BIENNIAL REPORT ON CLIMATE CHANGE RISKS TO THE FINANCIAL SYSTEM

2023

Issue 1

AMCESFI | Autoridad Macroprudencial Consejo de Estabilidad Financiera

GOBIERNO DE ESPAÑA
VICEPRESIDENCIA PRIMERA DEL GOBIERNO
MINISTERIO DE ASUNTOS ECONÓMICOS Y TRANSFORMACIÓN DIGITAL
BANCO DE ESPAÑA Eurosistema
CNMV Comisión Nacional del Mercado de Valores

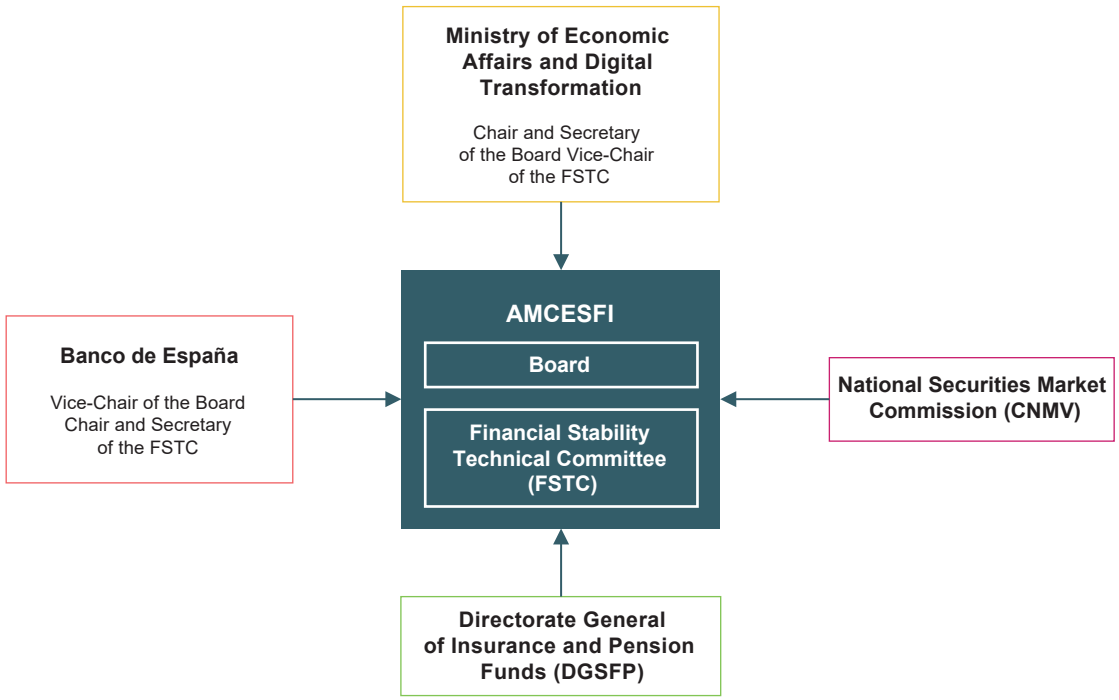
About AMCESFI

AMCESFI *(Autoridad Macroprudencial Consejo de Estabilidad Financiera)* is the macroprudential authority for the Spanish financial system. Set up in 2019, its goal is to contribute to the stability of the financial system as a whole by identifying, preventing and mitigating any circumstances or actions that may give rise to systemic risk. For this purpose, AMCESFI is empowered to issue opinions, warnings and recommendations on matters that affect financial stability.

AMCESFI is organised as an operationally independent collegiate body attached to the Ministry for Economic Affairs and Digital Transformation. It also includes representatives of the three Spanish authorities with sectoral responsibilities for the regulation and prudential supervision of the Spanish financial system, namely the Banco de España, the National Securities Market Commission (CNMV) and the Directorate General of Insurance and Pension Funds (DGSFP) of the Ministry of Economic Affairs and Digital Transformation.

AMCESFI comprises two permanent structures: a Board and a Financial Stability Technical Committee (FSTC). By its very nature, it has no human, material or financial resources of its own; its activity is underpinned by the support it receives from its member institutions.

Figure 1 Structure of AMCESFI



SOURCE: AMCESFI.

This *Biennial report on climate change risks to the financial system* has been prepared and published under the mandate established in Article 33 of Law 7/2021 of 20 May 2021 on climate change and the energy transition.

For further information on AMCESFI, see the website https://www.amcesfi.es/wam/en/.

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Introductory letter from the First Deputy Prime Minister and Minister for Economic Affairs and Digital Transformation

Dear reader:

Nadia Calviño, Chair of the AMCESFI Board.

It is my pleasure to present the first edition of the *Biennial report on climate change risks to the financial system.* This report was coordinated by AMCESFI, with the participation of the Banco de España, the National Securities Market Commission and the Directorate General for Insurance and Pension Funds.

Climate change constitutes the most important global challenge of our time. The increase in global temperature as a result of greenhouse gas emissions into the atmosphere increases the likelihood of adverse climate events, which have a high economic and financial cost. These adverse events, or physical risks, can take the form of one-off events, as in the case of most natural disasters, or slower progressing phenomena, such as desertification, rising sea temperatures and chronic droughts.

To address the urgency and magnitude of the challenges associated with climate change, we need to move forward with the progressive decarbonisation of our economies, in line with the 2015 Paris Agreement.

The Spanish Law on Climate Change and Energy Transition, passed in 2021, sets out the main commitments that will enable us to achieve climate neutrality by 2050.

The National Integrated Energy and Climate Plan 2021-2030, in turn, translates these commitments into a roadmap for advancing decarbonisation in the current decade, thanks to an ambitious reform and investment plan.

Meeting these decarbonisation commitments will require a major reallocation of resources within the Spanish economy and an unprecedented investment drive that will require the involvement of the financial sector as a catalyst.

Spain is accelerating this process thanks to the Recovery, Transformation and Resilience Plan (RTRP), allocating 40% of its investments to the ecological transition (some €28 billion in its initial phase).

These investments will be reinforced by the second phase of the RTRP, which will mobilise additional transfers and loans totalling around €94 billion, with a green share in line with the initial 40%.

Lastly, the State Budget has also increased the amounts earmarked for green investments, and the items contributing to meeting climate change objectives now exceed 30% of eligible expenditure.

In this transition process, it is crucial to adequately quantify the physical risks associated with climate change, to be aware of its economic implications in general and for financial stability in particular, in the absence of adaptation and mitigation measures.

In parallel, this analysis of physical risks must be complemented with a quantification of the transition risks derived from the policies associated with the decarbonisation of the economy.

This report analyses, from a global standpoint, the impacts of physical risks associated with climate change and transition risks to the Spanish financial system. It also endeavours to help raise awareness among citizens, companies and financial institutions themselves of the risks posed by not taking action in this area.

Protecting the planet from the effects of climate change is a moral obligation towards future generations and, furthermore, the best economic policy to minimise the impact of the materialisation of physical risks by making our productive and financial system more resilient.

Also, evidence shows that an orderly and predictable transition is preferable to a scenario in which measures are taken late and in a disorderly manner.

The preparation of this first edition of the report has been a very enriching exercise for everyone involved in its writing, since it has encouraged cooperation between institutions and the sharing of data and methodologies. This report will be enhanced in future editions, as regulatory measures come into force at European and national level to increase the availability of data provided by supervised financial institutions, as well as through refinements in the methodologies for measuring these risks.

Lastly, in addition to the actions mentioned, we are working on the promotion and advancement of sustainable finance through a set of actions that enable us to promote innovative sources of financing, such as green bonds, or to support our productive system, our SMEs, in adapting to regulatory changes, among other objectives.

These measures are reflected in the *Green Paper on Promoting Sustainable Finance,* which the government has been working on in recent months and which is presented separately.

Executive summary

This *Biennial Report on climate change risks to the financial system* for 2023 has been prepared pursuant to Law 7/2021 of 20 May 2021 on climate change and energy transition (LCCTE by its Spanish abbreviation). This law confers on AMCESFI the mandate to coordinate a report prepared jointly by the three sectoral supervisory authorities: the Banco de España, the National Securities Market Commission and the Directorate General of Insurance and Pension Funds. The report seeks to assess the climate change risks to the Spanish financial system, as well as to examine the degree of compliance with the Paris Agreement goals.

The report presents an initial analysis of the impact of transition and physical risks on the financial system. Transition risks are those associated with the actions required to decarbonise the economy. These measures can have an adverse impact on the macroeconomic environment, which is more pronounced in sectors of activity dependent on fossil fuels and with higher carbon dioxide (CO_2) emissions and in households that spend more on energy in relative terms, and may also be accompanied by shocks in financial markets. These adverse effects and their intensity may vary over time depending on the transition strategies adopted. The physical risks, associated with the increase in the frequency and severity of extreme events (such as floods, droughts and storms) should the climate change process be consummated, could have a major impact in the medium and long term in the absence of containment and mitigation measures.

Transition risks were assessed by focusing on a common scenario for the entire financial system, in which the transition occurs abruptly and in a disorderly manner, affecting the economy and financial markets. The hypotheses underlying this scenario, which is aligned with those used by other European supervisory authorities and those designed by the Network for Greening the Financial System (NGFS), are the late implementation of decarbonisation measures and their inadequate design. The scenario envisages an increase of €240 in the price per tonne of CO_2 (to €325), which would induce the gradual decarbonisation of emitters' production processes and spending patterns by transferring the social cost of emissions to them. Over a three-year analysis horizon, the economic sectors most dependent on fossil fuels would register very sharp drops in activity, with an overall contraction in GDP and a negative impact on house prices. In addition, asset valuations in different markets would fall and risk premia would increase, thus narrowing interest rate spreads on corporate bonds of firms in the most energy-dependent productive sectors. Consequently, the more sudden the rise in the price of CO_2 and the later measures are adopted, the less time firms and households will have to adapt and the greater the disruptive impact.

As a result, a disorderly climate transition would have adverse effects on the various financial intermediaries, which would be far stronger than

those posed by a more gradual and well-planned transition, as shown by the analysis. The immediate deterioration of financial conditions caused by the increase in the price of a tonne of CO_2 would generate losses in investment fund portfolios amounting to 5.7% on average. These losses would be greater in equities-focused funds and funds with more investments in polluting companies. Pension funds would experience a negative impact through channels like those of investment, the impact being higher in those with more investments in equities, or in investment funds. Through these same channels, and based on conservative assumptions of exposure of their portfolios to equities, pension funds would suffer losses of 8.2%. Similarly, losses in the financial markets would lower the value of insurance undertakings' investment portfolios, reducing their capital adequacy ratio by 16%, to 201%. In the case of the banking sector, the macroeconomic downturn would result in losses on the loan portfolio. To these losses would be added the fall in the market value of credit institutions' investment portfolios, which as a whole would lower the capital adequacy of institutions over the three-year horizon by 1.2 percentage points, bringing the CET1 ratio to 11.6%.

While there is a high degree of uncertainty about the possible costs of the climate transition, these would probably be lower if measures to promote the decarbonisation of the economy are taken early and in a non-disruptive manner. Although the banking sector would also be affected in this type of scenario of gradual and controlled transition, with a slight increase in losses due to credit risk, the impact would be more restrained. To the extent that the cost, in terms of real activity, of an orderly transition would result in lower tensions in financial markets, other financial intermediaries would also be affected to a lesser degree. As already noted, costs to financial sectors may increase if measures, even if they are taken early, have design errors or are not accompanied by mechanisms to mitigate their impact on the reallocation of resources between sectors and between companies, as well as on the most vulnerable households.

If the transition to a more sustainable economy is not completed, climate change will pose significant physical risks to economic activity and the financial system. The analysis and quantification of physical risks is currently at an early stage, constrained by factors such as the scarcity of data, the limited usefulness of historical information for the analysis of a disruptive event such as climate change and the fact that the analysis horizons are significantly higher than those typically used in stress test exercises, all of which require new methodological developments.

The increase in the frequency and severity of weather shocks, through their negative effect on growth,[1] would cause significantly higher losses

1 Weather shocks include desertification, floods, fires and rising sea levels.

for financial institutions than those posed by the energy transition. Illustrative exercises suggest that, by 2030, the deterioration in GDP growth caused by a lack of action and the consequent materialisation of physical risks would already raise the probability of default due to significant credit risk, compared with alternative scenarios where the energy transition is favoured.

In addition, weather shocks can affect financial sectors through a broad range of channels, and their impact is explored, tentatively, through the examination of certain events. Financial sectors can be affected by high-intensity extreme weather events, such as droughts, heatwaves or storms and by others that progress more slowly, such as desertification or rising sea levels. Given the complexity of the impact analysis, this report makes a limited and exploratory examination of the costs induced by two specific extreme weather events on the financial system, which by no means exhaust the range of events that can occur. Specifically, it can be seen that droughts and heatwaves can impair the credit quality of the bank loan portfolio and, therefore, damage the profitability and solvency of the sector. The main cause of this deterioration would be its negative impact on labour productivity and, in turn, on output growth, particularly in those sectors most exposed to these climate-related events, such as construction or agriculture. Regarding the insurance sector, the greater frequency of weather shocks would lead to an increase in claims and a deterioration in the capital adequacy ratio of the undertakings.

Climate change impact analysis poses significant challenges for financial supervisors. These challenges stem from uncertainty about climate change, the need for additional data and improvements in their quality, as well as the limitations of current models. In this context, the results of this report are exploratory in nature, and contribute to narrowing the considerable uncertainty in this area, but they must be refined and extended in future editions, as more climate scenarios are developed, more data become available and methodologies are improved. In fact, in these exercises it has been considered that the events that lead to the materialisation of the risks associated with climate change occur exclusively in Spain, although this is, naturally, a global phenomenon. Given its complexity, consideration of the international context will be addressed in future reports.

Improved data provided by supervised financial institutions is critical for greater accuracy in future climate change analyses. The LCCTE[2] requires that institutions whose securities are admitted to trading on regulated markets, credit institutions, insurance and reinsurance undertakings and companies due to their size, prepare an annual report in this area. Specifically, these institutions

2 Article 32 of the LCCTE establishes that the content of the reports on the estimation of the financial impact of the risks to society associated with climate change will be determined by royal decree, within two years of the approval of this law. The draft royal decree was released for public consultation in April, with a deadline for comments running to 5 May 2023.

will have to assess the financial impact on society of the risks associated with climate change generated by the exposure of their activity to climate change, including the risks of the green transition and the measures taken to address them.

1 Introduction

1.1 Climate change and financial stability

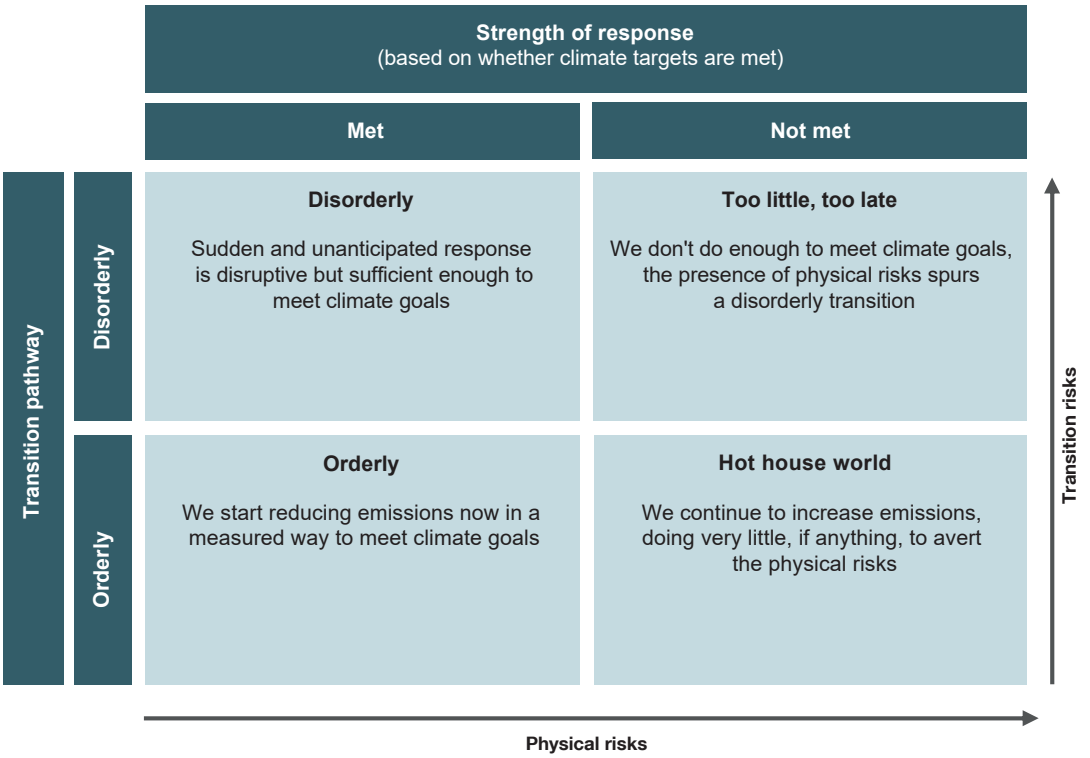
In the context of Spain's international commitments on climate and sustainable and inclusive development, the Spanish Parliament passed Law 7/2021, of 20 May 2021 on climate change and energy transition (LCCTE by its Spanish abbreviation). The 2015 Paris Agreement – ratified by Spain in 2017 – and the 2030 Agenda for Sustainable Development have laid the foundations for the design and implementation of a framework for sustainable and inclusive economic development. As part of these commitments, the European Union (EU) has established its own legal framework to make headway in this transition and achieve the established objectives.[3] Also, in response to the commitment made at international and European level, this law, which includes in Article 1 the commitments made by Spain, has been drafted with the following general objectives: "to facilitate the decarbonisation of the economy, its transition to a circular model, so as to guarantee the rational and supportive use of resources; and to promote adaptation to the impacts of climate change and the implementation of a sustainable development model that generates decent employment and contributes to the reduction of inequalities".

The LCCTE defines the institutional framework that will facilitate the progressive adaptation of the country's reality to the requirements that regulate climate action. One of its objectives is to guarantee the coordination of sectoral policies, ensuring the coherence thereof and the use of synergies to achieve the goal of climate neutrality. The financial system plays an important role in the transition to a decarbonised economy, and its efficiency and robustness are of great significance. To this end, it is essential to pre-empt and reduce climate risks to the sector.

For this reason, one of the obligations established by the LCCTE is for the Banco de España, the National Securities Market Commission (CNMV) and the Directorate General of Insurance and Pension Funds (DGSFP) to prepare, under the coordination of the AMCESFI, a biennial report on the assessment of the risk to the Spanish financial system posed by climate change. This report, which is being prepared in 2023 for the first time, has the mandate to conduct an assessment of the risk to the Spanish financial system arising from climate change and proposals for possible actions to combat it, as well as to analyse the degree of alignment of Spain's financial system with the climate goals of the Paris Agreement and EU regulations. The report must be published and sent to the Spanish Congress of Deputies and the Senate.

3 Regulation (UE) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law').

Figure 1.1.1 Physical risks vs. transition risks: temperature and climate change cost scenarios



SOURCE: NGFS (2019).

Numerous studies have analysed the impacts of climate change and its economic costs. The earliest analyses most notably include The Economics of Climate Change: The Stern Review,[4] which is one of the most influential reports on climate change and its costs and risks. This report highlighted that the benefits of strong and early action far outweigh the economic costs of no action, and also warned of the significant impact of climate change on growth and development, as well as the consequences of delaying actions, which would be dangerous and much more costly. Published in 2006, the Stern report was a call for international action to reduce emissions and the impact of climate change on global production, human life and the environment. More recent studies have estimated that failure to achieve the emissions reduction targets of the Paris Agreements would have a high economic cost. Thus, in 2050 global GDP could be at least 10% lower than in the alternative scenario where global temperature did not increase.[5]

The supervisory authorities of the financial system must play a major role in the fight against climate change, ensuring an adequate assessment of the

4 Nicholas Stern. (2006). "The Economics of Climate Change: The Stern Review".
5 SwissRe Institute. (2021). "The economics of climate change: no action not an option".

impact of climate risks. Climate change entails adverse economic and financial consequences – of varying severity depending on sectors of activity, geographies, and types of financial intermediaries – that may have systemic effects on financial stability and economic growth. Climate change will affect the financial system both directly and indirectly (for example, due to adverse developments in the credit and market risk of its counterparties), through physical risks (such as weather shocks and natural catastrophes), or through the so-called transition risks (a consequence of the transformations associated with the policies implemented to mitigate the effects of climate change). An adequate assessment of these risks is a prerequisite, among other aspects, for the efficient design of the transition to a decarbonised economy.

The economic impact of the physical risks of climate change on general economic activity can be very significant, impacting the financial system through very diverse and complex channels.[6] Physical hazards can be acute, if they arise as a consequence of one-off events, or chronic, if they arise as a consequence of longer-term changes in the climate. In addition, these risks include slow onset events, such as rising sea levels, desertification or glacier melt, but also extreme events, such as heatwaves or floods. Both types of events translate into losses and damage, which will have a substantial impact on financial institutions along various channels. Thus, sectors such as agriculture and fisheries, as a result of increased temperatures or the frequency and intensity of storms, may see their property damaged or their commercial activity interrupted. These real negative impacts can also have a significant effect on other sectors, such as energy, tourism and construction. Through the impact on these sectors of activity, the financial system can be affected in various ways. The analysis of the impact of physical risks is at an early stage due to the challenges involved: uncertainty about future emission and temperature paths, limited data and much longer prediction horizons than usual, which therefore require new methodological developments, since over such long timescales it is normal to assume that agents will react to these risks in the future.

Policies to promote the transition to a decarbonised economy can also adversely affect various sectors. Transition risks, a consequence of the adjustment towards a low-carbon economy, have an impact, as changes in policies and technology may entail a reallocation of resources between sectors and companies, affecting their activity and the price of assets, as the costs and opportunities of the process become discernible across the various sectors of economic activity. Thus, sectors such as energy, transport, manufacturing and construction may suffer from the impacts of climate change mitigation measures and accumulate a larger share of the costs of the energy transition. Households for whom energy costs are the largest share of their shopping basket could also be

6 BCE. (2019). *Financial Stability Review, Special Feature A* (Climate change and financial stability), May.

significantly affected. The risks to financial stability[7] will be less pronounced if the transition is orderly and predictable, so that agents can plan ahead.[8] On the other hand, delaying decision-making will bring with it more far-reaching adjustments in the future, which may lead to sudden market adjustments or even a recession.

