difference between the CFALTL and the carbon intensity of the economy (i.e. the horizontal distance of each point from the 45º line in Chart 2.7).

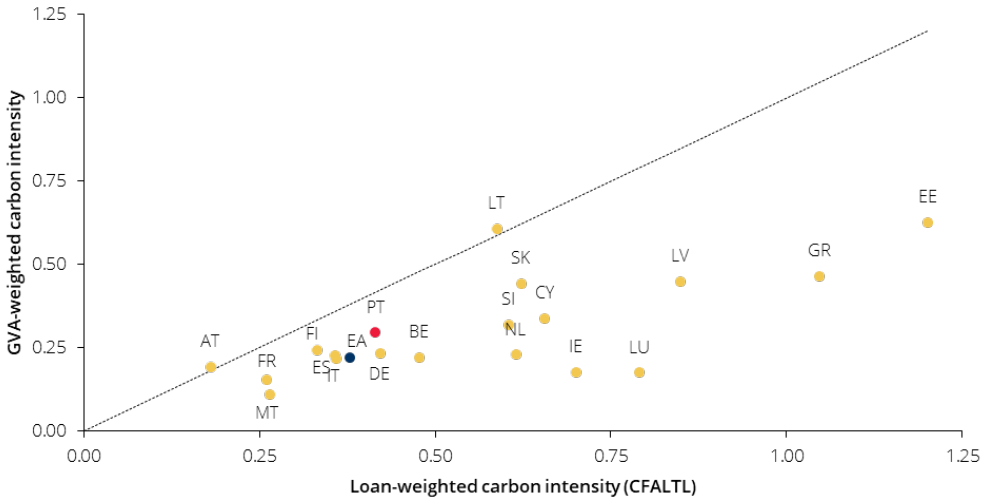
[23] Calculated as the ratio of direct GHG emissions from NFCs in all euro area countries to total GVA in these countries.

[24] This analysis considers only those countries that were part of the euro area in 2021.

[25] GHG emissions from firms generally result from the (direct or indirect) use of fossil fuels to generate the energy that enables them to carry out their economic activity. Thus, the carbon intensity of the economy is directly linked to its energy intensity, i.e. the amount of energy consumed per unit of output.

In conclusion, the CFALTL indicator suggests that the Portuguese banking system is in an intermediate position in terms of exposure to transition risks and is not among the most (or least) exposed to this process. Nevertheless, this indicator points to an impact close to, but higher than that observed, on average for the euro area as a whole.

Chart 2.7 • Carbon intensity of the economy and weighted by bank loans (euro area, 2021)
| In kg of CO2 equivalent per euro



Sources: European Central Bank (Consolidated Banking Data), Eurostat and Banco de Portugal calculations. | Notes: Loans by sector of activity refer to end-2021. The carbon intensity indicator corresponds to the ratio of GHG emissions to GVA.

Indicator 2 – Carbon intensity of bank loans to NFCs (loan carbon intensity – LCI)

This indicator corresponds to the ratio of direct GHG emissions from NFCs (in kilograms CO_2 equivalent – kg CO_2e), E_t, to bank loans to NFCs L_t:

$$LCI_t = \frac{E_t}{L_t}$$

The LCI is a measure of the intensity of GHG emissions from NFCs in relation to lending: a lower volume of emissions per euro of loans granted should correspond to a lower exposure to transition risks. The LCI varies inversely with the volume of loans (denominator) and positively with direct GHG emissions.

The analysis of this indicator becomes clearer when contributions to its changes are broken down, i.e. between GHG emissions and bank loans. The LCI has been declining since its peak in 2017 (Chart 2.8). The cumulative change between 2017 and 2021 mainly reflected a decrease in GHG emissions and, from 2021 onwards, also an increase in loans to NFCs. In 2021 the Portuguese banking system's LCI exceeded the euro area average, standing at an intermediate position (eighth) close to but above the median (Chart 2.9).

Chart 2.8 • Carbon intensity of Portuguese bank loans (LCI) – level and contributions to changes | In kg of CO2 equivalent per euro

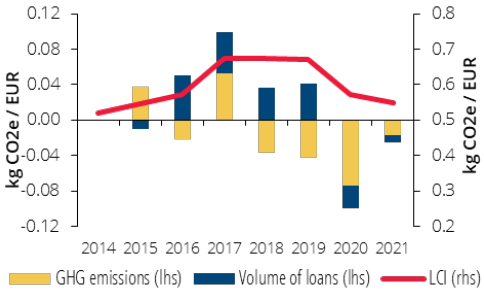
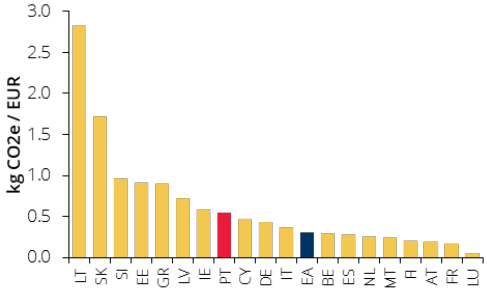


Chart 2.9 • Carbon intensity of loans by euro area banks | In kg of CO2 equivalent per euro



Sources: European Central Bank (Consolidated Banking Data) and Eurostat. | Note: The carbon intensity indicator of loans corresponds to the ratio of GHG emissions to bank loans.

These indicators – CFALTL and LCI – capture the banking system's direct exposure to transition risks, as they both relate to direct GHG emissions from NFCs (total or sectoral). These indicators provide complementary insights into how this risk interacts with exposure to NFCs. In the case of the CFALTL, the fact that it depends solely on the portfolio composition of bank loans to NFCs, rather than on its total volume, makes it particularly suitable to analyse exposure for each activity sector, together with its carbon intensity. Turning to the LCI, by analysing the contributions to changes therein it is possible to identify changes in absolute exposure to both transition risk (changes in GHG emissions) and credit risk (changes in loans).

The CFALTL and LCI indicators are a means of assessing the banking system's exposure to transition risks. Both indicators put Portugal in an intermediate position in the euro area context, albeit pointing to a higher impact on average.

Limitations of the analysis and future developments

The indicators of exposure to transition risks analysed here (CFALTL and LCI) have some constraints. By using aggregate information on GHG emissions and GVA (and carbon intensities), i.e. at country level, they fail to capture NFC-specific situations. As noted in Section 1.2, taking into account more granular information – i.e. at individual firm level – would make it possible to produce a more precise measure of banks' exposure to transition risks. In addition, the availability of information on indirect emissions (scope 2 and 3) remains as a major data gap and, as such, these indicators only consider direct emissions (scope 1), thus not covering transition risks upstream or downstream in the value chain of each sector of activity. These aspects will be developed and incorporated into future analyses of the Banco de Portugal.

Exposure analysis – Credit risk in climate-policy-relevant-sectors (CPRS)

A second means of characterising the banking system's exposure to climate-related transition risks is based on the joint analysis of the most affected sectors in the course of this process and the credit risk assessment of NFCs. To this end, sectors of activity are grouped according to their relevance to the climate transition process, as defined by Battiston *et al.* (2017). The CPRS have been identified taking into account the following factors: direct and indirect contribution to GHG emissions (e.g. production and distribution of fossil fuels or renewables); relevance to climate policy (e.g. sensitivity of the cost structure to regulatory or fiscal changes based on GHG emissions); and their role in the energy value chain (production, use, consumption).

This methodology led to the identification of the following CPRS: Agriculture, Fossil-fuel, Energy-intensive, Utilities, Buildings, and Transportation. The remaining sectors have been grouped into a residual category (Other). The level of detail of the sectors of activity also makes it possible to break down some of the CPRS into sub-sectors, taking into account their line of business.[26]

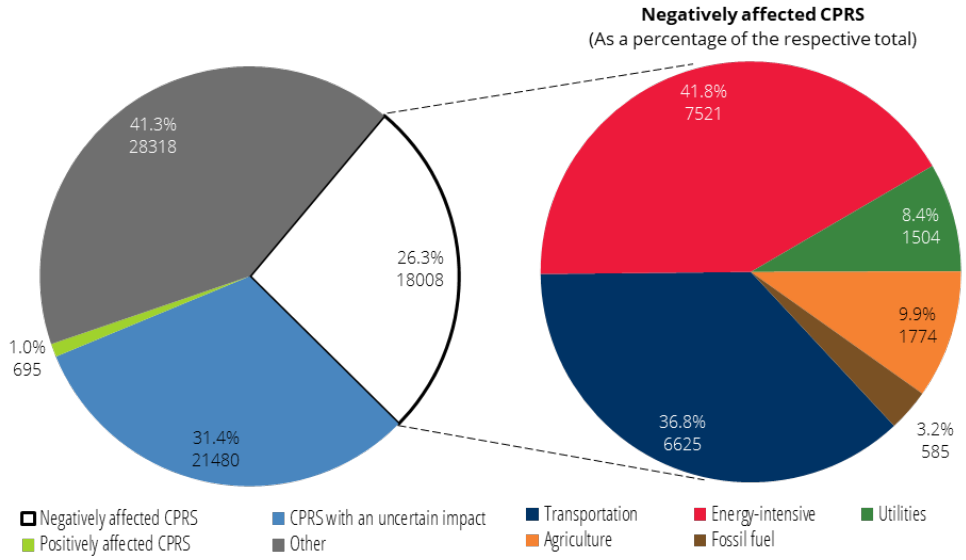
The activity of these sub-sectors could be influenced – either negatively or positively – by the transition to a low-carbon economy. Negatively affected CPRS refer to sectors that produce or use fossil fuels or are more energy intensive. For firms in these sectors, the increase in carbon or energy costs is likely to directly affect their production costs. Positively affected CPRS include sectors that produce or use renewables or have low energy intensity. Finally, for some sectors the impact is uncertain: they may not be directly affected by carbon tax or energy price shocks, but they may be indirectly affected by the impact on the sectors most exposed to the consequences of the transition.

In 2021, the various CPRS accounted for approximately 59% of total loans to NFCs (Chart 2.10). Sectors related to the production of fossil fuels, which are GHG-emission-intensive or energy-intensive, are likely to be hit by more negative impacts from the climate transition process. These sectors accounted for around 26% of bank loans to NFCs, of which almost 80% relate to energy-intensive and transportation sectors. Exposure to firms that could benefit from the transition process (e.g. firms producing or using renewables) was residual (around 1%). Finally, sectors where the impact of the transition is uncertain (sectors that could be only indirectly affected by the introduction of a carbon tax) accounted for 31%.

The right-hand panel of Chart 2.10 shows the breakdown of sectors whose activity is negatively affected by the climate transition process. These sectors mainly correspond to the Energy-intensive (such as some Manufacturing) and Transportation CPRS , with around 42% and 37% of loans to negatively affected CPRS respectively.

[26] For more information on the correspondence between sectors of activity according to the Statistical Classification of Economic Activities (NACE, CAE in Portugal) and the CPRS, see https://www.finexus.uzh.ch/en/projects/CPRS.html. For a detailed analysis of the Portuguese banking system's exposure to CPRS, see Marques and Carvalho (2021).

Chart 2.10 • Loans to NFCs in climate-policy-relevant-sectors (CPRS), by type of impact (2021) | Per cent, EUR millions

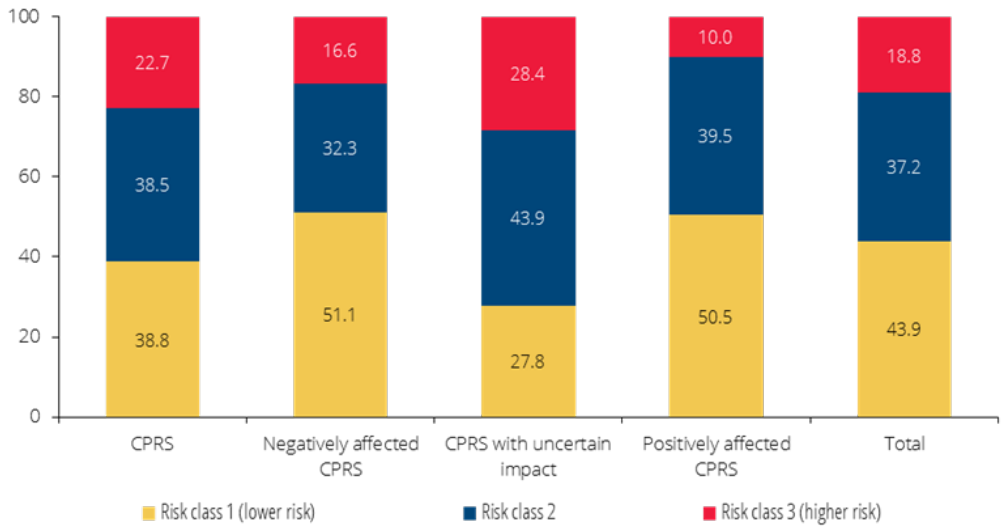


Source: Banco de Portugal. | Notes: The positively affected CPRS correspond to the 'Utilities' (renewable) and 'Transportation' (railways) sub-sectors; the negatively affected CPRS correspond to CPRS 'Fossil-fuel', 'Agriculture' (crops, animal and other), 'Energy-intensive', 'Transportation' (roads, air, water) and 'Utilities' (fossil-based, waste, water, and sewerage); the CPRS with an uncertain impact refer to CPRS 'Buildings' and the other CPRS sub-sectors not included in the previous categories.

The impact of climate-related risks is likely to be amplified if firms have higher credit risk resulting from financial vulnerabilities such as higher leverage or lower liquidity. This may contribute to a build-up of risk and a higher probability of its materialisation, which justifies a joint and regular analysis of the financial situation of NFCs and of banks' exposures to sectors more sensitive to transition risks. Accordingly, the analysis in this section combines information on exposure and credit risk in climate-policy-relevant-sectors. To this end, two approaches are used to identify the most vulnerable NFCs.

The first approach uses credit ratings obtained through the Banco de Portugal's In-house Credit Assessment System. In December 2021, the share of the highest risk class and, to a lesser extent, the intermediate risk class, was higher for loans granted to NFCs in CPRS than for total loans to NFCs (Chart 2.11). However, this mainly reflects CPRS with an uncertain impact. Negatively affected CPRS show a higher weight of the lower risk class. This result indicates that the credit risk of the sectors that, due to their activity, will tend to be negatively affected by the climate transition process is lower than the credit risk of the NFC loan portfolio.

Chart 2.11 • Stock of loans to NFCs by credit risk class and by CPRS (2021) | Per cent



Source: Banco de Portugal. | Notes: Stock of loans net of impairment. Credit risk, as measured by probability of default (PD), is based on credit ratings available in the In-house Credit Assessment System of the Banco de Portugal. Risk classes are based on the PD before the impact of the pandemic crisis. Risk class 1 (lower risk) corresponds to firms with a one-year PD below or equal to 1%; risk class 2 corresponds to firms with a one-year PD of above 1% and below or equal to 5% and risk class 3 (higher risk class) corresponds to firms with a one-year PD above 5%. Domestic activity.

Under the second approach, the most vulnerable NFCs are defined as those with cash-to-assets,[27] profitability[28] and interest coverage ratios[29] below the 25th percentile and leverage[30] and indebtedness ratios[31] above the 75th percentile. The available information does not point to a concentration of credit in more vulnerable firms among NFCs in negatively affected CPRS. Indeed, the share of lending to the most vulnerable firms in negatively affected CPRS is close to, but lower than, that for total firms (Table 2.5). As regards CPRS with an uncertain impact (which includes most construction, real estate and accommodation sub-sectors) across all indicators analysed, the percentage of outstanding loans to more vulnerable firms is higher than that for total NFCs.

[27] Ratio of the firm's liquid financial assets (currency and bank deposits) to total assets.

[28] Ratio of EBITDA (earnings before interest, taxes, depreciation and amortisation) to equity plus obtained funding. Obtained funding includes loans from financial institutions, subsidiaries and shareholders, debt securities and other funding. Equity and financing obtained are measured at book value.

[29] Ratio of EBITDA to financing expenses.

[30] Ratio of obtained funding and the sum of equity and obtained funding.

[31] Ratio of each firm's financial debt to total assets.

Table 2.5 • Stock of loans to NFCs by CPRS (2021) and quartile of economic and financial ratios | Per cent

	Negatively affected CPRS			CPRS with an uncertain impact			CPRS			Total NFCs		
	< p25	[p25, p75[	>= p75	< p25	[p25, p75[	>= p75	< p25	[p25, p75[	>= p75	< p25	[p25, p75[	>= p75
Cash-to-assets ratio	45.1	50.3	4.6	50.5	43.1	6.5	47.7	46.7	5.6	45.3	47.8	6.8
Profitability	15.7	77.6	6.7	33.4	61.0	5.6	25.1	68.8	6.1	21.1	71.0	7.9
Interest coverage ratio	22.8	67.2	10.0	36.5	56.2	7.3	29.9	61.6	8.5	25.5	64.5	10.0
Leverage ratio	4.6	61.2	34.2	5.5	44.9	49.6	5.0	52.3	42.7	5.6	57.0	37.4
Indebtedness ratio	4.1	50.0	45.9	5.2	35.3	59.5	4.6	41.6	53.8	5.0	47.4	47.6

Source: Banco de Portugal. | Notes: Stock of loans net of impairment. To calculate the quartiles of each ratio, information provided by the 2019 IES was taken into account (before the effects of the pandemic crisis) on NFCs with bank loans in December 2021. The percentiles covering vulnerable NFCs correspond to the cells highlighted in the table. Firms under sections K, O, T and U of the Portuguese Classification of Economic Activities (CAE) Rev.3 are excluded. On the grouping of positively or negatively affected CPRS with an uncertain impact, see Marques and Carvalho (2021) "Assessment of the exposure of the Portuguese banking system to non-financial corporations sensitive to climate transition risks", *Occasional Papers*, Banco de Portugal.

In conclusion, the average credit risk of the sectors that, due to their activity, will tend to be negatively affected by the climate transition process is close to, but lower than, the credit risk of the NFC loan portfolio. As such, there is no concentration of loans with higher credit risk in the sectors likely to be negatively affected by the climate transition process.

Limitations of the analysis and future developments

As regards the analysis of the credit risk of NFCs by CPRS, this classification does not provide a quantification of the transition risk inherent in each sector (or firm), but merely a qualitative indication of the type of impact it may face. In turn, the risk classes presented here did not include climate factors in their calculation, thus not reflecting transition risks for NFCs. The scenario analysis presented in Section 2.2 of this Report seeks to overcome these constraints by developing quantitative metrics to climate-related risks in the portfolio of loans to NFCs.

2.1.3 Interaction between exposure to physical risks and transition risks: non-financial corporations

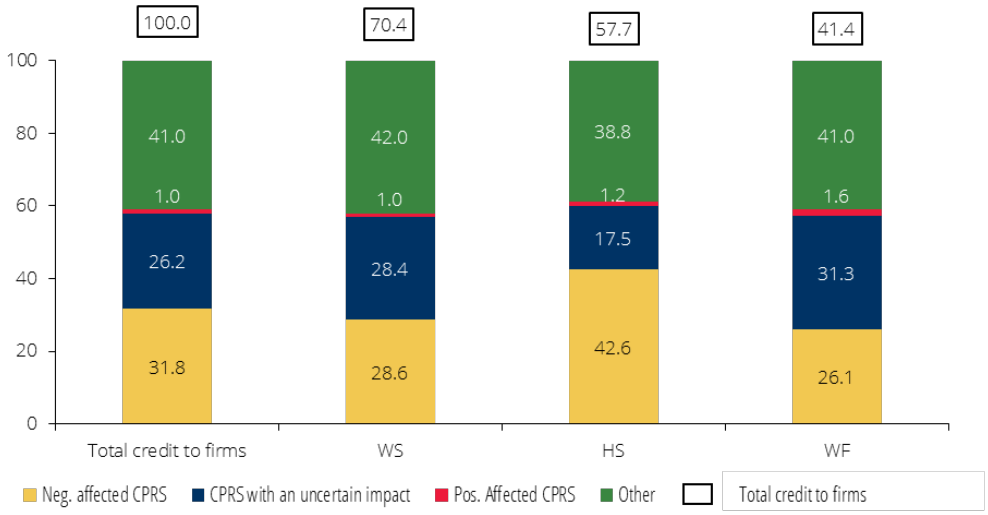
Given that firms' activities may be simultaneously affected by physical and transition risks, it is important to consider the interaction between these climate risks. In this section, it is considered that the activities of firms located in the areas most vulnerable to the materialisation of the physical risks identified in Section 2.1.1. may also be negatively or positively influenced by the transition to a low-carbon economy, according to the CPRS classification shown in Section 2.1.2.

