



No. 122-2021 **Analyses et synthèses**

A first assessment of financial risks stemming from climate change:

The main results of the 2020 climate pilot exercise



OVERVIEW

The climate pilot exercise conducted by the ACPR is unprecedented. It is the first time that a supervisory authority organised with the banking and insurance groups under its responsibility such a comprehensive and challenging exercise to assess the risks associated with climate change. Its unprecedented and ambitious nature lies in the time horizon over which the risks were assessed (30 years), the methodologies used (analysis of scenarios broken down by economic sector), its innovative hypotheses (notably the dynamic balance sheet), its coverage of physical and transition risks, and the fact that the participating institutions directly assessed their risks on the basis of common hypotheses. It illustrates the leading role played by the French financial authorities and the Paris financial centre and the progress made in the fight against climate change since the adoption of the Law on Energy Transition and Green Growth and the signing of the Paris Agreement in 2015.

This exercise, conducted from July 2020 to April 2021, achieved its objectives of:

- **Mobilising French banks and insurers**: Virtually all the banks and insurers that contributed to the preparation of the exercise were present, as the exercise was carried out on a voluntary basis, and others joined them even though they had not taken part in the preparatory phase: **in total, 9 banking groups and 15 insurance groups got involved over three quarters without accounting for the preparatory phase, despite the context of the Covid-19 crisis, to carry out this pilot exercise. This very high level of mobilisation enables us to present representative results (85% of the total balance sheet of banks and 75% of the total balance sheet of insurers) with high added value for these two sectors.**
- **Raising awareness about climate risks**: despite the methodological difficulties and the absence of certain key data, the participating institutions welcomed the relevance of this pilot exercise and the many advances it led to in terms of cross-disciplinary team mobilisation, internal discussions on risk analysis and the limits of the models currently used, but also in terms of strategic orientation and a better understanding of the issues and the impact of climate change on business models. **Financial institutions became aware of the fact that this type of exercise was not only feasible but also extremely useful for making headway in taking climate risk into consideration. The pilot exercise therefore served as a catalyst for spurring debate and, for some, sped up the mobilisation of teams and resources.**
- **Quantifying and assessing complex transition or physical risk scenarios, drawing in particular on the work of the NGFS**, which is the network of central banks and supervisors for greening the financial sector. The ACPR, with the help of Banque de France staff, prepared this exercise in accordance with the NGFS guidelines on the construction of climate change scenarios and based on two of the scenarios published by the NGFS in June 2020. These scenarios will also serve as a basis for other exercises currently being prepared, such as those of the Bank of England in June 2021 and the European Central Bank in 2022. **It is important that a growing number of supervisors take up this work in order to launch their own exercises and thus contribute to the development of a common base of knowledge and climate risk assessment.**
- **Providing a first measurement of risks and vulnerabilities to which French financial institutions are exposed**: the pilot exercise thus usefully complements the ACPR's previous analyses, published in April 2019, which were based on questionnaires. In addition to this snapshot, the pilot exercise adds a forward-looking view of risks over a long-term horizon, conditional on the implementation of several alternative scenarios. The exercise thus offered financial institutions the possibility of assessing their corrective actions (e.g. exit from certain sectors), thanks to the dynamic balance sheet hypothesis, and of taking new risks into consideration: potential hiatus between strategies for exiting certain greenhouse gas emitting activities and the objective of maintaining market shares, the willingness to finance the economy or to preserve a client relationship, which could result in a more lasting exposure to transition or physical risks than expected.

The pilot exercise revealed an overall "moderate" exposure of French banks and insurers to climate risks. However, this conclusion must be put into perspective in view of the uncertainties concerning both the speed and the impact of climate change. It also crucially depends on the assumptions, the scenarios analysed and the methodological difficulties raised by the exercise. Based on the current balance sheet structures, it nevertheless appears that considerable efforts must be made to help significantly reduce greenhouse gas emissions by 2050 and to contain the rise in temperature by the end of the century.

- **The pilot exercise exhibits, conditional on the retained scenarios and assumptions, an overall "moderate" exposure and vulnerabilities as highlighted in the ACPR's previous work.** According to the projections of the Intergovernmental Panel on Climate Change (IPCC) used in this exercise, France, which accounts for about 50% of the exposures of French financial institutions, and Europe, which accounts for about 75% of exposures, are relatively less affected than other geographical areas. France also produces less than 2% of global greenhouse gas emissions¹. On the other hand, exposures to geographical areas such as the United States (which accounts for around 9% of exposures) appears to be sensitive to transition risk.
- **The exposure of French institutions to the sectors most impacted by transition risk, as identified in this exercise (e.g. mining, coking and refining, oil, agriculture, construction, etc.), is relatively low.** In addition, institutions tend to reduce their exposures to these sectors by 2050. However, these sectors post the highest increase in the cost of risk and probabilities of default. The cost of risk rises threefold in these sensitive sectors. By way of comparison, the Covid-19 crisis led in 2020 to a twofold increase in the cost of risk for French banks in a context of heavy business losses. The contribution of these sectors to the rise in the cost of risk (e.g. provision for expected losses) appears to be greater than their share of banks' balance sheet. Relative portfolio losses for banks and insurers are also concentrated in these sectors, albeit with significant dispersions depending on individual exposures. **When interpreting these results, it should be borne in mind that none of the scenarios analysed implies an economic recession by 2050, contrary to the usual practice of stress tests**, but, for the adverse scenarios, a lower trend in activity. In this context, the increase in the cost of risk indicates that the energy transition, which is necessary in order to comply with the Paris Agreement, requires significant efforts to adjust the system and economic structures.
- **Even though France is relatively spared in the Intergovernmental Panel on Climate Change (IPCC) scenarios, the pilot exercise shows that the vulnerabilities associated with physical risk are far from negligible. Thus, on the basis of the information provided by insurers, the cost of claims could rise by a factor of 5 to 6 in certain French departments between 2020 and 2050.** The main hazards contributing to this increase in claims are related to the risk of "drought" on the one hand and that of "flooding" on the other, as well as to the rise in the risk of cyclonic storms in the overseas territories (French Caribbean). This increase in claims highlights an insurability risk in certain parts of the country, a risk, which insurers felt could be fully offset by an increase in contributions. As regards banks, the exercise shows that the progress made in taking physical risk into consideration is very limited in view of the findings of the ACPR in 2019 which already underlined that the assessment of this risk was lagging significantly transition risk analysis. Only two institutions were able to quantify the impact of an increase in the lack of insurance coverage on its credit risk parameters. This situation is primarily linked to the difficulty encountered by institutions in obtaining a precise view of the geographical location of their exposures (real estate, corporate) at the group consolidated level.
- **Banks and insurers must therefore step up their efforts to combat climate change today by integrating climate risks into their financial risk assessment process, as these efforts will contribute to the changes that will be observed in the medium and long-term. Taking**

¹ This favourable situation is due to the high share of nuclear power in electricity production in France. However, this situation is not without risks in the context of climate change, as illustrated by the severe drought episode of summer 2020. The drop in water level has indeed made it difficult to cool certain nuclear power plants, leading France to produce or import electricity from coal-fired power stations.

better account of climate risks is indeed necessary to promote a better allocation of resources and ensure the financing of the transition. While banks and insurers seem to be generally aware of this issue, their degree of maturity remains heterogeneous and some institutions have not necessarily yet integrated the proper degree of urgency to act.

This exercise also brought to light a number of methodological limitations on which progress needs to be made. It therefore marks the starting point for further work to improve the methodology of climate stress tests. The main points for improvement identified by the ACPR concern:

- **The hypotheses used to create the scenarios and identify sensitive sectors:** one difficulty encountered by the institutions that took part in the exercise was the low variability between the different scenarios put forward by the ACPR. This point had already been identified by the ACPR, which had led it to add a sudden transition scenario to the scenarios published by the NGFS. Moreover, the models used by banks to quantify risks are not able to integrate very smooth evolutions of macroeconomic and financial variables over a long period. The same applies to insurers, which are used to dealing with extreme climate shocks but not with smooth and deterministic impacts over a long period. The very long time horizon also implies costly work in projecting transition matrices. Finally, the absence of feedback effects between the sectoral structure of the balance-sheet of the financial sector and financial risks (generated by climate change) does not necessarily encourage institutions to implement an active risk reduction policy, as most of the transition scenarios considered reach the objective of carbon neutrality in 2050. A second difficulty lies in the identification of sectors that are sensitive or exposed to climate risk: this identification first of all depends on the method used. It then implies assumptions on the evolution of the energy mix, the intensity and the energy efficiency of production, which were not properly integrated in this exercise. Finally, there is the question of sectoral granularity and the linking of exposures or counterparties to a given nomenclature, in particular when those counterparties are active in several economic sectors.
- **Taking into account the "physical risk" is a notable area for improvement on which collective work is also needed** because it also implies taking into account interdependencies and a sound knowledge of the value chains, which remains largely insufficient. One of the main reasons for this is the absence or incomplete nature of the information published by companies. This obstacle may be gradually reduced with future ESG disclosure requirements for companies (at least at the European level). As regards the insurance sector, further work should be conducted on the insurance protection gap.
- **The improvement of the models used by banks and insurers and the data sources** is needed to take better account of climate risk (in particular at the sectoral or company and counterparty level). Several interesting methodological avenues implemented by financial institutions in the context of this exercise should be explored in greater depth.

Next steps: the results obtained will be followed up by the setting-up of new working groups with the Paris financial centre and with external counterparties. In addition, ACPR and Banque de France experts are actively contributing to the preparation of the exercise to be conducted by the ECB in 2022 and to the European and international work conducted in several fora such as the European Insurance and Occupational Pensions Authority, the Basel Committee on Banking Supervision, the International Association of Insurance Supervisors and the Financial Stability Board. **This financial risks assessment exercise induced by climate change will be repeated regularly. The next ACPR exercise may take place 2023/2024.**



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By:

Laurent CLERC, Anne-Lise BONTEMPS-CHANEL, Sébastien DIOT, George OVERTON, Solène SOARES DE ALBERGARIA, Lucas VERNET and Maxime LOUARDI

**DIRECTORATE FOR RESEARCH AND RISK ANALYSIS
AUTORITÉ DE CONTRÔLE PRUDENTIEL ET DE RÉOLUTION**

**AUTORITÉ DE CONTRÔLE PRUDENTIEL ET DE RÉOLUTION
4, PLACE DE BUDAPEST
75436 PARIS CEDEX 09**

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Key figures



Strong mobilisation of the financial centre

15 insurer groups - 22 insurers - and 9 banking groups participated in this exercise, representing respectively 75% of insurers' technical provisions and assets and 85% of French banks' total assets.

Exhaustive & completely unprecedented exercise

With a 30-year horizon, including three transition scenarios, two of them published by the NGFS, the network of central banks and supervisors for the greening of the economy, and one physical risk scenario.



Moderate exposition of the financial sector to the transition risk

In view of the analysis metrics used, which will be gradually refined, and within the limits of the assumptions and models used, the exercise confirms the moderate exposure of the French financial sector to transition risk. However, seven sensitive sectors concentrate a significant share of market losses and see their cost of risk tripled over the period.

Significant increase in loss ratios and insurance premiums

Climate change would entail a two-fold to five-fold increase in the loss ratio for claims related to natural disasters in the most affected departments throughout France, and premiums would increase by 130 to 200% over 30 years to cover these losses.





Introduction: reminder on the objectives and main features of the pilot exercise

The climate pilot exercise conducted between July 2020 and April 2021 by the Autorité de contrôle prudentiel et de résolution (ACPR – the French Prudential Supervision and Resolution Authority) is an important step in supervising climate change-related risks. This is the first time that a supervisory authority has performed a bottom-up climate-related stress test exercise as comprehensive and demanding as this one, based on a risk assessment directly conducted by the financial institutions under its responsibility on the basis of common assumptions.

The preparation of this exercise was carried out by working groups led by the ACPR, bringing together leading players in the banking industry and insurance groups. The preparatory work immediately began after three reports were published in April 2019².

In addition, the ACPR drew on various national and international studies. The designed scenarios thus build on the recommendations published by the network of central banks and supervisors for the greening of the financial system (NGFS³). They are based on an original

analytical framework developed specifically for this exercise with the involvement of Banque de France⁴ teams. This new analytical framework has benefited from numerous contributions resulting from exchanges with the academic sphere and climatologists. Lastly, this exercise benefitted from the guidelines of the Supervisory College of the ACPR as well as from the opinions of the members of its Committee on Climate Change and Sustainable Finance, chaired by Patrick de CAMBOURG.

Lastly, French banks and insurers have been able to share their expertise in climate change risk analysis over the past few years. In particular, the Caisse centrale de réassurance (the French central reinsurance fund), which is responsible for the natural disaster compensation scheme in France, and AON, a reinsurance broker, provided the assumptions for physical risk, based on projections by Météo-France, and for health risk, respectively, by considering the risks associated with the rise of vector-borne pandemics and the increase in acute respiratory pathologies linked to an increase in both the frequency and duration of heat waves.

² See in particular:

ACPR (2019a): "Climate Change: what risks to banks and insurers?", Analyses et Synthèses, April. https://acpr.banque-france.fr/sites/default/files/medias/documents/as_cover_note_en.pdf

ACPR (2019b): "French banking groups facing climate risk", Analyses et Synthèses n°101, April. https://acpr.banque-france.fr/sites/default/files/medias/documents/as_101_climate_risk_banks_en.pdf ACPR (2019c): "French insurers facing climate change risk", Analyses et Synthèses n°102, April. https://acpr.banque-france.fr/sites/default/files/medias/documents/as_102_climate_change_insurers_en.pdf

³ See notably <https://www.banque-france.fr/en/financial-stability/international-role/network-greening-financial-system>

⁴ Allen et al. (2020): Climate-related scenarios for financial stability assessment: An application to France, *Banque de France Working Paper*, No 774, July. <https://publications.banque-france.fr/en/climate-related-scenarios-financial-stability-assessment-application-france>

The main objectives of the ACPR's climate pilot exercise were to:

- assess the risks and vulnerabilities to which French banks and insurers could be exposed and their strategic reaction function in the face of these risks (under the dynamic balance sheet assumption), under different scenarios including orderly and disorderly transitions and a physical risk scenario, illustrating a laissez-faire policy and based on the IPCC's worst-case scenario. This scenario was assessed with the assistance of CCR regarding the exposures of French insurance and re-insurance undertakings.

- mobilise and raise financial institutions' awareness of climate change risks by contributing to improving their ability to anticipate and manage these risks, the materialisation of which may exceed their normal decision-making and exposure horizon. Beyond this, the exercise aims to identify current gaps in terms of data and resources (staff numbers, training needs, analytical capabilities, etc.).

Box 1 summarises the main features of this exercise⁵⁵.

Box 1- Main features of the ACPR's climate pilot exercise

- **A 30-year horizon covering the 2020-2050 period, which is sufficiently long to integrate the effects of climate change, in contrast to the usual duration considered for stress-tests (3 to 5 years);**
- **A bottom-up exercise covering banks and insurers aiming to analyse the interactions between the two sectors, in particular the impact of insurance coverage on banks' risk parameters**
- **An international dimension, designed to take account of the global nature of climate change and its differentiated impact across different regions of the world as well as of the international scope of the major French banking and insurance groups;**
- **A sector-specific, granular approach encompassing 55 sectors of activity, for each scenario and each geographical area considered, to capture the very contrasting effects of transition policies depending on the business sectors considered;**
- **The combination of two assumptions: first a "static balance sheet" assumption up to 2025, the traditional framework for supervisory stress-testing, then a "dynamic balance sheet" assumption, from 2025 to 2050, in order to analyse the strategies of financial institutions and the actions implemented to mitigate the effects of climate change; this assumption also aims to analyse the coherence of the strategies implemented by these institutions and their climate commitments;**
- **The exercise also includes the consideration of "second-round effects" to measure banks' indirect exposure to physical risk, under the hypothesis of an increase in the insurance protection gap for certain assets due to the increase in the cost and frequency of extreme weather events;**
- **Lastly, participation in the pilot exercise is voluntary and it is carried out by institutions without any regulatory purpose.**

⁵⁵ The assumptions used by the ACPR and the full features of the exercise are described in the "Main scenarios and assumptions of the pilot exercise" published on the ACPR website on 16/07/2020: https://acpr.banque-france.fr/sites/default/files/medias/documents/20200717_main_assumptions_and_scenarios_of_the_acpr_climate_pilot_exercise.pdf



Conditions for the implementation and conduct of the ACPR pilot exercise

1. Background

The ACPR's pilot exercise follows on previous works initiated by the Authority since 2015, notably in the context of the implementation of the French Law on Energy Transition and Green Growth (LTCEV) and of its participation, as a founding member alongside the Banque de France, to the network of central banks and supervisors for the greening of the financial sector, the NGFS.

These previous works focused⁶ on:

- i. An emphasis on the governance of climate change risks, including the publication in May 2020 of a good practices handbook for the banking sector and the launch in 2021 of similar work with insurers;
- ii. The regular monitoring of risks, based in particular on the analysis of non-financial disclosures of information regarding financial institutions' and insurers' environmental, social and governance (ESG) and their climate risk strategies under Article 173 of the LTCEV, or based on *ad hoc* surveys aimed at measuring the exposure of French banks and insurers to climate risk. This work was complemented by the publication in December 2020 of a joint report with the Autorité des Marchés Financiers (French Financial Markets Authority or AMF) on the climate commitments of financial institutions and the establishment of Climate and Sustainable Finance Commissions within these two authorities in 2019, following the financial centre agreement of 2 July 2019.
- iii. The analysis of climate change scenarios with the aim of measuring its financial impact and identifying potential vulnerabilities in the French financial sector, the climate pilot exercise materialising a first step towards such measurement.