Despite the existing uncertainty, the magnitude of the costs associated with the physical and transition risks depends on the way in which carbon emissions are reduced. The two most important dimensions for assessing the materiality of these risks are the degree of decisiveness in taking action, and whether action is taken in an orderly or abrupt manner.[9] Indeed, on the one hand, costs are influenced by the type and intensity of measures taken to reduce greenhouse gas emissions and, on the other, by whether the transition takes place in an orderly manner, through early and well-designed actions, or in a disorderly manner, either because the measures are taken late or with an unsatisfactory design. Figure 1.1.1 shows the relationship between climate change scenarios and the way in which the transition occurs.

This report is related to other initiatives that are being launched, such as the Green Paper for Sustainable Finance. The Green Paper aims to transform the financial system and mobilise the resources and investments required for the process to transform our productive fabric. The Green Paper contains measures to pre-empt and adequately manage the risks arising from climate change and to strengthen our competitive capacity. In particular, actions are proposed in the areas of transparency and accounting, regulation, development of financial products and markets, and contribution to the actions of the EU and all multilateral organisations.

Certain challenges have been posed in the preparation of this report, which could be progressively addressed in future editions. This first report analyses the physical and transition risks affecting each sector of the Spanish financial system. Based on different scenarios, the potential impact of physical and transition risks on the banking sector, securities markets, investment funds, insurance companies and pension funds has been analysed. The process pinpointed considerable challenges related to uncertainty about future scenarios, particularly pronounced in the area of physical risks; and stemming from the limitations of existing risk assessment methodologies. Similarly, certain information and statistical gaps have been identified, which are expected to be gradually filled in the future. Increased data availability will, for example, enable more in-depth analysis of the interconnections between different sectors of the financial system through common exposures to climate risks. Furthermore, the information collected by supervisors

7 For more details on the impact of transition risks on financial stability, see Margarita Delgado. (2019). "Energy transition and financial stability. Implications for the Spanish deposit-taking institutions". *Financial Stability Review,* 37, autumn. Banco de España.

8 BoE. (2015). "Breaking the Tragedy of the Horizon - climate change and financial stability", speech by Mark Carney, governor of the Bank of England, of 29 September.

9 NGFS. (2019). "A call for action. Climate change as a source of financial risk", April.

on the basis of Article 32 of the LCCTE, which requires securities issuers, credit institutions, insurers and other significant entities to prepare an annual report on the financial impact of climate change risks, will provide additional background information for the preparation of future editions of this report.

This report is integrated into the work on climate change that is being carried out at a national, European and international level. Evidence of the importance of climate change is the large volume of work produced in bodies and committees in which the Banco de España, the National Securities Market Commission (CNMV), the Directorate General of Insurance and Pension Funds (DGSFP) and the General Secretariat of the Treasury and International Finance (SGTFI) participate. Annex 1 lists the main papers published over the last two years in the context of various supranational initiatives. Annex 2 also lists the papers published by AMCESFI member institutions.

1.2 Degree of alignment with Paris Agreement climate goals

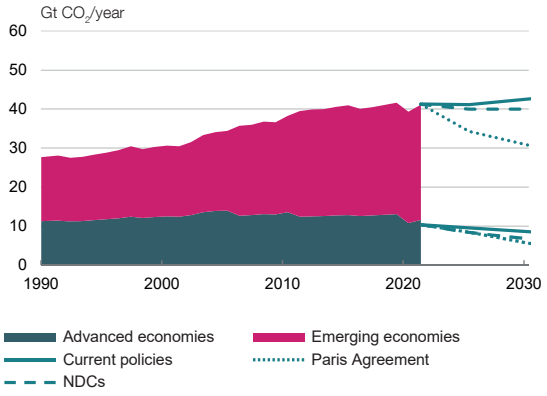
The Paris Agreement, a legally binding international treaty, was adopted in December 2015 and spans all aspects of the fight against climate change, including mitigation, adaptation and means of implementation. This Agreement, which was ratified by Spain in January 2017, includes, for the first time in an international treaty, the objective of restricting the increase in global average temperature to below 2ºC with respect to pre-industrial levels and pursue efforts to limit global warming to 1.5ºC. In addition, the signatory countries commit to prepare, communicate and maintain their nationally determined contributions or plans to combat climate change, which must include commitments to reduce emissions, and to implement national measures to achieve such objectives.

In this context, in December 2019 the European Council approved the goal of achieving climate neutrality in the EU by 2050, and on 5 March 2020 the Council of the European Union approved a long-term greenhouse gas (GHG) emissions strategy, which reflects this objective of climate neutrality. This strategy was updated in December 2020 with more ambitious targets for 2030, and once the new EU multiannual financial framework 2021-2027 was launched, it was further reinforced by the Next Generation EU instrument. Thus, the EU and its Member States committed to jointly reducing GHG emissions by at least 55% by 2030 compared to the 1990 baseline.

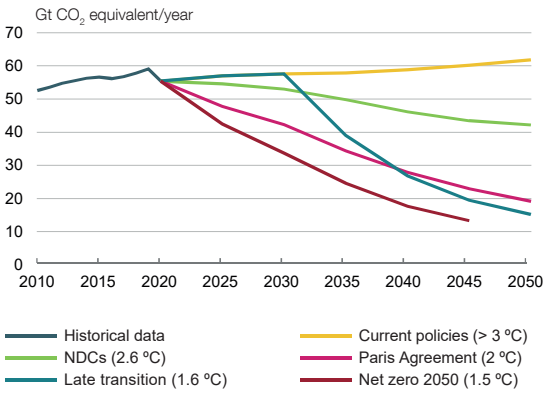
Spain is aligned with the European plans through the national objectives set in the National Integrated Energy and Climate Plan (PNIEC) 2021-2030. Under the long-term objective of making Spain a carbon neutral country by 2050,

Chart 1.2.1 Global warming and mitigation initiatives

1 CO_2, by region (a)



2 Annual GHG emissions (b)



SOURCES: IIASA NGFS Climate Scenarios Database and Our World in Data.

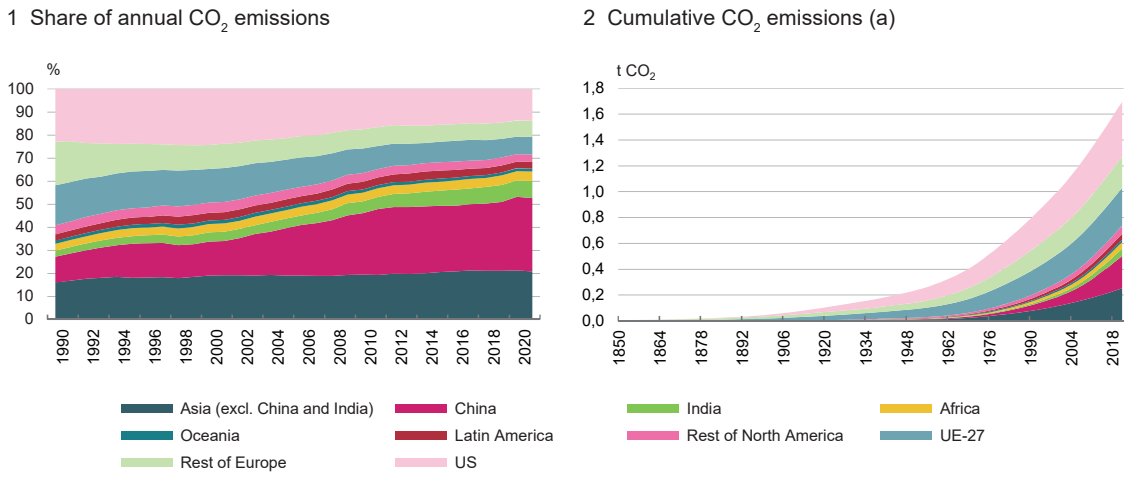
a Illustrates total CO_2 emissions from both fossil fuels and land use. Starting in 2021, three NGFS scenarios are represented corresponding to the continuation of current policies, the implementation of national commitments (NDCs) and the scenario associated with a warming of 2ºC in 2100 with respect to pre-industrial levels (Paris Agreement).
b The scenarios correspond to the paths presented by the NGFS. In brackets they are expressed in terms of global temperature increases in 2100 compared to pre-industrial levels.

the PNIEC includes measures geared towards achieving a reduction of at least 23% in GHG emissions by 2030 compared to 1990, which entails eliminating approximately one third of emissions between 2021 and 2030. According to the PNIEC, the sectors of the economy that are expected to reduce their emissions the most in absolute terms, accounting for 83% of the reduction over the period, are power generation (36 MtCO2e) and mobility and transport (27 MtCO2e), followed by the residential, commercial and institutional sector and industry (combustion), with additional reductions of 10 and 7 MtCO2e, respectively. Indeed, given that three out of every four tonnes of GHGs originate in the energy sector, the decarbonisation thereof is the cornerstone upon which to develop the energy transition and the decarbonisation of the economy. To this end, the PNIEC sets targets for decarbonisation of the energy system, in which renewables are expected to reach 42% of final energy use by 2030 and to account for 74% of electricity generation, as well as a 39.5% improvement in energy efficiency. The PNIEC also devotes a great deal of attention and proposes measures to reduce GHG emissions from the other sectors.[10]

In this context, in order to improve sustainability reporting by the private sector, the EU has approved Regulation (EU) 2019/2088,[11] on sustainability

10 The Spanish PNIEC and its objectives are currently under review, in accordance with EU legislation
11 Regulation (EU) 2019/2088 of the European Parliament and of the Council of 27 November 2019 on sustainability-related disclosures in the financial services sector.

Chart 1.2.2 Evolution of CO_2 emissions



SOURCE: Our World in Data.

a Cumulative CO_2 emissions since 1850, excluding those originating from land-use changes (LUC).

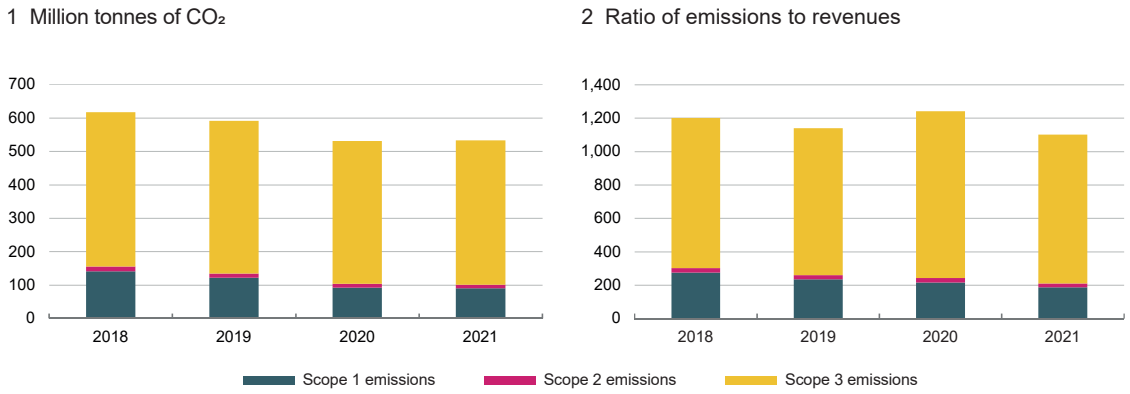
disclosures in the financial services sector, and Directive 2022/2464/EU,[12] **on corporate sustainability reporting (CSRD).** This directive, which amends, inter alia, the Non-Financial Reporting Directive, will enable the collection of standardised and comparable sustainability information from companies, including on their GHG emission reduction targets and on how their plans ensure a business model compatible with the objectives of the Paris Agreement. A phased-in period of implementation of this directive is foreseen, with listed companies being the first to be obliged to report, starting in 2025, for the 2024 financial year. Once application of this directive has begun, uniform and comparable information will be available to enable detailed monitoring of how the Spanish financial system as a whole, as well as the portfolios of financial system intermediaries, are aligned with these objectives.

Taking into account the legislative developments that are taking place, until the information provided by compliance with the CSRD is available, it has been decided to carry out an initial analysis of Spanish listed companies. Thus, an attempt has been made to approximate for Spanish securities issuers as a whole[13] information on: i) the evolution of greenhouse gas emissions of these entities in recent years, ii) the degree of alignment of these emissions with the goals proposed in the Paris Agreements and iii) governance, strategy and management of the risks and the emission reduction objectives of such entities.

12 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.

13 The number of issuers, both equity and fixed-income, which complies with Article 32.1 of Law 7/2021 of 20 May 2021 on climate change and energy transition is 99.

Chart 1.2.3 Greenhouse gas emissions of Spanish emitters



SOURCES: CNMV, Bloomberg and Refinitiv.

In the absence of existing regulations on corporate sustainability reporting, realised emissions and their future projections have been approximated from commercial databases[14] **and the answers obtained by the CNMV from a questionnaire sent to these issuers on a voluntary basis.** The information gathered reveals that GHG emissions of securities issuers decreased between 2018 and 2021. This reduction includes Scope 1, 2 and 3 emissions, but with important limitations in terms of reporting, in particular with respect to Scope 3 emissions. In any case, the sample is considered sufficiently representative for an initial analysis. Its sectoral coverage is also considered, as information is collected from the sectors with the highest CO_2 emissions, although no detail is provided on the financial system's Scope 3 emissions. Taking these precautions into account, as can be seen in Chart 1.2.3.1, the decrease in emissions has been progressive over the period analysed, with the exception of 2020-2021, which can be considered an atypical year due to the pandemic. The decrease in emissions was more intense in Scope 1 and a portion of Scope 3, possibly due to companies' efforts to reduce emissions on which they can have a more direct impact. Scope 2 and a portion of Scope 3 emissions also fell, but less sharply, as these are emissions that cannot be influenced so directly. The emissions intensity indicators (Chart 1.2.3.2), which illustrate the relationship between the volume of emissions to company revenues, also show a reduction over the period considered, although again not in 2020-2021.[15]

Issuers that disclose their future plans would be consistent with a temperature increase of around 1.5ºC in the long term when Scope 1 and

14 Information in the ESG field from commercial databases sometimes incorporates estimation models for certain variables.

15 The use of revenue in the denominator has the obvious advantage of enabling aggregation. However, it should be noted that measures of GHG-emission intensity are often applied to specific sectors, such as energy, which are very intensive in the use of inputs that generate a considerable carbon footprint. An example of such ratios would be GHG emissions divided by kilowatt hours. However, these measures are specific to each economic activity and cannot be aggregated.

Table 1.2.1 Increase in temperature based on the forecasts of securities issuers (ºC) (a)

Scopes 1 and 2			Scopes 1, 2 and 3		
Short term (b)	Medium term (c)	Long term (d)	Short term (b)	Medium term (c)	Long term (d)
1.33	1.47	1.47	1.93	2.08	1.84

SOURCES: CNMV and Bloomberg.

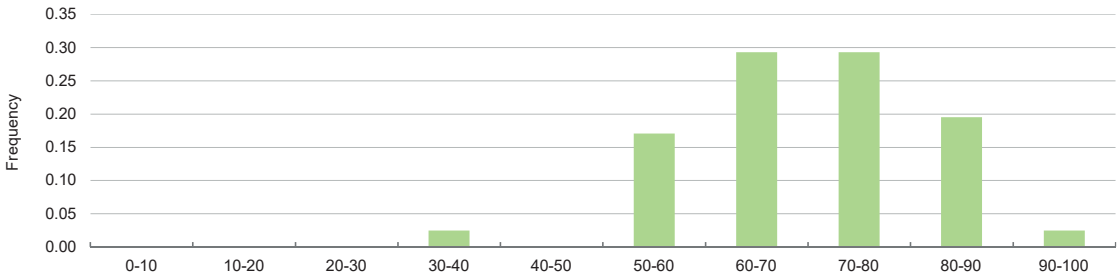
a The temperature increases presented are derived from the aggregation of the individual issuers' data weighted by their sales.
b Short term refers to a 5-year time horizon.
c Medium term refers to a time horizon of between 5 and 15 years.
d Long term refers to a time horizon of more than 15 years.

2 emissions are considered, although this is not true if Scope 3 emissions are included. To assess the degree of alignment of emissions with the targets proposed in the Paris Agreement, estimates have been made based on a publicly available methodology applied by the Science Based Targets Initiative (SBT),[16] which translates companies' greenhouse gas emissions targets into contributions to global warming. This contribution is represented in degrees Celsius above the current temperature, which makes it easier to assess these targets in relation to those mentioned in the Paris Agreement or to the EU's own targets. The limitations of the coverage of the sample are more important in this case, as estimates are only available for a set of large companies. Moreover, the full extent of emissions is not available either. As can be seen in Table 1.2.1, which presents these estimates for different time horizons and also distinguishes between emissions of different scopes, it can be seen that the targets of the issuers that disclose their plans for the future would be consistent with a temperature increase of around 1.5 ºC in the long term when considering scope 1 and 2 emissions, whereas if scope 3 emissions are included, with the limitations mentioned above, the temperature increase would rise to 2ºC. It therefore follows that, if the commitments made by issuers are met, a real reduction in emissions would be achieved, in line with the Paris Agreement targets. However, there is clear room for improvement in the formulation of the targets (e.g. the lack of short-term reduction targets on absolute emissions encompassing all three scopes and along the entire value chain).

Lastly, based on the voluntary responses obtained from the questionnaire on climate change sent to securities issuers including questions on governance, strategy, risk management and emission-reduction objectives, a synthetic indicator has been constructed. This indicator has a maximum value of 100 for each company, with higher index values being associated with a

16 SBTi is the result of a partnership between the Carbon Disclosure Project (CDP), the UN Global Compact, the World Resources Institute (WRI) and the World Wide Fund for Nature (WWF).

Chart 1.2.4 Histogram of the climate change index (questionnaire to issuers)



SOURCE: CNMV.

a The index was constructed on the basis of issuers' responses to a questionnaire sent by the CNMV to find out, in the context of climate change and its challenges, the position of issuers in relation to governance (10 questions), strategy and risk management (15 questions) and metrics and objectives related to climate change (5 questions). The index, the histogram of which is represented in the Chart, is constructed from the questions for which the answers are closed. Higher index values (out of a maximum of 100) for an issuer are associated with an issuer being better positioned to address the challenges of climate change.

greater capacity to meet these challenges. Given the qualitative nature of some answers and the impossibility of standardising others (for example, emission reduction targets are set in varied timeframes between companies), the indicator has been estimated on the basis of those questions that can only be answered using a closed set of answers.[17] The mean of this index is 69.5 and its standard deviation is 11.3 (see Chart 1.2.4). The mean of the index weighted by issuer revenues increases to 76.6, i.e. larger issuers have a higher index value. These mean values are relatively high, so it can be inferred that the Spanish issuers in the sample are aware of the challenges and risks arising from climate change and are devoting time and resources to improving the measurement and management of such risks. However, it should be noted that the responses of 59% of issuers (on average smaller than those who responded) are not known, that quantitative and performance responses have not been included, and that the quality of these responses has not been assessed.

17 An example of such a question would be: Does management assess and manage climate-related risks and opportunities?

2 Assessment of climate risks to the Spanish financial system

2.1 General framework

This Chapter describes the data sources and methodological tools used in the exercises carried out by the regulatory and supervisory authorities of the Spanish financial system to analyse the impact of climate risks. The most relevant risks arising from climate change for the financial system could materialise mainly through its credit and market exposures to other sectors. Each supervisor has assessed the risks in the segment of the financial system for which they are responsible and the tools used vary due both to the different nature of the sectors to which they are exposed and to the predominance of certain risks over others (credit, market, among others). The varying nature of the risks also determines the relevant time horizon for the analysis carried out by each supervisor.

Given the uncertain nature of the risks associated with climate change, sensitivity analyses and stress tests (forward-looking methodologies) provide a sound methodological basis for their prospective study. As it is not possible to anticipate with certainty the pattern and costs of transition to other means of energy production, or the type and intensity of physical damage associated with the degree of materialisation of climate change that cannot be prevented, it is essential to define and analyse different scenarios. Accordingly, sensitivity analyses and stress tests are the most widely used analysis tools, due to their flexibility for studying the impact of varying climate scenarios.

The macro-financial scenarios used for the analysis in this report are based on those developed by the Network for Greening the Financial System (NGFS). The scenarios developed by the NGFS differ in the timing at which climate change containment policies are introduced, which gives rise to different price paths for greenhouse gas emissions trading, and the intensity of the physical risks that materialise. The common scenario used in this exercise for the different financial segments considers a disorderly transition, and is consistent with that applied in other European exercises such as that of the European Systemic Risk Board (ESRB). This scenario assumes a sudden increase in the price of emission allowances per tonne of CO_2. This causes an alteration in the relative costs of the sectors of the economy, thereby provoking tensions in the financial markets, which in turn generate a negative impact on aggregate economic activity. Chapter 3 provides greater detail about the scenario considered.

The analysis is also necessarily supported by data on risk exposures for each sector of the financial system. To obtain these sectoral exposures, in the case of the banking and insurance sector, prudential supervisory information from the Banco de España and the Directorate General of Insurance and Pension Funds

(DGSFP) is used. For the securities markets sector, the National Securities Market Commission (CNMV) obtains data within the framework of its supervisory powers from investment funds and listed companies. In the case of the latter, the CNMV has obtained information through a voluntary questionnaire, completed with data from commercial data providers.

The analysis horizons applied to model transition risks vary between financial sectors. For investment funds, the insurance sector and pension funds, where the focus is on the deterioration of financial markets, the impact in the first year of the disorderly transition is assessed. For the banking sector, the impact of this scenario is assessed over a three-year timeframe, since credit risk usually takes longer to reflect macroeconomic deterioration. Moreover, in the case of the banking sector, another additional scenario of a prompter and orderly transition is used, which serves as a reference point to measure the medium-term consequences of the deterioration in economic activity and credit quality brought about by the disorderly transition.