The banking sector's exposure is measured through credit (loans and debt securities) granted to firms. Based on the assessment of the banking sector's exposure to physical risks set out in Section 2.1.1., the CPRS for the activities of each of the 50,000 firms considered in the analysis were attributed using the Statistical classification of economic activities in the European Community

(NACE, *Código de Atividade Empresarial* – CAE in Portugal). This resulted in the identification of the amount of credit associated with the interaction between the two types of climate risk.[32]

The analysis focuses on physical risk events identified as having a larger credit exposure of the banking sector to firms most vulnerable to the materialisation of risk (high and severe levels as identified in Table 2.2), in particular water stress, heat stress, and wildfires.

Chart 2.12 • Exposure of bank loans to firms located in areas most vulnerable to the materialisation of physical risks (high and severe levels) by CPRS category | Per cent of credit to firms



Sources: Banco de Portugal and Moody's Climate on Demand. | Notes: The risk events considered are water stress (WS), heat stress (HS), and wildfires (WF), in line with the banking sector's largest exposures to physical risk events as identified in section 2.1.1. The figures at the top of each bar correspond to the percentage of total credit to firms in each of the physical risk categories identified, while the figures inside the bars are linked to the share of each CPRS in total credit associated with the physical risk category under review. Negatively affected (Neg. affected) CPRS correspond to CPRS Fossil Fuel, Agriculture (Crops, Animal and Other), Energy-Intensive, Transportation (Roads, Air and Water) and Utilities (Fossil, Waste, Water and Sewerage); positively affected (Pos. affected) CPRS correspond to the Utilities (Renewable) and Transportation (Railways) sub-sectors; CPRS with an uncertain impact (Uncertain imp.) refer to CPRS Buildings and the other CPRS sub-sectors not included in the previous categories (Marques and Carvalho, 2021).

In the case of heat stress risk, the results indicate a concentration of joint exposure to the impact of a materialisation of physical and transition risks (Chart 2.12). Exposure to the firms most vulnerable to heat stress and the negatively affected CPRS corresponds to 24.6% of total credit to firms,[33] of which approximately half (12.6% of total credit to firms) belongs to the severe level of physical risk, i.e. credit granted to firms located in areas where the variation in maximum temperatures over the horizon used in the analysis is estimated to be among the highest overall (Table 2.2) Consequently, there is a potential worsening related to the materialisation of climate risks for these firms, which could result in higher losses for the banking sector.

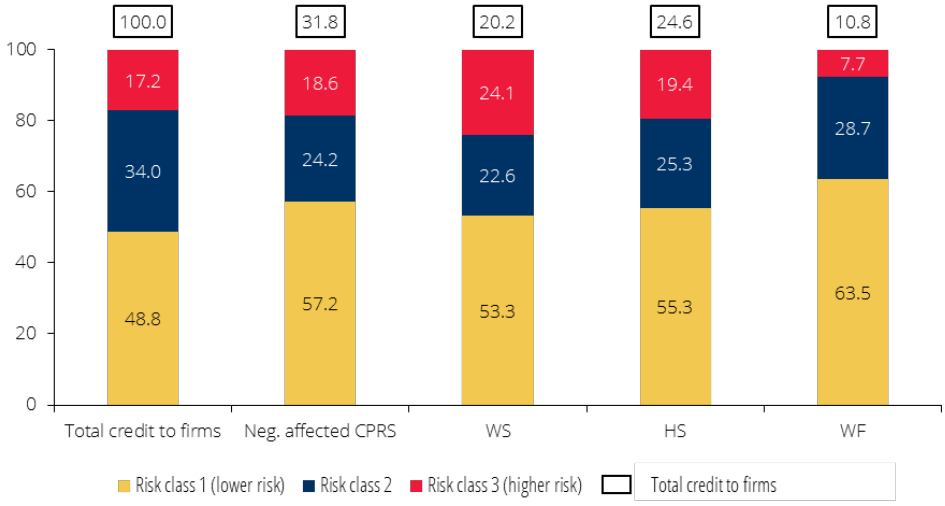
[32] For more details on the methodology used for identifying the firms and the physical risks considered in the analysis, please refer to the paragraph on Data in Section 2.1.1.

[33] Table 8 of the Annex.

Despite not showing a greater joint impact of transition and physical risks, the banking system's exposure to risks associated with water stress or wildfires against negatively affected CPRS is still relevant. The share of credit to the firms most vulnerable to transition risks and water stress or wildfire risks is lower than total credit to firms and does not indicate a concentration of risk. These exposures account for 20.2% of total credit to firms in the case of water stress and 10.8% of total credit to firms in the case of wildfires.[34]

Lastly, the credit quality of firms subject to both physical and transition risks is assessed.[35]

Chart 2.13 • Exposure of bank credit to firms located in areas most vulnerable to the materialisation of physical risks (high and severe levels) and transition risks (adversely affected CPRS) by risk class | Per cent of credit to firms



Sources: Banco de Portugal and Moody's Climate on Demand. | Notes: The risk events considered are water stress (WS), heat stress (HS) and wildfires (WF), in line with the banking sector's largest exposures to physical risk events as identified in Section 2.1.1. The figures at the top of each bar correspond to the percentage of total credit to firms in each of the physical risk categories identified, while the figures inside the bars are linked to the share of each risk class in total credit associated with the physical risk category under review. Negatively affected (neg. affected) CPRS correspond to CPRS Fossil Fuel, Agriculture (Crops, Animal and Other), Energy-Intensive, Transportation (Roads, Air and Water) and Utilities (Fossil, Waste, Water and Sewerage); positively affected (Pos. affected) CPRS correspond to the Utilities (Renewable) and Transportation (Railways) sub-sectors; CPRS with an uncertain impact (Uncertain imp.) refer to CPRS Buildings and the other CPRS sub-sectors not included in the previous categories (Marques and Carvalho, 2021). Credit risk, as measured by probability of default (PD), is based on credit ratings available in the In-house Credit Assessment System (ICAS) of the Banco de Portugal. The lower risk class (risk class 1) corresponds to firms with a one-year PD below or equal to 1%; risk class 2 corresponds to firms with a one-year PD above 1% and below or equal to 5% and the higher risk class (risk class 3) corresponds to firms with a one-year PD above 5%. This indicator does not include the impact of climate change.

Credit exposure to the firms most vulnerable to transition risk and physical risks from water or heat stress is more concentrated in the lower credit quality class (Chart 2.13). This analysis considers credit granted to firms located in areas most exposed to the materialisation of physical risk (high and severe levels), belonging, at the same time, to the sectors most exposed to transition

[34] Tables 7 and 9 of the Annex.

[35] The credit quality of firms corresponds to the probability of default of a given firm obtained from the credit ratings available in the In-house Credit Assessment System (ICAS), with reference to figures from the Simplified Corporate Information (*Informação Empresarial Simplificada* – IES) database for 2020. In its current version, the ICAS model does not incorporate risks arising from climate change when calculating default probabilities.

risks (negatively affected CPRS). In the case of water stress and heat stress events, the share of the higher credit risk class is greater than its share in total credit to firms or in credit to firms that are negatively affected by transition risks, indicating the possibility of an accumulation of risk for the banking sector. However, credit exposure (in both cases, approximately 5% of total credit to firms) is low.

Limitations of the analysis and future developments

This section presents limitations that in general have already been identified in sections 2.1.1 and 2.1.2. In this case, it is particularly relevant – with regard to the assessment of physical risks – that the firms' location only takes into account the head office address and not the address of all its establishments, which has an impact on the identification of their total exposure to physical risks. The analysis would also benefit from including other factors, such as mitigating factors, which allow for a better assessment of the banking sector's exposure to the impact of physical risks materialising. In terms of transition risks, the CPRS classification does not reflect a quantification of the transition risk associated with each activity sector and is merely a qualitative identification of the type of impact the firm may face.

Finally, the interaction between physical and transition risks would also benefit from including the possibilities of: (i) several climate-related events occurring simultaneously and (ii) amplifying effects occurring during the transition to a low-carbon economy.

2.1.4 Climate transition risks: exposure to households (housing loans)

Households' real estate holdings are the most important component of their wealth, the main source of their debt and, to this extent, an interest payment and capital repayment burden. This Section explores the implications for the banking system of its exposure to climate transition risks associated with the housing loan portfolio.[36]

Climate transition can affect homeowners via two channels. On the one hand, through effects on disposable income. The need to reduce greenhouse gas (GHG) emissions can be expected to lead to an increase in the price of carbon allowances – most likely through taxes – which will result in higher energy prices. As a result, and to the extent that economic agents find it difficult to replace more carbon-intensive energy sources with cheaper sources, household disposable income will be negatively affected. This scenario could hamper and ultimately jeopardise the regular repayment of housing loans for some households.

On the other hand, the transition process could have an impact on property values. Household wealth could be affected by the environmental impact on property values, in particular if households are unable to meet higher energy certification requirements or related emission reduction efforts. The decrease in property values results in a negative effect on household wealth, reducing the value of the collateral underlying housing loans.

This Section presents an approach to analysing the banking system's exposure to the climate transition risks underlying the housing loan portfolio by identifying households' vulnerabilities according to: (i) the share of energy expenditure in income and (ii) the energy efficiency of properties approximated by energy expenditure per square metre and occupant. Subsequently, this information is used to assess the impact of climate transition risks on the bank loan portfolio, secured by immovable property, for own and permanent residence.

[36] This Section does not analyse the physical climate risks underlying the housing loan portfolio.

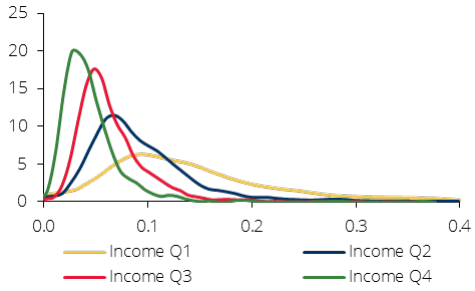
Effects on household disposable income: energy expenditure

The Household Budget Survey (*Inquérito às Despesas das Famílias* – IDEF) is a possible source of information to assess the share and composition in the household budget of expenditure likely to be affected by the climate transition. The most recent IDEF was conducted in 2015/16 and contains data for 2015.

Household energy expenditure on housing is likely to increase with the transition process. In 2015 the average annual energy bill per household in housing (expenditure on electricity, gas and other fuels) was €1,222. Expenditure on electricity and gas accounted for 60% and 34% of the housing energy bill in Portugal, respectively, with the remaining 6% being spent on liquid and solid fuels. The distribution of the energy expenditure-to-income ratio stood at an average (median) of 10.3% (6.8%). For lower incomes (quartile 1), the average (median) value was 19.3% (13%) and the right distribution tail was wider, justified by the demand rigidity of this type of expenditure (Chart 2.15).

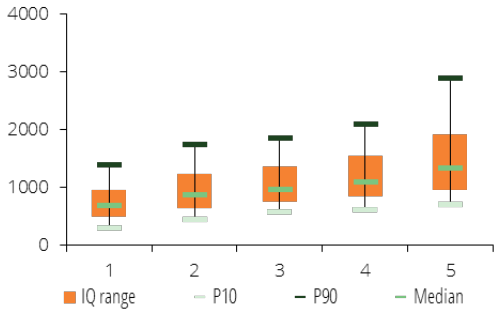
The IDEF also provides an idea of the dispersion in the distribution of energy expenditure on housing for the same level of income. Chart 2.16 shows the dispersion of energy expenditure on housing by income quintile, suggesting that there are several other factors that determine this expenditure (such as household composition, type of dwelling and degree of energy efficiency).

Chart 2.15 • Distribution of energy expenditure-to-income ratio (2015) by income quartile | Probability density



Sources: Banco de Portugal and Statistics Portugal (IDEF).

Chart 2.16 • Energy expenditure on housing (2015) by income quintile | In euros



Sources: Banco de Portugal and Statistics Portugal (IDEF).

The analysis carried out on the IDEF indicates that lower income households tend to be the most affected by a rise in energy prices, as they allocate a larger share of their budget to this type of expenditure. This analysis also suggests that the income level captures only part of the variability in the ratio of energy expenditure to income level.

Given that an analysis close to that presented in this section is not available for most euro area countries, it is not possible to compare the impact of climate transition risks on the banking system's exposure to housing loans.[37] However, the share of energy goods in the consumption basket used to calculate the Harmonised Index of Consumer Prices is lower in Portugal (4.6%) than in the euro area average (6.1%). This suggests that Portuguese households are less exposed to rising energy prices than euro area households on average.[38]

[37] In this respect, see Box 2 "Financial sector exposure to household transition risk – an application to Ireland" in ECB/ESRB (2022).

[38] For the shares of HICP expenditure categories, see the ECB's website.

Effects on the disposable income of households with loans secured by immovable property: energy expenditure

The IDEF includes other variables characterising households and their dwellings, which makes it possible to understand how energy expenditure varies with other socio-economic factors. In particular, the IDEF has a binary variable that identifies, for each household, whether or not the primary residence has an associated housing loan. Where there is a loan, the IDEF does not record the respective loan amount.

The CCR provides information on the (outstanding) amount of housing loans but does not contain data on the borrowers' income or the area of the property pledged as collateral. In order to cross-check CCR and IDEF data, this analysis follows the methodology of Abreu et al. (2021), which uses reporting under Instruction of the Banco de Portugal No 33/2018[39] to recover these variables from the CCR using proxies. Instruction No 33/2018 contains information on four variables that enable it to relate data contained in the CCR: initial date of the agreement, agreement maturity date, bank granting the loan and transaction amount.

In Instruction No 33/2018, the borrowers' income is reported with reference to an update date (updated income) or the date of origination of the agreement (original income). Therefore, in order to show the income of all borrowers in the same year, an adjustment factor has been applied, which is proportional to wage growth since the reference year of the reported income and 2021.

Property area was approximated using the ratio of the property's value reported under Instruction No 33/2018 to the median value of the bank valuation for the municipality/NUTS 2 where the property is located and with reference to the month and year of valuation. Where the property's valuation date is prior to January 2011, its value has been updated for 2021 using Confidencial Imobiliário's residential real estate price indices.[40]

Based on IDEF data, a regression was estimated to explain energy expenditure on housing on the basis of annual income, household size,[41] property size, property location and a set of binary variables, including one identifying the properties with associated housing loans. The regressors included in the model present the expected signal and are mostly statistically significant. Using these variables, energy costs have been extrapolated to households with loans secured by immovable property recorded in the CCR.[42]

The distribution of the energy expenditure-to-income ratio in the housing loans under review recorded an average (median) of 7% (5.8%). 36% of these loans were granted to borrowers with an energy expenditure-to-income ratio above 6.6% (Chart 2.17). These loans are concentrated in the lower income quintiles (1 and 2), which illustrates the greater vulnerability of these households to energy price rises, given that, in general, they have lower wealth levels and a lower ability to change the composition of their consumption.

[39] This Instruction requires credit institutions and financial companies to report to the Banco de Portugal information on the characteristics of the credit agreements governed by Decree-Law No 74-A/2017 of 23 June 2017, their collateral and the borrower(s) income, as well as information on early, partial and total repayments and on renegotiations of these credit agreements.

[40] Confidential Imobiliário is a firm that collects statistical information on the real estate market in Portugal used by the Banco de Portugal to monitor house prices, together with the official statistics of Statistics Portugal.

[41] Use of the OECD-modified equivalence scale that assigns a value of 1 to the first adult in a household, 0.5 to the remaining adults and 0.3 to each child.

[42] As at 31 December 2021, the portfolio of loans secured by immovable property for own and permanent residence accounted for approximately 97% of the housing loan stock. Despite some limitations in the information characterising households and dwellings, it was possible to include around 65% of this exposure in this analysis.

This analysis therefore confirms that the situations of greater vulnerability to an energy price rise – and, consequently, with the highest risk of defaulting on housing loans as a result of that rise – correspond to lower income levels. Government policies promoting investment in the thermal efficiency of properties could help reduce energy bills, especially in the case of economically vulnerable households, and thereby mitigate the impact of an energy price rise that might occur during the climate transition.

Effects on the value of properties with associated bank loans: energy efficiency of dwellings

Property values may be affected if borrowers are unable to meet higher energy certification requirements or associated emission reduction efforts. A drop in property values reduces the collateral available to the banking system and has a negative wealth effect on households.

Given that the CCR does not include information on the energy certification of buildings, a proxy was estimated for their energy efficiency. However, this procedure does not overcome all information limitations (for example, it does not contain information on the quality of the buildings' construction or on equipment for air conditioning and domestic hot water production).

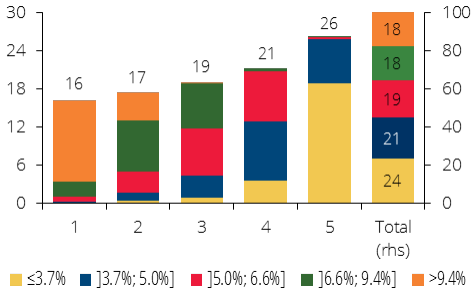
The properties' energy intensity has been approximated by energy costs in dwellings in relation to household size and property area. In order to incorporate factors that influence energy efficiency – such as location and area – households (and their property) were broken down into different subsamples on the basis of these two variables,[43] and the 10th percentile of energy intensity was calculated for each subsample, which can be taken as their efficiency benchmark. The energy intensity of each dwelling was then divided by the benchmark of the subsample to which it was allocated, resulting in a standardised indicator that is comparable between households (properties) with different characteristics. Higher values in this indicator are therefore associated with lower energy efficiency levels.

63% of the housing loans under review were concentrated in the higher energy-intensity quintiles (3, 4 and 5), i.e. those referring to lower energy-efficient properties (Chart 2.18).[44] However, only 4% of the housing loan amount has at the same time a high energy intensity and current loan-to-value (LTV) ratios above 80%, thus mitigating any potential impact from a reduction in the value of less energy-efficient properties on banks' exposures.

[43] Location refers to NUTS2 (seven regions); the size of the property in square metres was divided into quintiles.

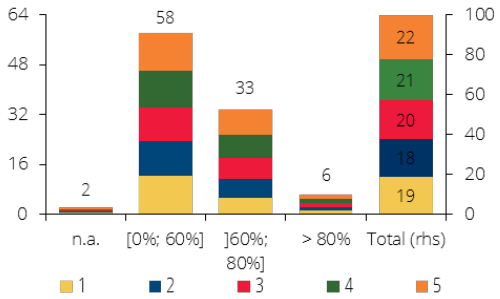
[44] According to ADENE data, 68% of certificates issued between 2014 and 2022 for residential buildings had a lower energy certification (C, D, E, F).

Chart 2.17 • Loans secured by immovable property, by energy expenditure-to-income ratio and income quintile (2021) | Per cent



Sources: Banco de Portugal and Statistics Portugal (IDEF).

Chart 2.18 • Loans secured by immovable property, by energy expenditure-to-income ratio and LTV (2021) | Per cent



Sources: Banco de Portugal and Statistics Portugal (IDEF). Notes: The standard efficiency indicator has been divided into quintiles where the 1st corresponds to a higher efficiency level; the current LTV has been calculated based on granular data at loan level (CCR). Where the date of the property's last valuation is prior to 2022Q1, its current value is estimated using Statistics Portugal's Housing Price Index.

This analysis leads to the conclusion that only a small portion of bank loans simultaneously has a high risk level – identified here by current loan-to-value (LTV) ratios above 80% – and lower energy efficiency. This indicator should be monitored in the future, as also the future effects of potential mitigating factors such as: (i) higher legal requirements in terms of energy certification, (ii) tighter credit supply conditions for new loans, and (iii) incentives that can be developed to improve the energy efficiency of older properties.

Limitations of the analysis and future developments

The analysis highlights the current data gaps in the quantitative analysis of transition climate risks related to households. This exercise combined two databases (IDEF and CCR) to estimate an energy efficiency measure for properties pledged as collateral for housing loans granted by the banking system. This indicator assumes that the estimated econometric relationships within the IDEF sample for 2015/16 apply to borrowers with housing loans recorded in the CCR.

In addition, the most recent IDEF was carried out in 2015/16 and contains data for 2015. This analysis therefore does not incorporate changes in the composition of expenditure in response to subsequent changes in relative prices, income level or other structural changes. It is also particularly important to develop initiatives that complement data on real estate collateral in terms of their energy certification.

2.2 Climate scenario analysis: credit risk of non-financial corporations

This section analyses climate-related risks in the Portuguese banking system through NFCs' exposures. To this end, the analysis used the very long-term climate scenarios developed by the NGFS. These scenarios incorporate transition risks and physical risks over the projection horizon (2020-2050). The analysis provides trajectories for NFCs' probability of default (PD), loss given default (LGD) and expected losses using the scenarios' macro-financial and climate variables.

This model incorporates – for the climate scenarios below – firm-level elements for differentiation depending on each firm's: (i) greenhouse gas emissions; (ii) exposure to physical risk events taking into account its geographical location; (iii) characteristics (such as sector and size); and (iv) financial situation at the end of 2020. This analysis is thus characterised by a high level of data granularity.