Furthermore, the pilot exercise is also part of a dynamic European environment. These results will thus contribute to the ongoing reflections on the integration of these risks into the risk management of financial intermediaries⁷ and in prudential requirements (particularly under Pillar II⁸) which is among the priorities of the

⁶ All of these analyses can be found on the ACPR website at https://acpr.banque-france.fr/sites/default/files/medias/documents/20200525_synthese_gouvernance_anglais.pdf

⁷ See, for example :

- ECB's November 2020 guide to managing climate change and environmental risks:

<https://www.bankingsupervision.europa.eu/ecb/pub/pdf/ssm.202011finalguideonclimaterelated-andenvironmentalrisks~58213f6564.en.pdf>

- Opinion on the supervision of the use of climate change risk scenarios in ORSA :

<https://www.eiopa.europa.eu/sites/default/files/publications/opinions/opinion-on-climate-change-risk-scenarios-in-orsa.pdf>

⁸ See for example:

European Union's sustainable finance strategy. The exercise and the difficulties encountered underline the need for better availability of climate-related data at EU level (physical damage data, transition risks). The revision of the Directive on the non-financial reporting and the associated standardisation process will help bridge this data gap

2. Implementation of the pilot exercise

The assumptions of the pilot exercise were published in July 2020, following a public consultation phase, and a year of preparative work with the industry in working groups with major banking and insurance players. In order to limit the cost of the exercise, it was also agreed upon to retain a certain number of standard stress-testing procedures, such as those used by the European Banking Agency and the European Insurance and Occupational Pensions Authority.

A Q&A procedure was therefore established with the institutions participating in the exercise. The frequency of this procedure was set on a weekly basis over the entire duration of the exercise, and ended in mid-April 2021 with a series of bilateral interviews and two feedback sessions with the participants.

In addition to methodological clarifications on assumptions or scenarios, the financial institutions' questions focused mainly on requests for additional information or data aimed, in particular, at refining their risk assessment, particularly of their sectoral or international exposures. These discussions also highlighted methodological issues that had not been identified during the preparatory phase. One of the issues with the most structuring effects was the application of IFRS standards. In standard stress-testing exercises, such as those of the European Banking Agency,

where the projection horizon is limited to 3 years, it is assumed that claims at default that reach their maturity are reissued as defaulted exposures. However, given the 30-year span of the pilot exercise scenarios, this assumption becomes problematic because it creates an artificial build-up of defaulted exposures (see in particular the section of this document dedicated to methodological lessons).

The implementation of the dynamic balance sheet assumption required a review of the consistency of the institutions' individual answers to ensure that their aggregation is compatible with the projected economic structures to be funded for each scenario. This was done in October 2020 for banks, on the basis of a first submission of credit projections, and in January 2021 for insurers, at the time of final submission of financial reports. This quality assurance process was carried out in two stages.

As a first step, the ACPR requested of some banking institutions that they make minor corrections to the evolution of portfolio segments where it did not appear to be consistent with that of the sector-specific structure of the economy. As a second step, the ACPR identified, for each sector/scenario/geographical area combination, individual developments that appeared to be too far out of line with developments in the rest of the financial centre.

These corrections were very limited because, overall, the changes in the composition of portfolios remained broadly consistent with the evolution in the structure of this sector of the economy in all relevant scenarios. In addition, these corrections have made it possible to maintain diversity among the strategies used by financial institutions to mitigate the impact of risks related to climate change.

- The consultation launched in November 2020 by the European Banking Authority on ESG risk management and supervision of credit institutions and investment firms: <https://www.eba.europa.eu/calendar/discussion-paper-management-and-supervision-esg-risks-credit-institutions-and-investment>

- EIOPA's Technical Advice on the integration of sustainability risks and factors in the delegated acts under Solvency II and IDD :https://www.eiopa.europa.eu/sites/default/files/publications/advice/technical_advice_for_the_integration_of_sustainability_risks_and_factors.pdf

The overall timetable set for the exercise was fully respected, despite the exercise being launched in the midst of the COVID crisis. One reason for this may be that the scenarios published in July by the ACPR included the Eurosystem's first estimates of the impact of this crisis, with a detailed sectoral breakdown of activity that was particularly useful. The other stems from the strong involvement of the banking and insurance teams that participated in the exercise.

The submissions were made in January 2021. Following a new quality assurance procedure, a sensitivity exercise to measure the indirect impact of physical risk on the banking sector was launched, but with limited success, notably owing to tighter submission deadlines.

3. The pilot exercise has achieved its main objectives

Despite its complexity and unprecedented nature, the climate pilot exercise has achieved its main objectives.

3.1 Very strong industry-wide mobilisation

Almost all the banks and insurers that contributed to the preparation of the exercise took part in it, the exercise being conducted on a voluntary basis. Others joined the exercise, although they had not taken part in the preparatory phase: in total, 9 banking groups (the 6 main French groups as well as 3 public sector financial institutions) and 15 insurance groups (or 22 undertakings)⁹ rallied over several months, despite the backdrop of the COVID crisis, to carry out this exercise. This very strong mobilisation gives us representative results (85% of the total balance sheet for the banking side, and 75% of total balance sheet and technical provisions for insurers) with high added value in both sectors.

⁹ The list of participants is presented in Annex A

¹⁰ NGFS, Guide to climate scenario analysis for central banks and supervisors, June 2020 : https://www.ngfs.net/sites/default/files/medias/documents/ngfs_guide_scenario_analysis_final.pdf

3.2 Stakeholder awareness of climate change risks:

Despite the many difficulties encountered and the absence of certain key data, the participating institutions commended the benefits of this pilot exercise and the progress it has fostered in terms of cross-functional mobilisation of teams, internal reflections on risk analysis and the limits of the models currently used, but also in terms of strategic guidelines and towards a better understanding of the issues and the impact of climate change on their business model. In particular, despite the many limitations that such a pilot exercise may pose, financial institutions have become aware that this type of exercise is not only feasible but also extremely useful in advancing their consideration of climate risk. The pilot exercise was therefore a catalyst for reflection and, for some, accelerated the mobilisation of teams and resources.

3.3 Quantification and assessment of complex transition and physical risk scenarios based on the work of the NGFS

The ACPR, assisted by Banque de France teams, designed this exercise in accordance with NGFS guidelines on the building of climate change scenarios and by retaining two of the scenarios published by the latter in June 2020¹⁰. These scenarios will also serve as a basis for other exercises under preparation, such as those of the Bank of England starting in June 2021 or those of the European Central Bank in 2022. It is therefore important that more supervisors take up this work in order to be able to launch their own exercises and thereby contribute to the development of a common knowledge base and assessment of climate risks.

3.4 A first assessment of risks and vulnerabilities to climate change

The pilot exercise usefully complements previous ACPR analyses, published in April 2019, based on *ad hoc* surveys. In addition to this snapshot, the pilot exercise adds a forward-looking view of risks over a long-term horizon that is conditional on the implementation of several alternative scenarios. The exercise thus provided financial institutions with the opportunity to assess their corrective actions (e.g. exit from certain sectors), using the

dynamic balance sheet assumption, thus becoming aware of new risks: potential discrepancies between exit strategies from certain greenhouse gas-emitting activities and market share retention objectives, between a desire to finance the economy or to maintain a customer relationship, which may result in a more lasting exposure to transition or physical risks than expected.



Transition risk: a rather moderate impact by 2050

1. Reminder on transition scenarios

It is important to emphasize that the development of scenarios to measure the impact of climate change on financial risks comes with significant uncertainties. Indeed, any scenario on CO₂ emission trajectories is based on a set of assumptions modelling the interactions between socio-economic systems and the climate. These interactions could indeed be affected by the existence of tipping points, irreversibility or threshold effects. The exact nature of these interactions is complex and potentially non-linear¹¹.

The results displayed in this publication are therefore contingent to the assumptions and models used, which present many simplifications.

In order to perform this exercise, the ACPR and the Banque de France relied on the guidelines¹² published by the NGFS¹³ and retained three transition scenarios, two of which were published by the latter in June 2020.

The transition scenarios include a baseline scenario, corresponding to an orderly transition,

and two disorderly transition scenarios (see Chart 1 below). Each of these scenarios combines different assumptions in terms of (i) trajectory of the carbon tax; (ii) total productivity levels of factors.

The baseline scenario chosen by the ACPR and drawn from NGFS work, corresponds to an orderly transition consistent with the narrative of the *Stratégie Nationale Bas Carbone* (the French National Low Carbon Strategy, or SNBC), which is France's roadmap for fulfilling its commitments made under the Paris Agreement. It is the most favourable scenario, although it includes a significant increase in the price of carbon, inducing a non-trivial adjustment in the economic system.

The first adverse disorderly transition scenario is that of a late transition. It assumes that the target for reducing greenhouse gas emissions is not met by 2030, which calls for the implementation of more proactive measures. This scenario exactly replicates the aggregate level emission, carbon price and GDP trajectories of the representative scenario for a "disorderly" transition published by the NGFS in June 2020. It makes the assumption that carbon sequestration technologies are less efficient

¹¹ See for instance NGFS publications on these issues (<https://www.ngfs.net/en>) as well as the recent reports from the Basel Committee. (<https://www.bis.org/press/p210414.htm>).

¹² For a complete overview of the assumptions and models used to develop these scenarios, see :

- T. Allen et al: "Climate transition scenarios for assessing financial stability: an application to France", Working Paper No. 774, Banque de France, July 2020. [https://publications.banque-](https://publications.banque-france.fr/)

france.fr/sites/default/files/medias/documents/wp774.pdf

- ACPR, " Scenarios and main assumptions of the ACPR pilot climate exercise", https://acpr.banque-france.fr/sites/default/files/medias/documents/20200717_main_assumptions_and_scenarios_of_the_acpr_climate_pilot_exercise.pdf

¹³ See for instance :

<https://www.ngfs.net/sites/default/files/medias/documents>

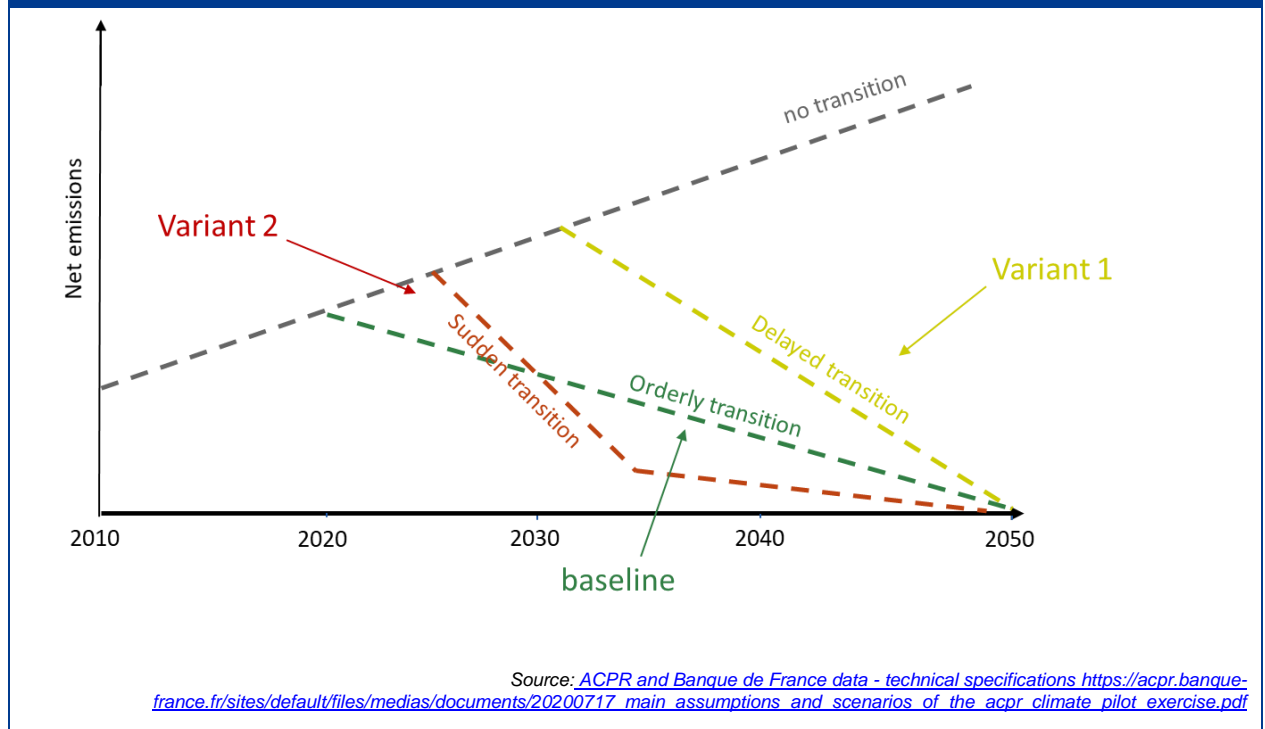
than expected to offset emissions. It is based on a very high increase in the price of carbon in 2030 in order to maintain the carbon neutrality target in 2050. Indeed, it rises from \$14 per ton of CO₂ globally in 2030 to \$704 in 2050. This increase is reflected in a series of heterogeneous shocks to the industries and led to a very strong increase in real energy prices (+125%) over the period for France.

The second adverse scenario for a disorderly transition - later called the "sudden transition" scenario - combines a sharp increase in the price of carbon, which reaches \$917 per ton of CO₂ in 2050, and a less favourable evolution of productivity than in the baseline scenario from 2025 onwards. Moreover, renewable-energy

technologies are less efficient than expected, implying even higher energy prices and additional investment needs.

In interpreting the results presented in the remainder of this chapter, it should be borne in mind that none of the scenarios analysed trigger an economic downturn by 2050, contrary to the usual stress-testing practice, but they do integrate, for adverse scenarios, a slower economic growth. In this context, impacts are interpreted in relative terms, as deviations from the baseline scenario.

Chart 1- Schematic representation of the transition and physical risk scenarios included in the ACPR pilot exercise



2. The impact of transition risk on French banks

The impact of transition risk on French banks can be broken down into three components, which are discussed later in this section. The first section tackles the implementation of the dynamic balance sheet assumption, which enables institutions to take management decisions in response to the different scenarios analysed and to reallocate their corporate

portfolio across different economic sectors from 2025 onwards. This assumption makes it possible in principle to analyse the long-term strategies implemented by institutions. The second section relates to credit risk projections in the various transition scenarios. The last one focuses on analysing the impact of financial shocks caused by the implementation of energy transition policies. The results obtained for the six main French banking groups are displayed hereafter (except in the section on dynamic

balance-sheet which also aggregates public financial institutions). More specifically, the data submitted by public or development banks are presented in a box (see Box 2).

2.1 Dynamic balance sheet

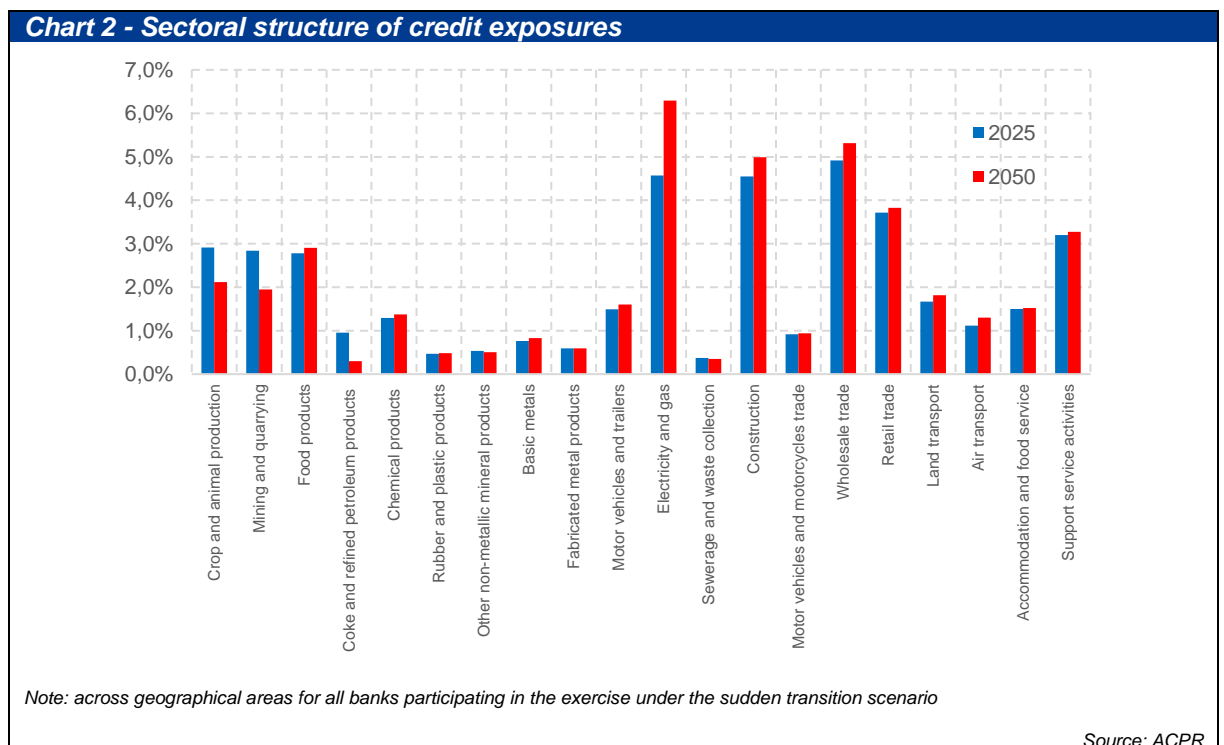
The institutions' initial submissions related to the dynamic balance sheet assumption. Participants were expected to project their credit exposures in the various scenarios provided by the ACPR. These projections, although subject to a consistency check presented in the section dedicated to the implementation of the exercise, offered institutions the possibility to reallocate their corporate credit portfolio across different economic sectors.

These balance sheet projections show a distortion of the sectoral structure of corporate credit exposures, to the detriment of the sectors most affected by the transition scenarios. For example, Chart 2 below shows that the electricity and gas sector, which stands to benefit from the transition in the scenarios, sees its share in total exposures increase sharply, while the mining and quarrying sector, which is

negatively impacted by the transition, sees its share in corporate exposures of banks declining.

Moreover, the implementation of the dynamic balance sheet assumption highlights the diversity of the strategies that banks have undertaken. Chart 3 shows how the exposure of the six largest banking groups to the manufacture of coke and refined petroleum products sector will change between 2025 and 2050 according to the sudden transition scenario. On this chart, one could note that two institutions (black and green curves) have chosen to adjust the structure of their exposures by following the sectoral distortion induced by the scenario.