In view of the diversity of assets to which each sector of the financial system is exposed when assessing physical risks, the data and analysis methods used to perform this analysis differ. In the case of the banking sector, the physical risk scenarios for droughts and heatwaves from the European Central Bank are used, which consider that these events have an impact on productivity, which are more pronounced in certain sectors of activity. Additionally, for the banking sector, an analysis of the exposure of the mortgage loan market to flood risks is carried out based on data from the Ministry for the Ecological Transition and the Demographic Challenge and the Central Credit Register of the Banco de España (CIRBE). For the insurance sector, the analysis focuses on the effect on multi-risk insurance activity[18] and combined agricultural insurance, using for the latter national sources from Agroseguro (for drought scenarios) and the AEMET (scenarios of high-impact storms).

2.2 Banking sector

The analysis of climate change risks to the banking sector uses the Banco de España's existing top-down stress test framework, called FLESB (Forward Looking Exercise on Spanish Banks).[19] The main channel for

18 Multi-risk insurance includes insurance that protects the assets of companies or individuals

19 This methodological framework uses the historical information available through the regulatory and supervisory report to the Banco de España, applies top-down models (designed and estimated within the Banco de España) and projects the financial evolution of banking entities using a three-year horizon based on predetermined scenarios. A first introduction to the FLESB methodology was published in the Financial Stability Report of November 2013. Since then, further methodological developments and improvements have been included, which are usually published in the Banco de España's Financial Stability Reports. A more detailed explanation of the extension of the methodological framework to capture the heterogeneity of the cyclical sensitivity of corporate exposures according to their characteristics can be found in Alejandro Ferrer et al. (2021). "An initial analysis of energy transition risks using the Banco de España's FLESB stress-testing framework". *Financial Stability Review,* No. 41 (autumn). Banco de España.

modelling the impact of climate change risks is credit risk losses on loans to non-financial companies, whose activity can be disrupted by transition and physical risks. The methodology applied makes it possible to capture the sensitivity of these exposures to climate risks with a high sectoral granularity. In addition, the methodology also projects the dynamic evolution of the magnitude of credit exposures, the other risk factors and components of the balance sheet and the income statement in a manner consistent with the scenarios to obtain results in terms of solvency and profitability.

To construct and model the risk parameters relevant to the exercise, data from the CIRBE are used, among other sources. This database is endowed with broad historical depth and granularity, so that data series are obtained from 2000 onwards for a broad disaggregation of credit exposures. In particular, for the credit exposures of each bank to productive activities, the CIRBE information affords the construction of the probability of default[20] (PD) of portfolios broken down by sector of economic activity and size of debtor company.[21]

Under different scenarios of climate risk materialisation, the methodology stresses the PD of companies' loan portfolios based on the impact on their real activity and financial position. The PD models used make it possible to attain a uniform impact on companies in different sectors of activity depending on the size of the disturbances in the real gross value added (GVA) attributed to them in the scenarios. In addition, the methodology also considers heterogeneous sectoral effects on the financial position of non-financial companies (such as profitability and leverage), as well as the development of other variables of the aggregate macroeconomic and financial framework included in the scenarios. Other credit risk parameters (for example loss given default (LGD)) of corporate credit exposures are projected in consonance with PD evolution and scenario assumptions.

The generation of other income and additional losses to those linked to impairments in the loan portfolio is also stressed using the FLESB methodology based on the impact of climate scenarios on the aggregate macroeconomic and financial framework of the economy. Therefore, the projections of the value of foreclosed real estate assets, the value of holdings of sovereign bonds and other market-based debt financing, or the evolution of the interest margin and other components of the operating margin, are also consistent with the climate scenarios envisaged.

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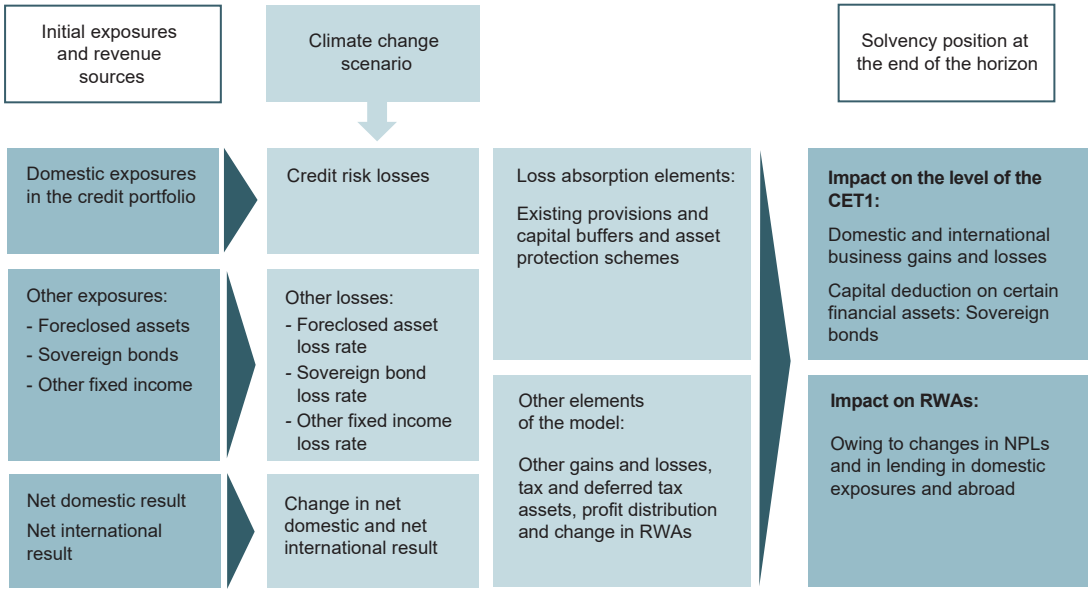
20 PD refers to the 12-month probability of a normal credit entering into a state of doubtful credit quality. In other words, it is the probability of migrating from solvency status S1 to solvency status S3 within this timeframe.

21 The company sizes considered are large companies, SMEs and individual entrepreneurs. The classification of companies based on their size is based on the definitions of Commission Recommendation 2003/361/CE of 6 May 2003 concerning the definition of micro, small and medium-sized enterprises.

Figure 2.2.1 Main elements of the bank stress test exercise



SOURCE: Banco de España.

2.3 Investment funds and securities issuers

Investment funds

The CNMV has developed a framework to quantify the impact of the climate transition on investment portfolios. The analysis considers both climate-related and financial variables and incorporates information with geographic and sector differentiation, data from individual companies and credit and market risk measures obtained for each instrument in the portfolio.

The methodology used quantifies the loss of value that each individual exposure and, therefore, each corresponding portfolio, could suffer in an adverse transition risk scenario. The sensitivity of each counterparty to the climate transition stems from its carbon intensity[22] and that of the economic sector in which it operates. Similarly, for each asset in the portfolio, financial risk indicators are considered to estimate the loss that instruments with different credit ratings, duration, convexity or volatility could experience in the climate

22 Carbon intensity data is defined as total direct (Scope 1) and indirect (Scope 2) CO_2 equivalent emissions in normalised tonnes to net sales or revenues in millions of US dollars (tCO2e/m$), following the methodology of R. Crisóstomo (2022). "Measuring transition risk in investment funds". CNMV Working Papers, No. 81. Scope 3 is not included due to a lack of data. For sovereign debt, carbon intensity is obtained in tCO2e/GDP. For comparison purposes, the carbon intensity of sovereign countries is shown on the tCO2e/m$ scale by mapping the quantile that each country occupies in the distribution for sovereign issuers with the corresponding quantile in the global distribution in tCO2e/m$.

Table 2.3.1 Distribution of investment fund portfolios

Asset class	Investment share (AuM %)	No. of positions	Unique ISINs
Equities	15.46	31,834	4,196
Corporate bonds	19.68	28,274	5,598
Sovereign debt	20.97	8,532	1,462
Other fund vehicles	34.42	12,877	3,802
Cash and cash equivalents	8.81	6,191	-

SOURCE: CNMV.

Table 2.3.2 Climate and financial risk metrics by asset class

	Climate risk metrics			Financial risk metrics				
Asset class	Carbon intensity	Economic sector	Country	Credit quality step	Duration	Convexity	Volatility	Investment style
Corporate bonds	✓	✓	-	✓	✓	✓	-	-
Sovereign debt	✓	-	✓	✓	✓	✓	-	-
Equities	✓	✓	-	-	-	-	✓	-
Other funds	✓	-	-	-	-	-	-	✓
AuM coverage (%)	91.8	100	100	93.5	100	100	91.2	100

SOURCE: CNMV.

transition. The climate-related and financial variables obtained for each exposure are compared with the reference values in their economic sector.

Data on the investment fund sector are obtained from the detailed composition of each portfolio reported to the CNMV. For all funds, their reported portfolio as of June 2021 is considered. The database is made up of 1,629 investment funds with 88,631 individual positions. The total amount of assets under management (AuM) included in the database is €307,373 million. The funds' exposures are classified into five asset classes, which represent more than 99% of the assets managed by Spanish investment funds: i) variable income; ii) corporate bonds; iii) sovereign debt; iv) investment in other fund vehicles, and v) cash and cash equivalents. Table 2.3.1 shows the distribution of investment fund portfolios by asset class.

Table 2.3.2 summarises the climate and financial indicators used to estimate the transition risk of each exposure. Credit and market risk measures (i.e. credit quality, duration, convexity, volatility and investment style) are obtained directly for each ISIN code, while climate indicators (i.e. carbon intensity, economic sector and country) are obtained directly, obtained

for the issuer of each exposure. If any climate indicator is not available for the issuer, the information is obtained for its parent company or its ultimate parent company. This procedure yields a data coverage in terms of assets under management (AuM) of 97.1% on average, ranging between 91.2% and 100% depending on the input considered.

Securities issuers

The assessment of climate risk on securities issuers is a complex task as a consequence of the limited information that the entities themselves make public, as well as the heterogeneity of the information itself. At the time of writing this report, the regulation that will determine the information that securities issuers must publish in relation to the assessment of the risk associated with climate change, as well as other issues concerning this matter, has not yet been approved. Therefore, to evaluate the alignment of securities issuers with the objectives of the Paris agreement and assess the climate change risk of these companies, different sources of information have been used.

On the one hand, a set of 99 securities issuers that meet the requirements of Article 32.1 of Law 7/2021 of 20 May 2021 on climate change and energy transition were sent a questionnaire to find out about the challenges arising from climate change in business management. This questionnaire requires, in particular, information on the field of corporate governance, on the identification of risks and opportunities and on the establishment of specific goals for reducing emissions. Information from commercial databases —Refinitiv and Bloomberg— has also been used, in order to have more comprehensive coverage in relation to the greenhouse gas emissions that Spanish companies have made in recent years and for the different scopes. The result of the analysis of both types of information (questionnaire and commercial databases) has been described in Chapter 1 of this report. Lastly, the estimates of the transition risk to variable income securities made within the framework of the analysis of the transition risk of investment funds have been taken and the aforementioned risk has been assessed for all issuers of Spanish securities, establishing a comparison with estimates obtained for issuers in other jurisdictions.

2.4 Insurance undertakings and pension funds

The DGSFP has assessed the transition risk at both insurance undertakings and pension funds, taking as a reference the European-wide stress tests carried out by the European Insurance and Occupational Pensions Authority (EIOPA) on occupational pension funds in 2022. In the case of insurance undertakings, the climate scenario affects the main elements of the balance sheet of an insurance institution, both on the asset side, in the valuation of investments,

and in the main liability headings, technical provisions.[23] These effects result in a decrease in the solvency of insurance undertakings. For pension funds, the methodology used analyses the effect on the investment portfolios of the pension funds.

The analysis was conducted on data at year-end 2021, with the cumulative effects of the first three years of the disorderly transition scenario of the NGFS concentrated in 2022. For the performance of the analysis, it was necessary to adapt the technical specifications of the European stress tests to make it possible to apply the related hypotheses to the data available from the information report for supervision purposes that insurance undertakings and pension funds periodically send to the DGSFP.[24]

With regard to physical risks, it is important to highlight that, although these are undoubtedly the risks that will have the greatest impact on the insurance sector and those that will most influence its evolution, their assessment is far more complex. Physical risks will have a greater impact, since they directly relate to the level of compensation that the sector will have to pay out in the event of a claim, and the level of damage that this type of claim generally entails is very high. The assessment of the impact of physical risks is more complex due to the lack of data available with the necessary granularity and the need to carry out an assessment not only at a regional level, but also at a global level, given that insurance undertakings offer international insurance coverage.

In the area of physical risks, two studies have been carried out: the first analyses the impact of an increase in damage to insured assets of companies and individuals, and the second addresses an increase in damages covered by combined agricultural insurance. In this first report, partial exercises are set out in which it has been decided to take into account solely the effect on damage to insured property of companies and individuals caused by an increase in high-intensity storms and the impact of an increase in droughts, frosts and hail in combined agricultural insurance. These impacts are reflected in the results of the insurance companies and, therefore, in their solvency.

23 Technical provisions reflect the current value of the obligations incurred from insurance and reinsurance contracts signed by the undertaking, as well as the expenses related to the fulfillment of such obligations.

24 In the case of the stress tests carried out by EIOPA at the European level, specific data requests were made to be able to apply the technical specifications.

BOX 2.A Work of the European Systemic Risk Board in the area of Climate Change

The European Systemic Risk Board (ESRB) has been addressing climate change issues for several years. The first report[1] —in 2016— by the ESRB's Scientific Advisory Committee,[2] analysed the consequences of an adverse scenario of a sudden and late transition to a low-carbon economy. The possibility of this scenario materialising is a source of economic and financial systemic risk due to the macroeconomic effect of higher energy costs in this scenario and its direct impact on financial institutions due to their exposure to carbon-intensive assets, which would suddenly lose value in a transition of this type. The report also explored the implications of climate change risk for macroprudential policy and the actions that could be taken at short and medium term.

More recently, the ESRB and the European Central Bank (ECB) have worked in coordination to jointly study the relationship between climate change and financial stability, and published three reports between 2020 and 2022. The first of these reports[3] raised the main issues to be addressed in dealing with the risks of climate change and its possible implications for financial stability. Among other matters, it analysed the potential economic and financial shocks arising from climate change, how these were being priced in financial markets, and the exposure of banks and insurers to climate change-related risks. These issues would form the basis for the work carried out by the ECB and the ESRB in the framework of a joint ECB/ESRB Project Team on climate risk monitoring (ECB/ESRB Project Team on climate risk monitoring).

In 2021, the ESRB and the ECB published a second report,[4] which underscored the heterogenous impact of climate change on the EU's financial system. The report analyses the potential risks of climate change to financial stability, addresses measurement gaps and establishes the need for climate policies to limit the impact of climate change on the economy, businesses and lifestyles. The analysis also highlights the disparity in performance between countries, leading to greater losses for banks that are more exposed to emissions-intensive activities. This report addressed two main challenges: on the one hand, the need for granular data to be able to measure the impacts of physical and transitional risks across geographies, sectors and firms and, on the other, the very dynamic nature of climate risk, including its long-term horizon, which requires innovation in the models used to identify potential financial losses.

The last report[5] of the ESRB and the ECB to date, addresses the dangers posed by climate shocks to financial stability. Interconnections are considered to be one of the amplifying factors of climate risk in the financial system, affecting both non-financial firms seeking funds and financial institutions. The scenarios analysed suggest that climate risks could materialise in a way that affects the financial system as a whole. Asset price adjustments could affect investment funds,

1 Daniel Gros, Philip R. Lane, Sam Langfield, Sini Matikainen, Marco Pagano, Dirk Schoenmaker and Javier Suárez. (2016). "Too late, too sudden: Transition to a low-carbon economy and systemic risk". Reports of the Advisory Scientific Committee, No. 6. ESRB.

2 This ESRB committee is composed of some fifteen academic and independent members. Another publication of this committee in the field of climate change was Martin Oehmke (2022). "Bank capital regulation and climate change". ASC Insight, No. 3.

3 See "Positively green: Measuring climate change risks to financial stability", June 2020.

4 See "Climate-related risk and financial stability", July 2021.

5 See "The macroprudential challenge of climate change", ESRB Report, July 2022.

BOX 2.A Work of the European Systemic Risk Board in the area of Climate Change (cont'd)

pension funds and insurance undertakings on the one hand, and financial institutions on the other due to possible defaults by non-financial firms. In addition, renewed attention is paid to the formulation of macroprudential policy actions as part of the response to address the impact of climate change on the financial system, with a view to ensuring that the financial system has adequate resources to cope with the risks associated with climate change.

In September 2022, the ESRB included climate risks in its Warning on vulnerabilities in the Union financial system. The Warning,[6] approved by the General Board of the ESRB on 22 September 2022, refers to climate risks as a structural factor that —together with others such as overcapacity, competition from new financial service providers and exposure to cyber risks— could negatively affect the resilience of financial institutions.

The work of the ESRB will continue under the mandate of the European Commission (EC). In 2021 the EC published its strategy to finance the transition to a sustainable economy,[7] which sets out a work programme for the coming years. The EC will examine, with the support of the European Supervisory Authorities (ESAs, which include the European Banking Authority, the European Insurance and Pensions Authority and the European Securities and Markets Authority), the ESRB and the ECB, whether macroprudential tools are capable of addressing financial stability risks related to climate change as part of a forthcoming review of the banking macroprudential framework; and, in the medium term, will continue to work on extending the scope of application to non-banking sectors and environmental risks.

6 Warning ESRB/2022/7, on vulnerabilities in the Union financial system.
7 "Communication from the Commission to the European Parliament, the Council, The European Economic and Social Committee and the Committee of the Regions. Strategy for Financing the Transition to a Sustainable Economy" and Annex, of 6 July 2021.

3 Transition risks

3.1 Scenarios

The analysis of transition risks focuses on the assessment of the impact of a disorderly transition scenario, triggered by a sudden and unforeseen increase in the price of CO_2 emissions. This scenario is closely related to the scenario developed jointly by the European Systemic Risk Board (ESRB) and the European Central Bank (ECB) for the assessment of the impact of disorderly transition on the various segments of the European financial system, based on the late transition scenario narrative of the Network for Greening the Financial System (NGFS).[25]

In particular, the scenario assumes that no measures are taken to promote the energy transition until 2030, at which time the implementation of such measures generates an increase of €240 in the emission price per tonne of CO_2. This marked increase with respect to current prices (around €85 per tonne) would seek to compensate for the previous long period of no action and would raise the price of CO_2 emissions above the level currently estimated to be necessary in 2030 to comply with the goal of limiting the increase in temperatures to less than 2°C established in the Paris Agreement.[26] The increase in the price per tonne of CO_2 is sudden, and occurs within a year. The fact that the implementation of the measure is not anticipated in the scenario implies that the availability of carbon dioxide emission reduction (DCR) technologies is still limited in it. Therefore, the disturbance produces a high increase in the cost of using fossil fuels. In particular, coal experiences a year-on-year increase in its price of 1,294% (see Chart 3.1.1); the impact is comparatively minor on the price of oil or gas, although it reaches very high levels (respectively, 275% and 239% year-on-year variation). Given the energy mix of the Spanish economy (see Chart 3.1.2), it is the increases in gas and oil prices that have the greatest impact on economic activity.

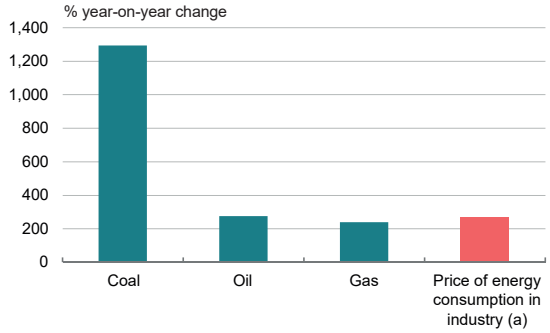
In this context of increasing energy prices, the energy transition scenario envisages an immediate tightening of the financial markets, which is accompanied by a worsening of the macroeconomic outlook at medium term. The deterioration of financial conditions is immediate, but it has an element of persistence and would extend at least over a three-year horizon. Given the severity

25 The document *Macro-financial scenarios for the 2022 climate risk stress test* includes the disorderly transition scenarios, which have been used by several European supervisory authorities in their stress tests on climate change risks. The European Insurance and Occupational Pensions Authority (EIOPA) has published in the document *Climate stress test for the occupational pensions sector 2022* the interest variables for their stress tests, which are consistent with those used in this report and in the European-level disorderly transition scenario.

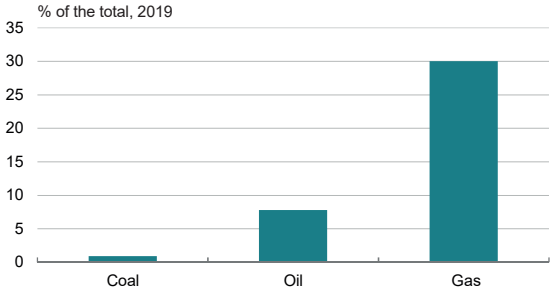
26 Current estimates to achieve a temperature increase of less than 2°C as set out in the Paris Agreement put the required emission price increases at lower levels than those considered in the scenario. See I. W. Parry, S. Black y K. Zhunussova. (2022). *Carbon Taxes or Emissions Trading Systems?: Instrument Choice and Design.* IMF Staff Climate Notes, 2022/006, y Joseph E. Stiglitz, Nicholas Stern, Maosheng Duan, Ottmar Edenhofer y Gaël Giraud. (2017). Report of the High-Level Commission on Carbon Prices.

Chart 3.1.1 Impact on energy commodity prices and energy consumption in Spanish industry

1 Impact on global energy commodity prices in the transition scenario



2 Industrial energy consumption in Spain by product type



SOURCES: National Statistics Institute, European Systemic Risk Board and European Central Bank.

a Sum of assumed changes in oil, gas and coal prices, weighted by their relative importance in industrial energy consumption in 2019.

of the disturbance, in this medium-term horizon, there is also a deterioration in the prospects for economic growth, employment, real estate valuations and other macroeconomic aggregates. As a whole, this scenario represents an upper bound of the expected effect in the face of more orderly or earlier transitions.