Scenario analysis exercises and stress tests are important risk analysis tools for the financial system and supervised institutions and are carried out regularly by financial supervisors. In recent years, climate risk assessment has been based on this type of analysis by a number of financial supervisors at European level. Alogoskoufis et al., (2021) developed the first top-down climate stress test for the euro area. This ECB stress test featured an unprecedented level of granular information – in terms of the geographical characterisation of climate-related risks, number of firms and banks included in the exercise – and a 30-year time horizon. The analysis presented in this section broadly follows this stress test's methodological approach.

The climate transition scenarios are not forecasts of the variables' future evolution, but rather plausible projections of their trend under certain assumptions over a very long time horizon (until 2050). Therefore, the results of this exercise are not the Banco de Portugal's forecasts, and no probability is defined for their materialisation.

Given the high degree of uncertainty inherent to projections over such a long time frame (2050), the analysis of the results focuses on the relative differences in impacts between scenarios over time and across sectors, rather than on estimated figures. Thus, this exercise is a long-run cost-benefit analysis of different climate transition scenarios from the perspective of credit risk of the banking system's exposures to NFCs.

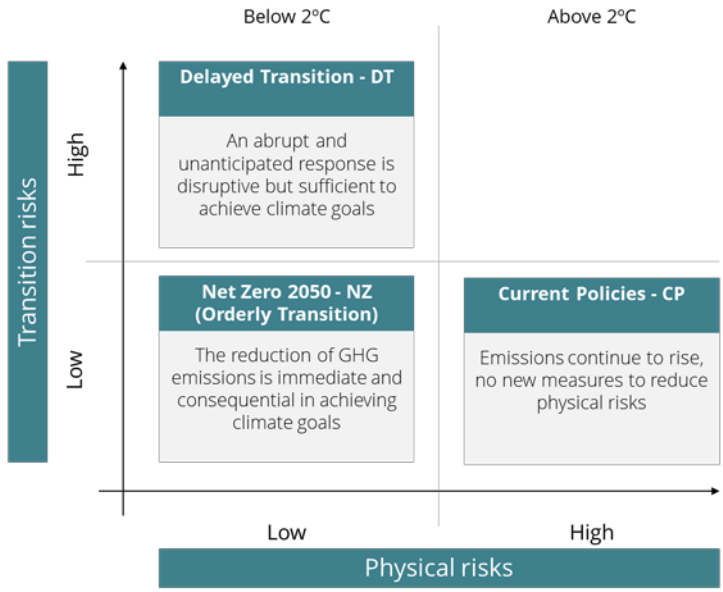
Climate transition scenarios

This analysis considers three of the scenarios developed by the NGFS (Chart 2.19). These scenarios differ from each other insofar as they show differences in climate policies and technological progress, resulting in different pathways to reduce GHG emissions and, consequently, global mean temperature at the end of the century.[45] The simulation exercise uses the NGFS Phase II scenarios published in June 2021.[46] This option ensures time correspondence with the information used for firms' total GHG emissions and additionally enables a comparison with the results obtained in the ECB's top-down stress test (Alogoskoufis et al., 2021).

[45] For the full list and description of the scenarios developed by the NGFS see the NGFS scenarios portal.

[46] The NGFS has disclosed climate scenarios every year since June 2020 (Phase I). The second version of the scenarios, i.e. the one used in this exercise, was published in June 2021 (Phase II). Phase III was published in September 2022.

Chart 2.19 • NGFS climate scenarios



Source: Banco de Portugal and NGFS (2021b), "Climate Scenarios for central banks and supervisors" (adapted).

In the orderly transition scenario "Net Zero 2050", global warming is limited to 1.5°C by 2100 meeting the Paris Agreement (2015) target of limiting the global mean temperature increase to 2°C above pre-industrial levels. This is achieved through climate policies that are introduced immediately (represented by a gradual increase in the price of GHG emissions) and technological progress (adoption of renewable energy and carbon dioxide removal technology), reaching net zero GHG emissions[47] by 2050 (Chart 2.20). Thus, society's adjustment to a low-carbon economy begins in the early 2020s, leading to a reduced materialisation of physical and transition risks.[48]

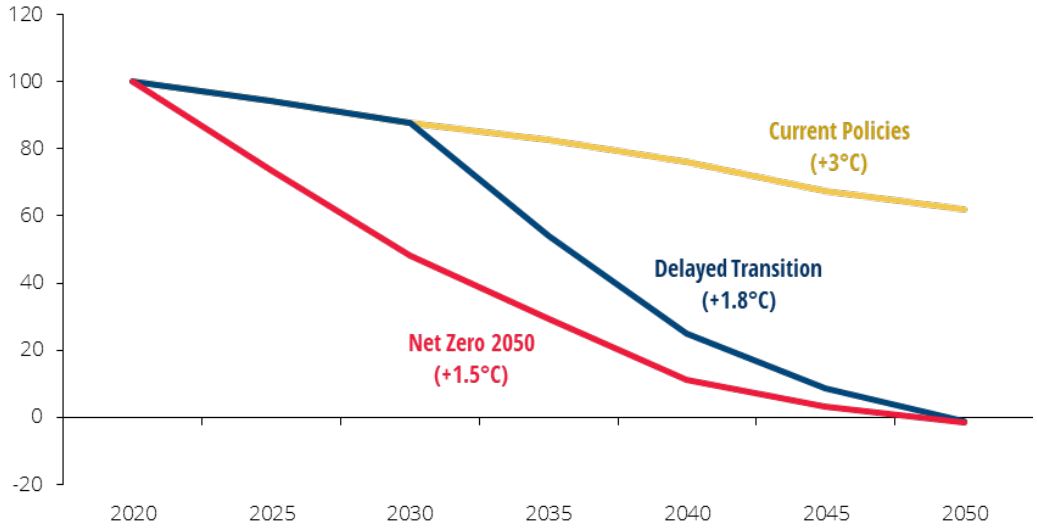
The Delayed Transition scenario assumes climate transition only begins in 2030, which leads to a more abrupt and significant increase in carbon prices and, consequently, in energy prices. This scenario brings higher transition risks to the economy, notably for firms. Postponing the transition also implies a greater global mean temperature increase (+1.8°C), with the resulting higher frequency of physical risks in the long run.

In the Current Policies scenario, no new climate policies are put in place until the end of the century beyond those identified until June 2021 (e.g. the price of GHG emissions remains stable at current levels), leading to a rise in temperature above 2°C (+3°C) and the resulting significant and increasing materialisation of physical risks over time.

[47] 'Net emissions' means GHG emissions released by human activities minus the GHG uptake by natural (e.g. soil, oceans, forests) or artificial sinks (e.g. carbon removal and storage technologies).

[48] On physical and transition climate risks, see Section 1.2 The financial nature of climate-related risks.

Chart 2.20 • Greenhouse gas emissions, projections for the European Union | Index (2020=100)

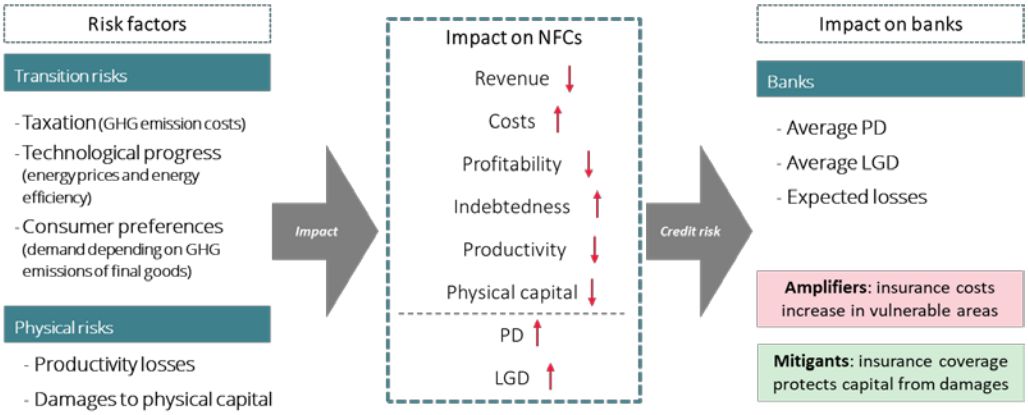


Sources: Banco de Portugal and NGFS calculations. | Notes: Phase II scenarios, NGFS (2021b). The estimated global mean temperature increase at the end of the century from pre-industrial levels is in brackets. The European Union still includes the United Kingdom.

Transmission channels

Climate-related risks are passed on to the banking system through the materialisation of transition risks and physical risks that impact the economic and financial situation of firms and, consequently, the credit quality of banks' exposures. The transmission process described below is firm-specific (micro). This exercise considers shocks to NFCs' profitability and indebtedness, which are reflected in their PDs, LGDs and expected losses (Chart 2.21). The narrative of each climate scenario determines the calibration of the intensity of the shocks considered.

Chart 2.21 • Micro transmission channels between climate-related risks and financial stability



Sources: Banco de Portugal and Alogoskoufis et al. (2021). | Notes: "Profitability" is the ratio of a firm's revenue minus operating costs to total assets. "Indebtedness" is the ratio of a firm's financial debt to total assets.

Transition risks are captured through three channels: (i) taxation, through a tax on each firm's direct GHG emissions; (ii) technology development, i.e. the transition to less polluting energy sources and the impact of such transition on changes in the prices of different energy sources; and (iii) changing consumer preferences, which determine changes in demand depending on the level of GHG emissions associated with the consumption of produced goods. Transition risk shocks affect operating costs (through changes in GHG emission prices and energy costs), revenues (through reduced demand of carbon-intensive goods made by NFCs) and indebtedness (through investment in cleaner technologies turning to financial debt).

With regard to physical risks, their materialisation reduces NFCs' physical capital productivity (chronic physical risks). Productivity losses associated with the increase in mean temperature are used as a starting point to infer the impacts of climate change, reflected in the deterioration of the physical capital of each firm. This shock is calibrated according to the difference between the temperature of the district in which the firm is located and the national mean temperature in 2020, as well as to the firms' exposure to sea level rises. Thus, the deterioration of physical capital at firm level reflects, for each scenario, long-term changes in climate-related patterns.

The impacts related to chronic physical risks are amplified by the expected impacts caused by a number of extreme weather events on NFCs' physical capital (acute physical risks). The materialisation of acute physical risks takes into account the exposure of each firm's location to two types of events: floods and wildfires. The information has been summarised into scores and incorporates the level of exposure to physical risk in relation to its distribution within a global territory, as described in Section 2.1.1. Physical risks have an impact on revenue (which decreases to the extent of the physical capital deterioration, i.e. lower productive capacity), operating costs (increase in assets' insurance premiums), indebtedness (damaged and uninsured assets are replaced by financial debt) and on the value of physical assets provided as collateral for loans.

The two shocks related to insurance coverage seek to capture the insurance sector's amplifying or mitigating role in spreading climate-related financial losses. These two shocks consider a share of insured assets, increasing until 2050 based on historical information on economic losses arising from extreme climate-related events,[49] as well on the narratives of the NGFS scenarios. In particular, the increase in the share of insured assets is assumed to be higher, the greater the physical risk losses associated with each scenario. Thus, insurance premiums tend to increase over time as a larger share of NFCs' assets are insured to protect against more frequent physical risks (amplifying effect). The replacement of damaged and uninsured assets implies an increase in debt, but only in the share of uninsured assets, which decreases over the projection horizon (mitigating effect).

The results presented in the following sections refer to the 50,000 firms with the largest loan exposure in the CCR in December 2021. Loans of firms that are part of economic groups were reallocated depending on the contribution to the group's total sales to reflect the economic relevance of the firms' activity. In December 2021, total loans to these 50,000 firms accounted for 79% of total loans from the resident financial system to NFCs.

Estimates of GHG emissions over the projection horizon and exposure to physical risks are considered at firm level. Estimates of GHG emissions were produced by Urgentem and are

[49] The share of insured assets was calibrated on the basis of historical information on economic losses from climate-related extreme events covered by insurance between 1980 and 2020 for Portugal and other European countries, available at https://www.eea.europa.eu/ims/economic-losses-from-climate-related. The starting point of each scenario is the historical value for Portugal, and the share of insured assets evolves in each scenario to converge towards the EU27 average in Net Zero 2050, the highest value among European countries (Denmark) in Current Policies, and the 75th percentile of all European countries (Switzerland) in Delayed Transition respectively.

consistent with NGFS phase II scenarios.[50] As in Section 2.1.1, information on the potential exposure of firms' location to the materialisation of acute physical risks is based on Moody's COD indicators.

Probability of default

The projection of PDs for non-financial corporations encompasses two sequential steps. First, historical relationships between the one-year PDs and NFCs financial ratios are estimated, as well as equations for developments in NFCs' assets, revenues and operating costs (estimation stage). Second, these accounting variables are projected over a long-term horizon (up to 2050) using the econometric relationships obtained in the first step and the NGFS climate scenarios (projection stage). The materialisation of transition and physical climate risks at firm level results from applying the set of transition and physical risk shocks mentioned above. Finally, projections of the variables make it possible to calculate financial ratios over the same time horizon, and consequently PDs.

The trend evolution of PDs until 2050 depends on projected profitability and indebtedness ratios, calculated from revenue, operating costs and assets projections. In addition to the impact channels referred to in the Transmission channels sub-section, the projection of these variables also takes into account nominal GDP inferred from the NGFS scenarios.[51] The dynamics introduced by the macro-financial variables[52] of NGFS scenarios define the trend of risk parameters in each scenario.

The evolution of real GDP in the Current Policies and Delayed Transition scenarios, compared to the Net Zero 2050, illustrates the economic impacts of not achieving or delaying climate transition.[53] In the Delayed Transition scenario, real GDP could be 7% lower in 2050, compared with Net Zero 2050, owing to abrupt rises in energy costs and increased uncertainty weighing on consumption and investment. In the Current Policies scenario negative impacts on real GDP increase over the course of the century, reflecting productivity losses caused by the increase in global mean temperature.

Probabilities of default under each climate scenario

Projections of NFCs' financial ratios and PDs for the end of the horizon (2050) indicate that in the Net Zero 2050 scenario, the median ROA will be higher and median indebtedness lower than in the other two scenarios**.** As a result, the median PD will be higher in the Delayed Transition or Current Policies scenarios, compared with Net Zero 2050 (Chart 2.22). By 2050, the estimated median PD for the Current Policies scenario exceeds that of the Delayed Transition scenario. These results illustrate the long-term impacts of postponing or not implementing the climate transition process on NFCs' financial situation and credit risk.

[50] Urgentem is a private UK-based firm of the US-based ICE group that provides information on GHG emissions and climate risk analytics to firms. Further details on Urgentem's activity are available at https://www.urgentem.net/.

[51] Nominal GDP projections have been calculated on the basis of the projections of real GDP and inflation estimated by the NGFS.

[52] The trajectory of these variables in each scenario illustrates the different assumptions embedded in the models used to generate them, notably with regard to increased energy efficiency and costs, taxation (e.g. taxes on GHG emissions and use of that revenue), uncertainty and impacts of rising temperatures on productivity. On the different assumptions made in the projections under different scenarios, see "NGFS Climate Scenarios for central banks and supervisors", June 2021.

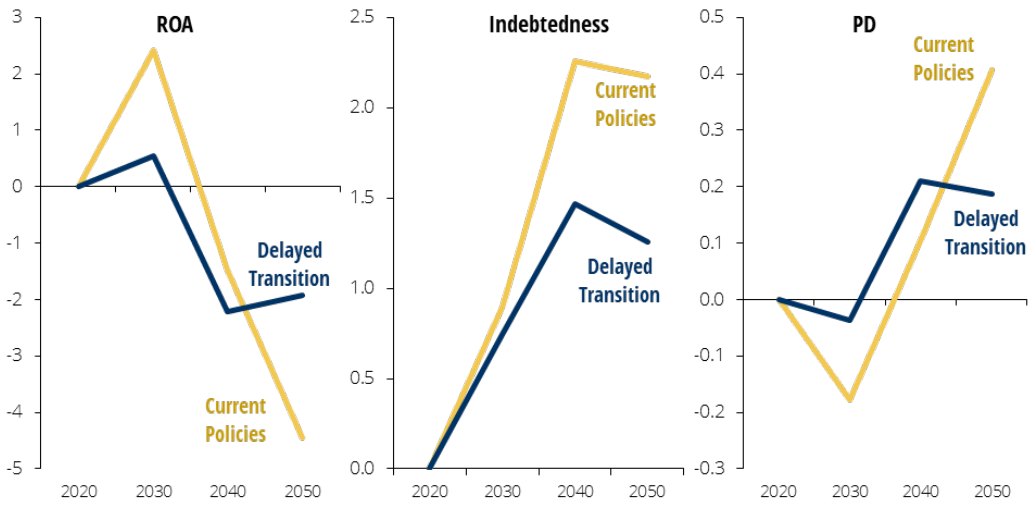
[53] Adão, B. et al., (2022) estimate the impact of climate change on Portuguese GDP using an Integrated Assessment Model (IAM). The authors conclude that an optimal policy design for mitigating the effects of carbon emissions would limit the temperature increase in Portugal by around 0.5°C, implying GDP losses, albeit with net benefits in terms of wellbeing, compared to a policy of doing nothing.

In the short run, i.e. by 2030, higher profitability ratios and lower PDs are projected in the Delayed Transition and Current Policies scenarios, compared with Net Zero 2050, as there are no transition risk shocks in either scenario. These dynamics thus point to the existence of costs related to the start of the climate transition process. However, the costs of an orderly transition, compared with delaying or failing to do so, tend to be temporary at different points and paces in time until 2050, as illustrated by NFCs' financial situation and PDs in the Delayed Transition and Current Policies scenarios.

In the Delayed Transition scenario, the abrupt start of the transition process in 2030 translates into a worsening of NFCs' financial situation, only partially reversed in the following years. The median ROA will remain around 2 p.p. lower than observed in Net Zero 2050 until that year, as a result of the sharp increase in energy and direct GHG emission costs. In addition, consumer preferences for less carbon-intensive products have a negative effect on the revenues of firms in the most polluting sectors. The median indebtedness ratio gradually deviates from that projected for the Net Zero 2050 scenario, reaching 1.3 p.p. higher by 2050, as a result of the moderate materialisation of physical risks. The latter increase corporate debt based on the assumption that the costs of replacing physical capital will be covered by additional debt issuance. From 2030 onwards, the median PD in the Delayed Transition scenario exceeds that observed in Net Zero 2050, with the differential remaining stable at around 0.2 p.p. by 2050.

In Current Policies, the absence of transition policies with a financial impact on NFCs is reflected, by 2030, in favourable developments in the median ROA and in a contained increase in the indebtedness ratio. In the long run, the increase in the risk premium for insured assets puts pressure on NFCs' profitability due to the higher incidence of extreme weather events. In 2050 the median ROA will be 4.4 p.p. below the level observed in the Net Zero 2050 scenario. At the same time, the damage to NFCs' physical capital continues to increase, leading to a significant rise in the median indebtedness ratio from 2030 onwards, which by 2050 will be 2.2 p.p. higher than in Net Zero 2050. The median PD increases continuously over the projection horizon, in line with the gradually increasing impacts of physical risks. In the mid-2030s, the median PD of the Current Policies scenario will exceed that observed in Net Zero 2050, standing 0.4 p.p. higher in 2050.

Chart 2.22 • Median ROA, indebtedness ratio, and PD differences against Net Zero 2050
| Percentage points



Source: Banco de Portugal. | Note: Differences in estimated PDs for the 50,000 firms considered in the projection exercise in the years specified.

These scenarios also make it possible to assess the impacts of transition risks and physical risks on different sectors of the economy. For all scenarios, at the end of the projection horizon, the median PD worsens across all climate-policy-relevant-sectors (CPRS). In Delayed Transition, in the mid-2030s, the Fossil-fuel, Utilities, Transportation and, to a lesser extent, Energy-intensive and Agriculture sectors show a differential from the median PD against the Net Zero 2050 scenario that is higher than the differential for all NFCs (Table 2.6). These sectors are particularly exposed to an abrupt climate transition due to their high levels of direct and indirect GHG emissions and energy intensity.

In the Current Policies scenario, the continuous increase in the deviation of the median PD from Net Zero 2050 is observed across all sectors. By 2050, the Fossil-fuel, Agriculture, Transportation, and Other sectors differ the most from Net Zero 2050, with the highest absolute increases in the median PD compared with 2020.