By contrast, two other banks (represented by the light blue and light green curves respectively – and which have relatively low shares of these sectors at the starting point) chose not to reduce significantly their exposure. Lastly, two institutions (yellow and blue curves) have implemented an exit policy in this sector, in line with their public commitments.



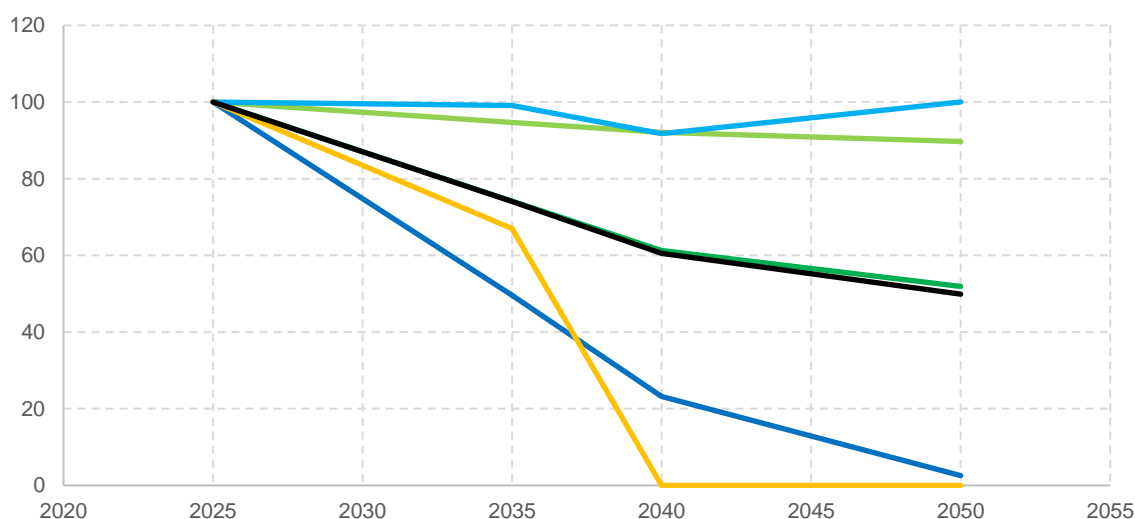
In general, two main types of strategies appear:

- Those of some institutions that choose to finance the economy as a whole, and

which, for this purpose, align the structure of their credit portfolios with the sectoral structure of the economy. However, it cannot be entirely ruled out that this choice reflects a passive adaptation strategy or a desire to reduce the cost of the exercise by minimising the risk of having to submit new projections after the consistency and quality assurance check carried out by the ACPR. It is also possible that this choice stems from the difficulty for some institutions to decide on strategic management actions with such a distant time horizon in mind.

- Other banks also conducted a sector-by-sector analysis in order to have a more detailed basis for the required reallocations. This choice may be conditioned by: (i) the existence of public commitments or of an already adopted sectoral policy; (ii) a willingness to support key sectors in the transition; (iii) pressure from civil society to reduce certain sectoral exposures; iv) finally, analyses on sectoral dynamics up to 2050 that diverge from that of the scenarios provided by the ACPR.

Chart 3 - Evolution of credit exposures in the sector of manufacture of coke and refined petroleum products



Note: across geographical areas for all banks participating in the exercise under the sudden transition scenario. Changes in exposure are normalised to 100 in 2025.

Source: ACPR

2.2 Credit risk

2.2.1 Aggregated results

To assess the impact of transition scenarios on credit risk, we use an approximation of the annual cost of credit risk¹⁴ (expressed in basis points) for each interval of time studied. The dual benefit of this metric is that it corresponds

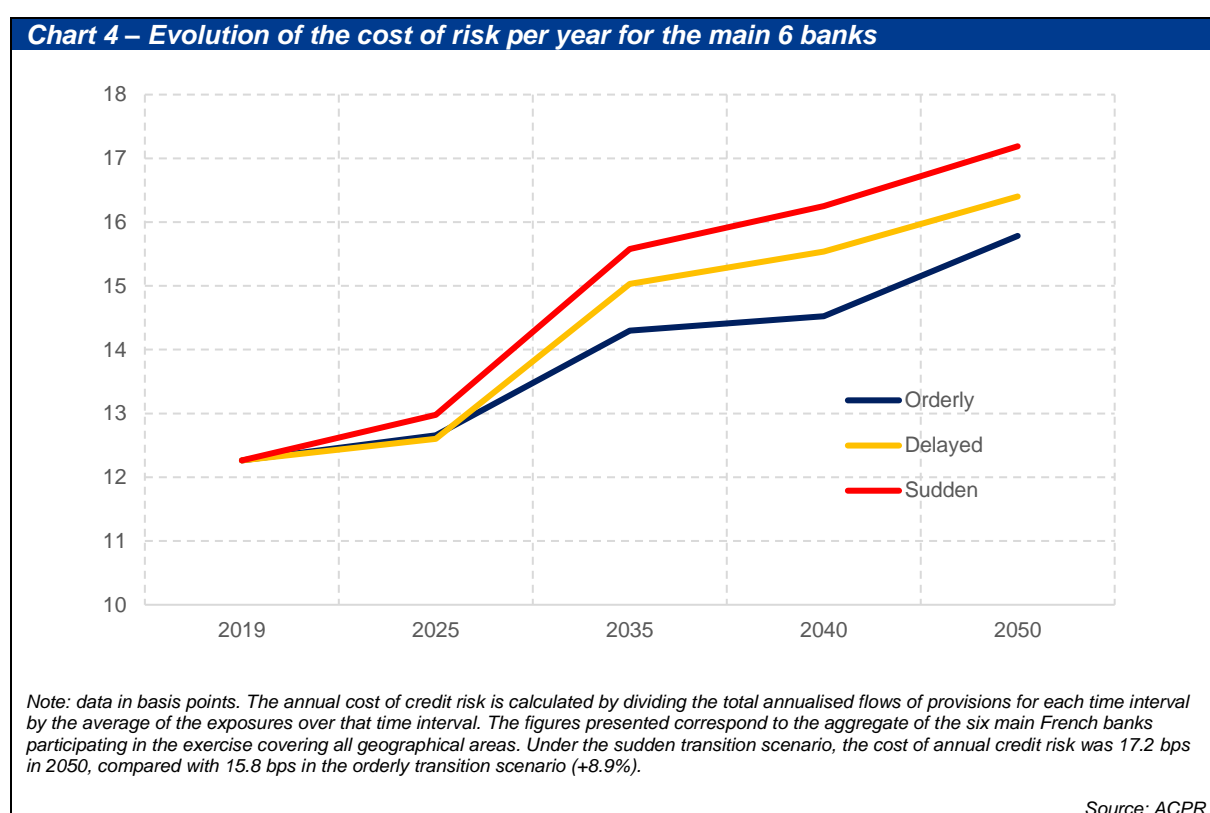
to a central risk management tool used by institutions and it limit comparison biases that would result from different methodological approaches.

The dynamics of the cost of credit risk at the level of the six main banking groups can therefore be observed for all relevant transition scenarios. As expected, institutions project a

¹⁴ The annual cost of credit risk is calculated by dividing the total annualised provisioning flows for each time interval by the average exposure over the same time interval. The figures presented correspond to the aggregate of the 6 main French banks participating in the exercise.

higher cost of credit risk in adverse scenarios than in the baseline scenario (see Chart 4). In the case of an orderly transition, the cost of risk is estimated to reach 15.8 bps in 2050 for the top 6 banks participating in the exercise, meaning a 22.4% increase compared with 2025, when the price of carbon rose significantly. This is not surprising given that the orderly transition scenario already entails a very significant economic adjustment and a near-tripling of the price of carbon between 2025 and 2050. This result in a slowdown in GDP growth, with significant impacts on sectors most

sensitive to an increase in the price of carbon, such as mining and quarrying or manufacture of coke and refined petroleum products. In the sudden transition scenario, the most adverse one, in 2050 the cost of risk would reach 17.2 bps (8.9% higher than in the orderly transition scenario)¹⁵ and 16.4 bps (+3.9%) in the late transition scenario. In the latter two scenarios, the cost of risk rises by 32.4% and 27.7% respectively, compared to 2025.



However, these initial results would need to be confirmed as part of a more prescriptive exercise from a methodological perspective, using more comprehensive scenarios. Yet, our analyses tend to confirm that a disorderly transition significantly affects the credit risk of banks. The magnitude of this impact is smaller than that observed in the biannual stress tests conducted by the European Banking Authority

(EBA). The reason stems from the fact that none of the transition scenarios considered includes a decline in GDP, contrary to the usual regulatory stress-testing framework.

2.2.2 Cost of risk dynamics by portfolio and geographical area

¹⁵ The last interval was chosen, as it is during that time that the cost of credit risk is the highest in all scenarios. Another possibility would have been to consider the average annual cost over the entire time period of the scenario. This, however, would not have changed the magnitude of the impacts.

Institutions were requested to perform credit risk projections on three portfolios: (i) the corporate portfolio including SMEs; (ii) the retail portfolio; (iii) and the sovereign portfolio, using the benchmark probabilities of default provided by the ACPR. In the orderly transition scenario, aggregate projections of institutions' risk costs rose by 22.4% between 2025 and 2050. The corporate portfolio accounts for almost 60% of this growth, the retail portfolio (households) accounts for about one-third, and the rest (6.5%) accounts for the contribution of the sovereign portfolio. By looking at the difference in the cost of risk between the sudden transition and orderly transition scenarios by 2050, one can draw the following conclusions. While banks may have been able to account for different sectoral dynamics depending on the level of adversity of scenarios, the risk assessment of the retail portfolio mainly relies on the usual macroeconomic variables (unemployment and GDP in particular). However, these variables do not vary much within different scenarios¹⁶. The difference in the cost of risk on the retail portfolio is limited to 0.5% between the two scenarios. As a result, the cost-of-risk deviation from the orderly transition scenario is concentrated on the corporate portfolio (+11.6% between the orderly transition scenario and the sudden transition scenario and therefore 75% of the inter-scenario deviation). The sovereign portfolio is very affected by the benchmarks set by ACPR¹⁷ (+87.5%) but explains 22.6% of the total deviation.

The breakdown of the evolution of the cost of risk according to the geographic location of exposures shows that the increase in the cost of risk in the orderly transition scenario between 2025 and 2050 comes, for 66.4%, from exposures located in the EU area (including France), for 11.6% from exposures in the United

States and for 21.9% from exposures located elsewhere¹⁸. The difference in the cost of risk between the sudden transition scenario and the orderly transition in 2050 is slightly higher in the United States (+18.5%) than in Europe (respectively +8.7% and +8.4% in France and the rest of the EU). The inter-scenario difference is slightly lower for the rest of the world (+6.1%). In the case of the United States, this impact reflects a compositional effect related to a larger share of sensitive¹⁹ sectors in the total corporate portfolio (10.4% versus 7.4% for the EU area including France) and to more marked impacts on some sectors in adverse scenarios (especially in the extractive industries sector). The scenarios for the rest of the world are less severe, also at the sectoral level, which leads to a lesser impact on the cost of risk. In the end, it is essentially the European portfolio (including France), which, due to its weight (74.2% of exposures in 2019), explains most of the difference between scenarios (74.5%).

2.2.3 Focus on the corporate portfolio and sectoral dynamics

It is possible to assess the contribution of sensitive sectors, such as those identified by the ACPR in the pilot exercise assumptions and scenarios (see Annex B), to the increase in the cost of risk (see Chart 5). These sectors accounted for 9.7% of institutions' total corporate portfolio. Under the orderly transition scenario, the cost of corporate risk rose by 24.6% (+5.2 bps) between 2025 and 2050. Approximately one third of this increase is attributable to sensitive sectors, which are therefore already significantly stressed in the orderly transition scenario. In 2050, the cost of corporate risk is 12.2% higher under the sudden transition scenario than in the orderly transition scenario (+3.3 bps). Sensitive sectors only account for 4.2% of this inter-scenario

¹⁶ For example, the unemployment rate differential between the accelerated and orderly transition scenarios never exceeds 0.4 percentage points.

¹⁷ ACPR sovereign default probability benchmarks were generated on the basis of changes in sovereign interest rates and GDP. The sharp changes in interest rates in the scenarios thus led to significant variations in the probabilities of default estimated by the ACPR.

¹⁸ The cost of zone-specific risk for this period increases by 21.8%, 42.9% and 34.4% respectively for the EU, the United States, and the rest of the world.

¹⁹ See Annex B for the definition of sensitive sectors and taxonomy used.

difference. Looking at the total impact (orderly plus sudden), the sensitive sectors explain 20.6% of the increase in the cost of corporate risk. It can be noted that the banking groups

were therefore able to quantify the various scenarios taking into account the differences in dynamics between sectors.

Chart 5 - Breakdown of the evolution of the corporate cost of risk by sectors

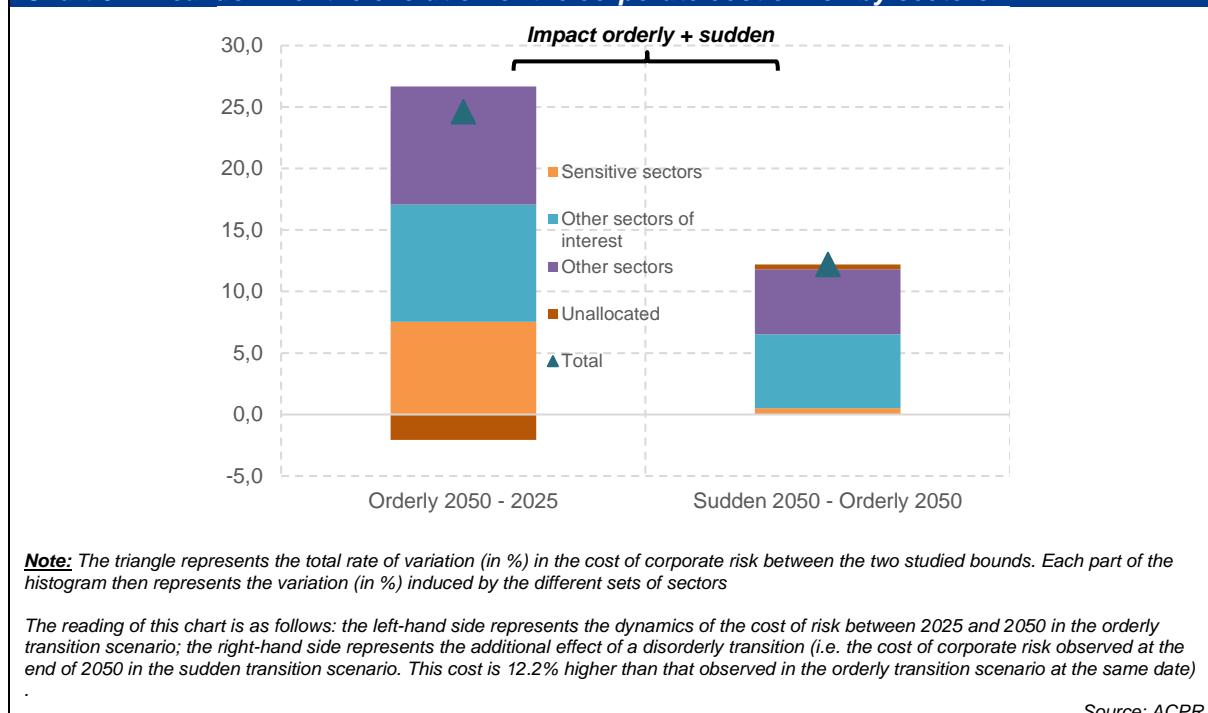


Table 1 below shows the cost of risk by grouping sectors according to their sensitivity to the transition risk. It confirms that the increase in the cost of risk is significant in sensitive sectors under any scenario. For example, the cost of risk is multiplied by 2.5 in the orderly transition scenario and by 3 in the sudden transition scenario compared with the level observed in 2025. By way of comparison, the cost of risk was multiplied by 2.1 in 2020 in the context of the COVID crisis associated with a sharp decline in economic activity.

In all scenarios, the sectors affected or those that relatively benefit from the transition remain the same ones. This is an observation that can be made when analysing the risk metrics associated with each sector. This exercise allows an analysis of these variables according to different reading grids: (i) by sector first, as shown in Chart 6 where the evolution of probabilities of default (PD) is represented over time for the different scenarios and for the most impacted sectors, (ii) by geographical area (iii) or even by scenario as shown in Chart 7.

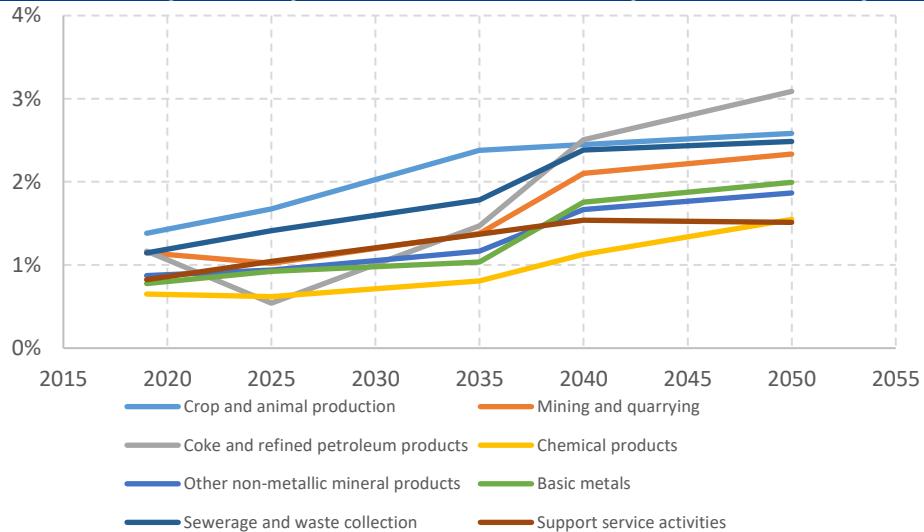
Table 1: cost of risk by set of sectors and scenario (in bps)

	Orderly 2025 (A)	Orderly 2050 (B)	Ratio (B) / (A)	Sudden 2050 (C)	Ratio (C) / (A)
Sensitive sectors	12.4	30.8	2.5	37.3	3.0
Other sectors of interest	19.0	23.3	1.2	27.8	1.5
Other sectors	19.4	24.1	1.2	26.8	1.4
Not allocated	39.1	36.4	0.9	37.0	0.9
Total	21.6	26.3	1.2	29.5	1.4

In Chart 7, it can be noted that the probabilities of default for the orderly transition scenario by sector (green curve) in 2050 are almost always lower than those of the sudden transition scenario (red curve) at the same point in time. The winning sectors are those for which the

probabilities of default are shown to be decreasing (e.g. construction sector). Compared to the 2019 levels, these deviations also illustrate what a forward-looking estimate of the climate change transition risk might be.