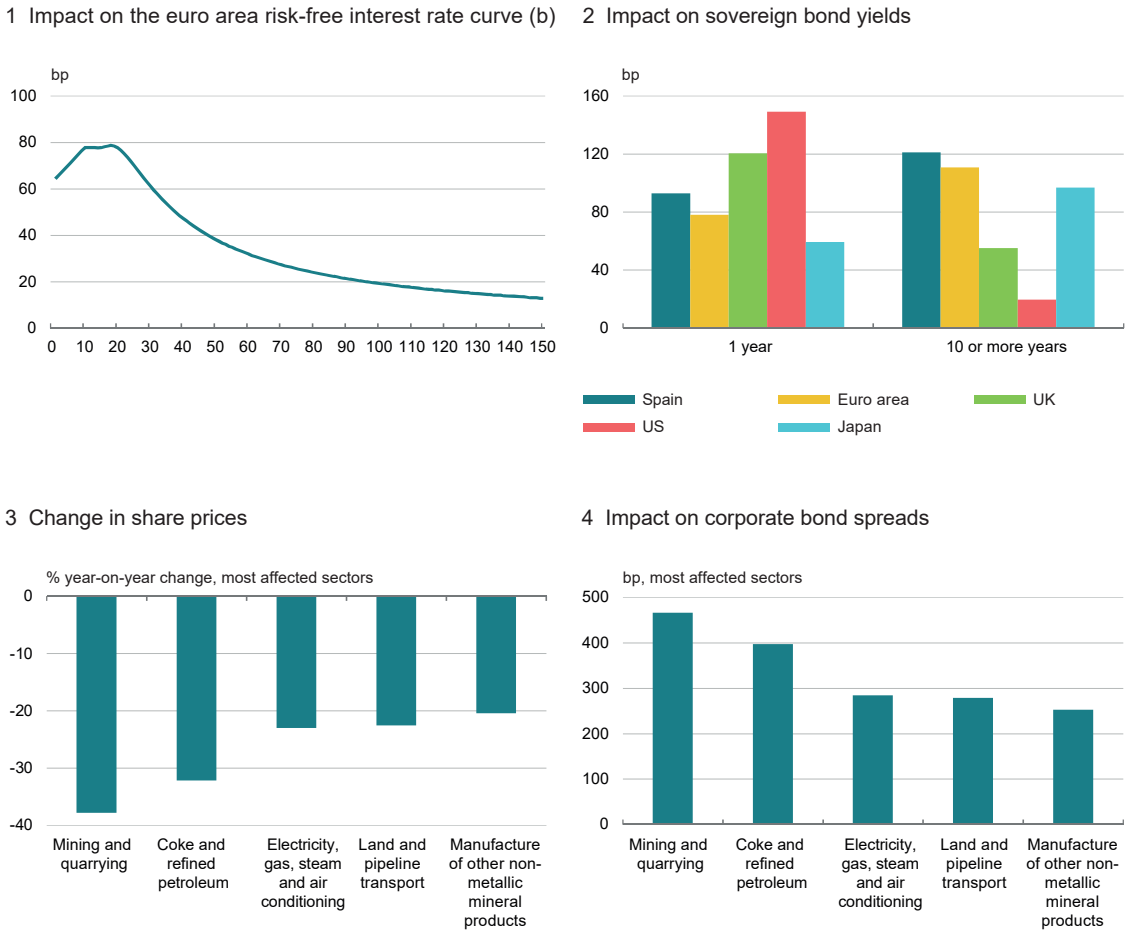
The adverse impact on financial conditions is reflected in the debt and equity markets (see Chart 3.1.2). In the adverse disorderly transition scenario, an increase in the level of the euro's risk-free interest rate curve is considered, which, although it extends to all maturities, is more pronounced in the shortest ones. Also, yields on sovereign bonds at different maturities increase, also contributing to a certain rise in risk premiums in the longer maturities in the case of the main European Union (EU) countries. The tensions in the stock market affect to a greater extent share prices and interest rate spreads (with respect to the risk-free reference) of corporate bonds in the sectors most dependent on energy and, in particular, on the use of fossil fuel.

The energy disturbance associated with the disorderly transition would adversely affect the growth of the Spanish economy. Specifically, a reduction of 3.8 percentage points (pp) in the cumulative growth of real GDP is estimated over a three-year horizon (see Chart 3.1.3.1), with respect to a trend baseline scenario in which there is no increase in energy costs envisaged in the disorderly transition scenario,[27] or any other type of energy disturbance.

This late and disorderly transition scenario has a greater impact on the activity of the sectors of the Spanish economy directly linked to fossil fuels

27 The use of a trend-based macroeconomic scenario makes it possible to exclude from the analysis shocks or growth dynamics related to the current economic situation, which would not necessarily apply in other contexts.

Chart 3.1.2 Impact on the financial environment (at one year) in the disorderly transition scenario (a)



SOURCES: European Insurance and Occupational Pensions Authority, European Central Bank, European Systemic Risk Board.

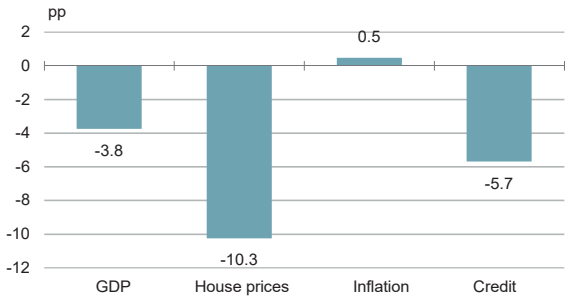
a Impacts are measured as differences in the value of variables in the disorderly transition scenario versus the baseline scenario. The scenario provides a disaggregation of the change in equity and corporate bond prices by productive sector, but not by country.
b Impact on the swap curve. The reference term is indicated in months on the horizontal axis.

or with a greater dependence on energy products. Among the sectors that experienced the greatest falls in real gross value added (GVA), those related to the extraction and processing of fossil fuels stand out, or those that use them intensively, such as air transport (see Chart 3.1.4).

The moderation of real activity is also accompanied by disturbances on different nominal macro-financial aggregates. Thus, over the three-year analysis horizon, the growth of house prices in Spain registers a significant moderation, of 10.3 pp, with the slowdown in the growth of credit to households and companies also being significant (down 5.7 pp, relative to the trend baseline scenario). For its part, inflation sees only a slight increase (see Chart 3.1.3), because the slowdown in activity and the substitution of inputs in production processes —particularly, fossil fuels— moderate the impact on general price levels.

Chart 3.1.3 Medium-term macro-financial impact of the disorderly transition scenario in Spain

1 Macroeconomic impact (a)



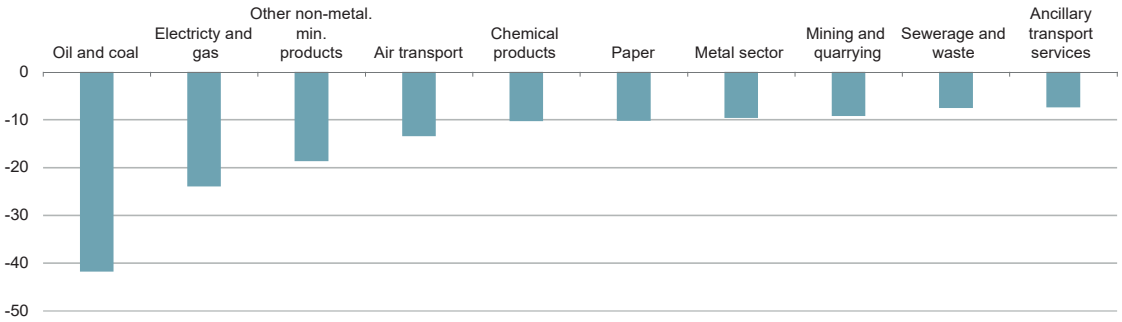
2 Impact on the financial environment (b)

SOURCE: Banco de España.

a Differences with respect to the baseline scenario in the three-year cumulative rates of change (t+1, t+2, t+3). Inflation is calculated using the harmonised index of consumer prices (HICP).
b In the case of interest rates, differences with respect to the baseline scenario in the average rates (t+1, t+2, t+3). In the case of equities, differences with respect to the baseline scenario in the cumulative rates of change (t+1, t+2, t+3) of the Madrid Stock Exchange General Index. The credit variable considered includes loans to households and firms.

Chart 3.1.4 Impact of a disorderly transition scenario on the growth of real sectoral gross value added in Spain over the medium term (a)

1 Differences in percentage points in the cumulative change over three years (t+1, t+2 and t+3) compared to the baseline scenario



SOURCE: Banco de España.

a The 10 most affected sectors according to the ranking of the disorderly transition scenario are depicted.

The tightening of global financial conditions in the short-term market scenario also translates into higher financing costs in the medium term. Over the three-year horizon of the disorderly transition macro-financial scenario, the 12-month Euribor interbank rate and the yield on Spain's long-term sovereign debt see respective increases of 90 bp and 120 bp with respect to the baseline

trend scenario without energy disturbances.[28] The negative impact of the disorderly transition on the cumulative return on equities is moderate (4.2 pp). The impact of the disorderly transition is asymmetric by sector, with strong corrections in the sectors most closely linked to fossil fuels, which are notably more moderate in other sectors that may even benefit from the substitution of activity.

The medium-term impact of the disorderly transition is modelled exclusively for the Spanish economy, in order to contain the complexity of the analysis. This focus on the medium-term macro-financial deterioration in Spain constitutes a limitation, given that a disorderly energy transition could also negatively affect the international setting, which would harm Spanish financial intermediaries, particularly the banking sector, which carry on a significant amount of international business. These additional impact channels will be studied in future reports and imply that the current exercise should be interpreted as a lower bound in terms of the macro-financial impact of climate risks.

Also, an alternative scenario of orderly energy transition has been designed in which the measures are taken in advance and have a moderate impact. This scenario assumes a lower increase in emission prices compared to current levels (€15) and the extension of the Emissions Trading System (ETS) coverage to all productive sectors, and distributes the cost of the energy transition more evenly. Moreover, these regulatory changes take place before 2030, allowing for an orderly transition path. Over the three-year study horizon, the impact on the level of real GDP is -0.6 pp with respect to the baseline scenario without any type of energy disruption.[29] Given the moderate nature of the disturbance in this orderly transition scenario, it is considered that this increase in the price of CO_2 emissions does not trigger financial stress. This makes it possible to assess the macro-financial cost relative to the most adverse scenario of disorderly transition, and is also comparable with previous analyses conducted by the Banco de España.[30]

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28 As Spain joined the euro area, drawing up a stressed financial scenario for it required the application of assumptions for the area as a whole. Thus, the scenario also envisages increases in the yields of the sovereign bonds of other European countries, whose current value is negatively affected, and in turn reduces the value of the holdings of these assets by different agents, in particular, by the various financial intermediaries.

29 This estimate differs from those obtained in the National Integrated Energy and Climate Plan (PNIEC), since it exclusively includes the effect of a disturbance, which is the increase in the price of a tonne of CO_2, without compensation measures. Conversely, the estimate of the macroeconomic impact of the orderly transition of the PNIEC additionally considers measures to promote investment, which causes GDP to increase in the transition scenario.

30 The narrative and level of severity of this orderly transition scenario is in line with the scenarios analysed in Alejandro Ferrer et al. (2021). "An initial analysis of energy transition risks using the Banco de España's FLESB stress-testing framework". *Financial Stability Review,* No. 41 (autumn). Banco de España, and in Banco de España. (2021). Box 3.1. *Financial Stability Report,* autumn 2021. Consistent with the present analysis, these works estimate a moderate macro-financial impact of different orderly energy transition models. As in these exercises, the extension of the scenario to a three-year horizon has used the Carbon Tax Sectoral (CATS) model, in accordance with the methodology published by P. Aguilar, B. González and S. Hurtado. (2021). "The design of macroeconomic scenarios for climate change stress tests". *Financial Stability Review,* No. 40 (spring 2021).

The disorderly transition scenario is applied in the rest of the report to the various financial sectors of the Spanish economy. In particular, the impact assessment exercise on the segments of securities issuers and investment funds (Section 3.3) and on insurance companies and pension funds (Section 3.4) studies the resilience to the tension in the financial markets over a one-year horizon. In these segments, the market risk dimension is the most relevant and its materialisation horizon is shorter. In the case of the banking sector (Section 3.2), the three-year macro-financial scenario is applied, under the assumption that the impact of the disorderly transition on its solvency and profitability would be more lasting over time, in particular, as negative effects materialise on credit risk and business volume. The orderly transition scenario, without significant short-term tension in the financial markets, but with a certain macroeconomic impact, applies only to the banking sector.

3.2 Banking sector

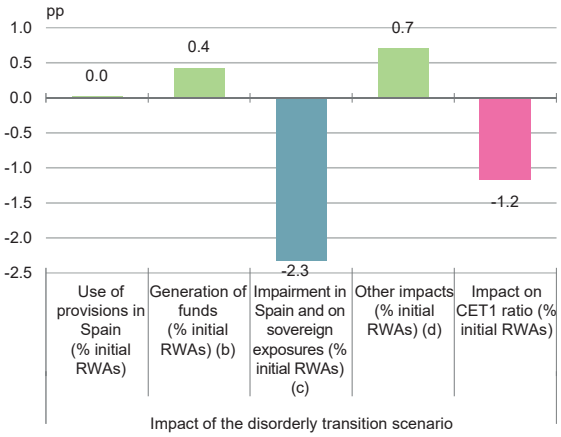
According to results obtained using the FLESB methodology, the materialisation of the disorderly transition scenario would entail a reduction in the solvency and profitability of banking entities, at the end of the analysis horizon. The aggregate CET1[31] ratio of the banking sector would fall by 1.2 pp at the end of the three years of the exercise, while the impact of profitability on initial RWAs would be -0.7 pp. In aggregate terms, the results indicate that the energy disruption associated with the disorderly transition would produce a material bank capital consumption, although the entities would maintain a level of aggregate solvency sufficient to comply with prudential regulatory requirements.

The reduction in the CET1 ratio in the event of the disorderly transition scenario is fundamentally due to greater losses from the credit deterioration of loans to the private sector and the loss of market value of sovereign exposures. As Chart 3.2.1 shows, these losses contribute, along with those associated with foreclosed real estate, to a combined impact of -2.3 pp on initial RWAs, and are not offset by other elements that positively boost the CET1 ratio. These elements include most notably the higher generation of operating income (0.4 pp on initial RWAs), favoured by the increase in net interest income due to the rise in interest rates in the scenario, and the positive performance of the other factors (0.7 pp on initial RWAs), which include the lower tax payments and distribution of profits, as a result of lower pre-tax profits, and a certain degree of deleveraging, which reduces RWAs (the denominator of the solvency ratio). All the effects considered are produced through the results and exposures in the business in Spain and in the Spanish and other euro area countries' sovereign

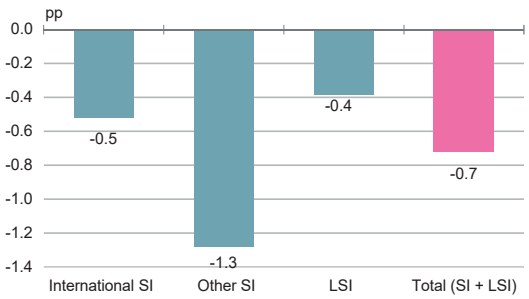
31 The solvency of institutions is measured by their CET1 ratio, which is the ratio of CET1 capital to risk-weighted assets (RWAs).

Chart 3.2.1 Impact of the disorderly transition scenario

1 Impact on solvency. Consolidated business (a)



2 Impact on profitability. Consolidated business (d)



SOURCE: Banco de España.

a Solvency impacts are defined as changes in the expected three-year CET1 ratio and different financial flows over the three years of the exercise (e.g. generation of funds) that would result from the materialisation of the disorderly transition scenario compared to the baseline scenario.

b The impact on the generation of funds derives from the change in operating income in Spain. The net result abroad is not impacted according to the design of the disorderly transition scenario.

c Impacts on financial impairment losses on loans and foreclosed assets in the Spanish business, as well as the impact on capital of the potential impairment of sovereign exposures at the consolidated level.

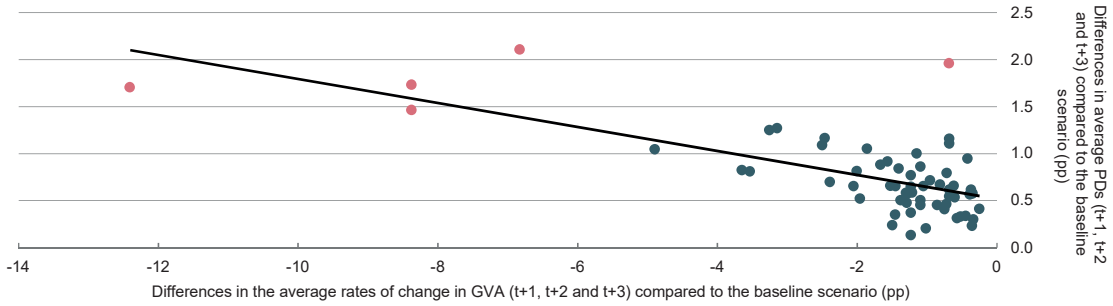
d Impacts on profitability are defined as changes in the ratio of profit after tax to RWAs that would be obtained if the disorderly transition scenario were to materialise compared to the baseline scenario. To calculate this profitability ratio, the numerator (profit after tax) is accumulated for the three years of the exercise, while the denominator corresponds to the value of the RWAs in 2021. There are only changes linked to the business in Spain. Institutions are grouped into: i) Spanish institutions supervised by the Single Supervisory Mechanism (SSM) with more significant international activity ("International SI"); ii) other institutions under direct supervision of the SSM ("Other SI"); and iii) smaller institutions under direct supervision of the Banco de España and with no significant international activity ("LSI").

debt portfolios. As the disorderly transition scenario does not consider an international macroeconomic deterioration, it has no impact on the results of the foreign business.

The worsening of companies' credit quality is generally more notable in those sectors most affected by the increase in the prices of CO_2 emissions and fossil fuels. These sectors, based on the estimated macroeconomic scenario, exhibit more pronounced falls in their activity, which translate into greater contractions in their real GVA. According to the probability of default (PD) models, these decreases in real GVA translate into heterogeneous increases in the probabilities of default, and a negative correlation between sectoral real GVA growth and PD (see Chart 3.2.2) can be appreciated. Among the sectors that suffer significant impacts are the manufacturing of other non-metallic mineral products (2.1 pp), gas, steam and air conditioning supply (1.7 pp), coke and refined petroleum (1.7 pp) and electricity supply (1.5 pp).

The heterogeneous effect of the disorderly transition on the credit quality of the various sectors is also explained by the differences in their initial financial position and the varying sensitivity of their payment capacities to the general

Chart 3.2.2 Differences in the average PD of loans to companies and change in real GVA in the disorderly transition scenario (a)



Sectors with the greatest impact on PD

1) Manu. other non-metal. mineral products
2) Real estate development
3) Gas, steam and air conditioning supply
4) Coke and refined petroleum
5) Electricity supply

SOURCE: Banco de España.

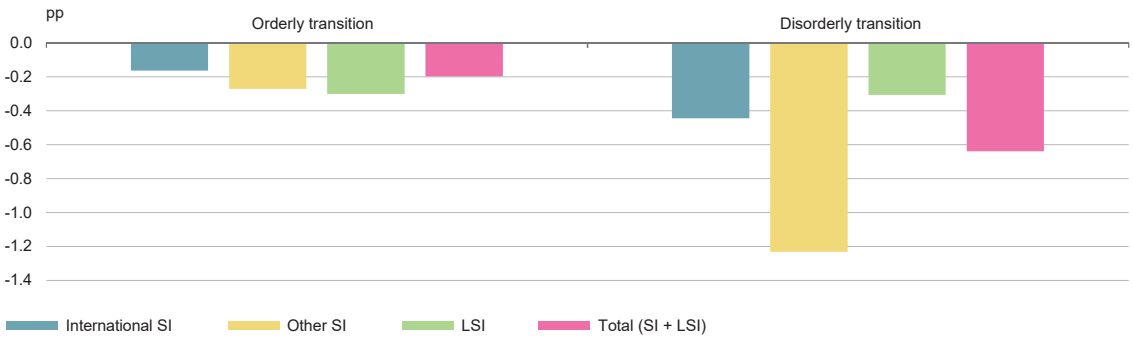
a Each point on the Graph represents a sector. PDs are estimated for each bank, but differences in weighted averages are plotted for each sector. Weighting is done by number of counterparties. The five sectors with the highest impact on PD are shown in pink.

macroeconomic deterioration. Of note in this regard is the significant increase in PD experienced by the real estate development sector (2 pp), which in this case reflects a high sensitivity to the economic cycle and the slowdown in house prices. More generally, higher interest rates in the scenario increase the financial burden on households and firms, and falls in share prices and the cost effects of inflation also contribute to reducing their ability to pay, beyond the effects on real GVA.

Although the main impact channel of the disturbances is through credit risk losses in corporate loan portfolios, the scenario also adversely affects other balance sheet and income statement items. There is another set of losses and income that are affected by the path of macroeconomic and financial variables. Among these, the developments in the interest margin of the institutions stands out, which improves due to the increase in interest rates in the adverse scenario. Another modelled adjustment channel, in this case with a negative impact, is the adjustment in the value of sovereign bond holdings, which takes into account the maturity structure, the geographical composition of the portfolio and the accounting classification of the exposures. This adverse impact is partially offset, since a significant percentage of the sovereign portfolio of Spanish banks is measured at amortised cost, so it is not affected by the increase in interest rates.

The estimated impact on the profitability of different types of banking entities varies depending on factors such as the sectoral composition of their loan portfolio and the relative weight of the business in Spain. As can be seen in Chart 3.2.3, the impact is more moderate at larger institutions with significant international activity. This is because a portion of their credit portfolio is not affected by the shocks studied, since this exercise focuses on the impact on business in Spain, and the impact of the disorderly transition in other countries

Chart 3.2.3 Impact on profitability of different transition scenarios. Consolidated business



SOURCE: Banco de España.

a The impacts on profitability are defined as changes in the ratio of profits after tax to RWAs that would be obtained if each transition scenario were to materialise compared to the baseline scenario. To calculate this profitability ratio, the numerator (profit after tax) is accumulated for the three years of the exercise, while the denominator corresponds to the value of the average RWAs in the same period.

is not modelled. The greater impact on the other significant institutions, at which international business is of a significantly lower relative importance, is due both to this factor and, additionally, to the sectoral composition of their portfolios, where exposures to sectors affected by the transition have a greater weight.