Table 2.6 • Median PD against Net Zero 2050 by CPRS | Percentage points

Scenario	Year	Fossil-fuel	Agriculture	Utilities	Energy-intensive	Transportation	Buildings	Other	Total
Delayed Transition	2030	-0.99	-0.05	0.16	-0.19	-0.29	0.04	-0.01	-0.04
	2040	1.44	0.24	0.12	0.23	0.51	0.13	0.19	0.21
	2050	0.60	0.26	0.12	0.20	0.30	0.14	0.17	0.19
Current Policies	2030	-1.56	-0.16	0.10	-0.35	-0.56	-0.04	-0.14	-0.18
	2040	-0.24	0.18	0.11	-0.18	0.05	0.18	0.13	0.10
	2050	0.61	0.65	0.27	0.14	0.50	0.40	0.44	0.41
Memorandum items:									
Median PD in 2020		0.7%	1.3%	0.7%	1.0%	1.6%	2.0%	1.3%	1.4%
Share of exposure to NFCs in 2021		3%	3%	5%	13%	15%	20%	41%	100%

Source: Banco de Portugal. | Notes: 'Share of exposure to NFCs in 2021' considers total credit to firms, defined as the sum of loans and debt securities issued by firms and held by credit institutions. Only the differences in estimated PDs for the 50,000 firms included/considered in the projection exercise are reflected.

The projections may display different dynamics depending on the risk factors (transition or physical) to which firms are most exposed. Exposure to transition risks is associated with the level of GHG emissions and energy consumption. In turn, the geographical location of firms' activities determines exposure to physical risks.

Results for firms most exposed to transition risks

Some firms are more exposed to transition risks due to their specific characteristics. For this reason, the firms in the decile corresponding to the highest total carbon intensity are analysed below.[54] This group includes almost the entire Fossil-fuel sector, a quarter of firms of the Energy-

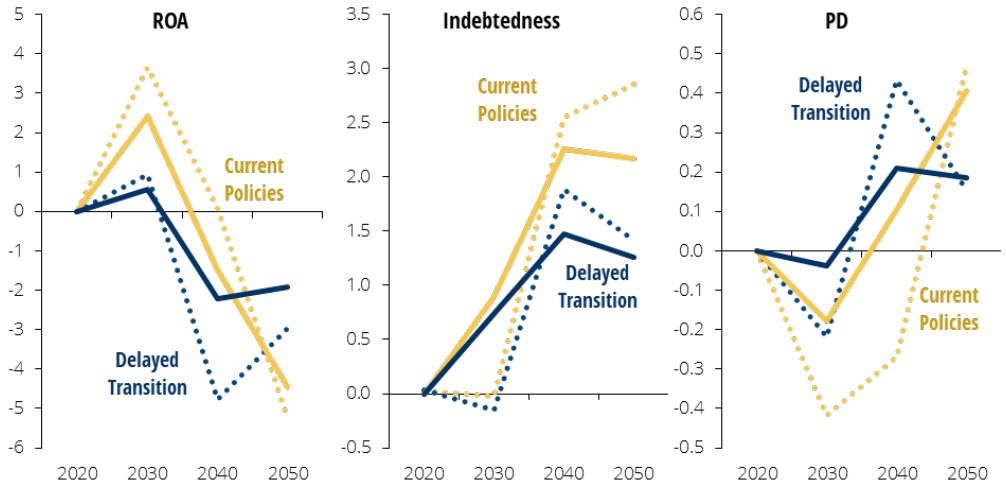
[54] Total direct and indirect GHG emissions per euro of revenue.

intensive sector and a third of Utilities. The banking system's exposure to these firms is significant, accounting for around 19% of total credit granted to NFCs.

These firms record greater increases in the median PD than those observed for the total sample in the Delayed Transition scenario. Compared with Net Zero 2050, the average differential of the median PD of NFCs most exposed to transition risks over the 2030s – during which transition risks are more severe – is 0.4 p.p., which is twice as high as that observed for the total sample in Delayed Transition (Chart 2.23). This reflects more significant changes in the profitability and indebtedness ratios in this group of firms. At the end of the projection horizon, the median PD of the firms most exposed to transition risks comes closer to the median of the total sample.

In the Current Policies scenario, compared with Net Zero 2050, the median PD of the firms most exposed to transition risks is lower than that observed for the total sample until around 2040. This result suggests a relative advantage of these firms in this scenario as they manage to avoid the significant impacts of climate transition related to their high levels of direct and indirect GHG emissions. However, the median PD for this set of firms increases at a higher pace than in the total sample, with the deviation from Net Zero 2050 exceeding that observed in the total sample by 2050. This suggests that even for the most polluting firms, the no climate transition scenario may be less favorable in terms of credit risk in the long run.

Chart 2.23 • Median ROA, indebtedness ratio, and PD differences against Net Zero 2050 for the top 10% carbon-intensive firms | Percentage points



Source: Banco de Portugal. | Notes: Differences in estimated PDs for the 50,000 firms selected for the projection exercise. Carbon intensity corresponds to the ratio of total GHG emissions to revenues. Solid lines correspond to the medians of the total sample of firms and dotted lines correspond to the medians of the sample of top 10% carbon-intensive firms.

Results for firms most exposed to physical risks

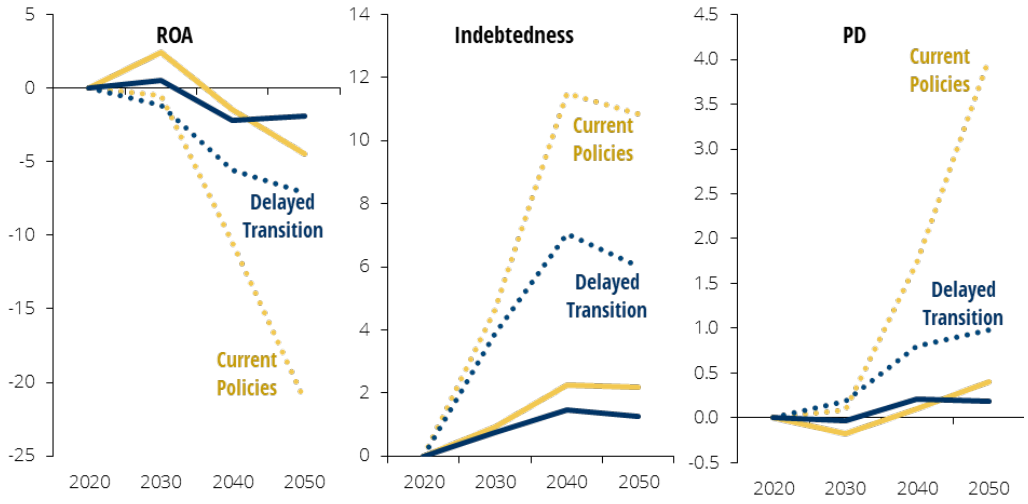
Some firms are more exposed to physical risks due to their specific characteristics. For this reason, the firms in the decile corresponding to the highest level of impact from physical risks are analysed below. Exposure to this group of firms corresponds to 9% of total credit to NFCs.

These firms post increases in the median PD that are significantly larger in the Current Policies and Delayed Transition scenarios than in Net Zero 2050, when compared with the total sample (Chart 2.24). Firms in areas with higher mean temperature increases will tend to experience

greater productivity losses and consequently lower profitability. On the other hand, NFCs most exposed to extreme weather events such as wildfires, floods, or rising sea levels, will incur higher costs with insurance premiums, decreasing profitability, and will have greater needs to replace the damaged capital, increasing indebtedness.

NFCs most exposed to physical risks record a 4 p.p. higher median PD in Current Policies and 1 p.p. higher in Delayed Transition, relative to Net Zero 2050. This result suggests that the climate transition process could, in the long run, be more beneficial for these firms than for the median firm in terms of credit risk. In Delayed Transition, the median PD starts to decline in the early 2040s, suggesting that, even in a late transition scenario, firms most exposed to physical risks may benefit from this process.

Chart 2.24 • Median ROA, indebtedness ratio, and PD differences against Net Zero 2050, in top 10% of physical risk impacts | Percentage points



Source: Banco de Portugal. | Notes: Differences in estimated PDs for the 50,000 firms selected for the projection exercise. Solid lines correspond to the medians of the total sample of firms and dotted lines correspond to the medians of the sample firms in top 10% of physical risk impacts.

Loss given default

LGD calculation over the projection horizon reflects the effect of the physical deterioration of the value of the collateral and changes in the market value of the collateral. The value of the collateral identified for each loan agreement is the starting point for estimating LGDs. Over the projection horizon, the value of each collateral will decrease due to deterioration linked to the materialisation of physical risks, in a manner consistent with that described under Transmission channels, and to the change in its market value. The LGD influenced by climate effects corresponds to the part of the loan amount not covered by the collateral. This LGD estimate is then calibrated by the value of LGDs reported by banks, thus incorporating an estimate of the effective capacity to recover collateral.

These results also refer to the sample of 50,000 firms with the highest loan exposure. LGD at firm level corresponds to the average LGD of the various credit agreements, weighted by the exposure amount of each agreement. In case the firm belongs to an economic group, the estimated LGD shall be the average between the LGD associated with loan agreements identified for that firm and the estimated LGD for the total exposure of the economic group.

Loss given default in each scenario

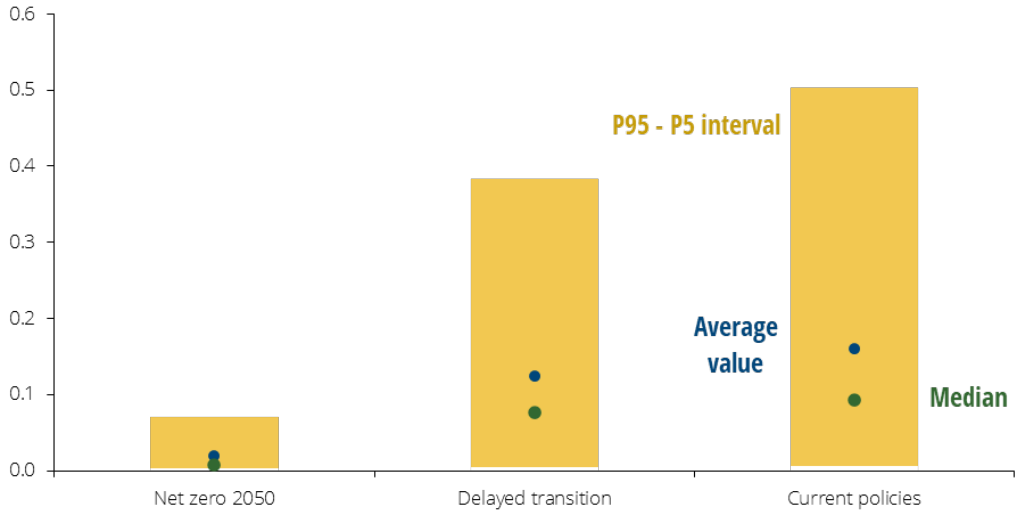
The results obtained indicate that LGDs in 2050 are higher than in 2020, in all three scenarios considered (Chart 2.25): the average increase is 0.02 p.p. in the Net-zero 2050 scenario, 0.12 p.p. in Delayed Transition and 0.16 p.p. in Current Policies (0.07, 0.38 and 0.50 p.p. respectively in the 95th percentile of the distribution).

LGDs in Current Policies and Delayed Transition outweigh LGDs in the Net Zero 2050 scenario over the entire projection horizon. Higher LGDs in those two scenarios compared with Net Zero 2050 reflect the combined effect of the progressive increase in the deterioration of physical goods over the projection horizon, particularly in the Current Policies scenario, and of the developments in collateral value – commercial and residential properties – which is lower in the Current Policies and Delayed Transition scenarios, over the whole projection horizon.

Regarding CPRS, and in view of the evolution of the Net Zero 2050 scenario, the estimated increase in LGD for the Current Policies scenario is most pronounced in the Fossil-fuel and Buildings sectors (Chart 2.26). The least significant increases are associated with the Transportation and Energy-intensive sectors. Differences in the collateral composition of corporate loans and in the impact of the physical collateral deterioration arising from their geographical location – which defines exposure to physical risk – lead to heterogeneity across sectors of activity.

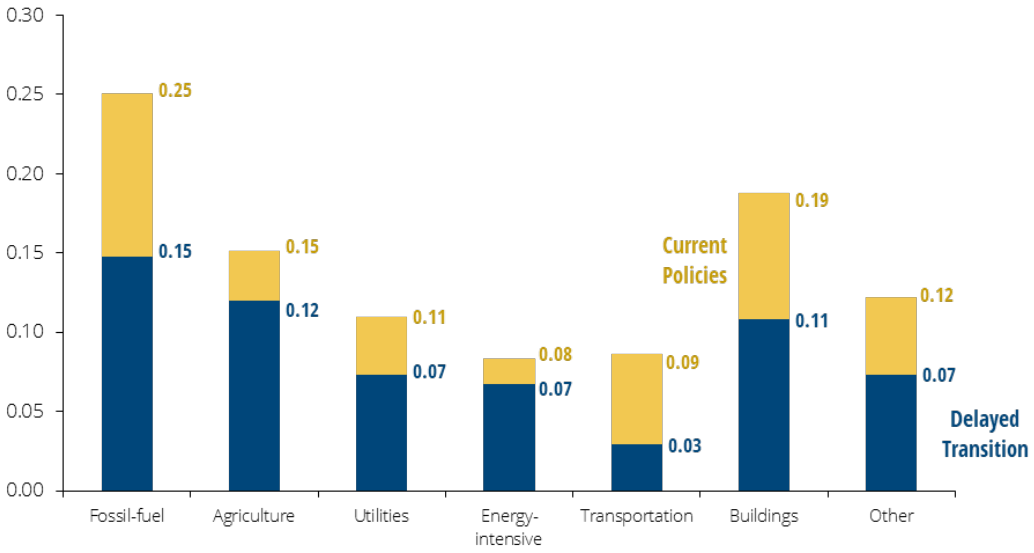
The average increase in estimated LGD for Current Policies outweighs the increase associated with Delayed Transition for all activity sectors. This difference is most significant in the Buildings and Transportation sectors, as opposed to smaller LGD differences between Current Policies and Delayed Transition in the Energy-intensive and Agriculture sectors.

Chart 2.25 • Descriptive statistics of the difference between LGD estimated in each scenario by 2050 and LGD estimated at the starting point | Percentage points



Source: Banco de Portugal. | Notes: Average LGD at firm level was calculated as the average LGD of credit exposures, weighted by the exposure amount of each agreement. Where the firm belongs to an economic group, its average LGD also takes into account the average LGD of the group, reflecting the intra-economic group credit reallocation carried out to define the sample of 50,000 firms considered in this exercise. 'Median' means the median of the differences in firm-level estimated LGDs between 2050 and 2020, 'Average value' means the average of the differences in firm-level estimated LGDs between 2050 and 2020 and 'P95-P5 interval' means the difference between the 95th percentile and the 5th percentile of the distribution of differences in firm-level estimated LGDs between 2050 and 2020.

Chart 2.26 • Median LGD in 2050 against Net Zero 2050 by CPRS | Percentage points



Source: Banco de Portugal. | Notes: The difference between the median of the Delayed Transition scenario and that of Net Zero 2050 by 2050 is represented by the blue bar. The difference between the median of the Current Policies scenario and that of Net Zero 2050 by 2050 is represented by the sum of the blue bar and the yellow bar. Only the differences in estimated LGDs for agreements of the 50,000 firms selected for the projection exercise were considered.

Expected losses

Expected losses on banks' loan exposure

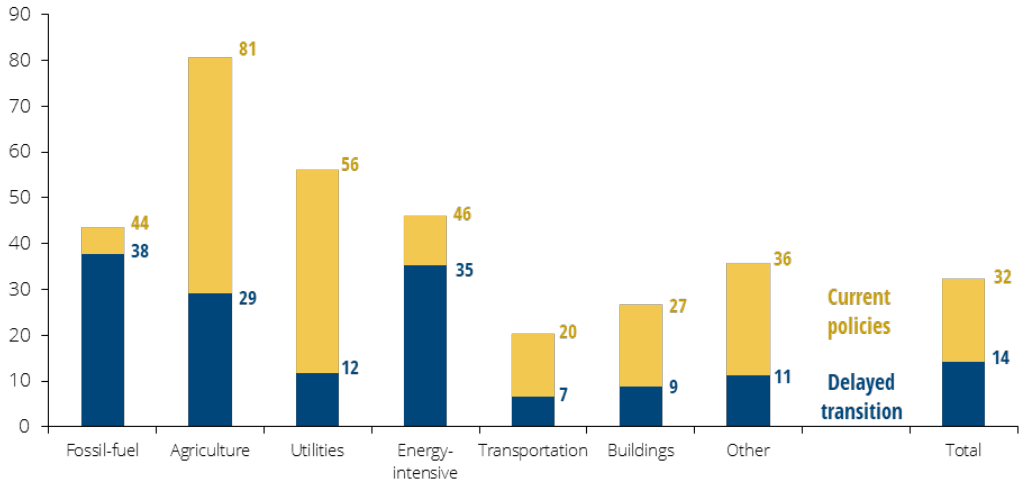
Expected losses on each credit exposure are calculated by multiplying the firm's PD by the LGD and by the amount of that exposure. The results below continue to refer to the sample of 50,000 firms with the highest loan exposure in the CCR.

The projection of the expected losses for credit exposures in the Delayed Transition and Current Policies scenarios by 2050 is 14% and 32% higher than for Net Zero 2050. Expected losses over the projection horizon show that initially – until 2030 in Delayed Transition and until the end of the 2030s in Current Policies – these are greater in Net Zero 2050. From each of those points in time, expected losses in the Net Zero 2050 scenario are smaller. These developments reflect the dominant effect of estimated PDs on expected losses in the three scenarios.

Expected losses projected for 2050 in the Current Policies and Delayed Transition scenarios exceed the corresponding figures for Net Zero 2050 in all activity sectors (Chart 2.27). In the Current Policies scenario, the largest differences from Net Zero 2050 are found in the Agriculture and Utilities sectors. In turn, Delayed Transition shows lower expected losses than the Current Policies scenario across all activity sectors, with less marked differences in the Energy-intensive and Fossil-fuel sectors.

The contribution of each sector of activity to the overall difference in expected losses between Current Policies and Net Zero 2050 depends on that sector's amount of exposure. Energy-intensive, Buildings, Transportation and Other sectors explain most of the difference in expected losses between Current Policies and Net Zero 2050 at the end of the projection horizon.

Chart 2.27 • Increase in expected losses on the loan portfolio by 2050 compared with expected losses in Net Zero 2050 | Per cent



Source: Banco de Portugal. | Notes: Figures weighted by loan amounts. Expected loss defined as the product of the PD and LGD of each of the 50,000 firms with the largest loan exposure in December 2021. The difference between expected losses in Delayed Transition and those in Net Zero 2050, expressed as a percentage deviation from Net Zero 2050, is represented by the blue bar. The difference between expected losses in Current Policies and those in Net Zero 2050, expressed as a percentage deviation from Net Zero 2050, is represented by the sum of the blue bar and the yellow bar.

Expected losses on banks' total exposure

The materialisation of transition and physical risks increases the credit risk of loans, but also of banks' exposures to debt securities – commercial paper and bonds. Some of these securities may be part of the banks' balance sheet without the need for market transactions, reflecting a form of lending somewhat similar to loans.

With reference to the 50,000 firms with the largest loan exposures in the CCR, in December 2021 these securities totalled €10.6 billion, corresponding to 14% of the total exposure of loans and debt securities. The prevalence of debt securities by sector of activity is very heterogeneous, ranging from 3% of total credit granted to the Buildings sector to 64% in the Fossil-fuel sector (Table 2.7). By firm size, the share of debt securities in total credit considered is much higher for large enterprises.

The working assumption was that the debt securities recovery capacity in the event of default would be similar to that of loan exposure, which meant assuming the same average LGD for loans and debt securities.

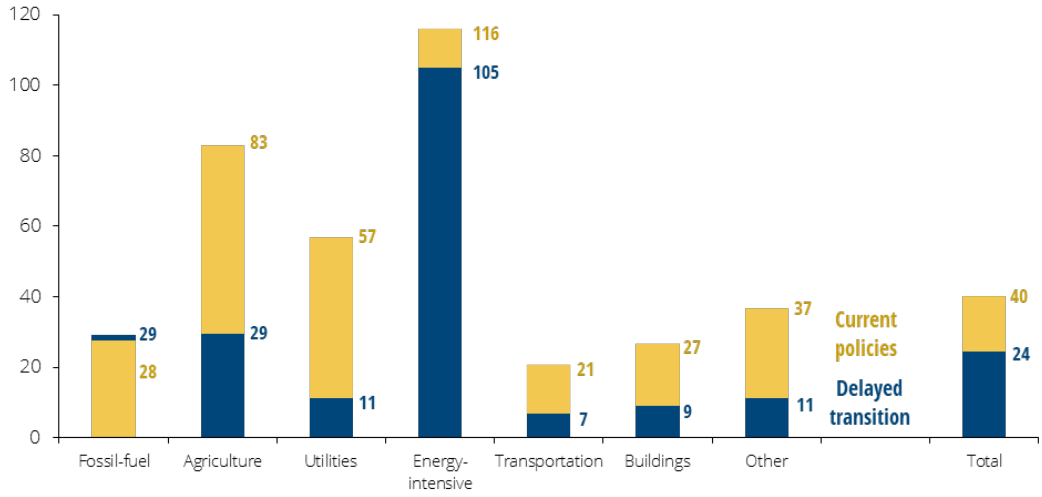
The incorporation of the exposure to corporate debt securities held by banks does not significantly change the results previously reported (Chart 2.28). Nevertheless, there is an increase in expected losses in the Current Policies and Delayed Transition scenarios compared with Net Zero 2050 at the end of the projection horizon. The Energy-intensive and Fossil-fuel sectors contribute more strongly to this increase, albeit for different reasons. In the Energy-intensive sector, the increase reflects a higher average credit risk associated with the securities portfolio. In turn, in the Fossil-fuel sector, securities contribute to a significant increase in the credit exposure considered for this sector.