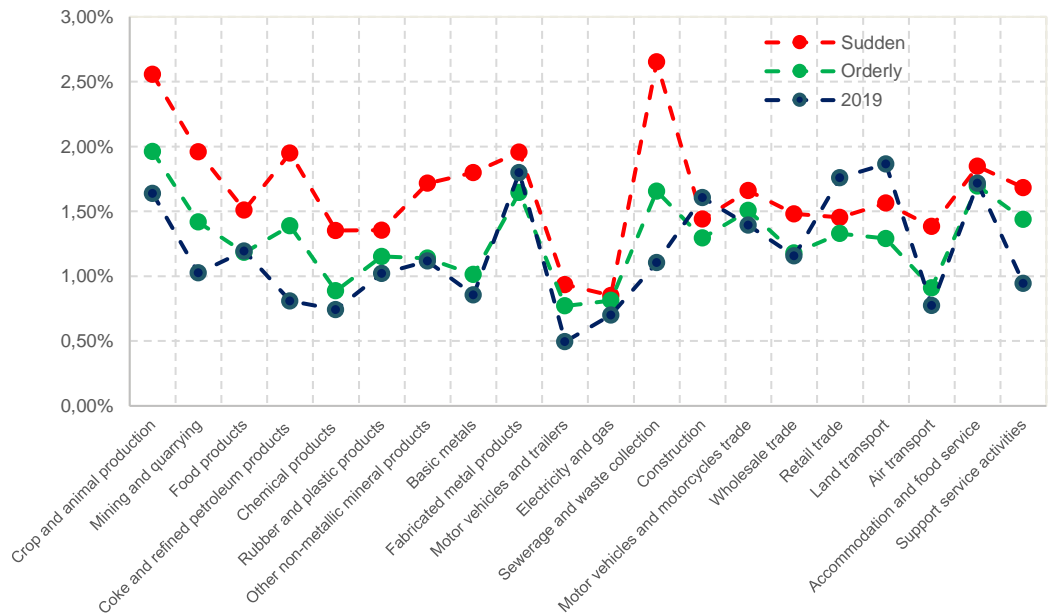
Chart 6 - Point-in-time probability of default broken down by economic activity



Note: the chart represents the weighted average (weighted using the exposures for each sector) of the one-year probabilities of default by sector for the 6 main French banking groups.

Source: ACPR

Chart 7 - Evolution of the probability of default broken down by sector



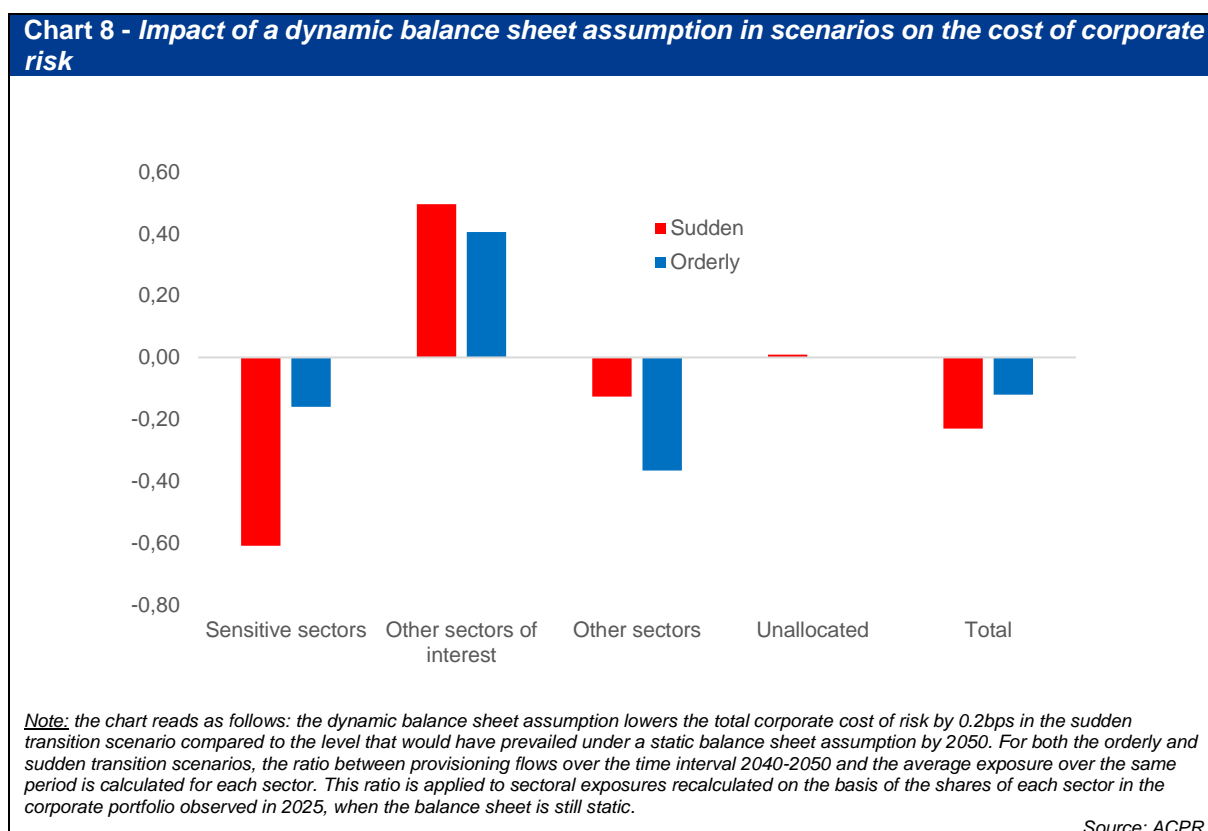
Note: the graph below represents the weighted average (weighted using total corporate exposures) of the one-year probabilities of default by sector of the 6 main French banking groups. The levels shown for the orderly and sudden transition scenarios correspond to those observed in 2050.

Source: ACPR

2.2.4 Impact of a dynamic balance sheet assumption on the evolution of the cost of risk

In the course of our analyses, the effect of the dynamic balance sheet is not the main factor explaining the observed difference between the orderly and sudden transition scenarios. Indeed, the possibility for institutions to reallocate their sectoral exposures leads to two opposite effects: i) first, a decrease in exposures to the sectors that are most affected in the scenarios, due to a reallocation of credit portfolios, ii) then, an effect linked to the starting level of these probabilities of default: since that starting level is initially higher in certain sectors that ultimately benefit from the transition, sectoral reallocation sometimes leads to an increase in the cost of risk.

Finally, under the dynamic balance sheet assumption, institutions increase their exposures to sectors that benefit from the energy transition with a decrease in their level of risk (in the form of a probability of default). In the end, these different effects partially offset each other and the dynamic balance sheet assumption as such ultimately has little impact on the total cost of risk (Chart 8). On the other hand, on a static balance sheet assumption, the rate of growth in the cost of risk would be greater for sectors sensitive to transition risk than for others.



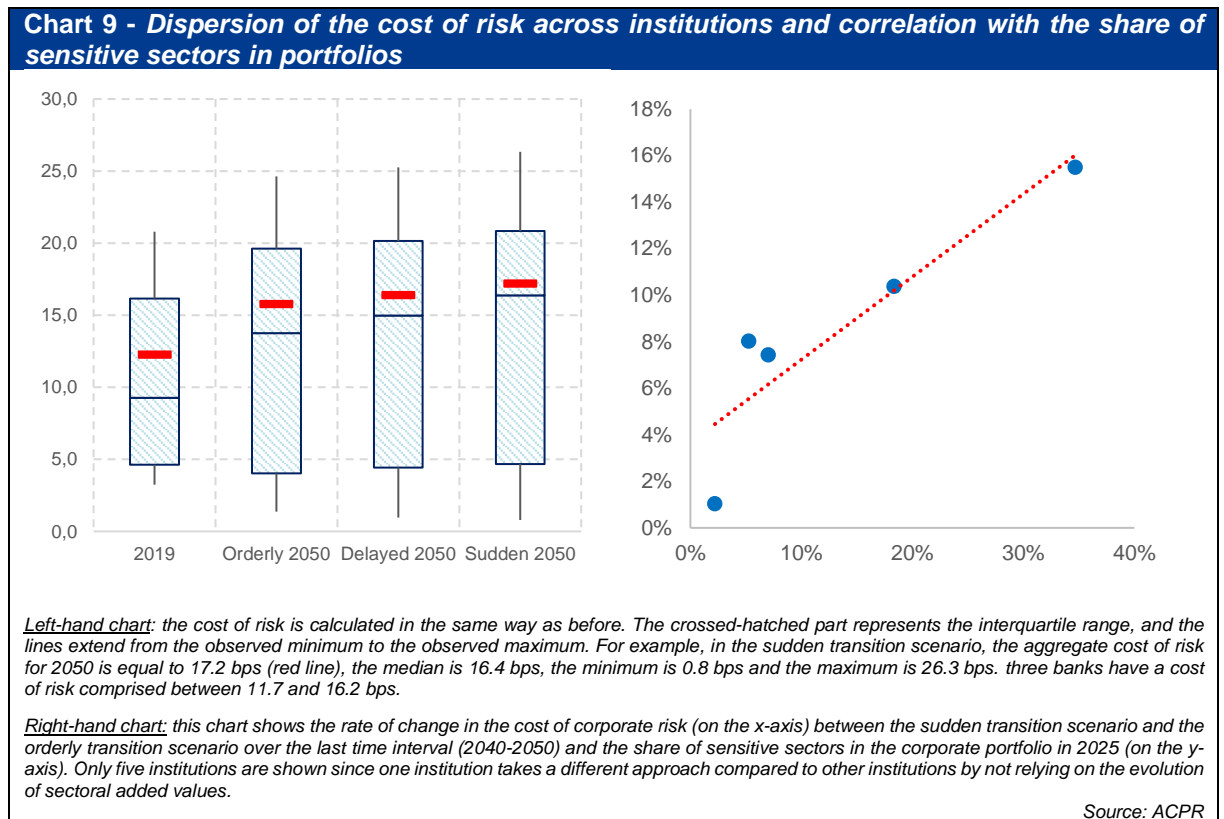
2.2.5 Dispersion of the evolution of the cost of risk across institutions

Overall, this exercise confirms that transition scenarios, especially when they are disorderly, are indeed a source of additional risk for French banks compared to an orderly transition scenario. Looking at the distribution of these

impacts for the 6 main institutions, a significant heterogeneity also appears in the levels of the cost of risk. Indeed, the interquartile range of the cost of risk is equal to 11.5 bps in 2019 but it reaches 16.2 bps (+40.8%) in the sudden transition scenario (15.6 bps in the orderly transition scenarios). This reflects the different

rates of change in the cost of credit risk (particularly corporate) between scenarios depending on the institution. These increase ranges from +0.8% to +46.0% for five institutions for which the cost of risk increases by 2050 in the sudden transition scenario.

Although the low number of points calls for caution in interpreting this result, we can nevertheless note an increasing relationship between the impact observed on the institutions and the share of sensitive sectors in their corporate portfolio (see Chart 9).



2.3 Market risk

Market risk is the second category of risks for which banks calculate projected losses. It is divided into two sub-categories: (i) the fair value revaluation of the trading book following an instantaneous market shock induced by the valuation of assets under adverse transition scenarios; (ii) the impact of market shocks on the counterparty risk in the most sensitive sectors. For these two components, the positions therefore remain constant. On the first component of market risk, the following exposures were studied: equity, corporate credit spreads (mainly related to bonds),

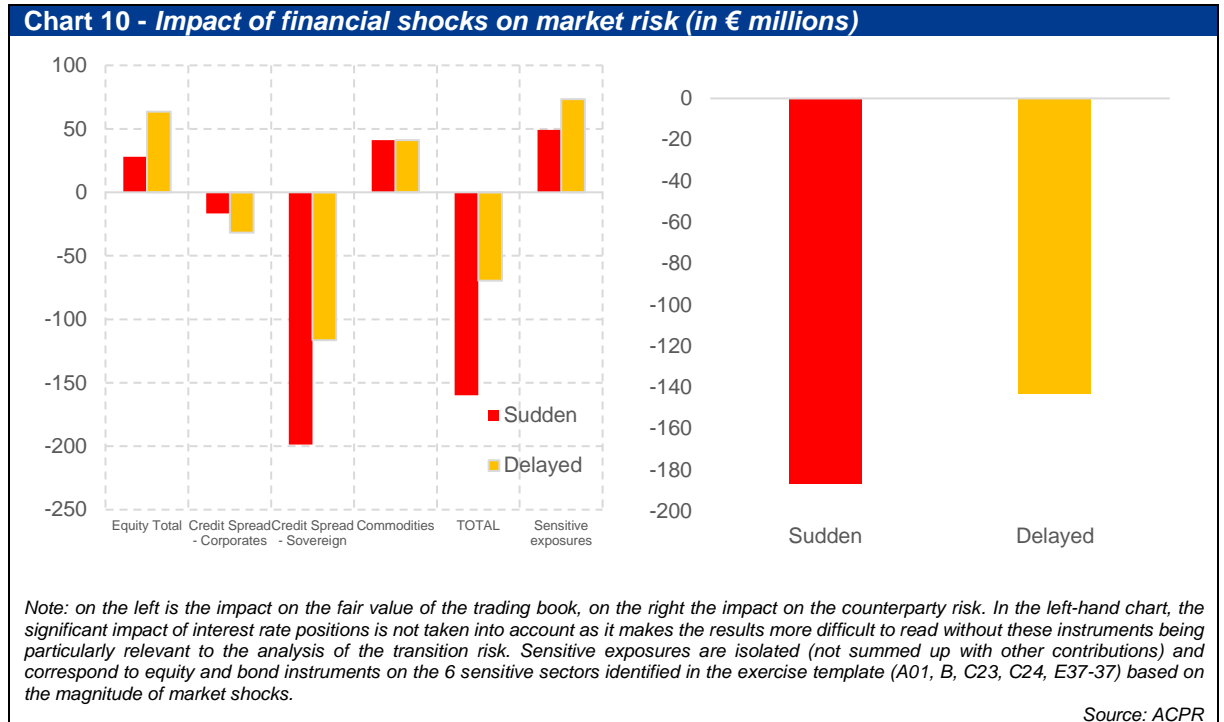
sovereign credit spreads, commodities (only oil-related positions) and finally interest rate²⁰ instruments. In total, the instantaneous impact of the transition scenarios on the top six banking institutions reaches 160 million euros in case of a sudden transition and 69.6 million euros in case of a delayed transition. As a result, the recorded losses are relatively modest compared with standard stress tests such as those usually carried out by the EBA. The market shocks used for this exercise were significant but applied to a small portion of the portfolio (equity in sensitive sectors and

²⁰ In the end, variations in the valuation of interest rate portfolios were excluded from the results, as the magnitude of the impacts (linked to massive interest rate variations in the scenarios)

complicates the reading of the results without these instruments being specifically linked to the analysis of the transition risk.

corporate credit spreads in the same sectors as well as to sovereign risk). In addition, the analysis per instrument shows that sensitive sectors may be the subject of short positions at the cut-off date studied (31 December 2019),

thereby offsetting the adverse impact of shocks. In the end, it is essentially on the sovereign segment, that the total impact is felt (-198.8 million euros in the sudden transition scenario), due to the very adverse interest rate scenarios.



The modest magnitude of these results calls for careful consideration as to how best to assess the impact of transition risk on market risk, particularly given the operational burden involved. Indeed, the information systems used in market risk management do not (at this time) allow for market risk to be analysed from a sectoral perspective as these systems are built around risk factors. Therefore, the implementation of this exercise has required extensive manual adjustments with a limited impact in the end. This issue was combined with the lack of understanding of the narrative underlying the market scenarios (scopes, sensitivity parameters studied, gap between the usual horizon for analysing market risk and that for transition risk). However, the following elements are worth noting. First, the exercise raised awareness within the functions in charge of market risk management regarding the need

to incorporate this sectoral dimension into market risk analysis. Indeed, repeated market shocks with unusual correlations are likely to occur in the coming years following the implementation of transition policies, such as carbon taxes. Second, the trading book does not represent the full range of market activities of banking institutions. It might be useful to integrate a broader view of market activities, such as transactions subject to fees.

The counterparty²¹ risk analysis, which is the second component of the market risk studied in this exercise, shows a total impact on the six largest banks in the range of €190 million and €145 million respectively in the sudden and delayed transition scenarios. The average impact per counterparty for each institution is thus €15.6 million and €11.9 million respectively (with an average maximum impact of €48

²¹ This risk is measured using the impact of default of the two largest counterparties of the institution

million). The majority of counterparties identified by institutions as being in vulnerable sectors and subject to default belong to mining and quarrying or manufacture of coke and refined petroleum products. This type of analysis

(similar to credit risk) is thus useful for identifying substantial market positions on carbon intensive counterparties.