Relative to this late and disorderly transition scenario, the alternative, early and orderly transition scenario shows a much more moderate negative impact. As previously indicated, this scenario is characterised by an increase in the CO_2 emission price of €15 per tonne, up to the current regulatory maximum of €100, with extension of ETS coverage to all sectors. In particular, as shown in Chart 3.2.3, the impact on profitability is more contained, standing at -0.3 pp over initial RWAs, compared to the -0.7 pp obtained in the disorderly transition scenario in aggregate terms at the end of the exercise. In terms of the CET1 ratio, the estimated impact in the orderly transition scenario would be -0.15 at year-end compared to the baseline scenario. These results indicate that the early implementation of energy transition policies, which implies less severe increases in the emission price of a tonne of CO_2, would have more acceptable effects on the economy and the banking sector.

Lastly, it should be considered that the estimated impact on the banking sector is limited by the transition risks specifically considered in the scenario. The study horizon (three years) is relatively short, and the possible changes in the productive system to adapt to the energy transition will conceivably have deeper and more extended effects over time. In addition, the energy transition will also affect countries outside the euro area, which could even lead to a reconfiguration of international trade and financial flows. The limited timescale and geographical scope of the study makes it necessary to consider the present study, as already noted, as a lower bound of the effect of

the disorderly transition. It nevertheless provides useful information to guide environmental and economic policy decisions, as this lower bound is material, and a significantly larger effect is found with respect to the orderly transition cost estimated in previous work.

3.3 Investment funds and securities issuers

Investment funds

As indicated in Section 2.3, the impact of the disorderly transition scenario is assessed using a portfolio at the ISIN level of each investment fund using a top-down modelling approach. The sensitivity of each counterparty to the climate transition arises from its carbon intensity and the economic sector in which it operates. Beyond sector information, company-specific factors, such as its product portfolio, its dependence on different energy sources or its technological portfolio, can significantly alter the climate risk profile of individual companies. Similarly, the behaviour of each financial instrument in the climate transition varies depending on the type of asset considered and the particular characteristics of each position.[32]

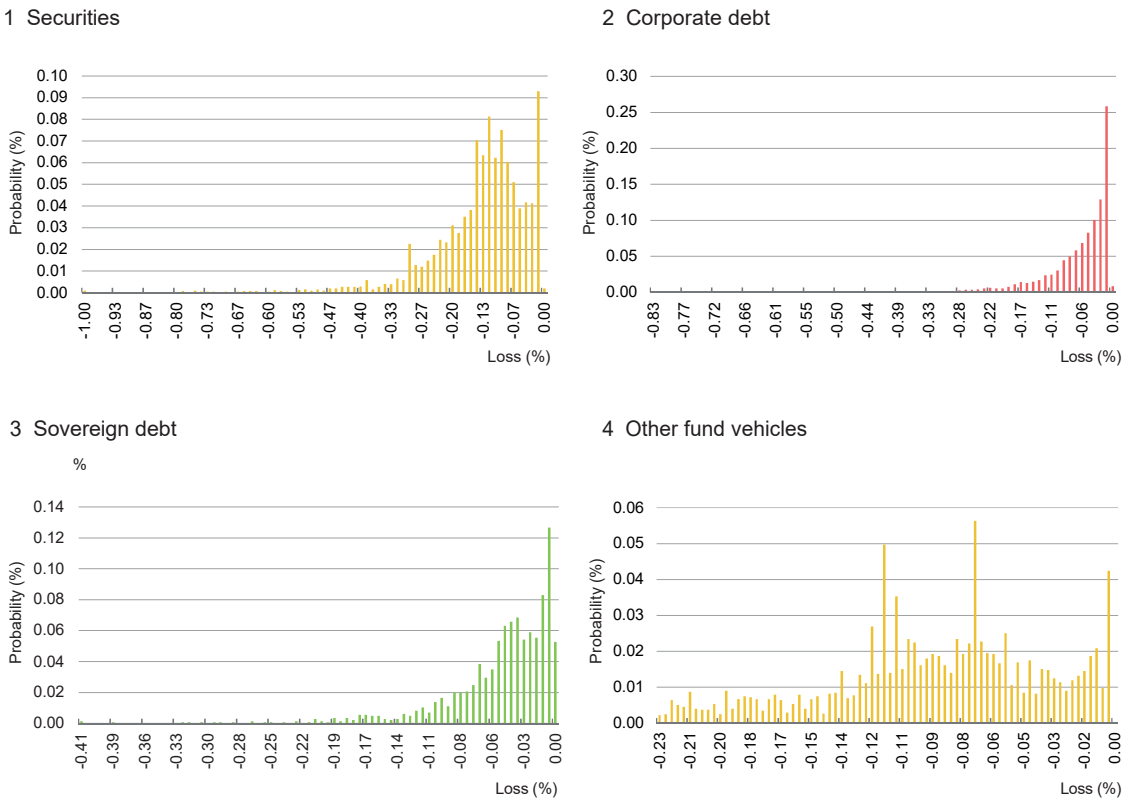
The high degree of carbon intensity heterogeneity in the 25 economic segments considered, as well as a remarkably high intra-sectoral dispersion, are determining factors in terms of the results. The distribution of transition risk losses differs by asset class (see Chart 3.3.1). The largest losses are observed for equity investments (-12.7% on average), followed by corporate bonds (-5.6%) and sovereign debt (-4.8%). In addition, there is substantial variability between financial instruments in each asset class.

Losses on equities exhibit a wider dispersion. The variability is explained by the varying carbon intensity, market volatility and the economic sector of the shares included in our database. The worst performing 1% of shares are characterised by high carbon intensity companies that operate in particularly polluting sectors. On the other hand, shares issued by companies with near-zero carbon emissions are among the most resilient in the transition risk analysis.

As regards corporate debt, a high percentage of bonds register small losses in a high transition risk scenario. In addition to the mitigating effect of bonds issued by companies with a low carbon footprint, almost half of the corporate debt in the database matures at short term (less than three years), giving rise to lower losses in a scenario of a widening credit spreads. In contrast, corporate bonds issued by companies with high carbon intensity and long residual maturities are the worst performers.

32 Further detail on the methodology, the data used and the results obtained in the investment funds can be consulted in R. Crisóstomo. (2022).

Chart 3.3.1 Distribution of losses in the disorderly transition scenario by asset class (a)



SOURCE: R. Crisóstomo. (2022).

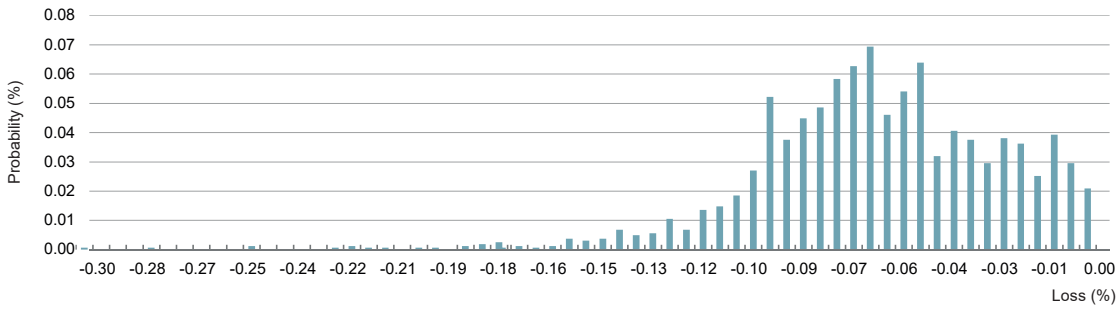
a Each chart shows the loss distribution of the financial instruments included in each asset class. The category of units in other fund vehicles includes the loss distribution of the CIUs in which Spanish mutual funds invest

The distribution of transition risk in sovereign debt also shows a high proportion of bonds with low impairment losses in respect of their fair value.[33] As in the case of corporate debt, the resilience of these instruments stems from the combined effect of low-carbon issuers and bonds with short-term maturities. Overall, two-thirds of the sovereign bonds in our database experience a loss in their lower market value of less than 5%, and perform better than other asset classes. However, significant losses are observed for very long-term sovereign bonds issued by the countries most exposed to the climate transition.

The average estimated loss in the investment fund sector is 5.7% (€17.5 billion in aggregate terms). These losses only take into consideration the direct and primary effects of the climate transition. Therefore, possible amplifiers, such as the market impact of forced sales, the relationship between losses and redemptions,

33 Fair value measurement, or mark-to-market, consists of valuing assets according to current market prices.

Chart 3.3.2 Investment fund losses in a disorderly transition scenario (a)



SOURCE: R. Crisóstomo. (2022).

a The analysis includes 1,629 investment funds domiciled in Spain with aggregate assets of €307,373 million. All investment styles are included.

the behaviour of managers, indirect contagions or other global factors, could trigger cascading effects and non-linear impacts that would significantly increase final losses.

The distribution of transition risk for investment funds is asymmetric and exhibits notable dispersion depending on the portfolio considered (see Chart 3.3.2). In a disorderly transition scenario, funds in the worst percentile suffer a loss of 21.3% on average, while the best performing funds experience no loss. The detailed composition of each fund makes it possible to analyse the causes of transition risk and characterise the portfolios that experience the highest and lowest losses.

Funds that invest in shares of highly polluting companies suffer the greatest losses in the climate transition. Funds in the worst percentile have a high average carbon intensity and invest 94.8% of their portfolio in equities. In comparison, the fund sector as a whole invests only 15.5% in equities and has a carbon intensity of 137.2.[34] The funds that perform best are characterised by being vehicles in constitution or liquidation (lacking active investments) or those in which most of their resources are invested in cash or cash equivalents.

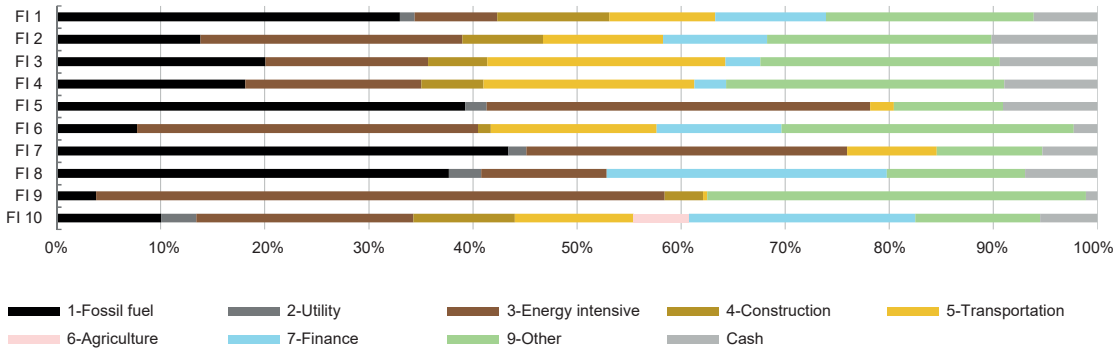
The worst performing funds invest 64.6% of their portfolio in Climate Policy Relevant Sectors (CPRS), which are expected to perform worse in the climate transition.[35] By comparison, the fund industry as a whole invests only 12.2% of its portfolio in CPRS sectors.

Sustainable funds display significant differences compared to the mutual fund sector in terms of transition risk. The sustainable fund portfolio has a lower

34 Intensity measured in tonnes of CO_2 equivalent over revenue in millions of US dollars (tCO_2e/m).

35 Battiston, Mandel, Monasterolo, Schütze and Visentin. (2017). "A climate stress-test of the financial system", *Nature Climate Change,* 7.

Chart 3.3.3 Sectoral breakdown of the 10 worst performing funds



SOURCE: R. Crisóstomo. (2022).

carbon intensity than the fund sector (115.5, compared to 137.2).[36] Moreover, sustainable funds invest a higher percentage of their portfolio in shares (25.17%, compared to 15.46% in the fund sector).

Despite overweighting riskier assets (equities), sustainable funds perform better than traditional funds in the climate transition. In tail risk, sustainable funds in the worst performing 1% and 5% percentiles experience an average loss of 14.7% and 11% (compared to 21.3% and 15.5% for the fund sector). Also, the average loss observed for sustainable funds is 5.7%, and they perform better than the corresponding fund industry portfolio with a comparable asset class allocation.

For the Spanish funds analysed, the exposure to transition risk of their assets is lower than that of their comparable EU funds, but they also show less alignment with the EU taxonomy.[37] This is explained by the relationship observed in the estimated taxonomy alignment and transition risk measures in many economic sectors. Thus, of the NACE codes that exhibit a positive transition risk measure, about half also display a measure of positive estimated taxonomy alignment. Consequently, funds that invest in sectors with high transition risk and/or in low-carbon activities tend to show a higher probability of alignment with the EU taxonomy.[38] Lastly, it should be noted that the sustainable

36 Measured in tCO_2e/m.

37 To understand these figures, it should be noted that Alessi and Battiston (2021) is only applicable to NACE-coded investments (i.e. equities and corporate bonds). Consequently, non-NACE exposures (i.e. sovereign debt and other fund vehicles) are weighted by zero in the portfolio aggregation, which reduces the measure of alignment with the taxonomy and the aggregate transition risk measure.

38 As a representative example, the transition risk measure of NACE sector 35.11 (electricity production) is 0.39, which is the share of electricity produced using fossil fuels. However, this sector also has a measure of alignment with the taxonomy of 0.35, which corresponds to the share of electricity that is derived from renewable sources. Consequently, all NACE 35.11 companies receive high values for transition risk and alignment with the taxonomy, regardless of whether their electricity is generated employing renewable sources or by burning fossil fuels. This example illustrates the need to use individual company data to complement the sectoral analysis.

Table 3.3.1 Taxonomy alignment and transition risk exposure of investment funds

Asset class	Transition-risk exposure (TEC)	Taxonomy alignment (TAC)	Eligible portfolio	Adjusted TEC	Adjusted TAC
ES investment funds	4.37%	0.94%	33.88%	12.91%	2.79%
ES sustainable funds	3.78%	2.67%	47.98%	7.87%	5.57%
EU investment funds	6.11%	1.37%	20.91%	29.20%	6.54%

SOURCE: CNMV.
Note: the TAC and TEC of EU investment funds are retrieved from Alessi and Battiston (2021). Adjusted TAC and TEC values are calculated as the standard TAC and TEC divided by the eligible portfolio.

fund portfolio is less exposed to transition risk and is greener than that of the investment fund sector.

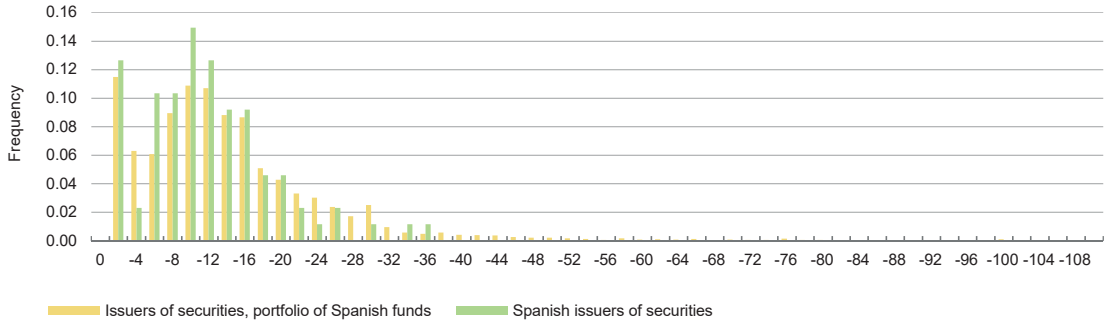
Securities issuers

Initial evidence of the transition risk of Spanish issuers in the sample portfolios reveals that they are in a relatively better position than issuers from other jurisdictions. From the climate stress tests conducted for the portfolio of Spanish investment funds, the estimated losses of the shares in their portfolio were obtained. In total, loss estimates are available for a total of 4,196 shares from 67 jurisdictions, of which 87 correspond to Spanish issuers. The analysis of the distribution of issuers' losses reveals that the average expected loss of Spanish issuers (-10.8%) is lower than the average of the other issuers in this sample (-13.2%) and that its dispersion is also less marked.

The sectoral analysis of losses for Spanish issuers reveals that energy companies have the highest expected loss, as well as a greater degree of dispersion.[39] In the case of energy companies, this fact could be explained by the high level of heterogeneity of companies that belong to this sector, since it groups together both those that emit the most greenhouse gases and others that specialise in generating electricity from renewable energy sources, which emit almost no greenhouse gases. Relatively high losses (on average) are also observed in the goods and consumer sector, accompanied by high variability. Once again, business heterogeneity within this sector, with a high number of companies with very different business models, would explain this outcome.

39 This sectoral analysis does not include the financial system, which is discussed in other sections.

Chart 3.3.4 Histogram of losses on equities in the disorderly transition scenario



SOURCES: CNMV and R. Crisóstomo. (2022).

Table 3.3.2 Expected transition risk losses of Spanish securities issuers (%)

	Average	Standard deviation	Weighted average (a)	Maximum	Minimum
All sectors	-10.8	7.2	-9.1	-35.6	0.0
Energy sector	-14.7	10.6	-13.3	-32.6	0.0
Construction and real estate sector	-13.4	4.4	-14.5	-24.4	-9.1
Industrial sector	-9.6	5.3	-5.5	-24.7	-0.8
Consumer goods and services sector	-12.0	7.8	-10.4	-35.6	-1.3

SOURCES: CNMV and R. Crisóstomo. (2022).

a Average weighted by the companies' revenue.

3.4 Insurance undertakings and pension funds

Insurance sector

The impact of the disorderly transition scenario on insurance undertakings has been measured by analysing its effect on the solvency ratio.[40] Specifically, the impact on own funds was studied[41] which are modified by the different valuations of assets and liabilities. The exercise was carried out for all Spanish insurance companies that are subject to the Solvency II regime.[42]

40 The solvency ratio is the ratio of own funds to the regulatory capital requirement. For the purpose of this exercise, a stress test was carried out on own funds, with the regulatory capital requirement remaining constant.

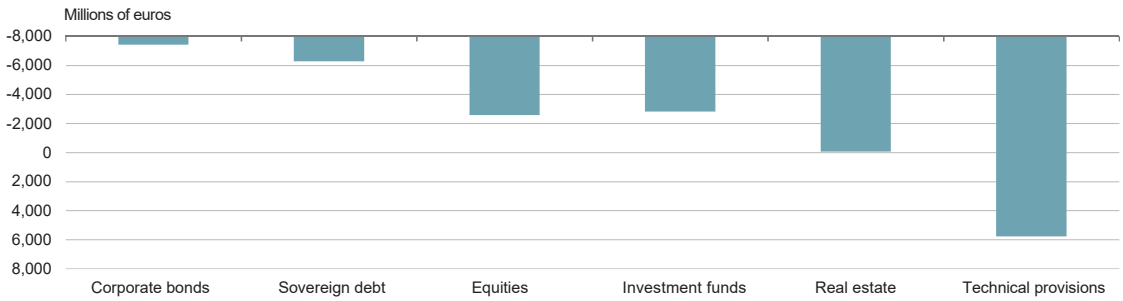
41 Own funds are calculated as the difference between assets less liabilities, so a decrease in the value of assets means a decrease in own funds, however, a decrease in the value of liabilities means an increase in own funds.

42 Those Spanish insurance undertakings covered by the special solvency regime have not been the subject of this exercise because the periodic reports submitted by these entities to the supervisor lack the data necessary for them to be so and, above all, because they have a residual weight both in the volume of premiums (0.14%) and the volume of technical provisions (0.21%) over the entire Spanish insurance sector.

The shocks applied suppose a fall in the value of the insurance undertakings' assets (corporate bonds, sovereign debt, equities, investment funds and real estate), which gives rise to a negative effect on their own funds. In the case of insurance undertakings, it is also essential to take into account the effect of the rise in risk-free interest rates on the main liability item, technical provisions. Technical provisions are calculated by discounting the flows of payments to be met by the insurance company for the commitments assumed under insurance contracts. Increases in interest rates, such as those set out in the technical specifications of the EIOPA stress tests, imply a higher discount rate and, therefore, decrease the amount of the provision.

It should be noted that the European solvency regulatory framework allows insurance undertakings offering insurance products with long-term guarantees to apply a number of mitigating measures in the calculation of their technical provisions to reflect the long-term nature of these commitments. Among these measures, the volatility adjustment and the matching adjustment stand out, which take into account the composition of the asset portfolio of the insurance companies to determine the discount hypotheses in the measurement of insurance liabilities. In the exercise conducted, these adjustments have been considered in those entities that are already using them in their calculation of technical provisions. The European supervisor periodically publishes the volatility adjustment, which is calculated for each currency based on a portfolio of reference assets. For the purposes of the exercise, this adjustment remained constant, and had a greater impact, given that in the scenario proposed, this adjustment would increase, resulting in a lower volume of technical provisions and, therefore, higher own funds. The matching adjustment allows a discount curve to be applied in the valuation of technical provisions derived from the specific assets assigned. This adjustment must be previously authorised by the supervisor and requires compliance with strict requirements. Among these requirements, it is anticipated that the insurance undertaking's asset portfolio subject to matching must be held to maturity by the entity. Therefore, the investment portfolios affected by the matching adjustment did not have any impact on the exercise performed, since the effects of falls in the value of the investments are fully offset by the corresponding fall in the amount of technical provisions.

Chart 3.4.1 Impact on insurance undertakings' own funds



SOURCE: Directorate General of Insurance and Pension Funds.

In addition, the tax effect of the disorderly transition scenario on the insurance undertaking's own funds has been taken into account, assuming that the average tax rate is 25%. Chart 3.4.1 shows a greater impact on own funds arising from investments that have a greater weight in undertakings' balance sheets, such as fixed income. On the other hand, this negative effect on own funds as a consequence of the decrease in the valuation of investments is partially offset by the reduction in the valuation of the liability item, technical provisions.

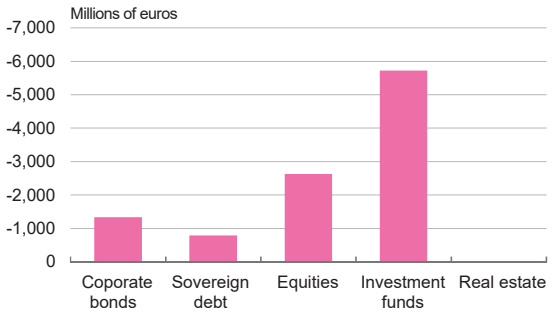
The insurance sector could face a disorderly transition scenario such as the one proposed herein. This scenario causes the solvency ratio of the insurance sector to decrease by 39 pp, falling from a solvency ratio of 240% at year-end 2021 to one of 201%.