Table 2.7 • Total credit structure, by CPRS as at December 2021 | Per cent

	Loans	Debt securities
Proportion considering CPRS exposure		
Agriculture	96	4
Buildings	97	3
Energy-intensive	78	22
Fossil-fuel	36	64
Transportation	92	8
Utilities	70	30
Other	85	15
Proportion considering firm size exposure		
Microenterprises	99	1
Small-sized enterprises	98	2
Medium-sized enterprises	91	9
Large enterprises	63	37
Memorandum items:		
Proportion considering total exposure (loans + securities)	86	14

Source: Banco de Portugal. | Notes: Debt securities include commercial paper and bonds issued by NFCs and held by credit institutions as at December 2021. Large enterprises are the size class that holds the highest proportion of debt securities in all sectors of activity.

Chart 2.28 • Increase in expected losses on the loan portfolio in 2050 compared with expected losses in Net Zero 2050 | Per cent



Source: Banco de Portugal. | Notes: Figures weighted by exposure amount, defined as the sum of loans and debt securities in financial institutions' portfolio as at December 2021. Expected loss defined as the product of the PD and LGD of each of the 50,000 firms with the largest loan exposure in December 2021. The difference between expected losses in Delayed Transition and those in Net Zero 2050, expressed as a percentage deviation from Net Zero 2050, is represented by the blue bar. The difference between expected losses in Current Policies and those in Net Zero 2050, expressed as a percentage deviation from Net Zero 2050, is represented by the sum of the blue bar and the yellow bar, with the exception of the Fossil-fuel CPRS where the relationship is reversed.

Comparison with the euro area

A comparison between the results obtained for Portugal and the results obtained by the ECB for the euro area should take several aspects into account. In particular, differences in the economic structure of firms, in the composition of credit exposures, in statistical sources and also methodological differences in the adjustment of the exercise for Portugal should be taken into account.

From a qualitative perspective, the results obtained for Portugal are broadly consistent with those of the ECB economy-wide climate stress test for the euro area (Alogoskoufis, et al., 2021). By 2050, PDs, LGDs and expected losses in the Delayed Transition and Current Policies scenarios are estimated to exceed those of Net Zero 2050. Also, as estimated for the euro area, corporate profitability in the Net Zero 2050 scenario exceeds that of the other scenarios by 2050, while indebtedness is lower. The pathways of these variables over the projection horizon are broadly close to each other in the two exercises. Similarly, the results obtained for Portugal are also qualitatively close to those obtained for the euro area for those firms that are most vulnerable to the materialisation of transition and physical risks.

Moreover, the results obtained in ECB/ESRB (2022)[55] for the difference between expected losses in the Current Policies and Net Zero 2050 scenarios for the euro area banking system as a whole are, at the end of the projection horizon, of similar magnitude to those presented in this report for the Portuguese banking system.

Limitations of the exercise

The projection of climate scenarios involves a significant set of assumptions amid high uncertainty, which greatly increases over horizons as extended as those considered. The NGFS scenarios are a very important milestone in streamlining the assumptions, criteria and time horizon of the impacts of climate change on the economy and financial stability. There are naturally some limitations in the analysis carried out in this report and several challenges for future exercises.

Models portraying the interaction between the economy and the climate system naturally adopt numerous assumptions regarding various aspects such as the levels of GHG concentration in the atmosphere, population and economic activity developments, and the pace and composition of technological innovations needed for the technological transition. Each of these components adds uncertainty about economic developments and has an impact on the multiple variables estimated by the NGFS, such as GDP and energy prices (equilibrium). These assumptions influence the modelling of shocks at firm level, in particular those related to energy costs and GHG emissions. The narrative of each scenario itself – i.e. the description of the dynamics of projected variables and the transmission channels between the physical world and economic activities – determines when the shock to demand for firms' goods and services is manifested as a result of consumer preferences for less carbon-intensive products.

Future exercises may deepen the interaction between developments in economic activity and PDs, LGDs and expected losses, as well as define additional assumptions linked to the transition process. The current version of this exercise incorporates the trend evolution of GDP inferred for each scenario in the estimation of total assets of firms contributing to the estimation of PDs and in the valuation of some asset classes identified as loan collateral. Developments in GDP may additionally contribute to the definition of new assumptions on the evolution of transition scenarios, such as the pace of firms' entry and exit from the market, as a result of the transition process.

[55] See Chart 29, right-hand panel, ECB/ESRB (2022), *The macroprudential challenge of climate change*, Report of the Project Team on Climate Risk Monitoring (July).

In terms of chronic physical risks, shocks in the Current Policies and Net Zero 2050 scenarios have been modelled as losses in economic activity due to productivity shocks computed at different points of global mean temperature distribution. Although these projections do not necessarily correspond to the most likely results in each of the scenarios, they show the trade-off between inaction and mitigation measures that can be implemented to buffer the effects of climate change. Since only one transmission channel between temperature increase and economic activity (productivity) was considered, the impact of chronic physical risks may have been underestimated. In the same vein, the NGFS macro-financial and climate scenarios considered in this exercise do not incorporate potential damage from extreme weather events, only impacts of chronic physical risks. This limitation is in part overcome by the incorporation of acute physical risks (floods and wildfires) using the impact mechanism described in the Transmission channels sub-section.

This exercise incorporated the static balance sheet assumption for banks, i.e. the composition and size of the credit portfolio remains unchanged over the projection horizon. This is a significant limitation, as banks are expected to adjust their exposures to assets that are more sensitive to climate transition or located in geographical areas more exposed to physical risks. This exercise did not incorporate restrictive or relaxing credit standards applied by the banking system to the economy, changes that could contribute to the materialisation of transition scenarios, for example in delivering the necessary investment for the technological transformation of firms' business (Battiston et al., 2021).

Climate change is a potential source of systemic risk with possible consequences for the financial system as a whole (banking and non-banking). Considering banks, insurers, pension funds and different types of investment funds in the same exercise would allow for a more in-depth assessment of the risks to financial stability associated with climate change and the process of transition to a low-carbon economy. Most of the climate scenario simulation exercises developed so far do not include such a complete representation of the financial system.[56]

[56] In March 2023, the European Commission mandated the European Central Bank (ECB), the European Systemic Risk Board (ESRB), the European Banking Authority (EBA), the European Securities and Markets Authority (ESMA) and the European Insurance and Occupational Pensions Authority (EIOPA) to conduct a joint exercise to assess the resilience of the financial sector in line with the "Fit for 55" package. For more details, see https://www.esma.europa.eu/sites/default/files/library/Mandate_for_the_FF55_one-off_exercise.pdf.

3 Microprudential supervisory approach to climate risks

3.1 The Single Supervisory Mechanism

The Single Supervisory Mechanism is the banking supervision system comprising the European Central Bank and the national competent authorities of euro area countries,[57] including the Banco de Portugal. The SSM's objectives are to ensure the safety and soundness of the European banking system, to increase financial integration and stability in Europe, and to ensure consistent supervision, based on the sharing of expertise between the participating authorities and the ECB.

The mandate and tasks of the ECB and national authorities participating in the SSM are set out in (i) Council Regulation (EU) No 1024/2013 of 15 October 2013 conferring specific tasks on the European Central Bank concerning policies relating to the prudential supervision of credit institutions and (ii) Regulation (EU) No 468/2014 of the European Central Bank of 16 April 2014 establishing the framework for cooperation within the SSM between the ECB and national competent authorities and with national designated authorities (SSM Framework Regulation) (ECB/2014/17).

Under the SSM framework, the ECB is responsible for the effective and consistent functioning of the system, also carrying out the tasks linked to the prudential supervision of credit institutions in the euro area, in cooperation with the national supervisors of the participating Member States.

Under the cooperation framework, banks considered significant are subject to direct supervision by the ECB. Less significant institutions are supervised directly by national supervisors, following a decentralised implementation approach to supervisory tasks, which ultimately belong to the ECB,[58] without prejudice to some specific matters remaining under its care.

The SSM Regulation and the SSM Framework Regulation set out the criteria for classifying institutions as "significant" or "less significant". To qualify as significant, banks must fulfil at least one of these criteria: (i) the total value of the bank's assets exceeds €30 billion; (ii) for groups, the total value of the group's assets exceeds €5 billion and the ratio of its cross-border assets/liabilities in more than one other participating Member State to its total assets/liabilities is above 20%; (iii) it is of economic importance for the specific country or the EU economy as a whole; and (iv) it has requested or received funding from the European Stability Mechanism or the European Financial Stability Facility. Even if a supervised entity does not meet any of these criteria, it can still be considered significant if it is one of the three most important institutions in a given participating Member State.

[57] EU countries whose currency is not the euro can participate in the SSM. If they choose to do so, their national supervisors enter into a "close cooperation" with the ECB. This is the case for Bulgaria's NCA, which joined the SSM in July 2020, through a 'close cooperation' with the ECB. Prudential supervision in this jurisdiction under the SSM framework began on 1 October 2020. This was also the case for Croatia's NCA, which became a member of the SSM on 1 January 2023, when it joined the euro.

[58] As recognised by the General Court of the European Union in Case T-122/15, *Landeskreditbank Baden-Württemberg – Förderbank v ECB*, the ECB has been conferred specific tasks relating to the supervision of all credit institutions under the SSM, without prejudice to the decentralised implementation of some of those tasks in relation to less significant credit institutions.

As at 1 March 2023, the entities classified as significant by the SSM covered a total of 110 banking groups, comprising more than 850 banks (including the parent companies and their subsidiaries) and accounting for around 82% of the euro-area banking system's assets.[59] The ECB has full supervisory, investigatory and sanctioning powers[60] over these banks and is also responsible for assessing the suitability of management and supervisory board members.

The list of significant institutions includes the three largest institutions in Portugal: Caixa Geral de Depósitos, Banco Comercial Português and Novo Banco. Domestic subsidiaries of foreign significant institutions, such as Banco BPI and Banco Santander Totta, are also supervised directly by the ECB. At present, 76% of banking activity in Portugal is carried out by institutions that are part of banking groups considered significant and are therefore directly supervised by the ECB.

There are also 24 banks considered less significant in Portugal. The Banco de Portugal is responsible for prudential supervision and has investigatory and sanctioning powers, albeit under the oversight of the ECB, in accordance with the regulations, guidelines or general instructions it addresses to the national competent authorities. Instructions given by the ECB may refer to the specific supervisory powers for groups or categories of credit institutions for the purposes of ensuring the consistency of supervisory outcomes within the SSM. In more serious situations – and when necessary to ensure the consistent application of SSM supervisory standards – the ECB may at any time after consulting the NCAs decide to directly exercise all powers in relation to an LSI.

While the ECB exercises its supervisory powers over significant institutions, this does not dispense with the involvement of the NCAs in the supervisory process. The SSM combines the capabilities of the ECB and those of the national authorities, which perform their tasks in close, intense cooperation.

Each significant bank is supervised by a Joint Supervisory Team (JST), comprising staff of the ECB and the supervisors of the countries in which that bank, its banking subsidiaries or significant branches are established. The JST works under the coordination of a designated ECB staff member who provides guidance, organises and assigns the supervisory tasks and activities in the supervisory work programme for each significant institution. Joint supervisory team members follow the JST coordinator's instructions without prejudice to their tasks and duties with their respective NCA. The JSTs also comprise sub-coordinators designated by each national authority that assist the JST coordinator in organising and coordinating supervisory tasks. The number of staff members appointed to the JSTs by each national authority meet minimum criteria set by the ECB in order to ensure the effort is evenly distributed among the authorities that are part of the SSM. The Banco de Portugal participates – with full cooperation, transparency and independence – in the joint supervisory teams of the significant institutions operating in the Portuguese banking system. The Banco de Portugal contributes with an in-depth knowledge of the institutions operating in the country and with specific knowledge of Portuguese regulations.

The decision-making process within the SSM also involves national supervisors. The Supervisory Board is responsible for planning and carrying out the SSM's supervisory tasks[61] and is composed of a Chair, a Vice-Chair, four ECB representatives and representatives of the national supervisors (usually the director responsible for banking supervision). Each participating Member State has one vote, irrespective of the institutions covered by the decision and the size of its banking system.

[59] https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.listofsupervisedentities202304.en.pdf?1f06b9dc136a8559b82c52e9c3ea97b0

[60] Some sanctioning powers remain within the remit of NCAs but the ECB may request that they exercise them.

[61] The SSM decision-making process is based on a non-objection procedure, where the Supervisory Board submits complete draft decisions for adoption by the Governing Council. If the Governing Council does not object within a maximum period of ten working days the decision is deemed adopted. The Governing Council cannot change complete draft decisions but can only approve or object to them.

Within this framework, all credit institutions in the participating Member States are subject to harmonised supervision, based on common supervisory procedures and methodologies, which are applied consistently.

The ECB's supervisory activities aim to ensure credit institutions comply with prudential rules and regulations issued by the European Parliament and the Council of the European Union, as well as by the European Banking Authority. The ECB may also draw up guidelines applicable to all institutions under its direct supervision, which are approved by the Governing Council following a proposal from the Supervisory Board.

ECB Banking Supervision sets its supervisory priorities annually by drawing on an assessment of the main risks and vulnerabilities to the European banking sector. A set of strategic objectives and a work programme are defined for each of these priorities.

3.2 SSM supervisory strategy for addressing climate-related risks

Climate-related commitments[62] – at both EU and national levels – set transition objectives for the economic model and entail new risks and targets for the financial system. Therefore climate-related and environmental risks[63] have been increasingly integrated into SSM supervisory processes in a close collaboration between the ECB and national supervisors.

Climate-related risks have distinct features from the risk factors usually monitored by the banking system, such as the context of uncertainty involved and the time horizon within which they may materialise. Climate change can affect banking sector stability through physical risks and transition risks. In addition, climate-related risks manifest and amplify the various financial risks – namely credit, operational, liquidity and market risk – and may also entail relevant legal and reputational risks for banks.[64]

The exposure to climate-related and environmental risks and their potential financial impact have been included since 2019 in the SSM risk map, which identifies key risks for the euro area banking system.[65] Climate-related and environmental risks are considered to be of low impact and low probability, as this map displays the risks that inform supervisory priorities in the short to medium term and climate-related and environmental risks are more relevant in the longer term.

Climate-related and environmental risks are one of the three supervisory priorities defined for 2023-2025, specifically aimed at ensuring that banks are addressing emerging risks. The supervisory priorities for 2023-2025 explicitly set the need for supervised institutions to "step up their efforts in addressing climate change",[66] noting that the associated dynamics pose effective risks that should be addressed in the short to medium term.

Thus, the assessment by each supervised institution of the materiality of risks stemming from climate change and environmental degradation, and the consequent definition of concrete mitigation

[62] European Climate Law: https://ec.europa.eu/clima/eu-action/european-green-deal/european-climate-law_en;

[63] The SSM generally uses the term "climate-related and environmental risks" in its publications, for both risk classification and for supervisory expectations, which will therefore be favoured throughout this chapter.

[64] For a more detailed description see Chapter 1 of this Report.

[65] SSM risk map: 2019 - https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ra/ssm.ra2019.en.pdf; 2021 - https://www.bankingsupervision.europa.eu/ecb/pub/ra/html/ssm.ra2021~edbbea1f8f.en.html

[66] SSM supervisory priorities for 2023-2025: https://www.bankingsupervision.europa.eu/banking/priorities/html/ssm.supervisory_priorities202212~3a1e609cf8.pt.html#toc4

actions, is central to the work programme of supervisors and, of course, of the banks themselves. Against this background, and within the scope of the supervisory strategy outlined by the ECB in close collaboration with national supervisors, SSM initiatives in this field have been intensified. In particular, the SSM has sought to ensure that banks develop their processes for identifying, managing and mitigating climate-related and environmental risks in a proactive and continuous manner, and that they publicly disclose meaningful information on the materiality and impact of these risks. Through these initiatives, the SSM aims to increase banks' resilience to climate-related and environmental risks, thereby contributing to the soundness of the European banking sector.

Among the main supervisory initiatives carried out in this area – by the ECB for SIs and the Banco de Portugal for LSIs – are (i) the definition of supervisory expectations on the identification and management of climate-related risks, (ii) assessment and monitoring exercises on the institutions' current practices to evaluate their alignment with those supervisory expectations (including on the disclosure of meaningful information), as well as (iii) stress tests focusing on climate-related and environmental risks. These aspects are further developed in the following sections.

The SSM's supervisory activities have helped to raise awareness among banks of the relevance of this topic and have also contributed to include climate-related and environmental risks in the annual Supervisory Review and Evaluation Process (SREP).[67] In addition to these initiatives, the following are also in the work programme: (i) review of banks' compliance with new ITS reporting and Pillar 3 disclosure requirements related to climate risk; (ii) deep dives on reputational and litigation risk associated with climate-related and environmental strategies and risk profiles for selected banks; (iii) preparatory work for reviews of banks' transition planning capabilities and readiness for environmental, social and governance (ESG) related mandates expected to arise in the sixth Capital Requirements Directive (CRD VI); and (iv) targeted on-site inspections on climate-related aspects.

3.3 Setting supervisory expectations for identifying and managing climate-related risks

In 2020, the ECB set out in its Guide on climate-related and environmental risks[68] that supervised institutions should adopt a strategic, forward-looking and comprehensive approach to identifying and managing the potential impacts of climate-related and environmental risks on the various prudential risk categories (ECB (2020)). This Guide sets 13 supervisory expectations on how the banks under direct ECB supervision should consider climate-related and environmental risks when formulating and implementing their business strategy, governance and risk management frameworks and when disclosing meaningful information (Table 3.1). Despite the various ongoing regulatory initiatives already mentioned in Section 1.3 of this report, the SSM's definition of these expectations is based on the current regulatory framework[69], which determines that material risks must be managed in a prudent and proportionate manner.

The supervisory expectations were published by the ECB in November 2020. Significant institutions are expected to identify concrete initiatives to implement policies and procedures to ensure adequate

[67] As part of the SREP, supervisors regularly assess and measure the risks to which each bank is exposed and require specific actions to address the issues identified. For further details, see https://www.bankingsupervision.europa.eu/about/ssmexplained/html/srep.en.html.

[68] https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.202011finalguideonclimate-relatedandenvironmentalrisks~58213f6564.en.pdf

[69] CRD - Capital Requirements Directive (Directive 2013/36/EU of the European Parliament and of the Council of 26 June 2013); CRR - Capital Requirements Regulation (Regulation (EU) No 575/2013 of the European Parliament and of the Council of 26 June 2013).

management of climate-related and environmental risks in the short to medium term, on the basis of proportionality criteria and of the materiality of these risks they were or might be exposed to.

Supervisory expectations are not binding and no deadline for compliance by significant banks was set at that time. More recently, in November 2022, the ECB set a deadline for all significant institutions' practices to achieve full convergence with supervisory expectations by the end of 2024.

The main concern of financial regulators and supervisors is to ensure that the banking system stands strong against these new challenges and achieves an orderly transition that does not jeopardise the provision of essential financial services to the economy.