Box 2 - Results of the pilot exercise for financial institutions in the public sector

In addition to the 6 main French commercial banks, three other institutions volunteered to participate in the pilot exercise: the Caisse des Dépôts et Consignations (French deposits and consignments fund, Savings Fund and General Section), the Agence Française de Développement (French Development Agency) and the Société de Financement Local (French local financing company, SFIL). For these three public sector financial institutions, the methodology and scenarios of the pilot exercise were not always adapted to their business model, which was very different from that of commercial banks, especially for the latter two. For example, in the case of the Agence Française de Développement, the bulk of the financing concerns the geographical area labelled "Rest of the world". Economic developments in the euro area are described in the scenarios provided by the ACPR/Banque de France in an aggregated manner and therefore without sufficient differentiation between countries that present very different vulnerabilities. This approximation, a reasonable one for commercial banks (as credit exposures are mostly located in Europe and the United States) was therefore not appropriate for the portfolio of the AFD. Similarly, the scenario does not describe specific trends at the level of local authorities, which is the main source of SFIL²² credit exposure. This has required in a significant additional effort to adapt the exercise to the specific characteristics of these two institutions.

Agence Française de Développement (AFD)

The AFD approach was broken down into two steps. Sovereign and then non-sovereign portfolio stress. As regards the first cited portfolio, AFD's country economists assessed the sovereign rating trajectories of 20 countries representing 66% of sovereign exposure, based on the "rest of the world" scenario and the narrative accompanying the Banque de France's methodological document describing the building of the scenarios. By taking into account criteria such as sectoral diversification of the economy, the energy mix and the potential impact on public finances, AFD was therefore able to differentiate the impact of the countries under consideration on the ratings. This assessment led to a downgrade of the sovereign portfolio by slightly less than one notch under the sudden transition scenario. It also indirectly affects the rating of corporate counterparties (support capacity when the State is a shareholder of the counterparty and country caps). Corporate counterparties are then subjected to specific line by line stress based on three criteria: changes in value added and sector margin and financial resilience of the counterparty.

Altogether, this analysis led to downgrades by three notches or more for 17 sectors accounted for 38.9% of the non-sovereign portfolio for a total weighted impact equal to one notch. The downgrade across the entire portfolio (including sovereign portfolio) is of the same order. However, the AFD noted the need to further refine the analysis for two sectors: that of financial²³ counterparties which, in AFD's areas of intervention, may be highly specialised in risky sectors, and the electricity and gas sector which, in the scenarios, did not allow for a distinction to be made between the impacts according to the technological mix of the companies. The AFD has launched specific working groups for these sectors (accounting for 44.2% of the non-sovereign portfolio).

²² SFIL work is not finalised at the date of publication.

²³ For this exercise, the AFD has decided to apply an *ad hoc* three-notch downgrade assumption to its financial counterparties.

Caisse des Dépôts et Consignations Group

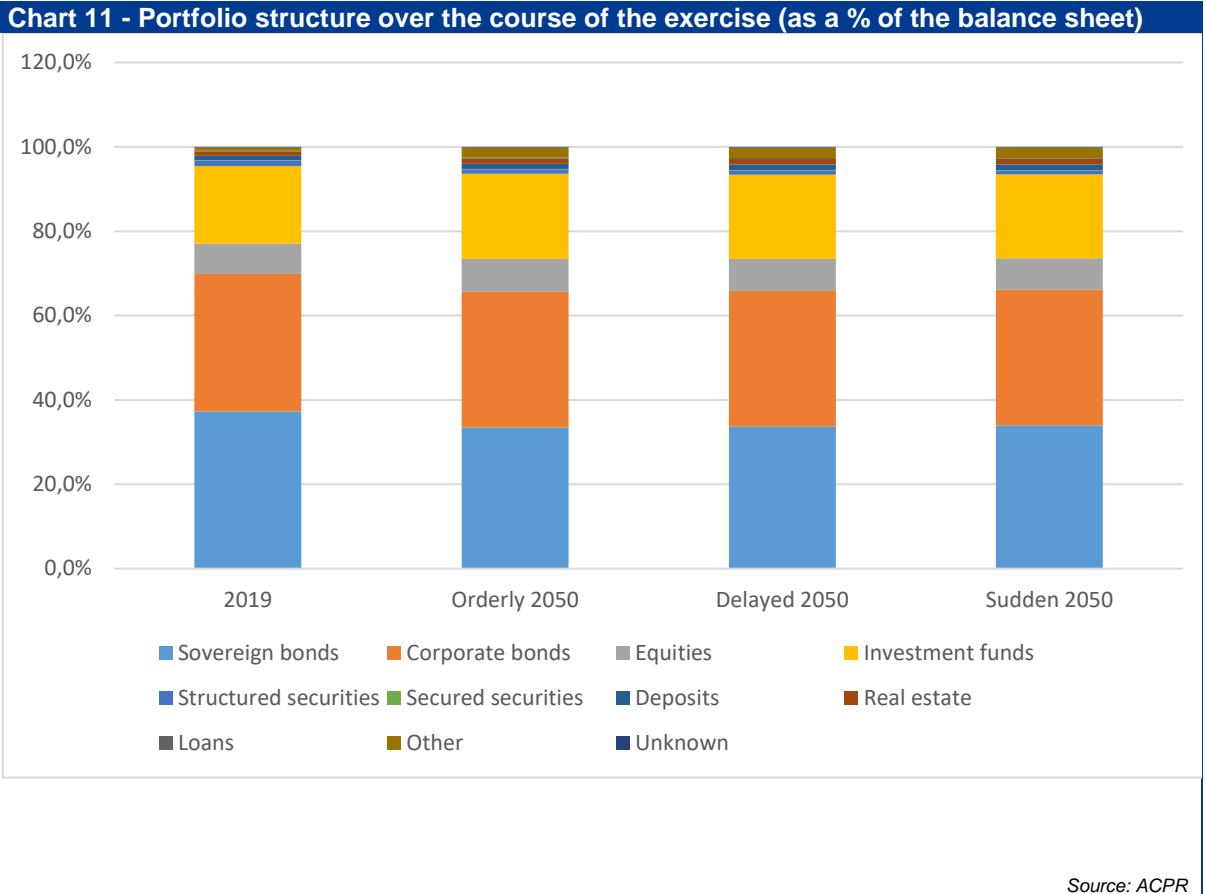
In the case of the CDC group, the scenarios were also not fully adapted to the group's activity as there was no element related to the issue of social housing financing (although such exposures could be associated with sovereign exposures) and the methodology excluded equity holdings. For "Section Générale", 62.7% of credit exposures did not fit into the segments studied in this exercise, in particular equity holdings. In the case of the "Fond 'Epargne" according to which exposures associated with social housing financing are considered as a sovereign exposure (as 95% of them are guaranteed by local authorities), 76.1 % of credit exposures fell within the scope of the exercise. Out of the three portfolios studied in the exercise, the Fond d'Epargne and Section Générale²⁴ projected the expected losses over the entire period encompassed in the exercise. Given the low level of corporate exposures (particularly in sensitive sectors), the CDC group did not differentiate between sectors. However, with the limited divergence in the trajectories of the macroeconomic variables (GDP, unemployment, etc.) retained in the model, the impacts of the adverse scenarios are ultimately very low. On the contrary, the most discriminating variable in the model retained is the risk-free interest rate. As the risk-free interest rate is higher in the orderly transition scenario, the latter constitutes the most adverse scenario for the CDC group.

3. Transition risk analysis for French insurers.

For several years now, French insurers have been involved in policies aimed at reducing the carbon footprint of their asset portfolios. Their current exposure to sectors that are potentially at risk in the event of transition risk shocks

remains limited to about 17% of their total assets. In addition, the majority of them committed to achieving carbon neutrality by 2030.

²⁴ This is based on a methodology developed by the General Section which adapted its IFRS9 model to project migration matrices with a 30 year horizon based on annualised macroeconomic data resulting from scenarios. Note that sovereign portfolio projections are not conducted using the ACPR benchmarks because it is impossible to normalise migration matrices on an *ad hoc* target.



The exercise only partially shed light on the implementation of portfolio reallocation strategies as participants generally maintained their asset allocation stable. While all companies implemented existing coal exit strategies, the shocks provided - which varied relatively little depending on variants - did not lead insurers to significantly alter their portfolio structure. The results above (see Chart 11) largely reflect a prolongation of the current portfolio composition, both in terms of asset classes and sectoral allocation.

The value of the assets held in the portfolio therefore mainly varies on account of assumptions regarding the pace of carbon tax developments and technological progress required to achieve the objectives of the Paris Agreement. On-balance sheet shocks have a different impact for different asset classes and business sectors. Measured as a deviation from the initial market value in 2025 and 2050, Charts 12, 13 and 14 show, by asset class, the sectoral impact of the two disorderly transition scenarios as a deviation from the baseline scenario (orderly transition).

Chart 12 – Sectors that are sensitive to the transition risk: impact of alternative scenarios on bond assets as compared to the reference scenario

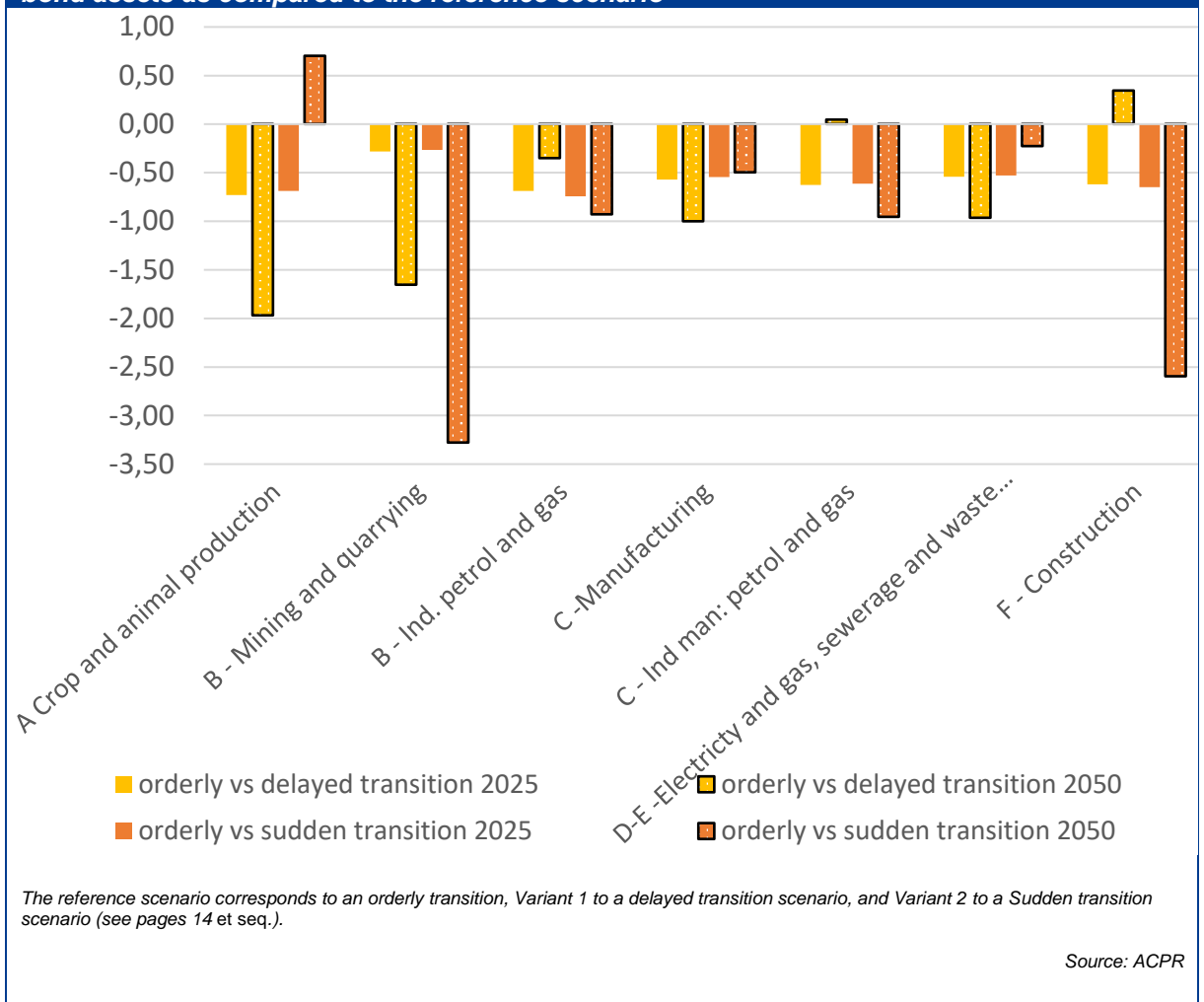
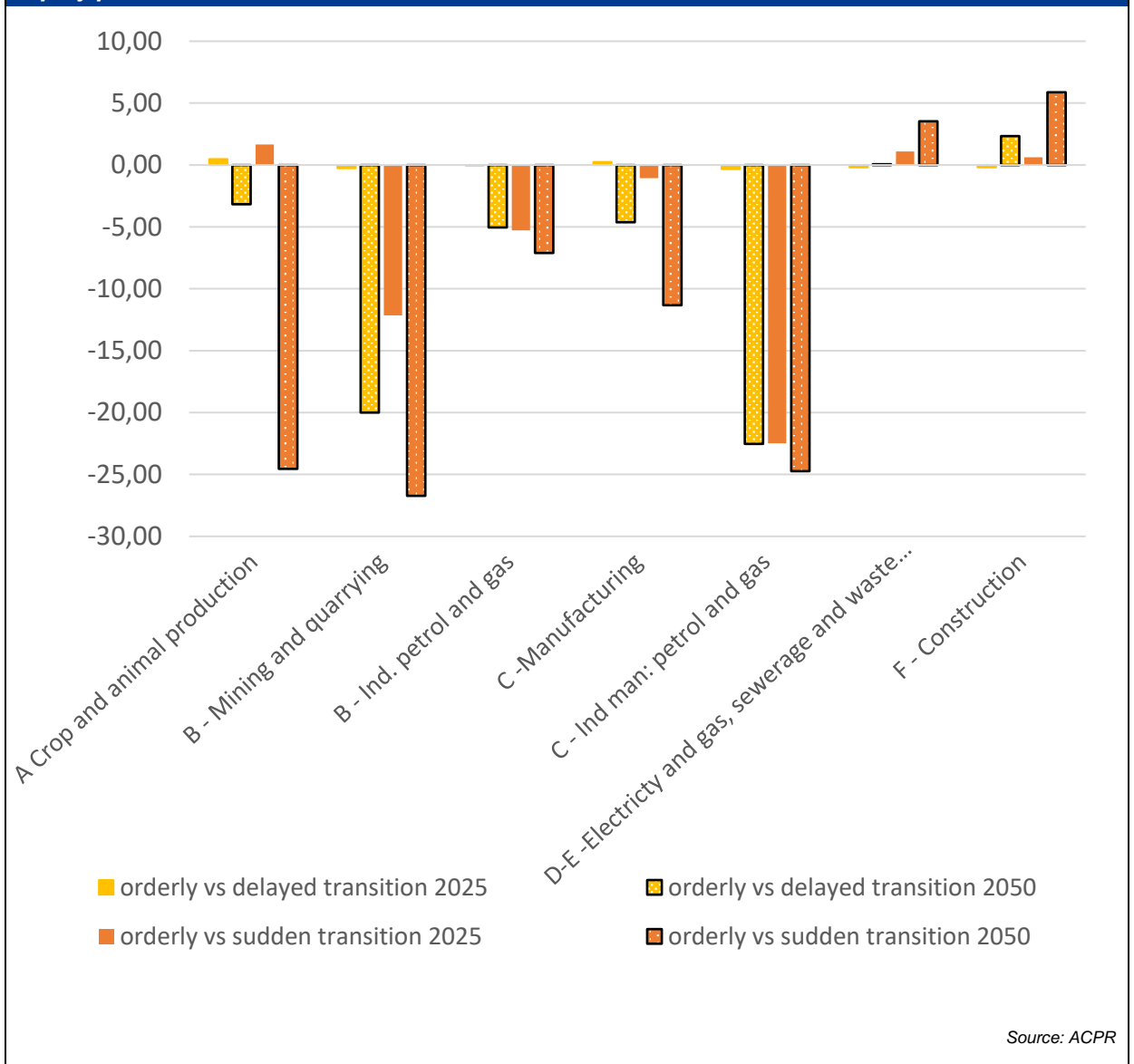


Chart 12 shows a limited overall impact on bond portfolios for the most carbon-emitting sectors. The value of extractive industry corporate bonds - the sector most affected in this asset class - decreases in the sudden transition scenario by about 4% more than in the reference scenario, and by 2% in the delayed transition one. The limited impact of the decline in value of corporate bonds from other polluting

sectors is mitigated by the already low level of exposure of French insurers to these industries: in 2019, the sectors included in these graphs represented less than 0.5% of the bond portfolio, illustrating the significant commitments already made within the French market in terms of climate-related investment policies.