Pension funds

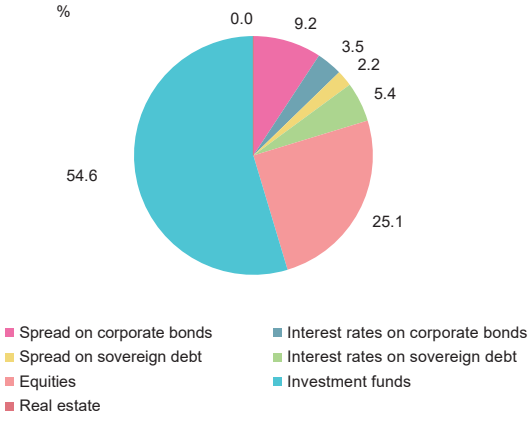
In the case of pension funds, the impact of the disorderly transition scenario on the asset portfolio of pension funds has been evaluated.[43] In the exercise, the impact on liabilities has not been considered because Spanish pension funds are mostly defined contribution plans[44] and the residual portion of the defined benefit plan is almost entirely assured.[45] Taking into account this disorderly transition

Chart 3.4.2 Impact of a disorderly transition on pension funds

1 Nominal impact by type of asset



2 Weight of the impacts by type of risk



SOURCE: Directorate General of Insurance and Pension Funds.

43 Open pension funds have been eliminated from the total amount of pension fund assets, as these are pension funds which in turn invest in other pension funds and, if taken into account, their assets would be duplicated.

44 In defined contribution pension plans, a periodic contribution is established, and future benefits are not stipulated. This signifies that at the time of redemption the plan holder can expect to recover his or her invested capital, as well as a return (positive or negative) that will vary depending on the investments made.

45 Although liabilities were also stressed in the EIOPA exercise, it must be taken into account that the exercise was focused solely on employment pension funds of the defined benefit system. In defined benefit pension plans, it is guaranteed that, at the time of redemption, the holder will receive their contributed capital, as well as a previously defined benefit or return.

scenario, the impact on sovereign debt, corporate bonds, equities, investment funds and real estate has been assessed. For corporate bonds and sovereign debt, an impact analysis was conducted based on the duration of the assets. In the case of investment funds included in the assets of pension funds, the decision was taken to use an analysis of equities, this being a conservative approach, in which the losses are greater than those that would result from measuring each one of the assets in the investment fund portfolio.

The total impact on assets amounts to €10,474 million, which represents a drop of 8.2 pp; the greatest impact on investments is concentrated in investment funds and equities. Chart 3.4.2 illustrates the impact both in nominal terms and in weight by type of asset.

4 Physical risks: exploratory analyses

If the transition to a more sustainable economy is not completed in time, climate change will pose physical risks to economic activity and the financial system. In this climate change scenario, the economy will be affected by slowly progressive events, such as rising sea level or desertification, and also by the increase in the frequency and severity of climate shocks (desertification, floods, fires, sea level rises, among others). Through various channels, these phenomena will lead to losses for financial institutions. The analysis and quantification of physical risks are currently at an early stage, limited by factors such as uncertainty regarding the future paths of emissions and, consequently, temperatures; the scarcity of data, and the fact that the analysis horizons are notably longer than those usual in stress testing exercises, which are aspects that require new methodological developments.

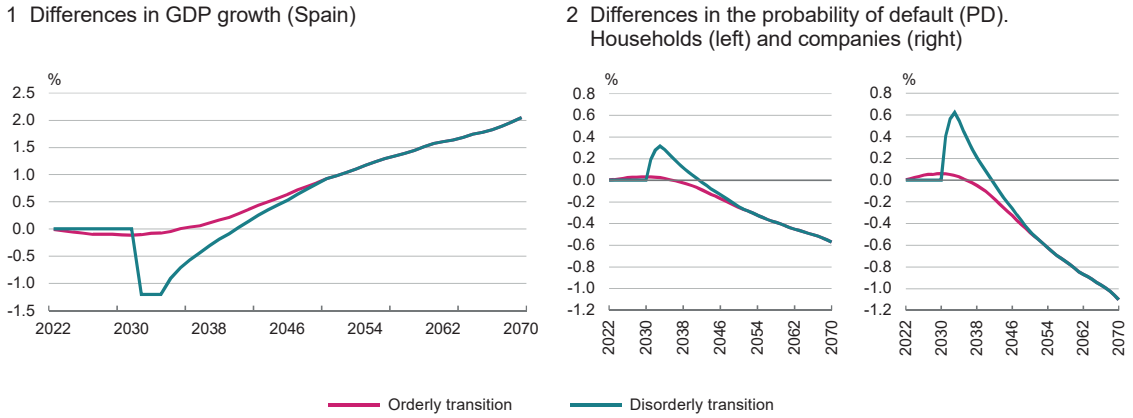
In order to illustrate the long-term consequences of the materialisation of physical risks in the absence of climate change mitigation and adaptation measures, a simplified example of their impact on credit risk is presented. This exercise compares the evolution of the probability of default (PD) in the loan portfolios of households and non-financial corporations, over a horizon reaching 2070, of two alternative transition scenarios, as opposed to the Greenhouse Planet scenario developed by the Network for Greening the Financial System (NGFS).[46] The Hothouse Earth scenario considers an absence of action in taking energy transition measures and, as a consequence, points to an acute environmental deterioration. Firstly, an orderly transition scenario, consistent with the one developed by the NGFS, where measures are taken early and gradually. Secondly, a disorderly scenario, consistent with the one used in the preceding section, where it is assumed that energy transition measures are not taken until 2030, at which time they are taken all at once. Specifically, failure to take action on climate change could lead to a level of GDP in 2070 that is 50 pp lower than in an orderly transition scenario, according to NGFS projections. In turn, a disorderly transition could imply a cumulative loss in the level of GDP in 2070 of 12 pp compared to an orderly transition.[47]

The results of the analysis of the evolution of the credit risk of the bank loan portfolio show that a failure to act in the climate transition to a decarbonised economy would have adverse effects on the financial system, which would not manifest themselves in the short term, but would be evident in the long term and would be of an appreciable magnitude. Thus, in the long term, credit risk would be higher in the no-action scenario, relative to both climate transition

46 See "NGFS Climate Scenarios Database", June 2021.

47 Specifically, the transition measures are assumed to have a negative impact on GDP in three years, in 2030; thereafter, a gradual return to the growth path of the orderly transition scenario is assumed, which is completed in 2050.

Chart 4.1 Impact of climate change risks on the banking sector. Transition scenarios compared to no-action scenario (a)



SOURCES: Network for Greening the Financial System, European Central Bank, European Systemic Risk Board and Banco de España.

a The PD projection is obtained by sequentially applying the estimated model with the historical data. The model depends on GDP growth, according to the scenarios considered, and on the PD lag, which allows it to be projected year by year, until 2070. The transition scenarios correspond to those explained in Chapter 3 of this report, extended under the assumption that in 2050 the costs are equal to those estimated for an orderly transition. The no-action scenario (i.e. maintaining current commitments) corresponds to the scenario published by the NGFS for Spain.

scenarios, with the benefits being more pronounced in the case of an early and orderly transition. The statistical model used, which links 12-month PD to annual GDP growth, shows that, from around 2030 onwards, credit risk would be higher in the no-action scenario, in which physical risks have materialised. The increase in credit risk would be particularly noticeable in the case of corporate lending.

Complementary to this stylised analysis, the negative impact of climate change on the financial system can be illustrated by specific exercises documenting the possible effects of adverse weather events, the intensity and frequency of which would increase if the climate transition fails to occur. To illustrate the impact of physical risks, this section presents partial analyses of specific events that can lead to losses for the banking sector, such as droughts and heatwaves, and for the insurance sector, the increased frequency of high-intensity storms.

4.1 Banking sector

This section focuses on the impact on the solvency and profitability of the Spanish banking sector of a scenario of severe droughts and heatwaves. This considers a range of shocks to macroeconomic conditions over a one-year horizon (t+1) and has been estimated by the Banco de España in a manner consistent with the narrative and sectoral shocks considered in the drought and heatwave scenario designed by the European Central Bank (ECB) and the

European Systemic Risk Board (ESRB)[48] for the 2021 European climate stress test exercise. To translate this scenario into impacts on the banking sector, the FLESB methodology is applied, as set out in Section 2.2, and is also applied to measure the impact of transition risks in Section 3.

The ECB/ESRB calibration of the drought and heatwave scenario considers that these extreme events have a negative impact on labour productivity due to extreme heat, which affects certain countries and sectors of activity more adversely. In particular, the negative shock to productivity is more severe in those economic activities where workers are more exposed to weather or the activity depends on it, such as the construction sector or agriculture. Consistently, these sectors show a larger deterioration in gross value added (GVA) in the ECB/ESRB scenario. Within the effects on real GVA estimated for European countries, the shocks would be more pronounced in southern European countries, so the study of their implications is of particular relevance for the Spanish banking sector. It is important to emphasise that heatwaves can have an adverse economic impact through other channels, although in this exercise we examine exclusively the one that results in the deterioration of productivity.[49]

The negative productivity shock in multiple sectors also translates into an adverse aggregate impact on activity and other macroeconomic variables. The one-year impact on real GDP growth of the scenario of droughts and heatwaves in the Spanish economy would be -1.3 pp, and would be accompanied by an impact of -4.2 pp on house prices and an increase of 1.5 pp in inflation with respect to the baseline scenario. These impacts, together with the estimated changes in the real GVA of the most affected sectors of the Spanish economy, are shown in Chart 4.1.1.[50] Due to the very nature of the shock analysed, a drought and heatwave episode in Spain over a limited period of time, the scenario does not consider financial stress, nor does it consider shocks to macroeconomic activity in the rest of the world. The full scenario considers a three-year horizon, the first of which incorporates the climate shock of droughts and heatwaves, and two additional years in which the scenario reverts to trend growth rates.

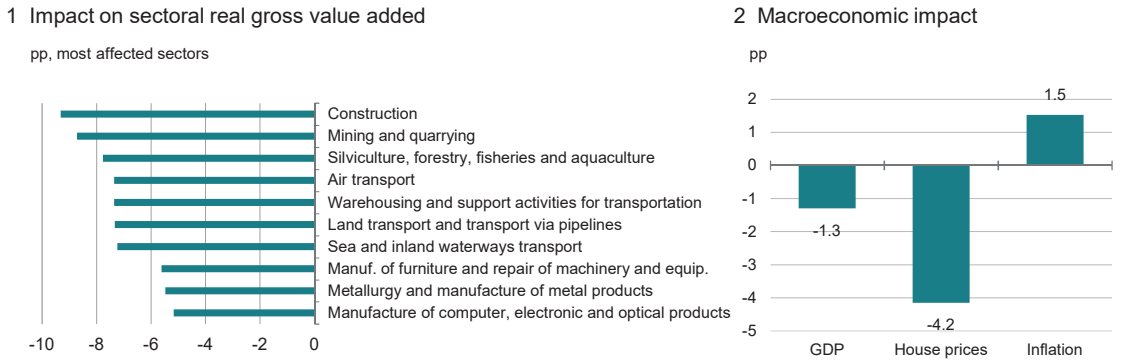
The episode of droughts and heatwaves envisaged would have a moderate impact on the profitability and solvency of the Spanish banking sector. At the end of the three-year study horizon, a reduction with respect to the baseline scenario of somewhat less than 0.2 percentage points (pp) is estimated in the aggregate CET1 ratio of the banking sector. The impact on profitability would be 0.3 pp on initial RWAs (see Chart 4.1.2). This aggregate impact is moderate, since

48 See *Macro-financial scenarios for the 2022 climate risk stress test.*

49 For a comprehensive discussion of the possible negative effects of heatwaves on the economy, see MITECO. (2022). *"Ficha de casos: Ola de calor de julio de 2022".*

50 This impact is measured against a baseline scenario that assumes trend growth in the Spanish economy to avoid including shocks or growth dynamics related to the current economic situation, which may lose validity over a longer time horizon where the risk of extreme heat events remains of significance. It should be noted that this is a departure from the adverse scenario designed by the ECB/ ESRB, which applies shocks to real sectoral GVA in 2022.

Chart 4.1.1 Impact on real GVA by sector and aggregate macroeconomic framework (a)



SOURCE: Banco de España.

a Figures for the aggregate and sectors of the Spanish economy. Impacts are defined as the differences with respect to a trend baseline scenario in growth rates at the one-year horizon (t+1). Inflation is calculated on the basis of the harmonised index of consumer prices (HICP). The impacts have been estimated by the Banco de España in line with the narrative and sectoral shocks of the drought and heatwave scenario of the European Central Bank and the European Systemic Risk Board.

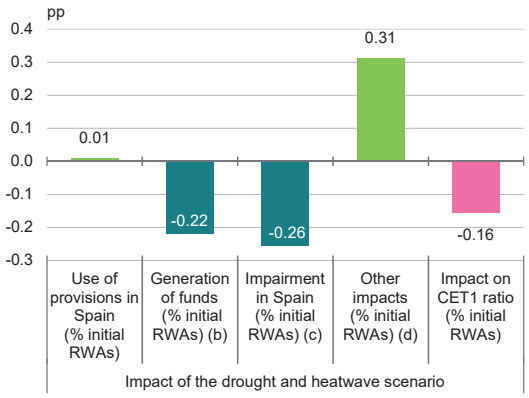
the drought shock has a limited effect at macroeconomic level, but the study of the impact channels identified is relevant for assessing the potential vulnerabilities of the banking sector to a higher degree of materialisation of this type of climate risk.

Capital consumption is mainly explained by higher impairment losses and lower net margin generation in the Spanish business. The slowdown in economic activity deteriorates credit quality and raises impairment losses which, together with losses on foreclosed assets, have a negative impact of 0.3 pp on initial RWAs. Similarly, the reduction in net operating income entails a lower generation of capital resources (0.2 pp of initial RWAs) with respect to the baseline scenario (see Chart 4.1.2.1). The positive effect of the other impacts (0.3 pp on initial RWAs) is principally associated with the higher degree of deleveraging of institutions in the drought and heatwave scenario, which reduces their RWAs (denominator of the solvency ratio). The impact on solvency is greater in the first year of the exercise, in which the drought and heatwave shock occurs, but the level of the ratio persists to a large extent over the three-year horizon (see Chart 4.1.2.2).

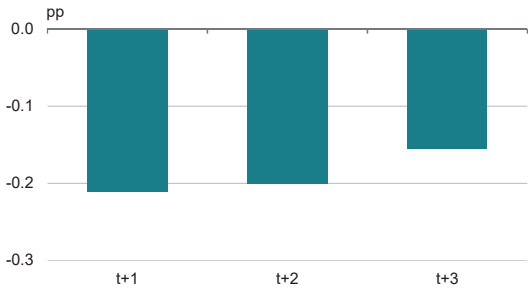
The deterioration in credit quality is higher in those sectors most affected by the fall in productivity (Chart 4.1.2.3). The activities most affected are those within the real estate sector, both construction and development, forestry and logging, and transport and related activities, with increases in their probabilities of default (PD) of between 0.5 pp and 1 pp compared to the baseline scenario. In comparison with the transition risk assessment exercise in Section 3, the aggregate macroeconomic impact is lower, and the indirect effects of the scenario are less pronounced. Accordingly, there is a stronger correlation between the impact on real sectoral GVA and PD in this scenario than in the disorderly transition scenario.

Chart 4.1.2 Impact of the drought and heatwave scenario

1 Impact on solvency. Consolidated business (a)

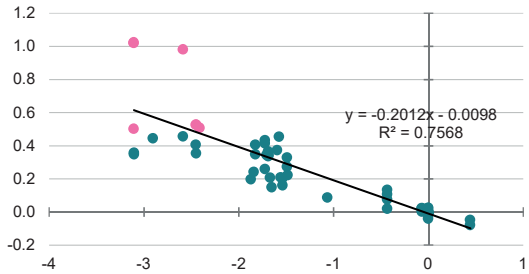


2 Annual impact on solvency. Consolidated business

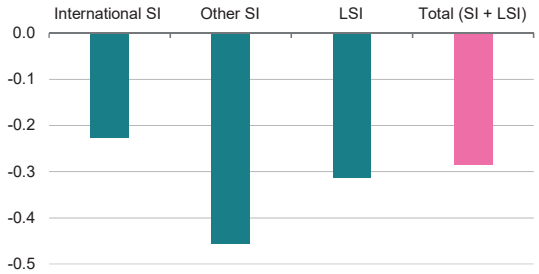


3 Differences in average PD of loans to companies and change in real GVA (e)

X-axis: diff. in average rates of change of GVA (t+1, t+2 y t+3) (pp)
Y-axis: diff. in average PDs (t+1, t+2 y t+3) (pp)



4 Impact on profitability. Consolidated business (f)



SOURCE: Banco de España.

a The impact on solvency is defined as the changes in the expected three-year CET1 ratio and different financial flows over the three years of the exercise (e.g. generation of funds) that would result from the materialisation of the drought and heatwave scenario compared to the baseline scenario.
b The generation of loss absorption funds is determined by the operating margin in Spain, including also the net result obtained abroad for those institutions with significant international activity. Since the impact on international activity is not modelled, the net result abroad in the drought and heatwave scenario does not vary with respect to the base scenario.
c Financial impairment losses on loans and foreclosed assets in the Spanish business. The impact on capital of the potential impairment of sovereign exposures at the consolidated level is not significant due to the absence of financial stress assumed for this portfolio.
d Other consolidated gains and losses, tax and exchange rate effects, distribution of profit, coverage of losses on ICO-backed loans by the State and change in RWAs.
e Each point on the graph represents a sector. PDs are estimated for each bank, but differences in weighted averages are plotted for each sector. Weighting is by number of holders. The differences compared to the baseline scenario are presented. The five sectors with the highest impact on PD are shown in pink.
f The impacts on profitability are defined as variations in the ratio of profits after tax to RWAs that would be obtained if the drought and heatwave scenario were to materialise compared to the baseline scenario. To calculate this profitability ratio, the numerator (profit after tax) is accumulated for the three years of the exercise, while the denominator corresponds to the value of the average RWAs in the same period.

The negative impact on the profitability of institutions, which for the most part is moderate, is greater in significant institutions with less international presence (O-SIIs). The results are broken down for three groups of institutions: i) the group of significant Spanish institutions supervised by the ECB with the most significant international activity, ii) other institutions under direct supervision of the ECB, and iii) smaller institutions under direct supervision of the Banco de España and without significant international activity (Less Significant Institutions,

LSI). The O-SIIs group is affected by the greater concentration of the portfolio in the affected activity sectors in Spain, and the non-significant presence of business abroad, which due to the very design of the scenario (climate disturbance focused on Spain) implies an absence of diversification. LSIs are affected to a lesser extent in relation to the O-SIIs group due to the lower weight of the corporate portfolio. Lastly, the size of the foreign business moderates the relative importance of losses for the most active SIs abroad.

Heatwaves and droughts can occur simultaneously in several countries in which Spanish banks operate. In the summer of 2022, simultaneous heatwaves occurred in various parts of the northern hemisphere; in particular, the heatwave that affected Spain had a very wide geographical distribution, and affected many countries simultaneously. Due to methodological and data limitations, the scenarios analysed in this section are limited to Spain and, in this first report, international scenarios are not covered, in which the advantages of geographical diversification would be fewer or could even be absent or contribute negatively if other areas affected receive a more adverse impact from climate change than Spain.

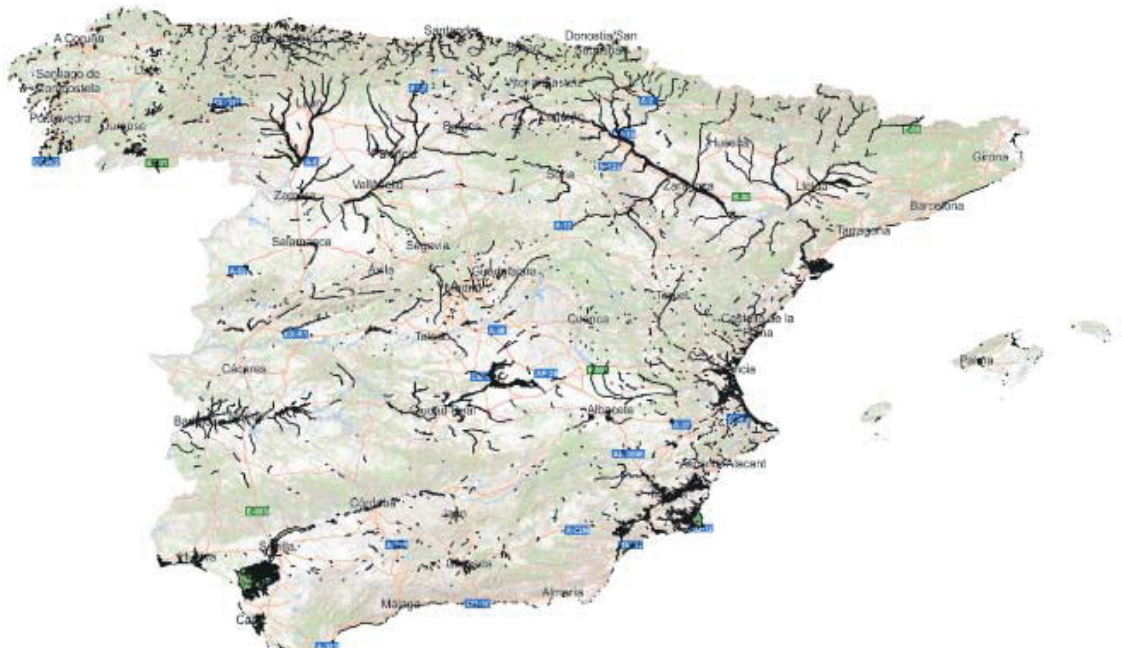
Additionally, the recurrence of droughts and heatwaves could increase their negative impact on the solvency and profitability of the banking sector with respect to what is estimated in Box 4.A for specific episodes. Climate change may manifest itself through an increase in the recurrence of droughts and heatwaves, not considered in this exercise, which would lead to a greater accumulation of negative effects on economic activity, profit or loss and solvency. The increase in the impact on activity above certain thresholds could also be accompanied by more pronounced financial tensions, which, as has been proven in the evaluation of a disorderly energy transition, would increase the severity of the adverse scenarios envisaged. Furthermore, as already noted, droughts and heatwaves may affect other geographies, and other extreme weather events may occur. In relation to this second possibility, Box 4.A documents the progress in measuring the exposure to flood risk of the mortgage loan portfolio in the business in Spain. All of this makes it necessary to consider the results in this section as a lower bound on the possible effects of physical climate risks on the banking sector.