Table 3.1 • Supervisory expectations

Area of supervisory expectations	#	Description
Business models and strategy	1	Understand the impact of climate-related and environmental risks on the business environment in the short, medium and long term
	2	Integrate climate-related and environmental risks (in the short, medium or long term) when determining and implementing their business strategy
Governance and risk appetite	3	The management body considers climate-related and environmental risks when developing (I) the overall business strategy, (ii) business objectives and (iii) risk management framework
	4	Explicitly include climate-related and environmental risks in their risk appetite framework
	5	Effectively oversee these risks through a clear assignment of responsibility within the management and supervisory bodies, and within the organisational structure (three lines of defence model)
	6	Establish aggregated internal reporting mechanisms that reflect their exposures to climate-related and environmental risks that facilitate decision-making/management
Risk management	7	Identify and quantify climate-related and environmental risks as drivers of existing risk categories in the risk management framework, to ensure capital adequacy
	8	Credit risk: consider climate-related and environmental risks at all relevant stages of the credit-granting process and to monitor the risks in their portfolios
	9	Operational risk: assess potential adverse impact on business continuity and activities' potential reputational and/or liability risks
	10	Market risk: assess potential impact on market risk positions and future investments (e.g. using stress tests)
	11	Incorporate climate-related and environmental risks into stress tests and sensitivity analyses
	12	Liquidity risk: assess potential net cash outflows or depletion of liquidity buffers
Disclosures	13	Publish meaningful information and key metrics on climate-related and environmental risks material to the institution, with due regard to the European Commission's *Guidelines on non-financial reporting: Supplement on reporting climate-related information*

Sources: Banco de Portugal and ECB.

It is deemed essential by the Banco de Portugal that Portuguese less significant institutions also work to adjust and ensure their sustainability in the transition to a low-carbon economy, taking into account national and European sustainability commitments and targets, as well as the increasing relevance of climate-related and environmental risks to banking activity due to the amplification of the various existing prudential risks.

To ensure a common and consistent treatment of supervised institutions, the Banco de Portugal established that the ECB's supervisory expectations for managing climate-related and environmental risks should be extended to LSIs under its direct supervision, in a manner that is proportionate to the nature, scale and complexity of their activities and risk exposures.

Thus, in April 2021, the Banco de Portugal published Circular Letter No CC/2021/00000010, which established supervisory expectations on the management of climate-related and environmental risks for the less significant institutions under its direct supervision[70] (Banco de Portugal (2021)). The Banco de Portugal stressed the importance of the institutions subject to this Circular Letter duly complying with the ECB guide, which should be followed and applied in the context of existing laws and regulations and in addition to the provisions of the Legal Framework of Credit Institutions and Financial Companies (*Regime Geral das Instituições de Crédito e Sociedades Financeiras*) regarding the management of material risks arising from banking activities. To provide supervised institutions with a transition period, the Circular Letter indicated that these matters would be incorporated in regular supervisory actions from the second quarter of 2022 onwards.

This initiative of the Banco de Portugal took into consideration the recommendation, included in the ECB Guide on climate-related and environmental risks, for national supervisors within the SSM to apply these expectations in their supervision of less significant institutions in a manner that is proportionate.

The publication of the Circular Letter also took into account the EBA communication of December 2019[71], which set out the EBA's action plan until 2025 for addressing environmental, social and governance risks (ESG) and encouraged institutions to act proactively in incorporating these risks into management frameworks and business strategies, despite the fact that the regulatory framework was still under development[72] (EBA (2019)). In line with the Banco de Portugal's actions, several national competent authorities set out supervisory expectations or published guidance on best practices and principles for assessing and mitigating climate-related and environmental risks[73] (NGFS (2021c)).

3.4 Monitoring the degree of implementation of supervisory expectations

In January 2021 the ECB asked significant institutions to conduct a self-assessment of their current practices against the supervisory expectations outlined in the Guide and to draw up implementation plans to overcome the gaps identified.[74] To ensure effective compliance with the expectations, the ECB again assessed banks' proactivity in managing climate risk in January 2022 through various supervisory initiatives. In particular, supervised institutions were asked to conduct

[70] https://www.bportugal.pt/cartacircular/cc202100000010

[71] https://eba.europa.eu/eba-pushes-early-action-sustainable-finance

[72] The mentioned EBA document was replaced by the "Roadmap on sustainable finance" in December 2022, which describes the objectives, timeline and tasks for addressing ESG risks until 2025 (available at https://www.eba.europa.eu/eba-publishes-its-roadmap-sustainable-finance).

[73] The NGFS progress report on the Guide for Supervisors (Table 3) provides examples of supervisory expectations on these issues published by several EU Member States: https://www.ngfs.net/sites/default/files/progress_report_on_the_guide_for_supervisors_0.pdf

[74] Assessment carried out at the highest level of consolidation.

a second self-assessment exercise on their preparedness for dealing with these risks, which was also used to take stock of the progress of previously identified initiatives planned for the short-term. In addition to significant institutions, the second exercise covered, some less significant ones from eight Member States, including Portugal.[75]

These supervisory exercises have reinforced the need for banks to deliver and implement targeted actions to adjust and adapt their practices, taking into account the supervisory expectations. The individual findings – relative to a peer group – were shared with the institutions scoped by the exercise specifying concrete areas for improvement. The outcome of the two supervisory reviews was also published in November 2021 and November 2022[76] (ECB (2021) and ECB (2022b)) and served to identify best practices that have since become benchmarks for institutions within the SSM.

In parallel with the 2022 self-assessment exercise, initiatives focusing on specific areas of supervisory expectations were implemented. An assessment of significant institutions' climate-related and environmental risks disclosures was published in March 2022, and the results of a subsequent review on this topic were released in April 2023 (ECB (2023b)). In the first half of 2022, the ECB carried out a climate risk stress test among significant institutions to assess banks' practices and the impact of physical and transition risks in the short and long term (ECB (2022a)) (Table 3.2). A brief summary of the findings of this exercise is included in section 3.4.1.

In the second half of 2021, the Banco de Portugal asked a sample of less significant institutions to conduct a self-assessment exercise covering the various areas of supervisory expectations. The purpose of this exercise was to assess the alignment between banks' practices and supervisory expectations. A summary of the findings of this exercise is included in section 3.4.2.

Table 3.2 • Key SSM initiatives on climate-related and environmental risks

November 2020	1st half 2021	1st half 2022	2nd half 2022	1st half 2023
Definition of supervisory expectations	Self-assessment exercise #1	Review of disclosures #2	Self-assessment exercise #2	Review of disclosures #3
Review of disclosures #1			Stress tests	

Source: Banco de Portugal.

[75] 107 SIs and 79 LSIs carried out the assessment.

[76] https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.202111guideonclimate-relatedandenvironmentalrisks~4b25454055.en.pdf; https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.thematicreviewcerreport112022~2eb322a79c.en.pdf

3.4.1 Significant institutions

Alignment between banks' practices and supervisory expectations

The ECB's review on the 2021 self-assessment exercise concluded that a very insufficient level of alignment with the supervisory expectations prevailed for most euro area SIs (ECB (2021)). The exercise found 90% of reported practices to be partially or not at all aligned with the ECB's supervisory expectations.

This first exercise served to identify areas for improvement and to highlight good practices. Around half of the banks recognised that climate-related and environmental risks will have a material impact on their risk profiles within the following three to five years, especially in terms of credit, operational and business model risk.

However, the ECB concluded that the assessment of the materiality of these risks presented shortcomings and was not robust. In addition, it was possible to conclude that, in 2021, around half of the banks covered by the exercise were already adapting their governance frameworks to reflect the relevance of climate-related and environmental risks. Following the ECB's assessment, almost all institutions were asked to submit implementation plans to improve their practices. The ECB assessed the quality of these plans to confirm whether they addressed existing gaps in the institutions' practices.

The ECB's 2022 self-assessment exercise (ECB (2022b)) took a more proportionate approach by differentiating the level of detail asked from institutions according to the perceived impact on the various categories of prudential risks. Thus, participation in the exercise's risk-specific modules – addressing credit, market, and operational risk – differed across institutions, taking into account the materiality of these risks for each institution. The ECB also evaluated the progress made on the action plan communicated in the previous year's self-assessment exercise. In addition, besides assessing the alignment of practices for risk identification, measurement and mitigation with the Guide on climate-related and environmental risks, the ECB evaluated complementary dimensions: soundness and scope of the practices adopted (broken down by portfolio and business line), as well as whether risk management policies had actually been implemented.

The materiality of climate-related and environmental risks for the banking system is now acknowledged by most institutions, including in the short to medium term. On the basis of this analysis, the ECB noted some degree of progress compared with the previous exercise, with most institutions adopting some practices in the various areas of supervisory expectations. This means that institutions had already assessed their exposures to these risks, allocated responsibilities to management bodies, set monitoring indicators, created and developed mitigation strategies for some of their exposures.

However, most institutions still fell short in the assessment of materiality of their exposures, in the collection of granular data, in the scope of practices in place and in the effective implementation of the established policies and procedures. The ECB acknowledged the prevailing challenges regarding data and methodologies that may limit the implementation of SSM supervisory expectations. Finally, the ECB considered that institutions should adopt a strategic approach and focus their efforts on implementing targeted measures to overcome the shortcomings identified.

The ECB defined end-2024 as the cut-off date for fully aligning institutions' practices with supervisory expectations and some intermediate milestones were set. In this context, the ECB decided to step up its supervisory actions to monitor and ensure effective compliance with the supervisory expectations.

Following the 2022 self-assessment exercise, and as published by the ECB, binding qualitative requirements were established for around 30 institutions, due to the identification of severe

shortcomings.[77] In addition, and also considering the results of the stress test (discussed below), the SREP scores of a very small number of banks were adjusted. According to the ECB, the SREP will progressively factor in the assessment of compliance with supervisory expectations – both qualitatively and quantitatively –, where appropriate, from 2023 onwards.

Assessments of compliance with supervisory expectations permit banks to receive specific feedback on the areas and issues requiring further attention, as well as information on each bank's assessment against its peer group. To promote effective and comprehensive implementation of these expectations, the ECB published, in parallel with the results of the 2022 self-assessment exercise, a compendium of good practices identified in around a quarter of the significant institutions that participated in the exercise[78] (ECB (2022c)).

Portuguese significant institutions participated in both exercises, either directly or as part of the banking group to which they belong. There was some heterogeneity in the results obtained by the various Portuguese institutions, in line with what was generally observed for SIs. Overall, the results for Portuguese banks suggest that they are progressively factoring-in climate-related and environmental risks and considering them in their business, in particular with regard to priority areas such as internal governance and operational risk management. Positive developments between the two exercises were also noted, with some of these institutions already implementing measures that come close to the SSM's supervisory expectations. Gaps still persist in some cases and the need to pursue a strategy to adapt and mitigate these risks should be reinforced.

Disclosure of meaningful information

Requirements for climate-related and environmental risk disclosures by financial institutions and non-financial corporations have become stricter, with the adoption of minimum mandatory disclosure requirements based on harmonised reporting standards over the coming years, as already described in Chapter 1.

In April 2023 the ECB published the results of the third assessment of significant institutions' climate-related disclosure practices and level of compliance with supervisory expectations in this area (ECB 2023b).[79] The assessment showed that the disclosure of climate-related information has improved substantially over recent years in terms of quantity, but still lacks substance.

While 75% of institutions disclose metrics and indicators on climate-related and environmental risks, increasing from around 50% in the previous year, less than half of the banks provide adequate information. Most institutions cannot substantiate their statements regarding their climate-related and environmental risk management policies. This will require a significant effort from banks to comply with the forthcoming Pillar 3 reporting obligations on ESG matters[80] that will soon enter into force.

The analysis also revealed that most of the less significant institutions that participated in the exercise do not disclose relevant information on these risks, with 80% of these disclosures being deemed inadequate. This report includes, as did the above-mentioned thematic review, the identification of the best practices observed in the supervised banks.

[77] In 2021, following the first assessment of significant institutions' practices and plans, qualitative SREP requirements were issued for those institutions that had not taken measures, or expected to do so, to implement supervisory expectations.

[78] https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.thematicreviewcercompendiumgoodpractices112022~b474fb8ed0.en.pdf

[79] The ECB considered publicly available information by 104 SIs and 28 LSIs, with a reference date of end-2021. https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.theimportanceofbeingtransparent042023~1f0f816b85.en.pdf

[80] https://www.eba.europa.eu/eba-publishes-binding-standards-pillar-3-disclosures-esg-risks

As in the 2022 thematic review and stress test, Portuguese significant institutions also participated in this exercise. The results of the analysis for some of these institutions are in line with those of the other SIs, despite some heterogeneity.

Stress tests

In the first half of 2021, the ECB conducted a top-down climate risk stress test[81] (Alogoskoufis *et al.*, (2021)). In the first half of 2022, the ECB carried out a bottom-up stress test on climate-related risks, in which most significant banks participated[82] (ECB (2022a)).

The bottom-up exercise was designed as a learning exercise for both banks and supervisors. Thus, in the ECB's view, this exercise was important for assessing the ability of institutions to carry out these analyses under appropriate conditions, and also for assessing its results. This exercise was developed to strengthen the methodological framework and the availability of data to assess these risks' financial impact, and thus had no impact on capital requirements.

The analysis served primarily to assess the status quo and obtain both qualitative and quantitative information to assess the level of preparedness of the banking sector for identifying and managing climate-related risks and their financial impacts. The key findings indicate that: (i) most banks do not yet include climate-related risks in their stress-testing frameworks and internal models, failing to meet supervisory expectations; (ii) climate risks are relevant for the vast majority of significant institutions, which generate non-negligible revenues from activities related to greenhouse gas (GHG)-emitting industries; and that (iii) expected losses in the long term (30 years) are projected to be notably low under all three climate-scenarios considered. The ECB concluded that these estimates may be underestimating actual risk, as the scenarios used were not adverse, as would be the norm in stress testing exercises.

In addition, the ECB acknowledges that data gaps and the need to strengthen the climate risk assessment framework – e.g. long-term horizons, non-linearities, high uncertainty and lack of historical evidence of losses – as well as the fact that the regulatory framework is still under development, stand out as important challenges that limit the robustness of results. Indeed, to overcome the lack of granular data for assessing the relevance and financial impact of climate-related risks, most banks made extensive use of proxies (alternative indicators and estimates) instead of real counterparty data to measure counterparty GHG emissions and energy performance certificates for housing collateral.

Fit and proper assessment of members of the management and supervisory bodies

One of the requirements for assessing the suitability of members of the management and supervisory bodies and key function holders is the knowledge and professional experience of applicants. The assessment is conducted both individually and collectively considering the composition of the body, as set out in Article 91 of the CRD, which was transposed into national law by Articles 30 et seq. of the Legal Framework of Credit Institutions and Financial Companies.

Within this assessment, the applicant's knowledge of ESG issues, as well as that of the body as a whole, has gained prominence. The arrangements to be made by the institution, if needed, to improve the body's knowledge of climate and environmental matters, for better collective decision-making, are also assessed.

[81] https://www.ecb.europa.eu/pub/pdf/scpops/ecb.op281~05a7735b1c.en.pdf

[82] https://www.bankingsupervision.europa.eu/press/pr/date/2022/html/ssm.pr220708~565c38d18a.en.html

The ECB and the NCAs have taken joint action to standardise the collection of information on applicants to management and supervisory bodies and, where applicable, key function holders in all countries that participate in the SSM. A new questionnaire was therefore developed in 2022 with a view to collecting specific information on knowledge and experience in the area of climate-related and environmental risks, inter alia. This provides for a more rigorous assessment of applicants' eligibility and professional experience considering these risks and areas of expertise, and as part of the collective assessment of the bodies during fit and proper assessments for significant institutions.

Against this background, in 2022 the Banco de Portugal included a new data collection questionnaire in the fit and proper process to assess the suitability of the members of management and supervisory bodies of significant institutions (Instruction of the Banco de Portugal No 15/2022).

This questionnaire is in line with joint ESMA and EBA Guidelines on the assessment of the suitability of members of the management body and key function holders (EBA/GL/2021/06), giving the supervisor a deeper understanding of how corporate bodies stand in this area, and promoting improvement of the skills of the relevant corporate bodies, as institutions are responsible for presenting the necessary mitigants and the measures they intend to take to address these shortcomings, where knowledge is deemed inadequate.

3.4.2 Less significant institutions

Alignment between banks' practices and supervisory expectations

In the second half of 2021, following the publication of Circular Letter No CC/2021/00000010 in April 2021, the Banco de Portugal requested a sample of institutions under its direct supervision to identify (i) practices for managing climate-related and environmental risks and areas where progress would be most needed, based on supervisory expectations set by the Banco de Portugal, and (ii) ongoing or planned actions to meet these expectations. These institutions accounted for around 95% of the total assets of the 24 domestic less significant institutions, as at 31 December 2021. This sample was selected following the principle of proportionality, taking into account the institutions' size and potential exposure to climate-related and environmental risks, as well as their business model.

The self-assessment exercise covered the various areas of supervisory expectations and the institutions' views on how banking operations could be affected by climate-related and environmental risks, both physical and transition risks, as well as on their materiality due to the specific nature of each business model.

The main findings of this self-assessment exercise indicated that less significant institutions generally found climate-related and environmental risks relevant, largely because of the need to adapt to changes in the regulatory framework (notably the ongoing initiatives of the European Commission and the EBA referred to in Chapter 1 of this report). Around half of the institutions covered by the exercise carried out preliminary initiatives to assess the materiality of these risk factors (Charts I.3.1 and I.3.2). The remaining institutions were aware of these new dynamics and their potential relevance, and most of these had taken some initiatives to assess materiality.

Chart 3.1 • Percentage of institutions assessing the materiality of climate-related and environmental risks

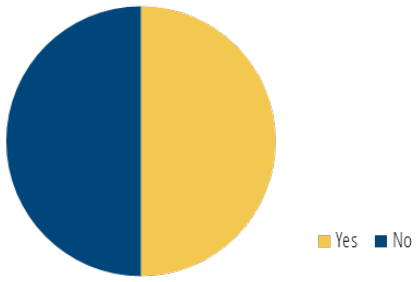
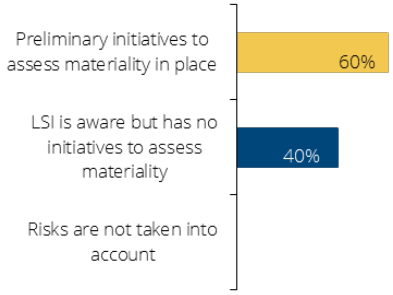


Chart 3.2 • When materiality is not assessed, what are LSIs doing?



Source: Banco de Portugal, based on the responses of the LSIs participating in the self-assessment exercise on climate-related and environmental risks. | Note: Chart 3.2. indicates the percentage of institutions that began taking climate-related and environmental risks into consideration and how they did so, despite not assessing their materiality.

Institutions also view changes to their business environment and the potential financial impacts of climate change and transition economic policies as being able to generate new business development opportunities, linked primarily to transition economic policies and the emergence of new technologies. The recognition of potential opportunities connected to the ongoing transition may provide an important incentive for institutions to act proactively, and institutions that do so swiftly may gain a competitive advantage (Chart 3.3).

Chart 3.3 • Factors generating opportunities

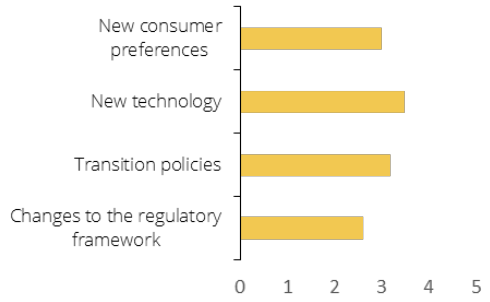
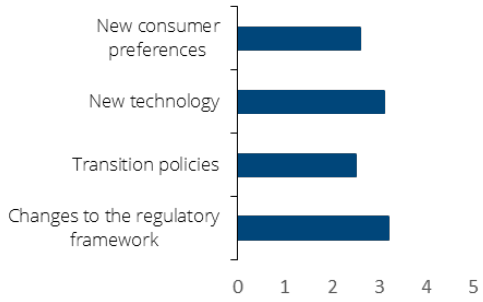


Chart 3.4 • Factors generating risks



Source: Banco de Portugal, based on the responses of the LSIs participating in the self-assessment exercise on climate-related and environmental risks. | Note: The score ranges from 0 to 5, where 0 is the least relevant and 5 the most relevant.

An analysis of the relevance of these risks to institutions shows that it was also a priority for less significant institutions (Chart 3.4), in particular, the need to define a more appropriate internal governance structure, granular monitoring metrics and the compilation of relevant data on a regular basis. **Where institutions had already conducted an assessment of the impact of climate-related and environmental risks, such assessments were found to be poor, less detailed and substantiated than those performed by significant institutions.**

Overall, less significant institutions deemed transition risks to be more relevant than physical risks in relative terms. In addition, the impact of transition risks was perceived by institutions as likely to occur in the short term, prior to the materialisation of physical risks.

Institutions' key concerns regarding transition risks – risks related to uncertainty about the path and speed of adjustment towards a sustainable low-carbon economy – focused on the impact of new regulations, the emergence of new technologies and expected changes in the preferences of economic agents.

At the time of the self-assessment exercise, institutions considered that the greatest impact of transition risks could, in the short term, occur in prudential risk categories related to credit, business model, operational and reputational risks (Charts I.3.5 to I.3.9). For credit risk, the materiality of impacts is thought to be significant also in the long run. By contrast, impacts on liquidity and market risks are perceived to be relatively less material.