Chart 13 – Sectors that are sensitive to the transition risk: impact of alternative scenarios on the equity portfolio as deviations from the baseline scenario

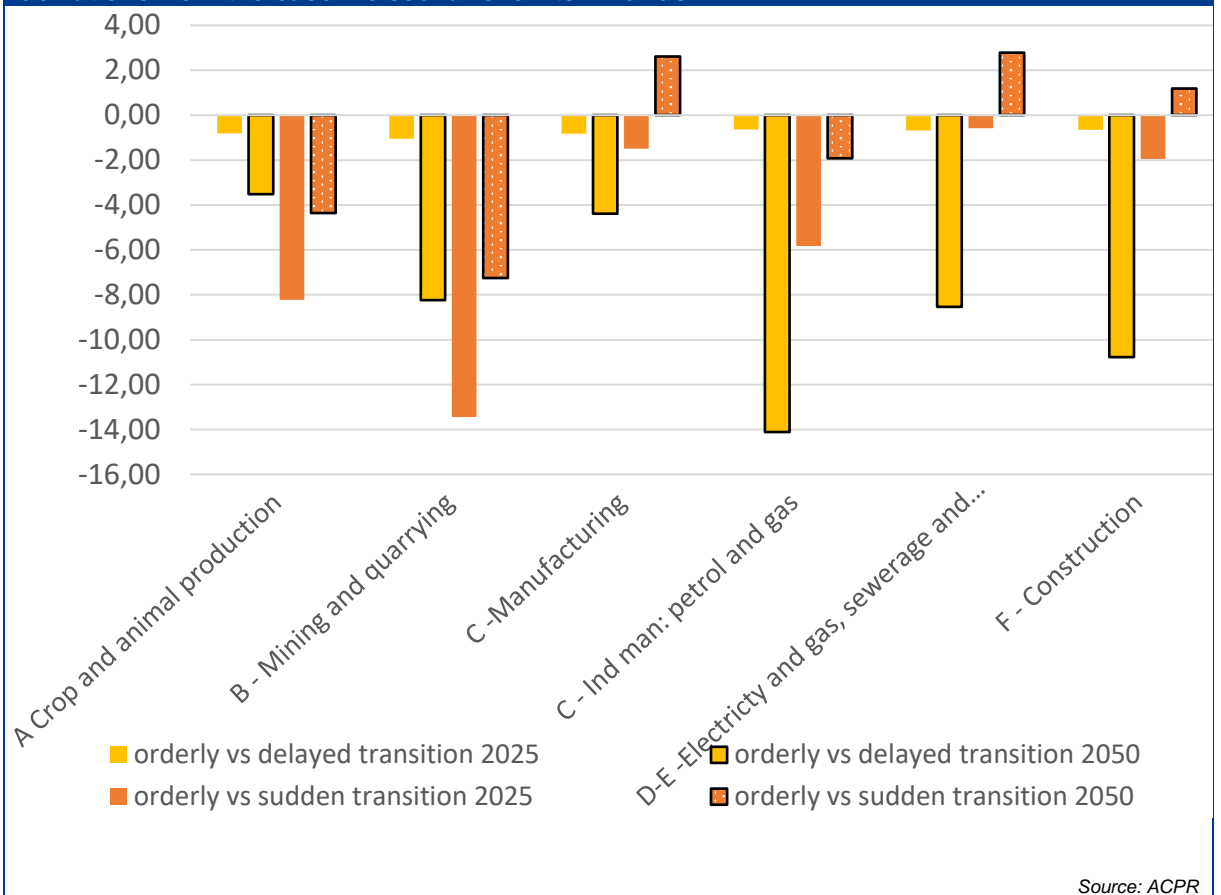


Source: ACPR

As equity portfolios are more sensitive to macroeconomic and financial volatility, a disorderly transition to a low-carbon economy results in larger shocks to equity market values. The impact of shocks is particularly strong for the agricultural, extractive and manufacturing sectors. However, although the shocks to equities are greater than the projected impacts

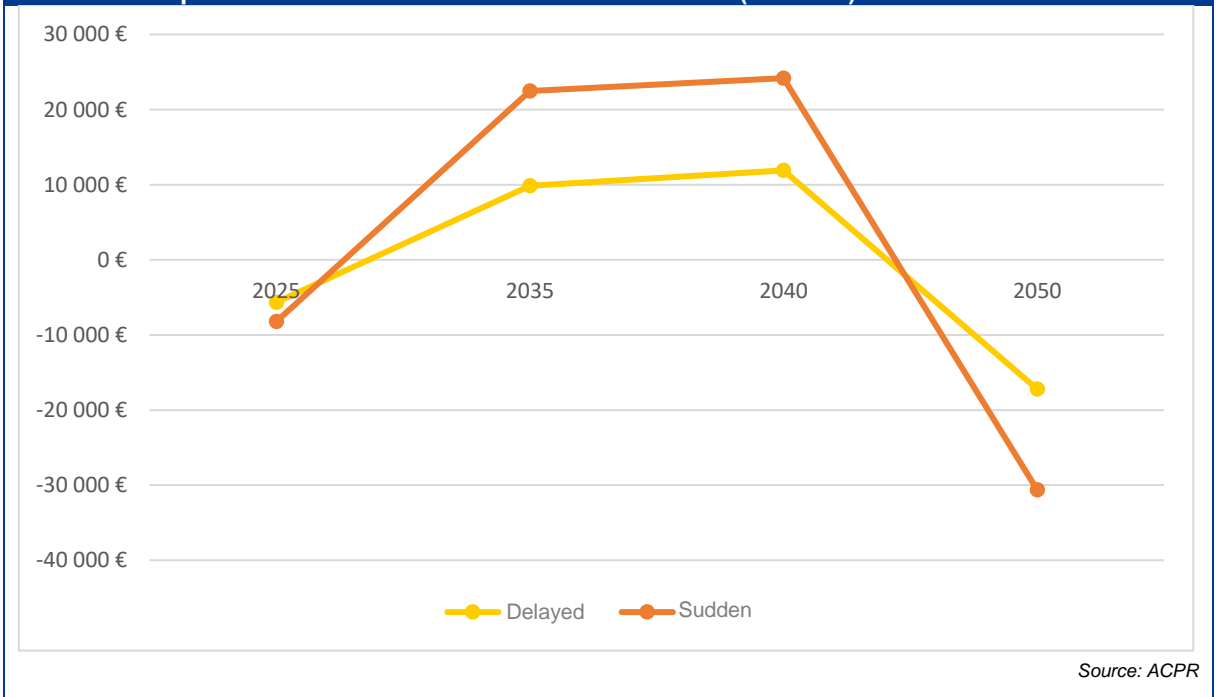
on bond portfolios, the impact of the shocks on insurers' asset portfolios is lower, given the relatively limited exposure of insurers to equities (9% of investments are in directly held equities or equity interests, and around 15 % if equities held through collective investment schemes are also taken into account).

Chart 14 – Sectors that are sensitive to the transition risk: impact of alternative scenarios as deviations from the baseline scenario: units in funds



Source: ACPR

Chart 15 - Impact vs baseline scenario: Total investment (€million)



Source: ACPR

However, the evolution of both corporate bond and equity prices is not the main factor explaining changes in the value of insurers' assets. Insurers manage their investment according to the characteristics of their liabilities: the longer the maturities of liabilities are, the more insurers invest in assets with a long maturity. The average duration of insurers' liabilities is 10 years in France, compared with 8 years for assets. As a result, the level of interest rates plays a key role in the valuation of insurers' balance sheets.

The scenarios considered in the pilot exercise involve disturbances in the global economy. The monetary policy response to these disturbances is a cut in interest rates to compensate for the slowdown in activity. This decrease in interest rates increases the value of bonds purchased at a time when interest rates were higher, with a positive effect on the total value of assets given the size of insurers' bond holdings and without significant increases in defaults in the different scenarios. The transition to a low-carbon economy would only become a threat to insurers if it resulted in a prolongation of the low interest rate environment. As the duration of assets is shorter than that of liabilities, the increase in bond values would not compensate for the increase in the value of liabilities, discounted at the risk-free rate. Furthermore, the scenarios do not directly take into account the consequences on the valuation of the insurers' balance sheet of an increase in the frequency and cost of extreme weather events should the implementation of transition policies be delayed or abandoned.

4. Transition risk has a relatively moderate impact

Overall, the pilot exercise thus reveals a generally "moderate" exposure of French banks and insurers to the climate transition risk.

However, this conclusion needs to be put into perspective in view of the uncertainty surrounding both the pace and impact of climate change. It is also contingent on the assumptions, scenarios analysed and methodological difficulties raised by the exercise.

Furthermore, while this analysis does integrate sectoral interactions and the risk of a significant, if not massive, devaluation of the prices of certain assets, it does not take into account the risks of a spillover effect, of supply chain disruptions or of amplification that are typically observed during episodes of financial stress or crises. The conservative assumptions adopted in this exercise therefore suggest that these estimates represent a downward bias in terms of financial risks. Lastly, in interpreting these results, it should be borne in mind that the scenarios analysed do not induce an economic downturn by 2050, as is the case with standard stress testing, but adverse scenarios do include a slower business growth component. In this context, the impacts are thus interpreted in relative terms, as a deviation from the baseline scenario of an orderly transition. However, the substantial increase in the cost of risk in some sensitive sectors, which is already induced by the orderly transition scenario, indicates that the energy transition which is necessary in order to comply with the Paris Agreement, presupposes a considerable effort to adjust the system and the economic structures.



Physical risks: significant increase in claims by 2050

1. Background on the assumptions made for the physical risk scenario by 2050

1.1 Physical risk assessed using the RCP 8.5 scenario of the IPCC

The physical risk assessed in this exercise is based on the following assumptions:

- 1/ an increase in the frequency and cost of extreme weather events due to climate change;
- 2/ the spread of vector-borne diseases/pandemics and respiratory pathologies caused by the increase of heatwave episodes and their duration, in particular through increased air pollution. These events are likely to have consequences for property and people. Insurance activities are thus primarily affected by these changes, and only insurers have had to apply these scenarios to their non-life²⁵ liabilities.

Physical risk is assessed on the basis of the Intergovernmental Panel on Climate Change's (IPCC) "RCP 8.5" scenario, which corresponds to a temperature increase comprised between 1.4°C and 2.6°C in 2050. This is the worst case scenario chosen by the IPCC. This choice takes into account the fact that, by 2050, the effects of the various IPCC scenarios are still rather undifferentiated. Choosing the worst-case scenario allows us to choose the scenario with the greatest potential impact. Given the inertia of climate change, which depends in particular on the accumulation of greenhouse gases over

the past 20-25 years, the behaviour and developments observed over the pilot period from 2020 to 2050 will condition longer-term developments up to the end of the century (see Chart 16 below).

1.2 Natural disaster scenarios: impact on the property damage business

The impact of the increased frequency and intensity of extreme weather events on the property damage business of insurers was assessed with the support of the Caisse Centrale de Réassurance (the public French reinsurer). The latter has carried out, for those organisations that so wished, an estimation of the damage suffered over the period 2020-2050 for all the perils covered by the natural disasters compensation scheme in France (droughts, floods, coastal floods and cyclones for the ultra-marine territories). These projections are based on those made by Météo-France at a very granular²⁶ level. Participants could also opt for their own loss projection models using the IPCC RCP 8.5 scenario, especially for the assessment of the physical risk outside French territory, using the weather projections made available by the NGFS.

²⁵ In order to take account of the indirect effects of these scenarios on banks, a second-round effects analysis has been included (see p. 46 and Annex C for a presentation of assumptions).

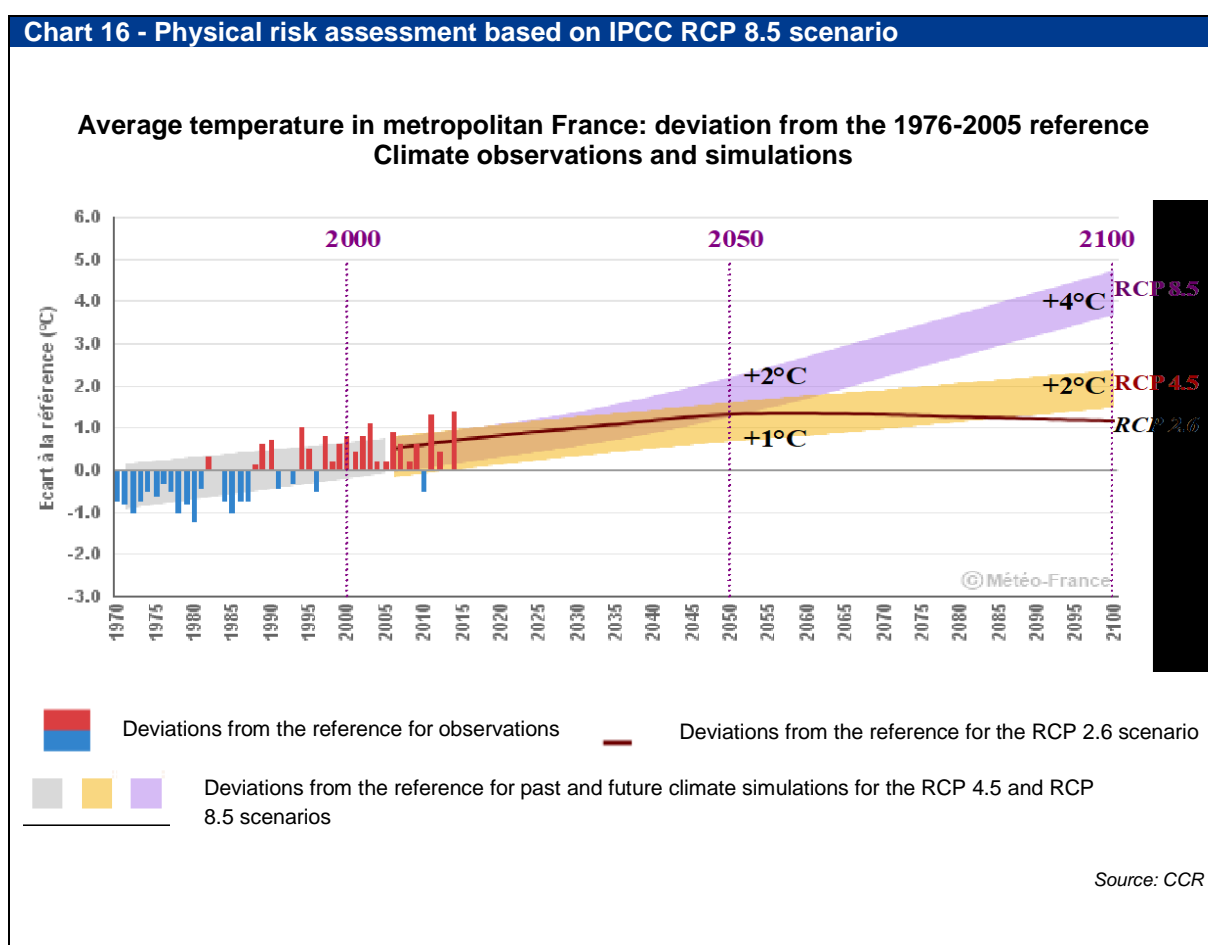
²⁶CCR (2018): Consequences of climate change on the cost of natural disasters in France by 2050

1.3 Health scenarios: the spread of vector-borne diseases or pandemics and the impact of urban pollution

Climate change and environmental degradation also have observable effects on the development of exotic diseases or chronic conditions related to heat exposure or increased levels of particulate matter in the air, and could therefore affect the health of the inhabitants of a given region.

The two health scenarios are based on assumptions regarding changes in mortality tables and health costs by geographical area and age of the population²⁷ provided by AON

(see Drif, Roche and Valade²⁸ and Drif, Messina and Valade²⁹) based on the temperature trajectories included in the scenario RCP 8.5. The aim was for insurers to assess the impact of the spread of these vector-borne diseases or pandemics and the increase in urban pollution on health claims, due to increased deaths, healthcare costs and work stoppages linked with climate change, for example due to an increase in the frequency and duration of heatwaves.



Because their role is to protect firms and households from the effects of adverse events, insurers face the risk of an increase in the

number of claims to be covered in the coming decades. This would be particularly relevant for property damage activities covering the

²⁷ This information is detailed in the technical documentation provided to undertakings prior to the exercise: https://acpr.banque-france.fr/sites/default/files/medias/documents/20200717_main_assumptions_and_scenarios_of_the_acpr_climate_pilot_exercise.pdf

²⁸ Effects of climate change on vector-borne diseases and personal insurance impact (2020).

²⁹ Effects of climate change on air pollution and impact on the insurance of persons (2020).

deterioration of real estate or motor property during extreme weather events and for health insurance, as pollution and rising temperatures lead to the development of diseases and pathologies. Insurance contracts including this type of cover are usually concluded for one year: insurers therefore have the possibility to adjust their pricing annually in order to integrate

2. Perils natural disasters (CATNAT)

The impact of the increased frequency and intensity of natural disasters on the property-damage activities of insurers was assessed with the assistance of the Caisse Centrale de Réassurance, which provided participants with the increase in claims per French department based on their exposures to various climate risks considered at a city level. From 2025 onwards, participants were given the opportunity to review their underwriting policy in view of the evolution of the loss ratio: by considering a geographical reallocation of their portfolio; by increasing premiums to compensate for the rising cost of claims; by revising their reinsurance programmes; or, finally, by adapting the products offered to reduce the risks borne by policyholders.

In their simulation, participants mainly chose to maintain their claims to premiums ratio throughout the projection. As a result, premiums increase by between 130% and 200% over 30 years depending on the category, i.e. an increase in insurance premiums comprised between 2.8% and 3.7% per year. Such an increase exceeds GDP growth by around 170 percentage points over the 30-year period covered by the exercise for certain specific insurance classes.

In particular, in the French territory as a whole, the claims of the insurance classes included in the calculation of the contribution to the natural disasters compensation scheme increased by 174% between 2019 and 2050. This increase also takes into account the assumption of an increase from 12% to 18% in the cost of funding CATNAT, the French state reinsurance system.

the increasing cost of claims into the premiums. However, such a strategy may not be sustainable in the long term, if the premiums charged to cover a given risk become prohibitive in relation to the amount to be insured. One of the objectives of the exercise was to make insurers aware of this insurability limit.

Given the choice made by participants in the exercise to keep their loss ratios constant over time, gross premiums increase by 172%—a steeper rise than GDP, which increases by only 33% over the same period.

Further assumptions on the behaviour of policyholders would therefore be required to assess the sustainability of such an increase in premiums and to be able to analyse more precisely the materialisation of an insurance protection gap. Furthermore, insurers have not taken advantage of the possibility of amending their underwriting strategy, in particular by reallocating their portfolio, in order to get out of the geographical areas most affected by an increase in claims or by refusing to insure the areas most exposed to climate change.

Chart 17 shows, for each French department, the per capita claims in 2019 and the evolution of loss ratios, expressed in percentage, for the perils modelled in the exercise, each of which is consistent with the IPCC RCP 8.5 scenario. The change in the claims expresses a combination of the following risks: an increase in the frequency and intensity of natural disasters such as droughts, floods, coastal floods and tropical storms for ultra-marine territories. The estimation of the claims depends on the concentration of the population and economic activities based on INSEE demographic projections for 2050 and taking into account the increase in the size of the population.

Thus, in the framework of the assumptions of this exercise, in addition to the effect of the

increase in insured amounts, the geographical distribution of the population and economic activities shows strong regional disparities. In the charts presented below, the amount of claims is compared to the number of inhabitants per department.