BOX 4.A Flood maps

In order to make headway in the measurement of physical risks, the Banco de España has carried out a first exploratory exercise to identify the dwellings that act as collateral for mortgage loans in Spain and are located in potentially flood-prone areas. Measuring the volumes of exposure to physical risks is primordial for the analysis thereof, which is not without complexity. The impact of each category of physical risks (such as floods, droughts and fires) can have a heterogeneous impact depending on the geographical location of the affected activities or assets, and high granularity geolocation exercises are necessary.

This initial analysis is carried out by combining data from the National Floodplain Mapping System, developed by the Ministry for Ecological Transition and Demographic Challenge (MITECO), the Land Registry and the CIRBE database. The starting point is the identification in CIRBE of the dwellings that act as collateral in the portfolio of bank mortgage loans to households. This database provides information at loan level, including the bank that grants the loan, the amount drawn down, the Loan-to-Value (LTV) ratio and the payment situation, among other variables. CIRBE also collects characteristics of the real estate that acts as collateral in loan transactions, including the land registry reference and the appraisal value. Using land registry data, geolocations of dwellings are obtained[1] which can be related to existing guarantees in CIRBE by

Gráfico 4.A.1 Flood-prone areas of Spain



SOURCE: National Flood Zone Mapping System, developed by the Ministry for Ecological Transition and Demographic Challenge.
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1 Only information compiled by the central Land Registry is available, which does not cover the Basque Country and Navarre.

BOX 4.A Flood maps (cont'd)

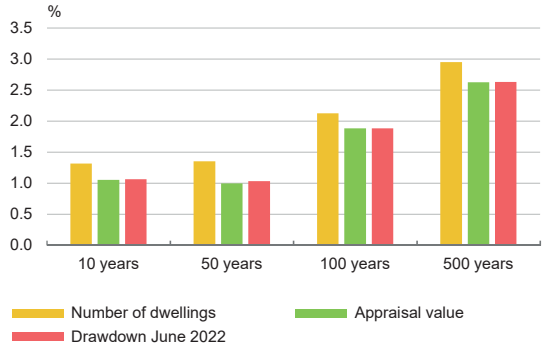
using the land registry reference. MITECO's flood risk data are also geolocated and the combination of the three databases makes it possible to identify whether a dwelling acting as mortgage collateral is located in a flood-prone area.

MITECO identifies flood zones with different frequencies (10, 50, 100 and 500 years) associated with these events (see Chart 4.A.1). The delimitation of these flood zones is carried out using various methods: from a hydrological study, from geomorphological-historical studies and from a mixed methodology that combines the two previous methods.[2] Both flood plains and coastal areas are used for this study (the latter are only categorised by frequencies of occurrence of 100- and 500-year events).

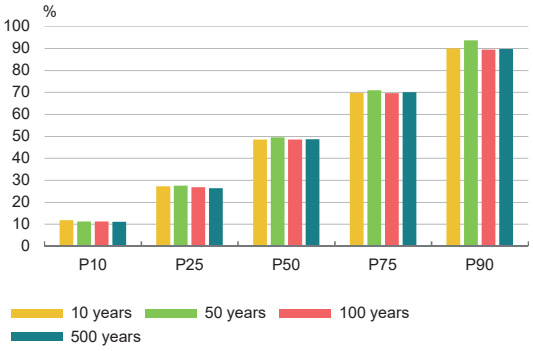
In a first descriptive approach, it is observed that only 2.7% of the geolocated sample of dwellings acting as mortgage collateral in June 2022 are located in flood zones with higher frequencies of events (10 and 50 years). Chart 4.A.2.2 shows the set of dwellings used as collateral in bank loans. These dwellings are those that are simultaneously identified in the CIRBE mortgage guarantee base and in the Land Registry (approximately a total of 3 million). 2.7% (1.3%) of these homes are located in flood-prone areas with an event frequency of 50 (10) years. In aggregate terms, also considering the flood-prone areas with lower frequencies, a total of 7.7% of this sample of dwellings would be in areas potentially affected by floods. It is necessary to take into account, however, that the event frequencies are very low (100 and 500 years) in these additional categories, so the immediate risks are much smaller. If instead of the number of dwellings the volume of credit drawn

Chart 4.A.2 Distribution of dwellings with associated bank debt in CIRBE in flood-prone areas (a)

1 Dwellings in each of the return periods



2 Percentiles of LTVs associated with dwellings in flood-prone areas (b)



SOURCES: Banco de España, Land Registry and MITECO.

a The sample corresponds to those loans granted to households registered in the CIRBE as at June 2022, the related collateral of which is a dwelling and whose land registry reference allows the geolocation to be obtained from the Land Registry (approximately 60% of this type of transaction). The Basque Country and Navarre are not included as their land registry information is not accessible.
b Loan-To-Value (LTV) is calculated as the current amount drawn down against the loan (as of June 2022) over the value of the collateral associated with the transaction.

2 Further information on the technical procedures for identifying flood-prone areas can be found at MITECO's website.

BOX 4.A Flood maps (cont'd)

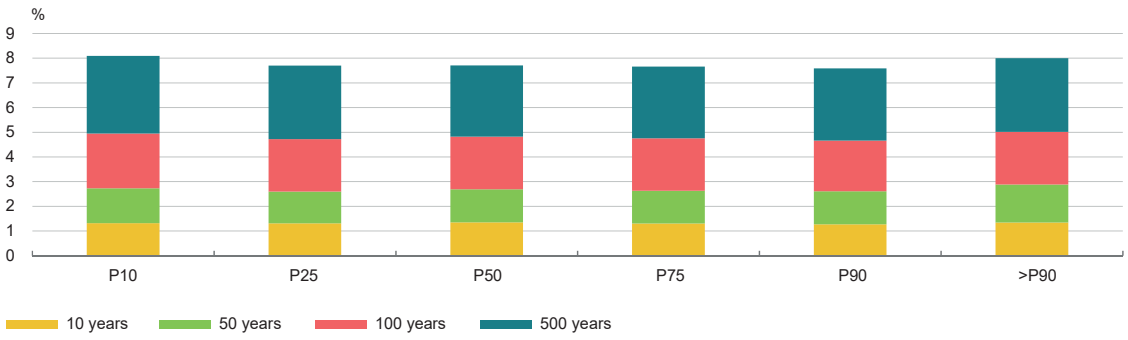
down or the appraisal value associated with them is considered, the percentage of areas at risk of flooding would be limited to 6.6% in June 2022. These percentages must be viewed with caution, since, although an extensive geolocated sample of household mortgages is available, they are not calculated using all of them.[3]

LTV distribution does not differ based on flood risk. Chart 4.A.2.1 shows the 10th, 50th and 90th percentiles of the distribution of the LTV ratio in transactions with associated housing guarantees in areas with different flooding frequencies. The differences based on flood frequencies are moderate in all percentiles.

Alternatively, a greater concentration of mortgage guarantees in flood-prone areas is not observed in any LTV percentile of the total sample of mortgage operations analysed. Specifically, we study whether mortgages with higher LTVs have a higher percentage of dwellings located in areas with a high probability of flooding. To do so, we obtain the percentiles of the LTV distribution in the mortgage transactions for which geolocation is available and calculate the percentage of housing guarantees which, within each section of this distribution, are located in areas classified as flood-prone. Chart 4.A.3 shows that in all the tranches of the LTV distribution analysed there is a similar percentage of dwellings in flood-prone areas corresponding to the different frequencies of events.

This first analysis suggests that the exposure of the bank mortgage portfolio to flood risks is limited and that there is no evidence of higher

Chart 4.A.3 Percentage of dwellings in flood-prone areas (a) **by LTV percentiles** (b) **of all CIRBE mortgages** (c)



SOURCES: Banco de España, Land Registry and MITECO.

a The percentage is calculated in terms of number of transactions, but the conclusions are maintained using the appraisal values or the amounts drawn down as of June 2022.
b Calculated as the amount drawn down against the current loan (as of June 2022) over the value of the collateral associated with the loan.
c The sample corresponds to those loans granted to households registered in the CIRBE as at June 2022, the related collateral of which is a dwelling and whose land registry reference allows the geolocation to be obtained from the Land Registry (approximately 60% of this type of operation). The Basque Country and Navarre are not included as their land registry information is not accessible.

3 On the one hand, the geolocation currently available of the dwellings identified as real estate collateral in CIRBE and located outside the Basque Country and Navarre is very extensive (approximately 60% of the total number of dwellings in CIRBE with these characteristics), but not complete. On the other hand, the identification of flood-prone areas is a dynamic exercise, which gradually incorporates new study sections in a progressive manner. See MITECO's website.

BOX 4.A Flood maps (cont'd)

LTV values in areas with higher flood risk. It is advisable, however, to monitor the exposures affected, since if climate change is not prevented, the frequency of events and the extent of flood-prone areas could increase in the future. The availability of geolocated data is very useful and the Banco de España will continue to work on improving the information available and conducting analyses to increase knowledge of the exposure to physical risks that may affect Spanish banking. In the same vein, future studies could examine the extent to which real estate appraisals already include flood risks or whether, on the contrary, there is a risk of sudden adjustments in appraisal values in the event of such events. It is also important to analyse the role that insurers would play should such floods materialise by absorbing a fraction of the potential damage, which would not necessarily result in a loss in value of the collateral.

4.2 Insurance sector

Physical risks generate a significant impact on society and, therefore, on the insurance sector, because when events related to these risks occur, they give rise to high-cost claims. Of all climate risks, those associated with natural disasters are those that have the greatest economic impact. These are those low-probability shocks that, due to their magnitude, generate negative impacts of high economic value.

Impact of weather shocks in relation to damage to insured property of companies and individuals

The objective of this section is to explore the potential losses that the Spanish insurance sector could suffer originating from an increase in damage to insured property of companies and individuals as a result of extreme weather events caused by climate change. To do so, the impact that an increase in such damage will have on the solvency ratio[51] of insurance undertakings is analysed. The increase in damage leads to higher payments to the insured (cash outflows for the insurance undertaking), which lead to a decrease in its assets and, consequently, in its own funds. A conservative approach has been chosen, by leaving the regulatory capital (denominator of the solvency ratio) unchanged, when it would foreseeably be reduced.

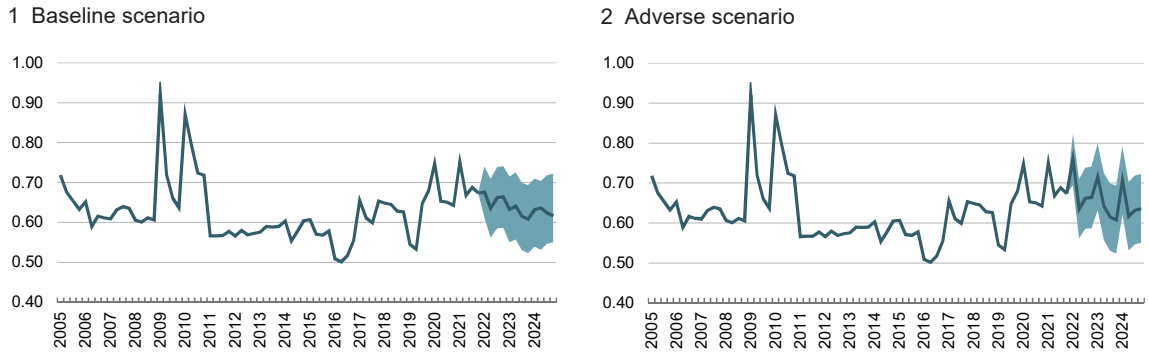
The insurance policies known as "multi-risk" protect the assets of companies or individuals against various events, including meteorological phenomena and repairs for broken windowpanes, machinery or electrical damage, among others. The main risk factor for this type of insurance are high-intensity storms and cyclones associated with areas of low atmospheric pressure, also called "deep storms". These storms can have a major impact on property and people due to the intensity of the winds they generate, with the loss rate in the specific quarter in which they occur reaching more than 70%. On average, the month in which most deep storms form in Spain is January.

To assess the impact of extreme weather events, a three-year prediction was made based on two scenarios:

- Baseline scenario: the prediction is made considering that high intensity storms do not occur.
- Adverse scenario: in the future projection, it is assumed that a deep storm occurs in the first quarter of each year.

51 The solvency ratio is the ratio of own funds to the regulatory capital requirement. For the purpose of this exercise, a stress test on own funds was carried out.

Chart 4.2.1 Evolution and prediction of the technical ratio in multi-risk insurance (2005-2024)



SOURCE: Directorate General of Insurance and Pension Funds.

Table 4.2.1 Technical ratio forecast (2022-2024)

	Baseline scenario			Adverse scenario		
	2022	2023	2024	2022	2023	2024
Technical ratio	65.9%	62.4%	62.7%	68.0%	64.5%	64.6%

SOURCE: Directorate General of Insurance and Pension Funds.

The financial variable considered is the technical ratio, measured as claims over premiums. This is a key variable since it also quantifies the profitability of the insurance policy, by measuring the extent to which the premiums paid by the insured are sufficient to cover the claims covered by the insurer. Applying the statistical model to the baseline scenario, the results of Table 4.2.1 are obtained.

It can be seen that the adverse scenario, which includes a shock in the first quarter of each year, more plausibly models what has happened in recent years.

The difference between both scenarios is approximately 2 pp each year, and translates into a decrease in the solvency ratio of the insurance sector of 0.1 pp. The gross increase in claims that insurance and reinsurance undertakings must pay due to extreme weather events in the adverse scenario amounts to €162 million. However, it must be taken into account that insurance companies do not assume the consequences of all the risks covered by the insurance policies they take out with their insureds, but rather, to diversify their risks, they arrange reinsurance contracts (or, in other words, they insure insurance contracts) whereby a portion of the consequences of the risks covered are assumed by both national and international reinsurers. As the impact of climate change on the solvency ratio is analysed and this is measured net of the effect of reinsurance, it is necessary to take this effect into account in the estimated losses. Thus, net reinsurance losses

incurred by the Spanish insurance sector would amount to €94 million. This implies a decrease in own funds of this amount, which means that the solvency ratio decreases by 0.1 pp, falling from 239.5% to 239.2%.

Although the effect on the solvency ratio does not appear to be significant, it should be noted that the accident rate in the insurance of damage to insured property of companies and individuals (multi-risk) is already part of a worsened situation, especially due to the occurrence of storm Filomena in the first quarter of 2021. Filomena caused the highest quarterly loss rate in the last ten years. The application of the simulated scenario, together with an accident situation already troubled by the environmental setting, means reaching a gross loss rate 8 pp higher than the average of the last ten years.

Impact of extreme weather events on the combined agricultural insurance loss rate

In relation to the evolution of the results of agricultural insurance, it is worth highlighting that in recent years it has been observed how the effects of climate change are leading to a worsening of the risk. In the period 2017-2021 there was a succession of climate events characterised by an increase in frequency (ever more climate events occur); the increase in severity (they are increasingly more intense); the increase in variability, since highly diverse events take place at any time of the year; and, lastly, the expansion of the geographical areas of occurrence.[52] Chart 4.2.2 shows the most significant extreme events in the last five years for the groups of agricultural lines[53] in group A (experimental production) and group B (viable production), showing how, in three of them, events of various types have caused loss/risk premium rates to exceed 118%, which can be classified as extreme rates.

While all lines of insurance will be affected by climate change, it is likely to be agricultural insurance in Spain that will suffer the most from its consequences. This is due to its high climate dependency and the catastrophic dimensions of the losses suffered by the agricultural and livestock sector, particularly due to major droughts and phenomena such as hail. The Spanish agricultural insurance system is one of the most complete and evolved in the world, with major advantages for both public authorities and the agricultural and livestock sector.[54]

52 A clear example of this is the occurrence of DANAs (high-altitude isolated depressions, until recently associated only with the eastern region of Spain) in inland areas of the Iberian Peninsula, or the large hailstorms that have taken place in recent years in different areas of the Iberian Peninsula.

53 Agroseguro classifies insurance lines into groups A, B and C; letter A corresponds to experimental lines without removal and destruction lines, letter B to viable lines, and letter C to experimental lines with removal and destruction of dead animals on the farm.

54 The structure of agricultural insurance is made up of public and private entities. The participating institutions are: the State, through the State Entity for Agrarian Insurance (ENESA), the Directorate General for Insurance and Pension Funds, the Insurance Compensation Consortium (CCS), the governments of the Autonomous Communities that supplement the subsidies for contracting agrarian insurance, the professional agrarian organisations, farmer and livestock farmer representatives and the insurance companies, grouped together in Agroseguro.

Table 4.2.2 Most extreme events in the last five years

Year	Event	*Loss/ Risk premium ratio* (Groups A+B)
2017	Spring **frosts** affecting wine grapes (43,200 hectares damaged) Record **drought** in terms of compensation (€227 million and 1.4 million hectares damaged)	135.6%
2018	Record **hail** in terms of compensation (All production areas damaged)	118.5%
2019	**DANA** in September 2019 (38,000 hectares damaged)	101.9%
2020	**Gloria:** rainstorms (Significant damage)	97.3%
2021 (a)	**Filomena:** olive groves, citrus trees and dried fruit Spring **frosts** affecting fruit trees Succession of **hailstorms** **Heatwave** in the Canary Islands	121.1% (b)

SOURCE: Directorate General of Insurance and Pension Funds.

a Events that occurred up to 30 September 2021.
b 2021 estimate updated using data as of 30 September 2021.

Given the close relationship between climate change and the main risk factors to which combined agricultural insurance is exposed, the objective has been to analyse the potential losses arising from exposure to the risk of an adverse climate scenario. For this purpose, an analysis is conducted of the impact on Agroseguro's business as a coinsurance[55] alliance made up of 18 insurance undertakings to insure against unforeseeable, catastrophic and uncontrollable risks to agricultural production in Spain.

Drought, frost and hail, with a share of between 55 % and 79 % of total claims, are the chief risk factors in agricultural insurance. Drought is the phenomenon most clearly linked to global warming. However, climate change is also increasing the risk of frost at times when crops are most vulnerable, as well as hail events. In particular, this study makes a four-year forecast based on two scenarios:

– Baseline scenario: generated from the average evolution of AEMET projections for the climate variables of interest (drought, frost and hail).

55 Coinsurance is an insurance contract whereby several insurance companies cover a risk in order to spread it, because the risks are so high that a single insurance company would not be able to bear them.

Table 4.2.3 Values assigned to climate variables in the baseline and adverse scenarios

	Baseline scenario				Adverse scenario			
	2022	2023	2024	2025	2022	2023	2024	2025
Rainfall (mm)	601.40	596.60	591.90	589.40	521.60	517.30	513.30	511.10
Days of frost in the risk area and season	1.792	1.791	1.782	1.762	7.948	7.948	7.948	7.948
Hail shock	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

SOURCE: Directorate General of Insurance and Pension Funds.

An intermediate greenhouse gas concentration scenario is assumed.

– Adverse scenario: the situation in 2012, the worst year in the series in terms of relative claims, has been simulated under the meteorological paradigm defined in the central scenario.

The financial variable of interest is also the technical ratio, as defined above, for which the groups of agricultural lines of group A (experimental production) and group B (viable production) are used. Also, the climate variables used to measure the physical risks are:

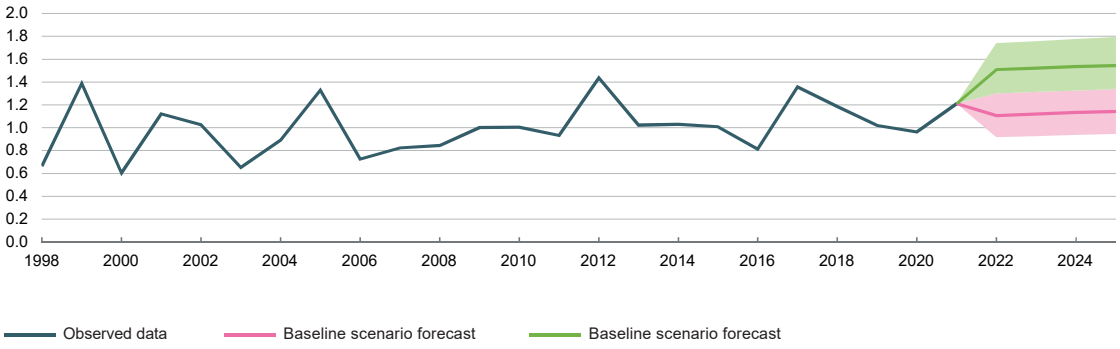
- For drought: average annual rainfall in Spain, measured in millimetres.
- For frosts: the number of days of frost, between April and October, in a series of weather stations located in high-risk areas.
- For hail: a binary variable (i.e. a shock).

There is an infinite number of variables that can be used to measure the risks of drought, frost and hail. Of all the possible measures, the above three variables have been selected because they are the ones that give the greatest predictive power to the model used to calculate the baseline and adverse projections. Table 4.2.4 shows the values assigned to the climate variables in each of the scenarios.

In contrast to drought and frost, the adverse scenario does not stress the hail variable, for two reasons: first, because in 2012, the year on which the adverse scenario is based, the loss rate attributable to hail was around the average for the period 1998-2021; second, because hail and drought are historically negatively correlated and it is therefore unrealistic to assume a simultaneous adverse scenario for the two physical risks.

The statistical model used to relate the financial variable to the climate variables and scenarios is a linear regression with four explanatory variables (the three

Chart 4.2.2 Evolution and prediction of the technical ratio of Agrosuguro Groups A and B (1998-2025)



SOURCE: Directorate General of Insurance and Pension Funds.

Table 4.2.4 Predicted technical ratio for Agroseguro Groups A and B (2022-2025)

	Baseline scenario				Adverse scenario			
	2022	2023	2024	2025	2022	2023	2024	2025
Technical ratio	110.6%	111.9%	113.2%	114.2%	150.8%	152.1%	153.3%	154.3%

SOURCE: Directorate General of Insurance and Pension Funds.

climate risk factors and weather). Applying the climate variables of the baseline scenario and the adverse scenario to the statistical model, the results for the technical ratio are as shown in Chart 4.2.2.