Impact of transition risks on the various categories of prudential risk

Chart 3.5 • Credit risk

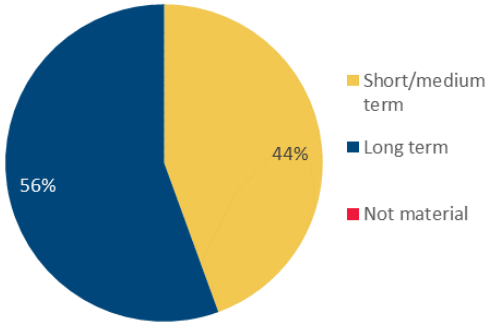


Chart 3.6 • Market risk

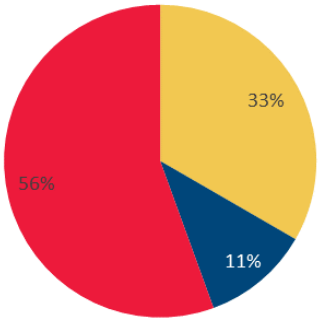


Chart 3.7 • Liquidity risk

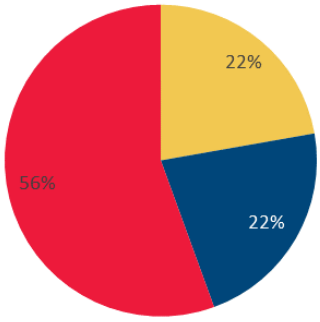


Chart 3.8 • Operational and/or reputational risk

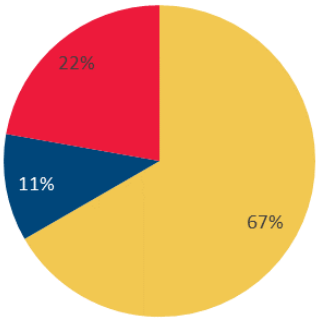
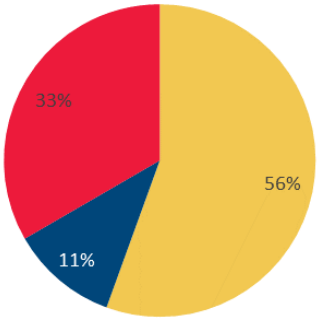


Chart 3.9 • Business model risk

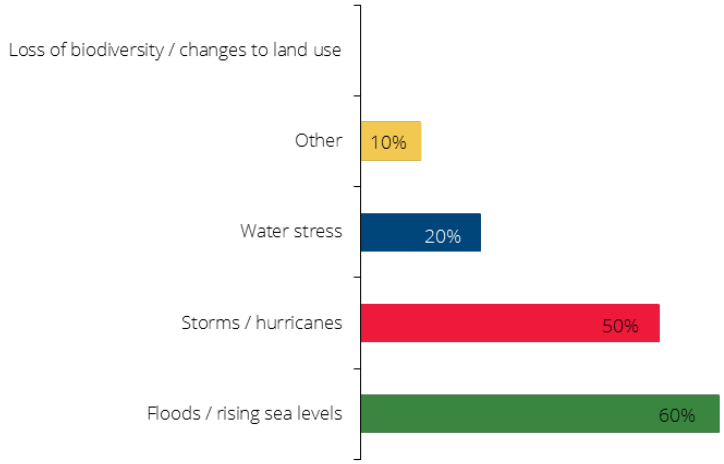


Source: Banco de Portugal, based on the responses of the LSIs participating in the self-assessment exercise on climate-related and environmental risks. | Note: Short/Medium term: < 5 years. Long term: > 5 years.

With regard to **physical risks** – which constitute the risks associated with more frequent and more severe natural disasters or with climate change-induced long-term effects – **climate events that give rise to greater concerns for the institutions included in the exercise are related to rising sea levels and to extreme events such as floods, storms and hurricanes** (Chart 3.10). **Although Portugal**

is particularly exposed to the impact of droughts, extreme heat and water stress, only a small number of institutions highlighted these phenomena as relevant.

Chart 3.10 • Climate-related factors generating physical risk



Source: Banco de Portugal, based on the responses of the LSIs participating in the self-assessment exercise on climate-related and environmental risks. | Note: Percentage of institutions that considers a given climate-related factor generating physical risk to be relevant.

Institutions consider that these physical risks will tend to manifest themselves in the medium to longer term, although most recent data suggests that the impact of these risks is already visible. Credit, business model, operational and reputational risks continue to be the most affected categories of prudential risk (Charts I.3.11 to I.3.15).

Impact of physical risks on the various categories of prudential risk

Chart 3.11 • Credit risk

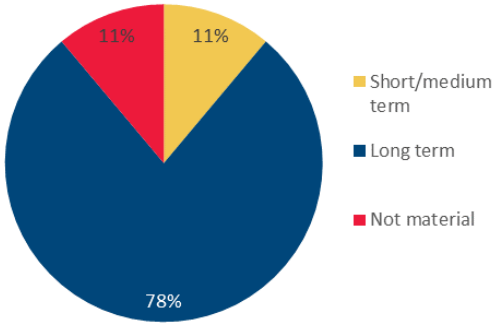


Chart 3.12 • Market risk

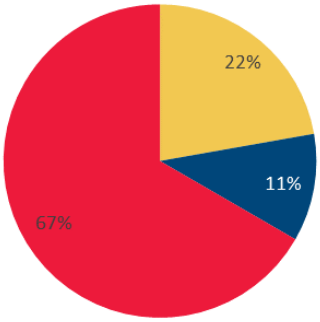


Chart 3.13 • Liquidity risk

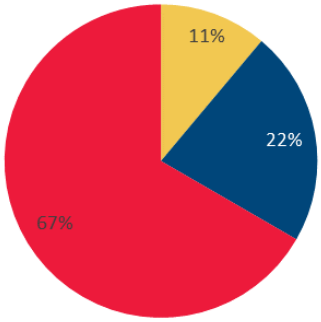


Chart 3.14 • Operational and/or reputational risk

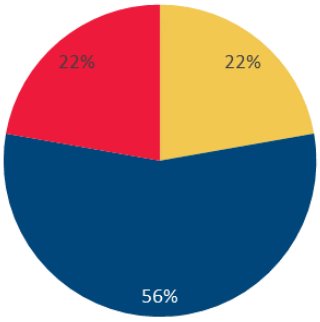
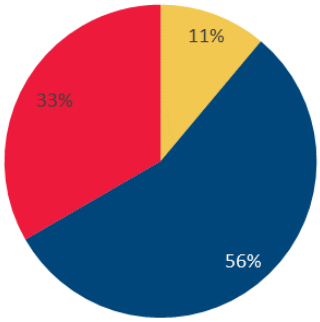


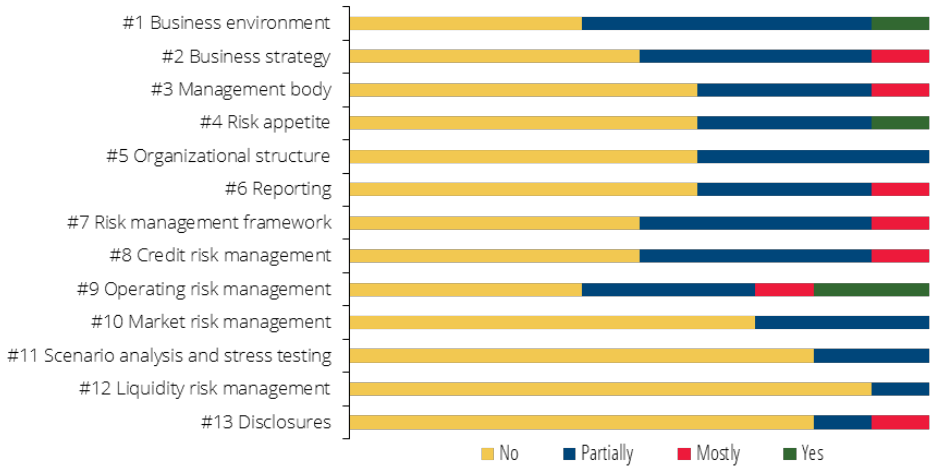
Chart 3.15 • Business model risk



Source: Banco de Portugal, based on the responses of the LSIs participating in the self-assessment exercise on climate-related and environmental risks. | Note: Short/Medium term: < 5 years. Long term: > 5 years.

Banks have initiated the process of assessing the materiality of climate-related and environmental risks, and have started to work towards defining action plans to meet supervisory expectations. **The gaps between risk identification and management practices and supervisory expectations, according to the information reported, are still significant for most institutions, including in foundational areas, related to materiality analysis, internal governance and reporting** (Chart 3.16).

Chart 3.16 • Level of alignment between institutions' current practices and supervisory expectations by area of supervisory expectations



Source: Banco de Portugal, based on the responses of the LSIs participating in the self-assessment exercise on climate-related and environmental risks.

Most less significant institutions have ongoing and/or planned initiatives for the short to medium term in all areas of supervisory expectations(Charts I.3.17 to I.3.21). **However, these initiatives need to be deepened and detailed**, as regards the necessary steps, allocated resources and implementation deadlines, in order to ensure their effective implementation or adjustment if necessary.

Chart 3.17 • Ongoing and/or planned initiatives – total

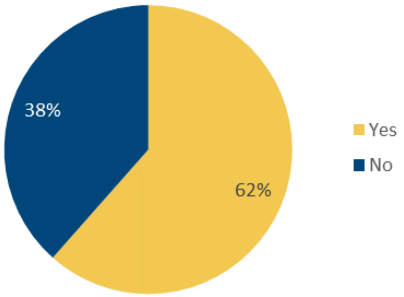


Chart 3.18 • Business models and strategy

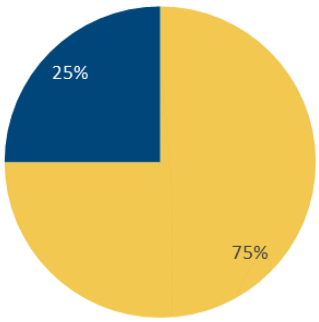


Chart 3.19 • Internal Governance and risk appetite

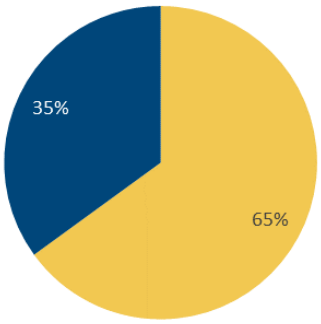


Chart 3.20 • Risk management

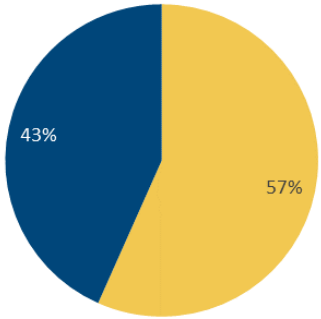
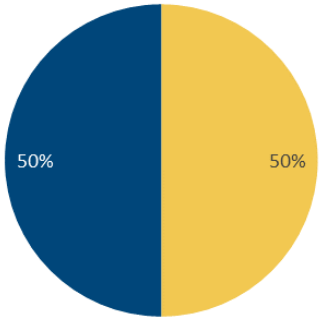


Chart 3.21 • Disclosures



Source: Banco de Portugal, based on the responses of the LSIs participating in the self-assessment exercise on climate-related and environmental risks.

The conclusions of the Banco de Portugal's analysis of the self-assessment exercise were communicated to the participating less significant institutions, with priority areas and potential concrete actions pinpointed.

Compared with the 2022 ECB self-assessment exercise, the Banco de Portugal found that **the level of progress of smaller banks is more limited than that of significant banks, and there is also greater dispersion across results – in relative terms and against significant institutions.** However, in some cases, a significant level of alignment with supervisory expectations could be observed, notably with regard to the institutions' business lines covered by the climate-related and environmental risk management policies, which may be due to smaller banks' business models being relatively less complex.

In November 2022, the Banco de Portugal held a meeting with Portuguese banks and the Portuguese Banking Association where it reiterated the importance of climate-related risks for the Portuguese banking system and shared the main findings of the self-assessment exercise for less significant institutions. This initiative aimed to step up the supervisory dialogue on these matters. It also aimed to share the main relevant regulatory and supervisory initiatives within the SSM, including the definition of the ECB's supervisory priorities establishing that significant institutions' practices must achieve full alignment with expectations by the end of 2024. The session also allowed for a discussion of the current concerns of the banking system and possible means of mitigating and overcoming some of the common challenges that institutions face in meeting supervisory expectations.

The Banco de Portugal also informed the institutions at this session of its intention to carry out a new self-assessment exercise in 2023 on the institutions' practices and action plans, with a broader sample of institutions. This second exercise will focus on the various areas of supervisory expectations, namely those related to the public disclosure of relevant information.

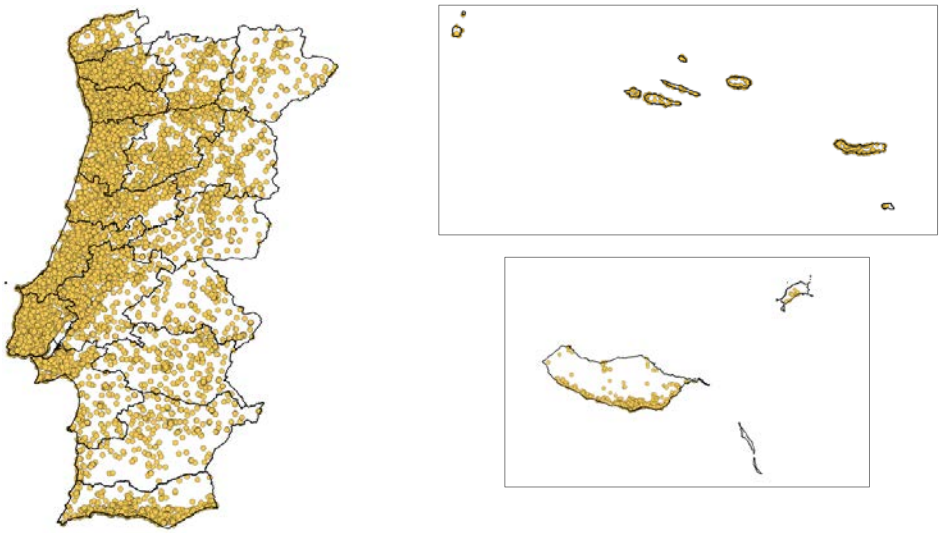
In line with the ECB's timelines for significant institutions, less significant institutions operating in Portugal are also expected to effectively converge with supervisory expectations by the end of 2024. Accordingly and in line with ECB guidance for SIs, the Banco de Portugal will, where appropriate, progressively incorporate compliance with supervisory expectations into the SREP assessment.

Fit and proper assessment of members of the management and supervisory bodies

With regard to LSIs fit and proper assessments, the Banco de Portugal is pondering the need to amend Instruction of the Banco de Portugal No 23/2018, in order to align it with the more detailed questionnaire applied to significant institutions and the joint ESMA and EBA guidelines referred to above (see Chapter 3.4.1). Regardless, the assessment of the eligibility and experience requirement for applicants and bodies as a whole includes the assessment of their knowledge of ESG matters. The arrangements being made by the institution, where needed, to improve the body´s knowledge of climate and environmental matters and thus ensure a better collective decision-making, are already assessed.

Annexes

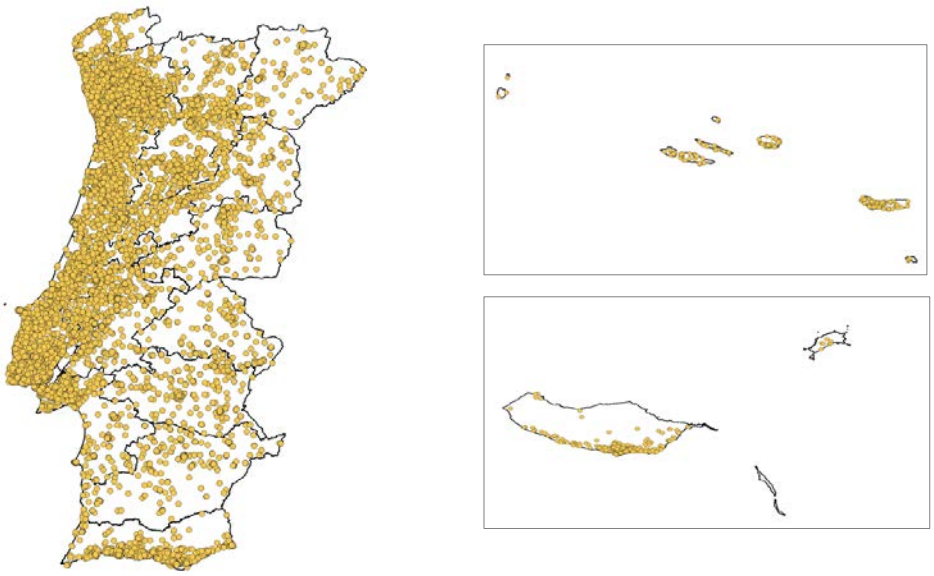
Chart 1 • Identification of enterprise location



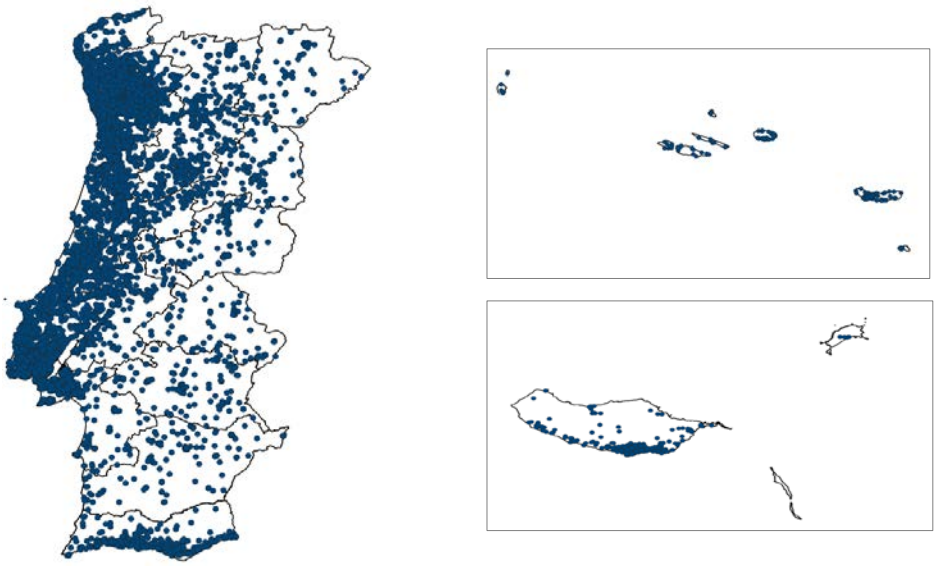
Sources: Banco de Portugal and Moody's Climate on Demand. | Notes: Each point corresponds to the location of an enterprise's head office. For mainland Portugal, the lines correspond to the districts. To help visualise and interpret the results for the Azores and Madeira archipelagos, smaller scales were used compared to the territory of mainland Portugal.