This representation sheds important light on the forecasting of physical risk. For some perils, such as drought (see Chart 18), a catch-up

effect is observed: the departments in which claims increase the most in the scenarios (dark red) are often those in which the amounts of claims are currently the lowest (low superimposed number). The departments in which large cities are located are therefore not affected more severely than the rest of metropolitan France, despite the high overall value of insured assets.

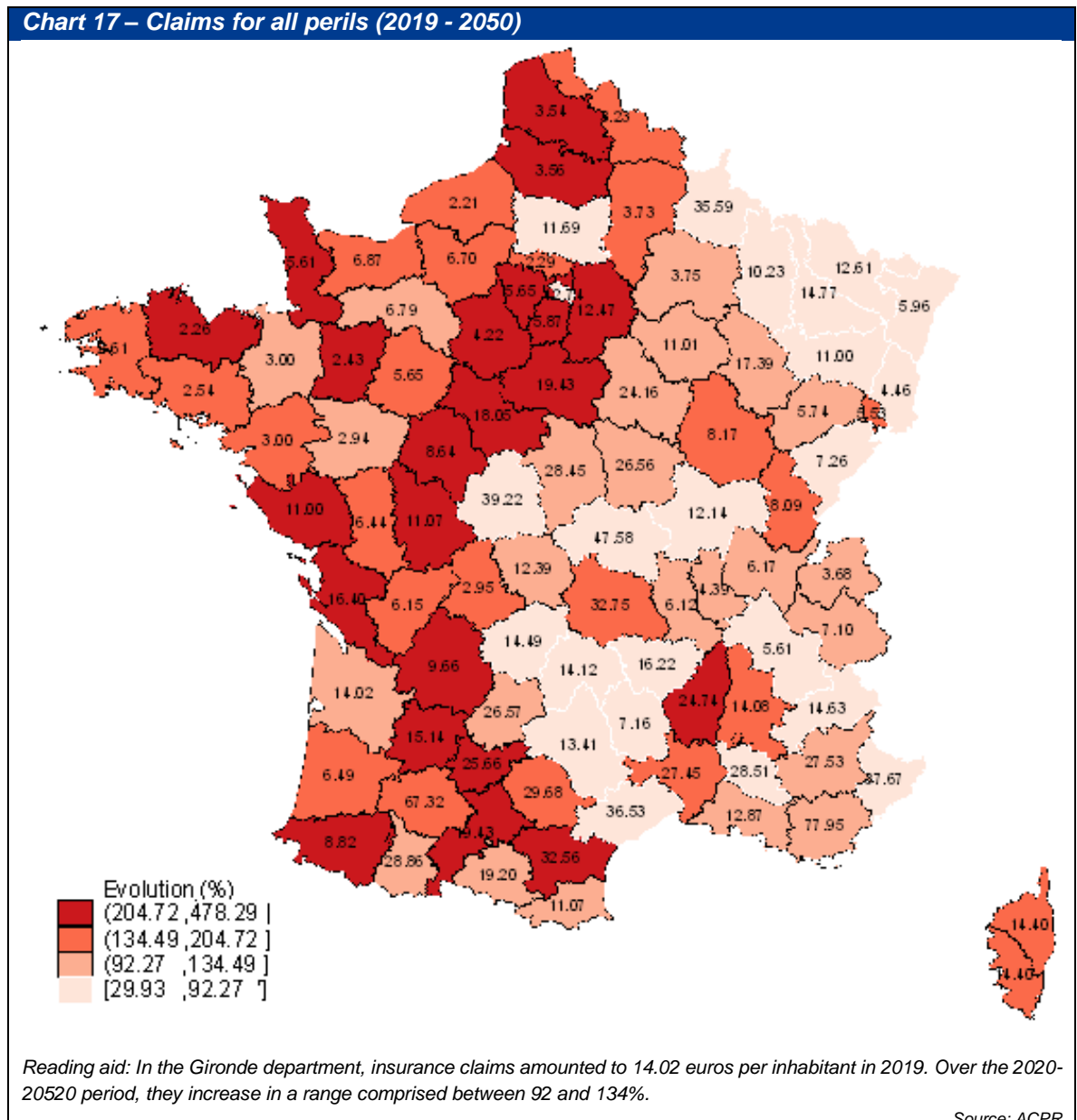
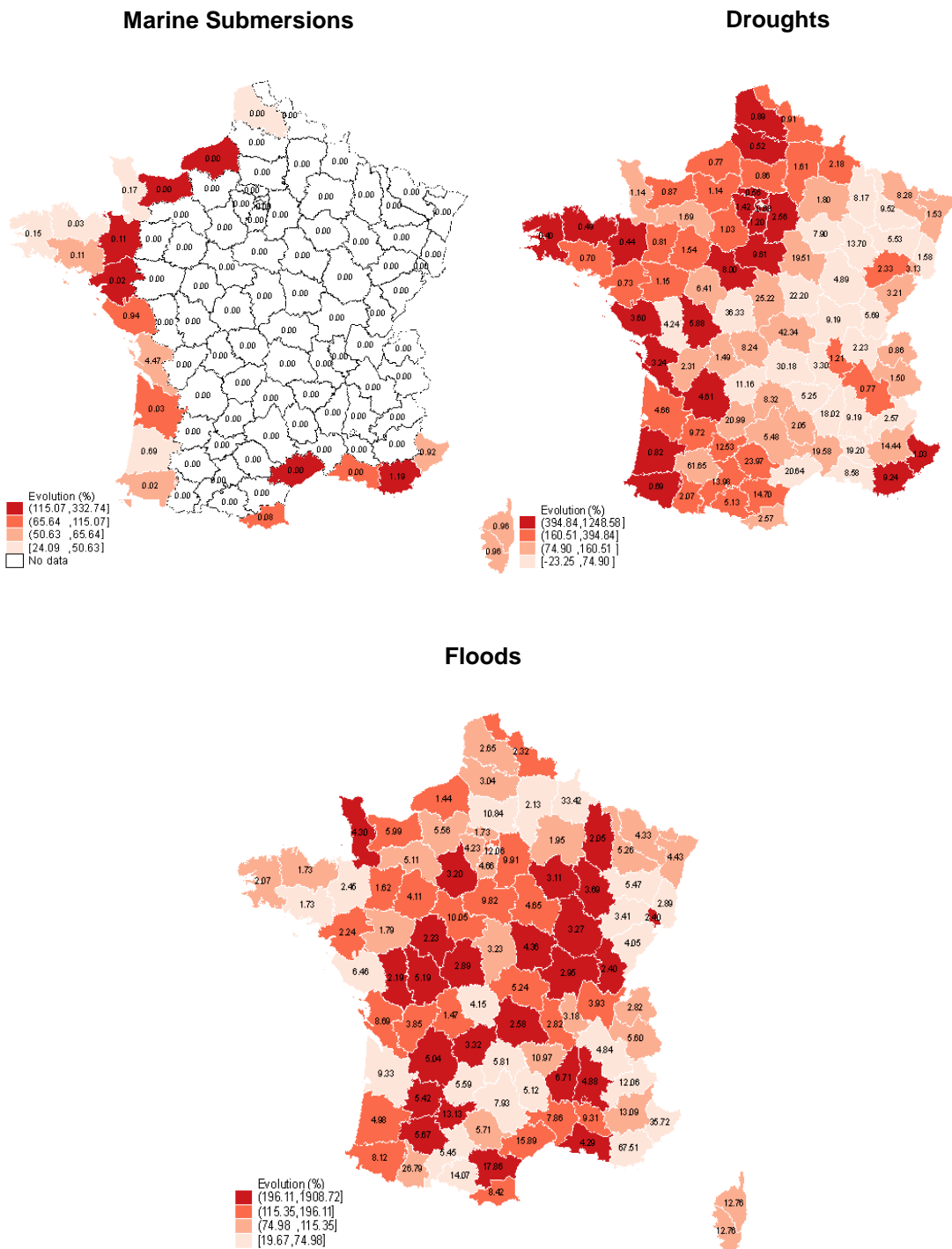


Chart 18 – Claims for marine submersion (coastal floods), droughts and floods (2019-2050)



Source: ACPR

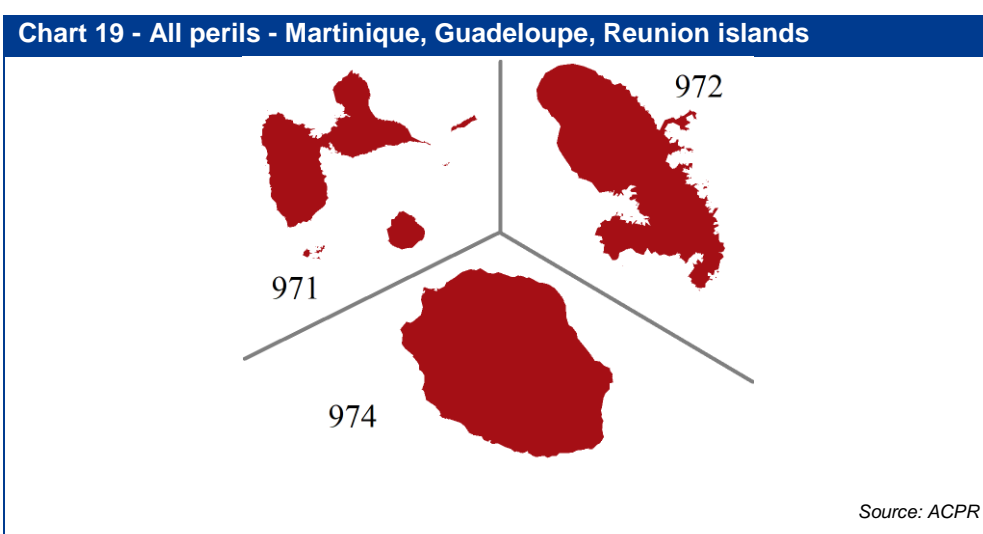
The peril for which the dual dimension of demographic intensity/intensity of the impact of the climate-related phenomenon is best illustrated is certainly coastal floods. The Alpes-Maritimes department- a densely built-up and

highly populated area- appears to be the only one with both a high initial level of losses and a significant evolution over time. The evolution of the claims by 2050 is mainly due to the rising sea level. Topography is therefore the main

factor that explains this development, with many low-lying areas in the Mediterranean regions, which are not particularly exposed at present, but which will be more so in 2050.

Finally, an increase in cyclonic storms was modelled solely for the French overseas departments (DOM), as this is the only part of the country where a causal link can be established with global warming. The results received were very heterogeneous depending on the modelling technique used by insurers:

the evolution of the cost of claims ranged from 20% over the period to more than 1000% when few events were recorded during the reference year. On average, the projected claims for Martinique, Guadeloupe and Reunion islands (see Chart 19) exceed the 'all perils' average for mainland France. Consequently, exposure in these regions may be high risk for some insurers depending on the breakdown of their non-life business.



3. Health hazards

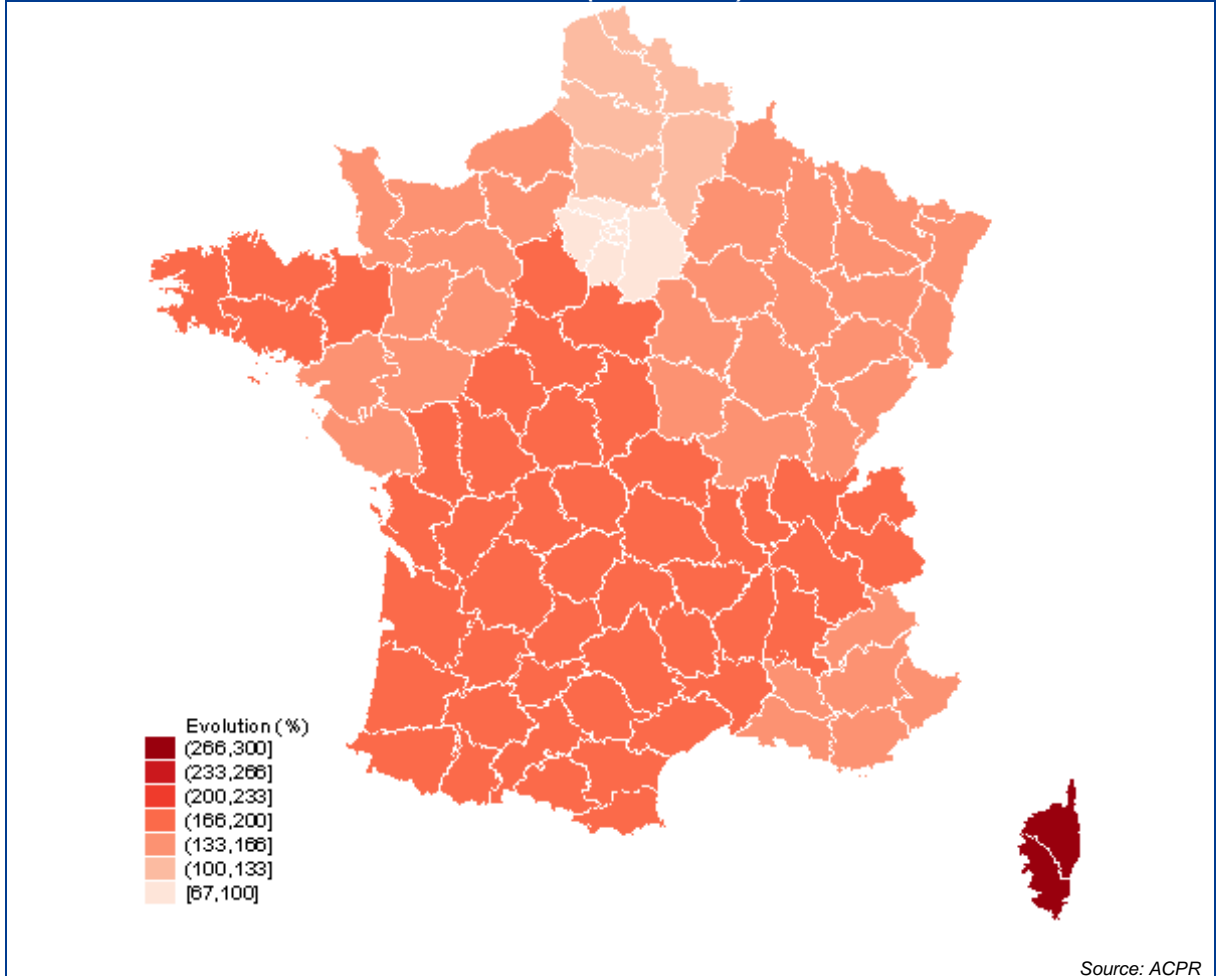
3.1 Vector-borne diseases / pandemics

Beyond its impact on the frequency and intensity of extreme weather events, climate change may have consequences for human health, through an increased spread of mosquito-borne viruses and the effects of air pollution. The work of Drif, Roche and Valade³⁰ quantifies the consequences of global warming on the risk of epidemics involving viruses

transmitted by the *Aedes Albopictus* mosquito in mainland France. This mosquito, which carries, among other diseases, those responsible for the Dengue fever, Chikungunya and Zika, arrived in mainland France in 2004 and is now present throughout the country. Its spread is boosted by global warming.

³⁰ Consequences of climate change for vector-borne diseases and impact on life and health insurance (2020)

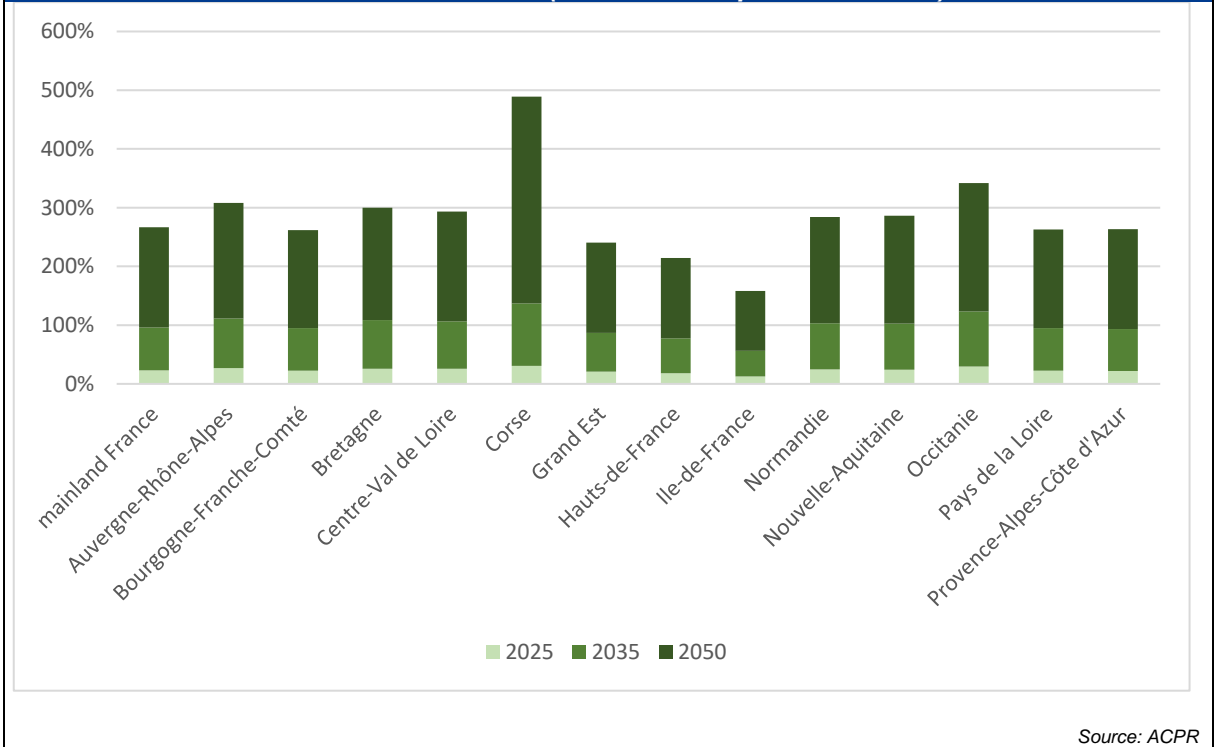
Chart 20 – Claims for vector-borne diseases (2019 - 2050)



The observed loss ratio would increase sharply in the southern regions, in Brittany and in Corsica. These trends are directly linked to the evolution of the average rate of infected people per region in mainland France between 2019 and 2050.