It can be seen that the technical ratio tends to worsen each year in both scenarios. Also, as a consequence of climate change, the technical ratio in the adverse scenario is around 153%, above the maximum of the 1998-2021 series (144% in 2012). This implies that, in the worst-case scenario, premiums collected would have to increase by 53% to cover the claims associated with this scenario.

The effect of the adverse weather scenario on the profitability of agricultural insurance and its implications for the solvency of the Spanish insurance sector, whose solvency ratio would decrease by 0.1 pp, has been estimated. The adverse weather scenario results in an increase in gross reinsurance claims payments of €297 million. However, as in the previous case, Agroseguro relies on reinsurance protection, which in this case is provided by the public entity CCS, which has a minimum share of 50% of excess claims, but in many crop categories covers up to 90%. Therefore, almost the entire impact of the simulated stressed scenario would fall on the CCS (€267 million), with the impact borne by private insurance

companies being €30 million. This would imply that the insurance sector's own funds would decrease by the same amount, which would consequently reduce the solvency ratio by 0.1 pp from 239.5% to 239.4%.[56]

56 To carry out this first exercise, the effect on the insurance sector's solvency ratio was calculated taking into account the mitigating effect of the CCS from its reinsurance coverage of combined agricultural insurance, but without including the CCS in the analysis of transition risks or in its role as a direct insurer of extraordinary risks. Notwithstanding the foregoing, it should be borne in mind that the CCS's activity has a significant impact on the Spanish insurance sector and should therefore be included in subsequent reports.
The CCS provides vital coverage by indemnifying damage caused by extraordinary risks arising from natural phenomena or events that have political or social incidence, on condition that insurance is taken out for the persons or property affected. The coverage of extraordinary risks is compulsorily included in the policies of certain lines of insured damage. This compulsory nature ensures the possibility of mutualisation of low frequency claims, but with a very considerable impact, and makes it possible to provide a feasible solution to the necessary coverage of events of significant dimensions that could have major effects on the stability of the insurance undertakings that deal with their coverage.

5 Conclusions

AMCESFI has assessed the resilience of the financial system to climate change, in response to the mandate of Law 7/2021 of 20 May 2021 on climate change and energy transition. To this end, both the risks arising from the transition to a decarbonised economy and the physical risks resulting from the effects of climate change have been considered. This exercise constitutes a first analysis of the issue, which will be developed and complemented in the future.

The analyses reveal that a gradual and well-planned transition to a decarbonised economy has a less severe adverse financial impact. Thus, a disorderly climate transition, characterised by the adoption of sudden and concentrated measures, would result in macroeconomic deterioration and negative shocks in the financial markets. In this scenario, the financial sectors would suffer losses through the deterioration in the market value of their assets and the materialisation of credit risk. Conversely, when transition measures are properly implemented and taken gradually and in advance, the financial system is less affected, since the macroeconomic impact is more moderate, and no shocks are expected in the financial markets.

In any event, the materialisation of climate change in the absence of measures that favour the transition will foreseeably have very high costs for the various financial intermediaries in the long term (much higher than in the transition scenarios). Also, the greater frequency and severity of extreme weather events will lead to lower growth and to asset impairment. The costs will be further increased by events that progress more slowly, such as desertification and rising sea levels. The analysis and quantification of these costs is limited by the scarcity of data and methodological difficulties associated with long analysis horizons, and also by the uncertainty about climatic aspects, such as temperature paths or extreme weather events.

Accordingly, the analysis shows that an increase in certain extreme weather events, such as droughts and heatwaves or high-intensity storms, would negatively affect financial intermediaries. More generally, illustrative exercises document the benefits of climate transition measures in the long term, stemming from higher economic growth, compared with the climate change materialisation scenario. This higher growth results, for example, in lower credit risk in the banking sector. The gains from the energy transition would also be felt in the long term even if measures are adopted suddenly and late, despite their adverse impact on economic growth in the short term.

A final thought. The information limitations that continue to exist, the complexity of modelling the interaction of economic and climate factors, and the existence of climate risk impact channels other than those identified

in this first report make it necessary to take the results with caution, as in some cases they may represent a lower bound of the economic and financial impact of this phenomenon. For future editions of this report, measuring the financial effects of climate risk will require continued learning and monitoring, and the development of additional sources of information.

Annex 1 European and global initiatives on climate risks to the financial system

This Annex contains the main papers on climate change published from 2021 to the closing date of this report in 2023 by various European and global bodies and committees in which one of the three sectoral authorities that make up AMCESFI participate.

Network of Central Banks and Supervisors for Greening the Financial System

The Network of Central Banks and Supervisors for Greening the Financial System (NGFS) was created in December 2017 at the One Planet Summit in Paris. It is made up of more than a hundred members, including central banks and supervisors, which, on a voluntary basis, contribute to the development of climate risk management in the financial system and support the transition to a sustainable economy by mobilising resources. Its goal is to promote the implementation of best practices and to carry out analytical work on green finance.

The Banco de España is a member of the NGFS.

NGFS and Financial Stability Board (FSB). (2022). *Climate Scenario Analysis by Jurisdictions: Initial findings and lessons.*

NGFS. (2022). *Dashboard on scaling up green finance.*

NGFS. (2022). *NGFS Climate Scenarios for central banks and supervisors.*

NGFS. (2022). *Final report on bridging data gaps.*

NGFS. (2022). *Capturing risk differentials from climate-related risks: A Progress Report.*

NGFS. (2022). *Credit Ratings and Climate Change - Challenges for Central Bank Operations.*

NGFS. (2022). *Enhancing Market Transparency in Green and Transition Finance.*

NGFS. (2022). *Annual report 2021.*

NGFS. (2022). *Statement on Nature-related Financial Risks.*

NGFS. (2021). *Guide on climate-related disclosure for central banks.*

NGFS. (2021). *Climate-related litigation: Raising awareness about a growing source of risk.*

NGFS. (2021). *NGFS - CFCMA Chairs Joint COP26 Statement.*

NGFS. (2021). *NGFS Glasgow Declaration: Committed to Action.*

NGFS. (2021). *Progress report on the Guide for Supervisors.*

NGFS. (2021). *Scenarios in Action: a progress report on global supervisory and central bank climate scenario exercises.*

NGFS. (2021). *NGFS Climate Scenarios for central banks and supervisors.*

NGFS. (2021). *Progress report on bridging data gaps.*

NGFS. (2021). *Annual report 2020.*

NGFS. (2021). *Dashboard on scaling up green finance.*

NGFS. (2021). *Report Sustainable Finance Market Dynamics.*

European Central Bank

The European Central Bank (ECB) analyses the impact of climate change and the transition to a carbon neutral society on the economy, as a basis for its work as a central bank and banking supervisor. The ECB has three main objectives in this area, which are framed in terms of:[1] i) climate risk management (for the analysis of monetary policy and the evaluation of financial stability, among other tasks); ii) support for the green transition, and iii) promotion of concerted actions with other institutions.

As a member of the Eurosystem and the Single Supervisory Mechanism, the Banco de España participates in the work of the ECB.

ECB (2023). *Policy options to reduce the climate insurance protection gap.*

ECB. (2023). *Towards climate-related statistical indicators.*

ECB. (2022). *ECB report on good practices for climate stress testing.*

ECB. (2022). *Banks gearing up to manage risks from climate change and environmental degradation - Results of the 2022 thematic review on climate-related and environmental risks.*

1 *Climate change and the ECB.*

ECB. (2022). *Good practices for climate-related and environmental risk management - Observations from the 2022 thematic review.*

ECB. (2022). *ECB takes further steps to incorporate climate change into its monetary policy operations.*

ECB. (2022). *Banks must sharpen their focus on climate risk, ECB supervisory stress test shows.*

ECB. (2022). *2022 climate risk stress test.*

ECB. (2022). *ECB takes further steps to incorporate climate change into its monetary policy operations.*

ECB. (2022). *Supervisory assessment of institutions' climate- related and environmental risks disclosures - ECB report on banks' progress towards transparent disclosure of their climate-related and environmental risk profiles.*

ECB. (2021). *The state of climate and environmental risk management in the banking sector - Report on the supervisory review of banks' approaches to manage climate and environmental risks.*

ECB. (2021). *Firms and banks to benefit from early adoption of green policies, ECB's economy-wide climate stress test shows.*

ECB. (2021). *ECB economy-wide climate stress test. Occasional Paper Series.*

Financial Stability Board

The Financial Stability Board (FSB) coordinates work at a global level to address the financial risks stemming from climate change.[2] These risks are global in nature and their effects concern all entities, sectors and economies. In July 2021, the FSB published a roadmap for addressing the financial risks of climate change, which coordinates work across standard-setting bodies and other international organisations. It covers four main areas: disclosures, data, analysis of vulnerabilities, and regulatory and supervisory practices and tools.

The Banco de España, the National Securities Market Commission (CNMV) and the Ministry of Economic Affairs and Digital Transformation participate in the FSB.

FSB and NGFS. (2022). *Climate Scenario Analysis by Jurisdictions.*

FSB. (2022). *Supervisory and Regulatory Approaches to Climate-Related Risks: Final report.*

2 FSB. *Climate-related risks.*

FSB. (2022). Progress Report on Climate-Related Disclosures.

FSB. (2021). *FSB Roadmap for Addressing Climate-Related financial Risks 2021.*

FSB. (2021). *Report on Promoting Climate-Related Disclosures 2021.*

FSB. (2021). *The Availability of Data with Which to Monitor and Assess Climate-Related Risks to Financial Stability.*

Basel Committee on Banking Supervision

Climate change has major economic and financial implications, which is why central banks and financial authorities around the world are playing an active role in promoting the transition to a sustainable economy. The Basel Committee on Banking Supervision (BCBS) supports these efforts and conducts its own analytical work in this area.[3]

The Banco de España is a member of the BCBS.

BCBS. (2022). *Principles for the effective management and supervision of climate-related financial risks.*

BCBS. (2021). *Climate-related risk drivers and their transmission channels.*

BCBS. (2021). *Climate-related financial risks – measurement methodologies.*

International Organization of Securities Commissions

The International Organization of Securities Commissions (IOSCO) has developed a roadmap for developing sustainable finance, underscoring the importance of mitigating greenwashing and doing what is necessary to create reliable sustainability impact information for investors.[4]

The CNMV is a member of IOSCO.

IOSCO. (2022). *Call for Action (IOSCO Good Sustainable Finance Practices for Financial Markets Voluntary Standard Setting Bodies and Industry Associations).*

IOSCO. (2022). *FR10/22. Retail Investor Education in the Context of Sustainable Finance Markets and Products.*

IOSCO. (2021). *FR09/2021. Environmental, Social and Governance (ESG) Ratings and Data Products Providers.*

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3 BIS. Climate change and green finance.

4 IOSCO. (2022). *IOSCO's 2022 Sustainable Finance work plan strengthens the organization's commitment to increasing transparency and mitigating greenwashing.*

IOSCO. (2021). *FR08/21. Recommendations on Sustainability-Related Practices, Policies, Procedures and Disclosure in Asset Management.*

International Association of Insurance Supervisors

Climate change is a key component of the strategic plan of the International Association of Insurance Supervisors (IAIS) because of its impact on insurers (through their insurance and investment activities). Its work in this area focuses both on assessing risks to financial stability and promoting a global supervisory response to climate change.

The Directorate General of Insurance and Pension Funds is a member of the IAIS.

IAIS. (2021). *Global Insurance Market Report – GIMAR special topic edition – The impact of climate change on the financial stability of the insurance sector.*

IAIS. (2021). *Application Paper on the Supervision of Climate-related Risks in the Insurance Sector.*

European Banking Authority

The European Banking Authority (EBA) plays an important role in supporting the European banking sector towards the goals of transitioning to a more sustainable economy and mitigating the risks arising from climate change and broader environmental, social and governance (ESG) factors.[5]

The Banco de España is a member of the EBA.

EBA. (2022). *EBA/REP/2022/26 - Report on incorporating ESG risks in the supervision of investment firms.*

EBA. (2022). *EBA/REP/2022/06 - EBA Report on developing a framework for sustainable securitisation.*

EBA. (2022). *EBA/DP/2022/02 - The role of environmental risks in the prudential framework – Discussion paper.*

EBA. (2022). *Implementing Technical Standards (ITS) on prudential disclosures on ESG risks in accordance with Article 449a CRR.*

EBA. (2021). *EBA Report on management and supervision of ESG risks for credit institutions and investment firms.*

EBA. (2021). *Mapping climate risk: Main findings from the EU-wide pilot exercise.*

5 EBA. (2021). *EBA statement in the context of COP26.*

EBA. (2021). *EBA response to EC Call for Advice on Article 8 Taxonomy Regulation.*

European Securities and Markets Authority

Investor preferences are increasingly taking into account products incorporating ESG factors, and their impact on the value of investments, their risks and their benefits are considerations taken into account by the European Securities and Markets Authority (ESMA) in its aim to step up investor protection and promote stable and orderly markets. ESMA's work, according to its roadmap 2022-2024, focuses on three main priorities: (i) addressing greenwashing and promoting transparency; (ii) building the capacity of national competent authorities and ESMA; and (iii) monitoring, assessing and analysing ESG markets and risks.

The CNMV is a member of the ESMA.

ESMA. (2022). *Sustainable Finance Roadmap 2022-2024.*

ESMA. (2021). *European common enforcement priorities for 2021 annual financial reports.*

ESMA. (2021). *ESMA Final Report - Advice on Article 8 of the Taxonomy Regulation.*

European Insurance and Occupational Pensions Authority

The insurance and pension fund industry plays a major role in addressing climate-related challenges, both as risk managers and as long-term investors.[6]

The DGSFP is a member of the European Insurance and Occupational Pensions Authority (EIOPA).

EIOPA. (2022). *Dashboard on insurance protection gap for natural catastrophes.*

EIOPA. (2022). *Application guidance on climate change materiality assessments and climate change scenarios in ORSA.*

EIOPA. (2022). *EIOPA assesses European insurers' exposure to physical climate change risks.*

EIOPA. (2022). *European insurers' exposure to physical climate change risk – Potential implications for non-life business.*

EIOPA. (2022). *Climate stress test for the occupational pensions sector 2022.*

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6 *"EIOPA underlines its commitment to supporting the insurance and pensions sectors in tackling climate change".*

EIOPA. (2021). *Methodological paper on potential inclusion of climate change in the Nat Cat standard formula.*

EIOPA. (2021). *Report on non-life underwriting and pricing in light of climate change.*

EIOPA. (2021). *Climate change, catastrophes and the macroeconomic benefits of insurance.*

Joint Committee of European Supervisory Authorities

EBA, ESMA and EIOPA. (2022). *ESAs Final Report on disclosures for fossil gas and nuclear energy investments under SFDR.*

EBA, ESMA and EIOPA. (2022). *Joint ESAs' Report on the extent of voluntary disclosure of principal adverse impact under the SFDR.*

Annex 2 Relevant publications by AMCESFI member institutions on climate change

This Annex compiles periodic papers and occasional articles on topics related to the analysis of climate change and its impact on the financial system, published by AMCESFI member institutions from 2021 to the closing date of this report in 2023.

Banco de España

"The Banco de España and climate change" (website section)

Financial Stability Report (half-yearly)

Supervision Report (annual)

Annual Report

"COP 26 Individual Pledge by Banco de España as NGFS Member" (Oct. 2021)

Los riesgos climáticos en el sector bancario
Video on YouTube. Banco de España (2023)

Climate-related disclosure of Banco España's non-monetary policy portfolios
Banco de España (2023)

"Machine Learning methods in climate finance: a systematic review"
Andrés Alonso-Robisco, José Manuel Carbó and José Manuel Marqués
Working Papers, No. 2310. Banco de España (2023)

"Climate risk and credit supply in Spain"
Roi Barreira and Julio Gálvez
Article 05, *Economic Bulletin,* 1/2023. Banco de España (2023)

"Carbon tax sectoral (CATS) model: a sectoral model for energy transition stress test scenarios"
Pablo Aguilar, Beatriz González and Samuel Hurtado
Occasional Papers, No. 2218. Banco de España (2022)

"Carbon pricing and inflation volatility"
Daniel Santabárbara and Marta Suárez-Varela
Working Papers, No. 2231. Banco de España (2022)

"Integrating the carbon footprint into the construction of corporate bond portfolios"
Mario Bajo and Emilio Rodríguez
Working Papers, No. 2226. Banco de España (2022)

"An estimation of the carbon footprint in Spanish credit institutions' business lending portfolio"
Luis Ángel Maza
Occasional Papers, No. 2220. Banco de España (2022)

"The role of a green factor in stock prices. When Fama & French go green"
Ricardo Gimeno and Clara I. González
Working Papers, No. 2207. Banco de España (2022)

"Analysis of ESG disclosures in Pillar 3 reports. A text mining approach"
Ángel Iván Moreno Bernal and Teresa Caminero García
Occasional Papers, No. 2204. Banco de España (2022)

"An initial analysis of energy transition risks using the Banco de España's FLESB stress-testing framework"
Alejandro Ferrer, Javier García Villasur, Nadia Lavín, Irene Pablos Nuevo and Carlos Pérez Montes
Financial Stability Review, No. 41, autumn. Banco de España (2021)

"The design of macroeconomic scenarios for climate change stress tests"
Pablo Aguilar, Beatriz González and Samuel Hurtado
Financial Stability Review, No. 40, spring. Banco de España (2021)

"Los productos financieros sostenibles desde el punto de vista de los supervisores y los reguladores: sector bancario"
Andrés Alonso and Clara I. González
La sostenibilidad y el nuevo marco institucional y regulatorio de las finanzas sostenibles, Chapter 16. Editorial Aranzadi (2021)

"Principales transformaciones en las áreas funcionales de las entidades financieras"
Andrés Alonso and José Manuel Marqués Sevillano
El rol de las finanzas en una economía sostenible, Chapter 5.5. Foundation Papers, No. 60. Study of the Financial Studies Foundation (2021)

"Impact of climate change risks on the banking sector"
Financial Stability Report, Box 3.1, autumn (2021). Banco de España

"The value of housing and ecological degradation: the case of the Mar Menor"
Financial Stability Report, Box 3.2, autumn (2021). Banco de España

"Recycling carbon tax revenues in Spain. Environmental and economic assessment of selected green reforms"
Ángel Estrada and Daniel Santabárbara
Working Papers, No. 2119. Banco de España (2021)

"El mercado de bonos verdes"
Ricardo Gimeno
El rol de las finanzas en una economía sostenible, Chapter 4.3. Foundation Papers, No. 60. Study of the Financial Studies Foundation (2021)

"Markets, financial institutions and central banks in the face of climate change: challenges and opportunities"
Clara I. González and Soledad Núñez
Occasional Papers, No. 2126. Banco de España (2021)

"Overview of global and European institutional sustainable finance initiatives"
Clara Isabel González Martínez
Analytical Articles, *Economic Bulletin,* 3/2021. Banco de España (2021)

"The role of central banks in combating climate change and developing sustainable finance"
Clara Isabel González Martínez
Analytical Articles, *Economic Bulletin,* 3/2021. Banco de España.

"El trabajo de los Bancos Centrales y Supervisores Bancarios"
Clara Isabel González Martínez
El rol de las finanzas en una economía sostenible, Chapter 2.3.1. Foundation Papers, No. 60. Study of the Financial Studies Foundation (2021)

"La tecnología y la digitalización como fuente de poder multiplicativo de las finanzas sostenibles"
José Manuel Marqués Sevillano
El rol de las finanzas en una economía sostenible, Chapter 5.3. Foundation Papers, No. 60. Study of the Financial Studies Foundation (2021)

"Recent changes in CO_2 emissions in Spain"
María de los Llanos Matea, Aitor Lacuesta and Darío Serrano-Puente
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Ministry of Economic Affairs and Digital Transformation

Directorate General for Insurance and Pension Funds

Sector Report Summary 2021

Glossary

AEMET	State Meteorological Agency
AMCESFI	*Autoridad Macroprudencial Consejo de Estabilidad Financiera* (Spanish macroprudential authority)
AuM	Assets under Management
BCBS	Basel Committee on Banking Supervision
BOE	Official State Gazette
bp	Basis points
CCS	*Consorcio de Compensación de Seguros* (Insurance Compensation Consortium)
CET1	Common Equity Tier 1
CIRBE	*Central de Información de Riesgos* (Central Credit Register of the Banco de España)
CNMV	*Comisión Nacional del Mercado de Valores* (NationalSecurities Market Commission)
CPRS	Climate Policy Relevant Sectors
CSRD	Corporate Sustainability Reporting Directive
DANA	High-altitude isolated depression
DGSFP	Directorate General of Insurance and Pension Funds
EBA	European Banking Authority
ECB	European Central Bank
EIOPA	European Insurance and Occupational Pensions Authority
EMU	Economic and Monetary Union
ESA	European Supervisoy Authorities
ESG	Environmental, social, and governance
ESMA	European Securities and Markets Authority
ESRB	European Systemic Risk Board
ETS	Emission Trading System
EU	European Union
Eur	Euro
FLESB	Forward-Looking Exercise on Spanish Banks
FSB	Financial Stability Board
FSCT	Financial Stability Technical Committee (AMCESFI)
GHG	Greenhouse gases
GVA	Gross value added
IAIS	International Association of Insurance Supervisors
IOSCO	International Organization of Securities Commissions
LCCTE	*Ley 7/2021, de 20 de mayo, de cambio climático y transición energética* (Climate Change and Energy Transition Law 7/2021 of 20 May 2021)
LGD	Loss Given Default
LSI	Less Significant Institutions
LTV	Loan-to-Value
MINECO	Ministry of Economic Affairs and Digital Transformation

MITECO	Ministry for Ecological Transition and the Demographic Challenge
mm	Millimetres
MtM	Mark-to-Market
NGFS	Network for Greening the Financial System
PD	Probability of Default
PNIEC	National Integrated Energy and Climate Plan
pp	Percentage points
RWA	Risk weighted assets
SGTFI	*Secretaría General del Tesoro y Financiación Internacional* (General Secretariat of the Treasury and International Financing)
SMEs	Small and medium-sized enterprises
USD	US dollar

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