Chart 2 • Enterprise location by size class

(a) Microenterprises



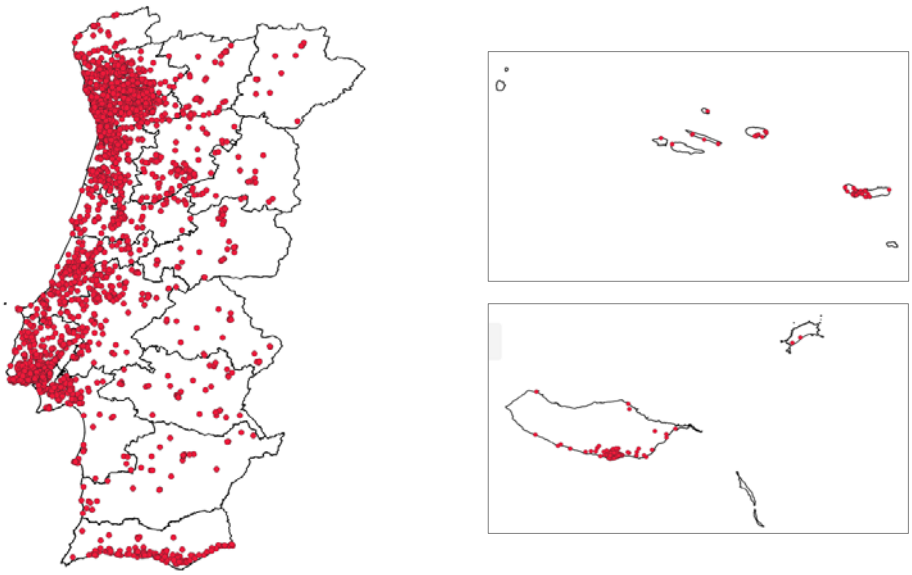
(b) Small-sized enterprises



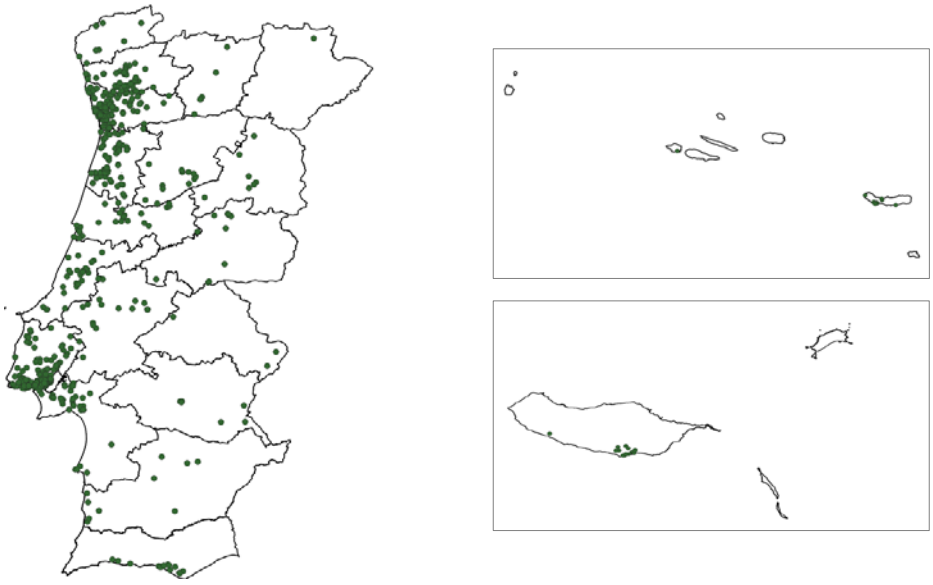
Sources: Banco de Portugal and Moody's Climate on Demand. | Notes: Each point corresponds to the location of an enterprise's head office. For mainland Portugal, the lines correspond to the districts. To help visualise and interpret the results for the Azores and Madeira archipelagos, smaller scales were used compared to the territory of mainland Portugal. The definition of size classes follows the criteria of Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises; enterprises that do not fall under the previous categories are classified as "large enterprises".

Chart 3 • Enterprise location by size class

(a) Medium-sized enterprises

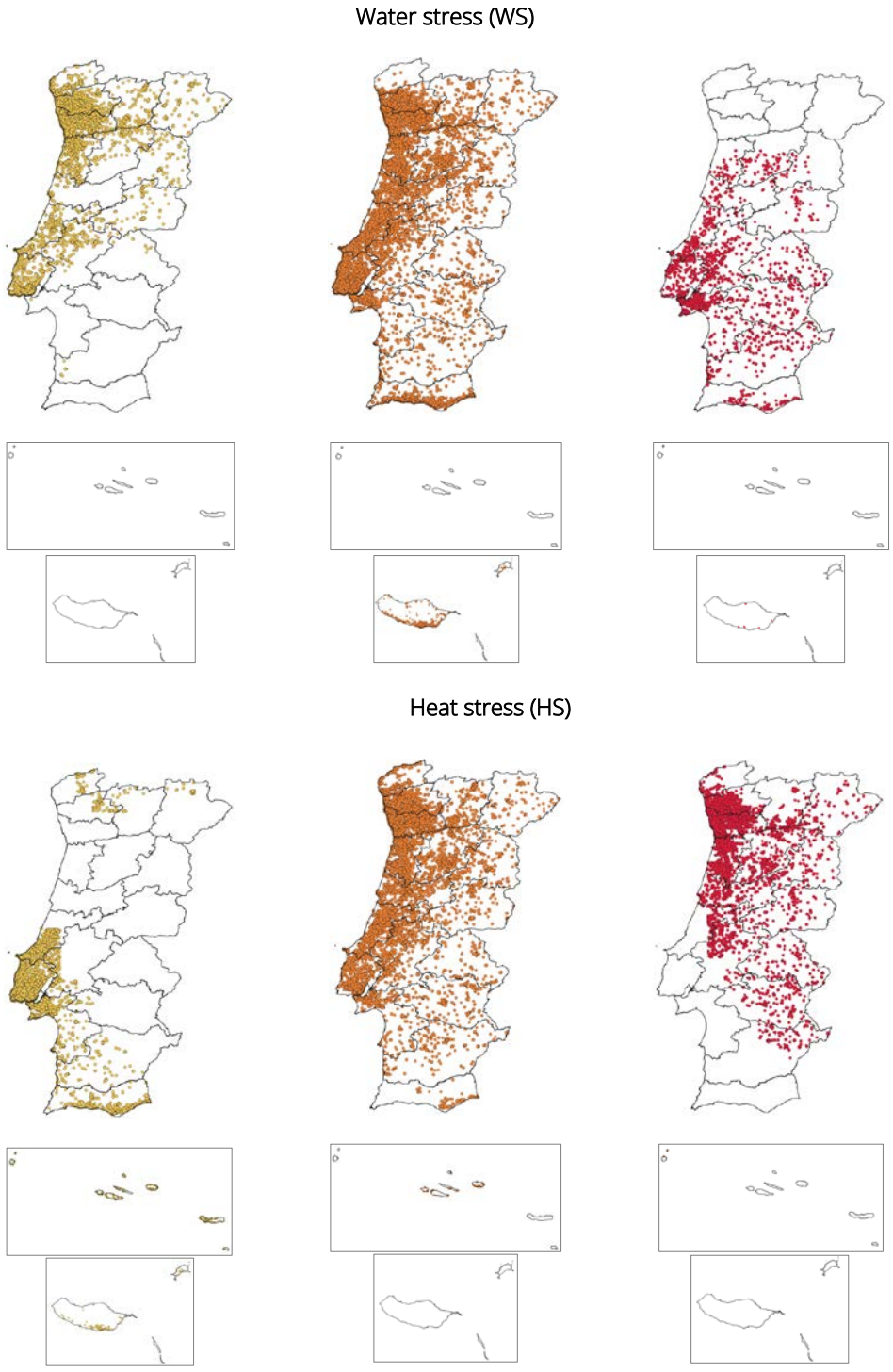


(b) Large enterprises



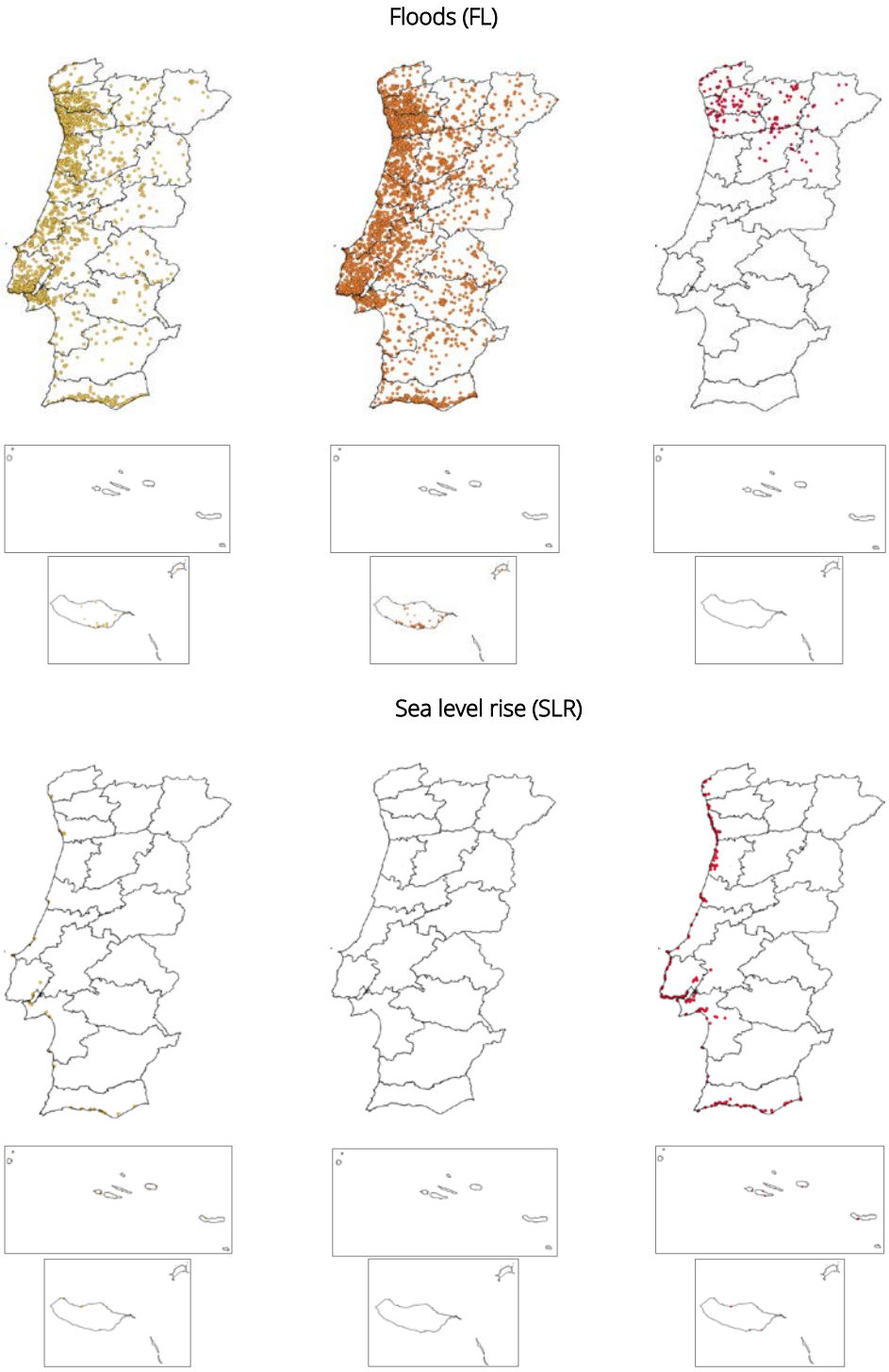
Sources: Banco de Portugal and Moody's Climate on Demand. | Notes: Each point corresponds to the location of an enterprise's head office. For mainland Portugal, the lines correspond to the districts. To help visualise and interpret the results for the Azores and Madeira archipelagos, smaller scales were used compared to the territory of mainland Portugal. The definition of size classes follows the criteria of Commission Recommendation of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises; enterprises that do not fall under the previous categories are classified as "large enterprises".

Chart 4 • Enterprises located in areas most vulnerable to the materialisation of physical risks (medium, high and severe levels)



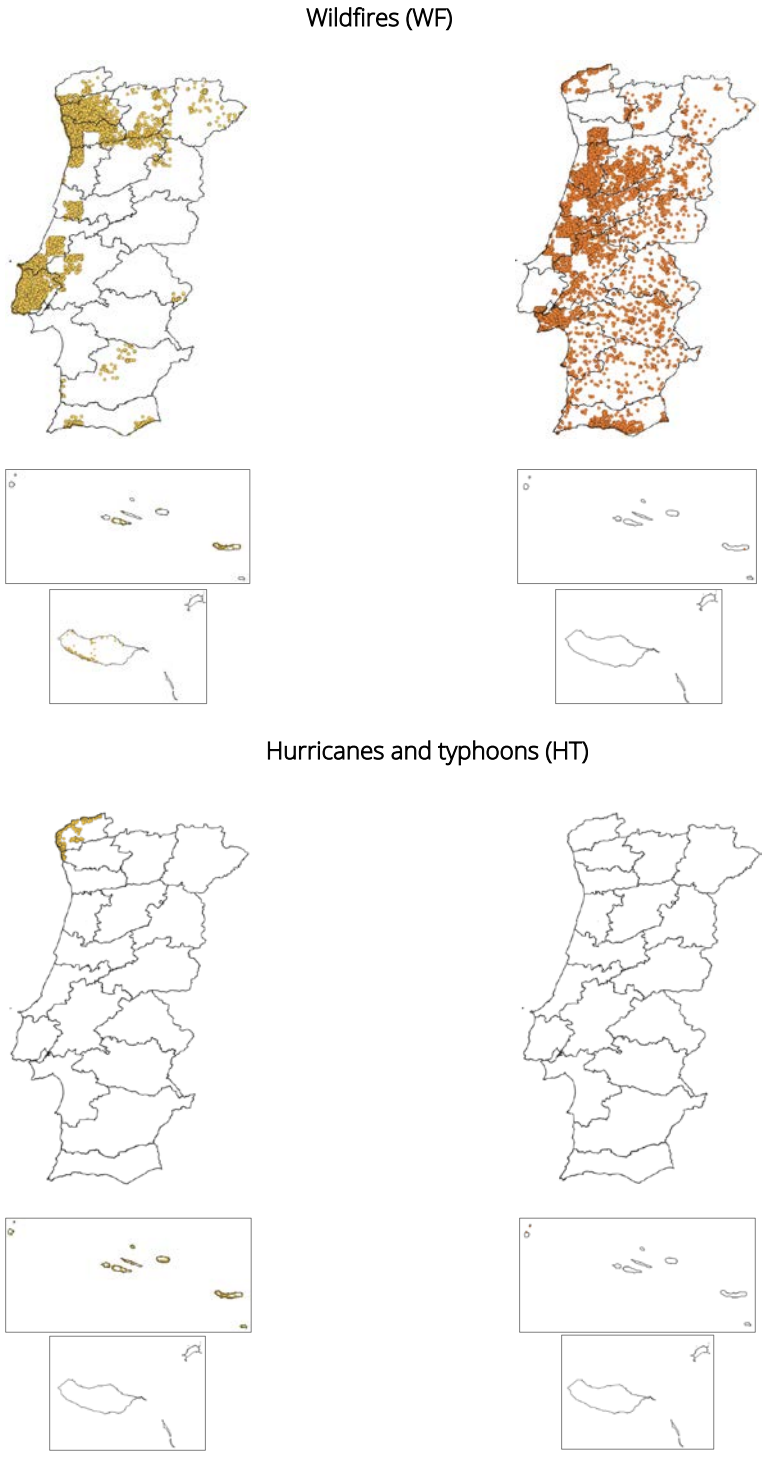
Sources: Banco de Portugal and Moody's Climate on Demand. | Notes: Each point corresponds to the location of an enterprise's head office. Yellow points correspond to medium risk, orange points to high risk and red points to severe risk respectively. For mainland Portugal, the lines correspond to the districts. To help visualise and interpret the results for the Azores and Madeira archipelagos, smaller scales were used compared to the territory of mainland Portugal.

Chart 5 • Enterprises located in areas most vulnerable to the materialisation of physical risks (medium, high and severe levels)



Sources: Banco de Portugal and Moody's Climate on Demand. | Notes: Each point corresponds to the location of an enterprise's head office. Yellow points correspond to medium risk, orange points to high risk and red points to severe risk respectively. For mainland Portugal, the lines correspond to the districts. To help visualise and interpret the results for the Azores and Madeira archipelagos, smaller scales were used compared to the territory of mainland Portugal.

Chart 6 • Enterprises located in areas most vulnerable to the materialisation of physical risks (medium and high levels)



Sources: Banco de Portugal and Moody's Climate on Demand. | Notes: Each point corresponds to the location of an enterprise's head office. Yellow points correspond to medium risk and orange points to high risk. For wildfire and hurricane and typhoon events, there are no enterprise locations associated with severe risk. For mainland Portugal, the lines correspond to the districts. To help visualise and interpret the results for the Azores and Madeira archipelagos, smaller scales were used compared to the territory of mainland Portugal.

Table 1 • Banking sector exposure to water stress risk and credit risk (ICAS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total bank credit
Class 1	1.3	0.1	13.5	31.3	2.5	48.8
Class 2	0.7	0.1	9.3	22.3	1.7	34.0
Class 3	0.4	0.0	4.2	12.2	0.4	17.2
Total	2.4	0.2	27.0	65.9	4.6	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

Table 2 • Banking sector exposure to heat stress risk and credit risk (ICAS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total bank credit
Class 1	0.0	2.3	16.8	17.0	12.7	48.8
Class 2	0.0	2.4	13.0	12.8	5.9	34.0
Class 3	0.0	1.1	6.7	7.6	1.7	17.2
Total	0.0	5.8	36.5	37.4	20.3	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

Table 3 • Banking sector exposure to wildfire risk and credit risk (ICAS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total bank credit
Class 1	0.0	1.6	26.5	20.7	0.0	48.8
Class 2	0.0	1.3	18.2	14.5	0.0	34.0
Class 3	0.0	0.7	10.3	6.2	0.0	17.2
Total	0.0	3.6	55.0	41.4	0.0	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

Table 4 • Banking sector exposure to flood risk and credit risk (ICAS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total
Class 1	1.3	28.2	6.4	12.7	0.2	48.8
Class 2	0.7	21.5	3.7	8.0	0.2	34.0
Class 3	0.4	9.0	5.0	2.8	0.0	17.2
Total	2.4	58.6	15.2	23.4	0.4	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

Table 5 • Banking sector exposure to risk of sea level rise and credit risk (ICAS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total bank credit
Class 1	26.4	21.6	0.1	0.0	0.7	48.8
Class 2	16.3	16.8	0.2	0.0	0.7	34.0
Class 3	7.0	10.0	0.0	0.0	0.2	17.2
Total	49.6	48.4	0.3	0.0	1.6	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

Table 6 • Banking sector exposure to hurricane and typhoon risk and credit risk (ICAS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total bank credit
Class 1	2.4	44.5	1.8	0.0	0.0	48.8
Class 2	2.7	30.4	1.0	0.0	0.0	34.0
Class 3	1.1	15.7	0.4	0.0	0.0	17.2
Total	6.2	90.6	3.3	0.0	0.0	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

Table 7 • Banking sector exposure to water stress risk and transition risks (CPRS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total
Negatively affected CPRS	0.8	0.1	10.7	18.2	2.0	31.8
CPRS with uncertain impact	0.6	0.0	5.6	18.7	1.3	26.2
Positively affected CPRS	0.1	0.0	0.3	0.7	0.0	1.0
Other	0.8	0.1	10.5	28.3	1.3	41.0
Total	2.4	0.2	27.0	65.9	4.6	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

Table 8 • Banking sector exposure to heat stress risk and transition risks (CPRS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total
Negatively affected CPRS	0.0	1.0	6.2	12.0	12.6	31.8
CPRS with uncertain impact	0.0	2.7	13.4	8.2	1.9	26.2
Positively affected CPRS	0.0	0.0	0.4	0.4	0.3	1.0
Other	0.0	2.1	16.6	16.8	5.5	41.0
Total	0.0	5.8	36.5	37.4	20.3	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

Table 9 • Banking sector exposure to wildfire risk and transition risks (CPRS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total
Negatively affected CPRS	0.0	1.0	20.0	10.8	0.0	31.8
CPRS with uncertain impact	0.0	1.3	11.9	13.0	0.0	26.2
Positively affected CPRS	0.0	0.0	0.3	0.7	0.0	1.0
Other	0.0	1.3	22.8	17.0	0.0	41.0
Total	0.0	3.6	55.0	41.4	0.0	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

Table 10 • Banking sector exposure to flood risk and transition risks (CPRS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total
Negatively affected CPRS	0.8	18.2	5.5	7.1	0.1	31.8
CPRS with uncertain impact	0.6	16.9	2.9	5.7	0.1	26.2
Positively affected CPRS	0.1	0.5	0.1	0.4	0.0	1.0
Other	0.8	23.1	6.6	10.3	0.2	41.0
Total	2.4	58.6	15.2	23.4	0.4	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

Table 11 • Banking sector exposure to risk of sea level rise and transition risks (CPRS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total
Negatively affected CPRS	19.7	11.8	0.1	0.0	0.2	31.8
CPRS with uncertain impact	8.7	16.7	0.2	0.0	0.7	26.2
Positively affected CPRS	0.3	0.7	0.0	0.0	0.0	1.0
Other	20.9	19.2	0.1	0.0	0.8	41.0
Total	49.6	48.4	0.3	0.0	1.6	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

Table 12 • Banking sector exposure to hurricane and typhoon risk and transition risks (CPRS) | Per cent of total credit to enterprises

	No risk	Low risk	Medium risk	High risk	Severe risk	Total
Negatively affected CPRS	1.2	29.4	1.2	0.0	0.0	31.8
CPRS with uncertain impact	2.8	22.6	0.8	0.0	0.0	26.2
Positively affected CPRS	0.0	0.9	0.1	0.0	0.0	1.0
Other	2.1	37.7	1.2	0.0	0.0	41.0
Total	6.2	90.6	3.3	0.0	0.0	100.0

Sources: Banco de Portugal and Moody's Climate on Demand.

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