The increase in average temperature and the resulting impact on the breeding of mosquitoes, which are disease carriers, lead to an increase in costs related to healthcare and work stoppages in these regions.

Chart 21 – Vector-borne diseases: claims (evolution compared with 2019)

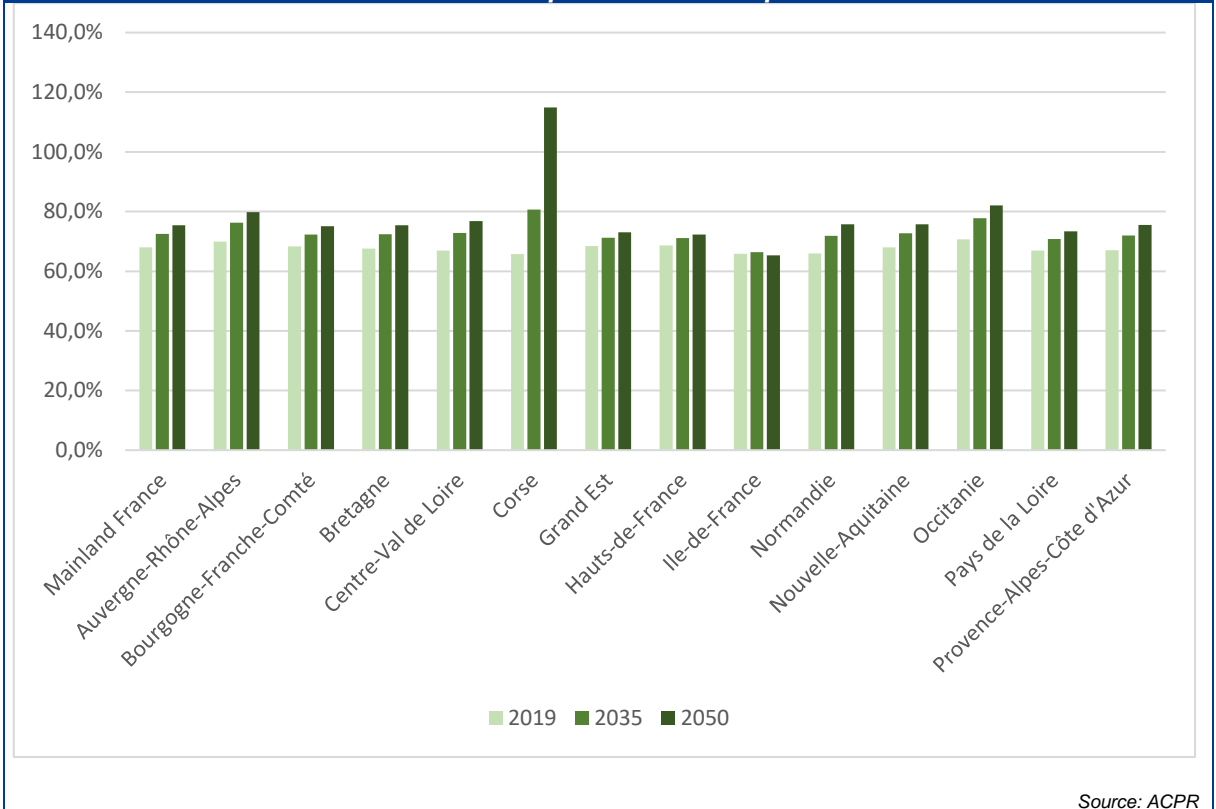


Source: ACPR

The number of claims caused by vector-borne diseases varies greatly from one region to another. The evolution of the loss ratio seems to be lower in the Île-de-France region. This trend can be explained by a high loss ratio in 2019 compared to the other regions of France. This would result in a decrease in the loss ratio over the whole period for this region, while it increases everywhere else in France. Conversely, loss ratios would increase sharply in Corsica, by 352% between 2019 and 2050,

while premiums would only increase by 159% between 2019 and 2050, resulting in a sharp deterioration in the claims to premiums ratio. However, in terms of amounts, Corsica remains the region with the lowest claims ratio in metropolitan France between 2019 and 2050.

Chart 22 – Vector-borne diseases: claims/premiums ratio up to 2050

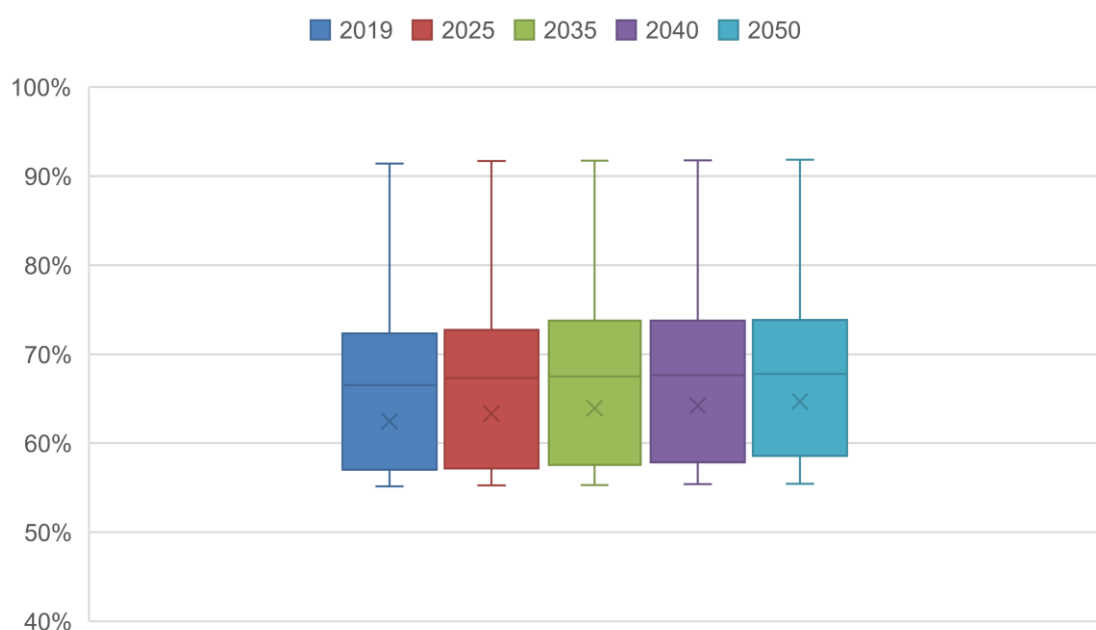


Source: ACPR

Contrary to the strategy adopted by insurers in natural disaster insurance classes, some participants in the pilot exercise did not transfer the totality of the increase in claims to the amount of premiums to be paid by the insured. The result is a slight deterioration in the claims/premiums ratio, on average, and a

tightening of intra-market distribution over the time horizon of the exercise.

Chart 23 – Vector-borne diseases: evolution of the claims/premiums ratio



Note: the claims/premiums ratio measures the ability of non-life insurers to cover claims paid over a given period with premiums collected over the same period.

Reading aid: In 2050, the median claims/premiums ratio of the sample is 68%, the average being 65%. The minimum ratio is 55% and the maximum one is 92%. The claims/premiums ratio of the first quartile is 59% and that of the 3rd quartile is 74%.

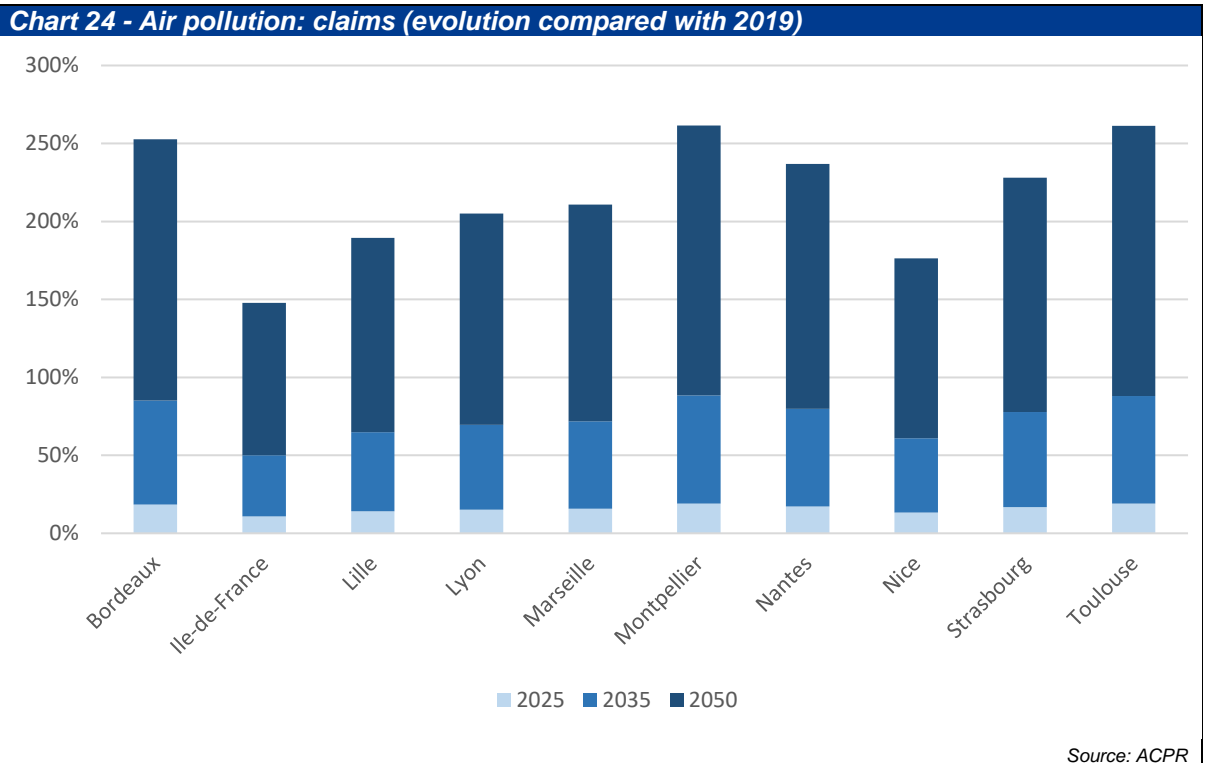
Source: ACPR

3.2 Air pollution

The work of Drif, Roche and Valade³¹ quantifies the effects of the change in air quality caused by the sharp increase in pollutant emissions, combined with the change in weather conditions, especially the rising temperature. Air pollution has a direct impact on health, leading to respiratory and cardiovascular diseases, cancers, and premature deaths. The scenarios developed in the exercise quantify the

consequences of an increase in temperatures on air pollution and its impact on death benefits, healthcare benefits, and benefits in the event of work stoppage. The consequences are most visible in major metropolitan areas, and the exercise also draws on assumptions about migration flows between French regions, again relying on INSEE projections for 2050.

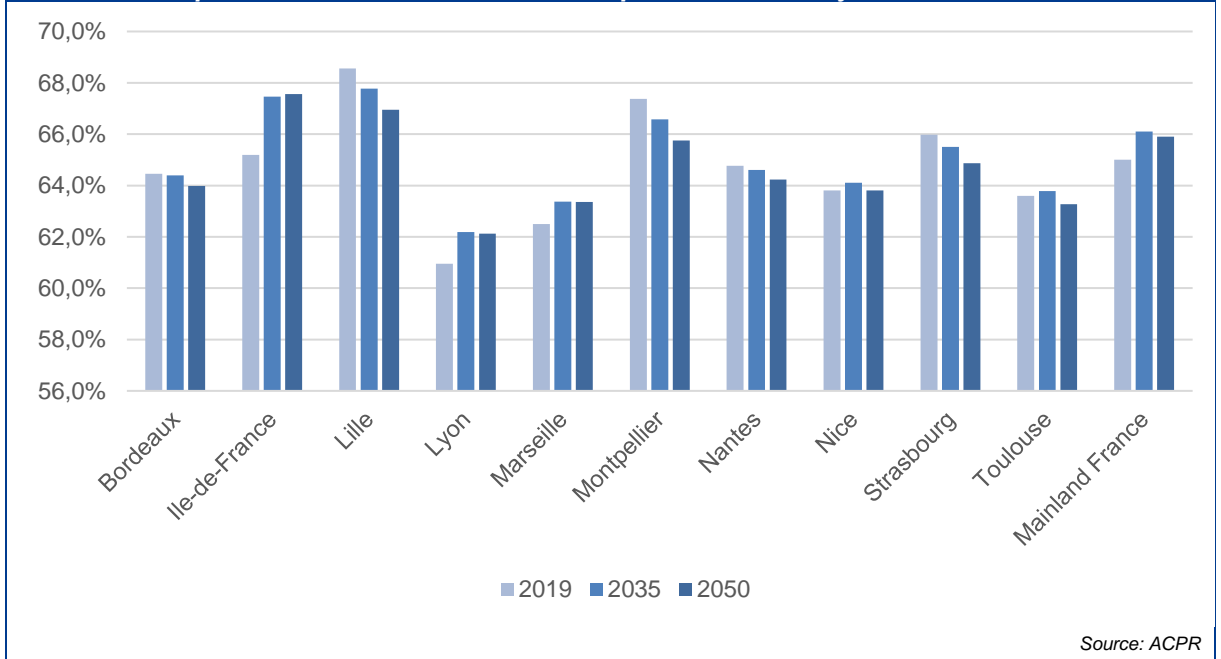
³¹ Effects of climate change on air pollution and impact on the insurance of persons (2020).



Claims associated with these risks would increase by 119% between 2019 and 2050 in metropolitan France, with an especially sharp increase in the cities of Bordeaux, Montpellier and Toulouse. For these three cities, this phenomenon can be explained by an increase in the number of contracts by more than 20% between 2019 and 2050.

The impact of the evolution of air pollution in the Île-de-France region between 2019 and 2050 was the least pronounced (see Chart 16): the number of claims over the same period would double, while the claims ratio in other cities would triple. It should be noted, however, that the Île-de-France region recorded 100 times more claims in 2019, on average.

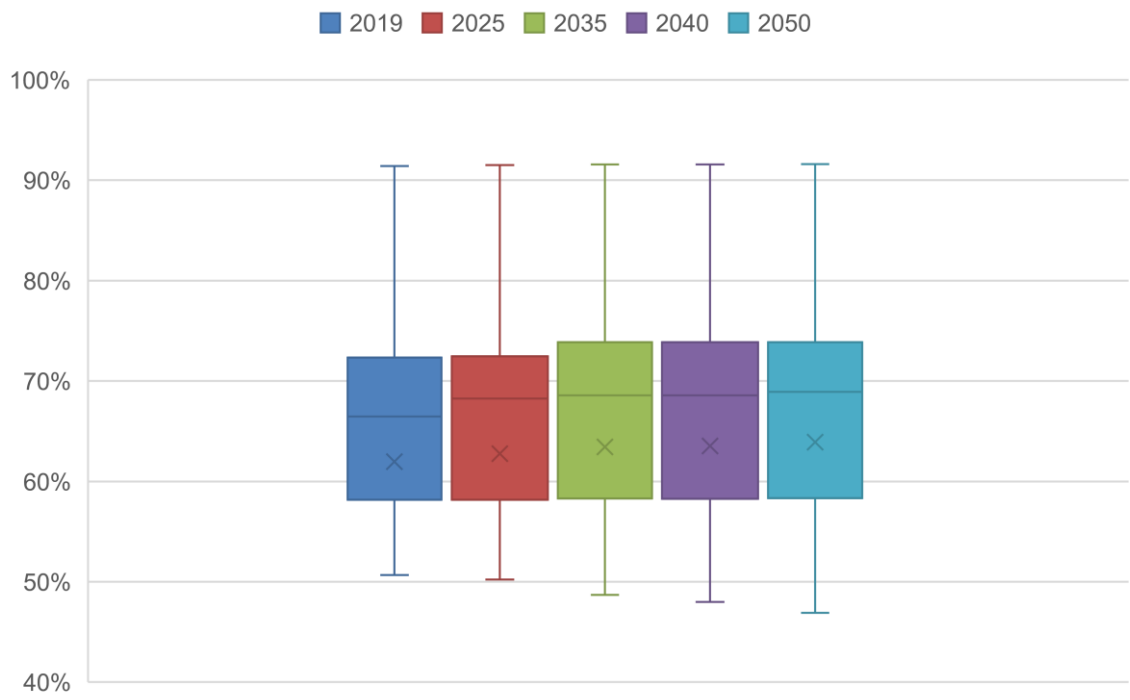
Chart 25 - Air pollution: evolution of the claims/premiums ratio by 2050



Premiums are projected to increase less rapidly than claims in the Île-de-France region, in Lyon, Marseille and Nice between 2019 and 2050, which explains an increase in the claims/premiums ratio compared to the previous period. For example, premiums in the Île-de-France region are projected to increase by 91% between 2019 and 2050, while the claims are projected to rise by 98%. By contrast, in most major French cities, the claims/premiums ratio is projected to decrease. This decrease, a sign of better profitability for insurers, cannot be explained by the demographic assumptions underlying the

scenarios. In most of these cities, the amount of claims to be paid per contract increases significantly, more than the average 110% increase observed on the whole territory. Insurers have not commented on their pricing strategy for this line of business, but they appear to have chosen to make policyholders bear cost of the increase in claims, as some geographical diversification is maintained in the portfolios. As a result, an increase in the dispersion of results is observed between 2019 and 2050.

Chart 26 - Air pollution: evolution of claims/premiums ratio



Source: ACPR

4. The effects of reinsurance

Insurers have various tools at their disposal to mitigate the impact of adverse events on their earnings. In particular, reinsurance makes it possible to cover excessive claims for a given event (natural disasters, increased mortality, etc.). By giving reinsurers part of the premiums they received, the insurer also transfers part of the insured risks.

Insurers have not explicitly mentioned any substantial changes to reinsurance programmes as a result of the increase in the claims due to climate change. The gradual decrease in the share of ceded premiums therefore appears to be mainly driven by the insurers' assumption that the claims/premiums ratio will remain stable over time (see Charts 27 and 28).

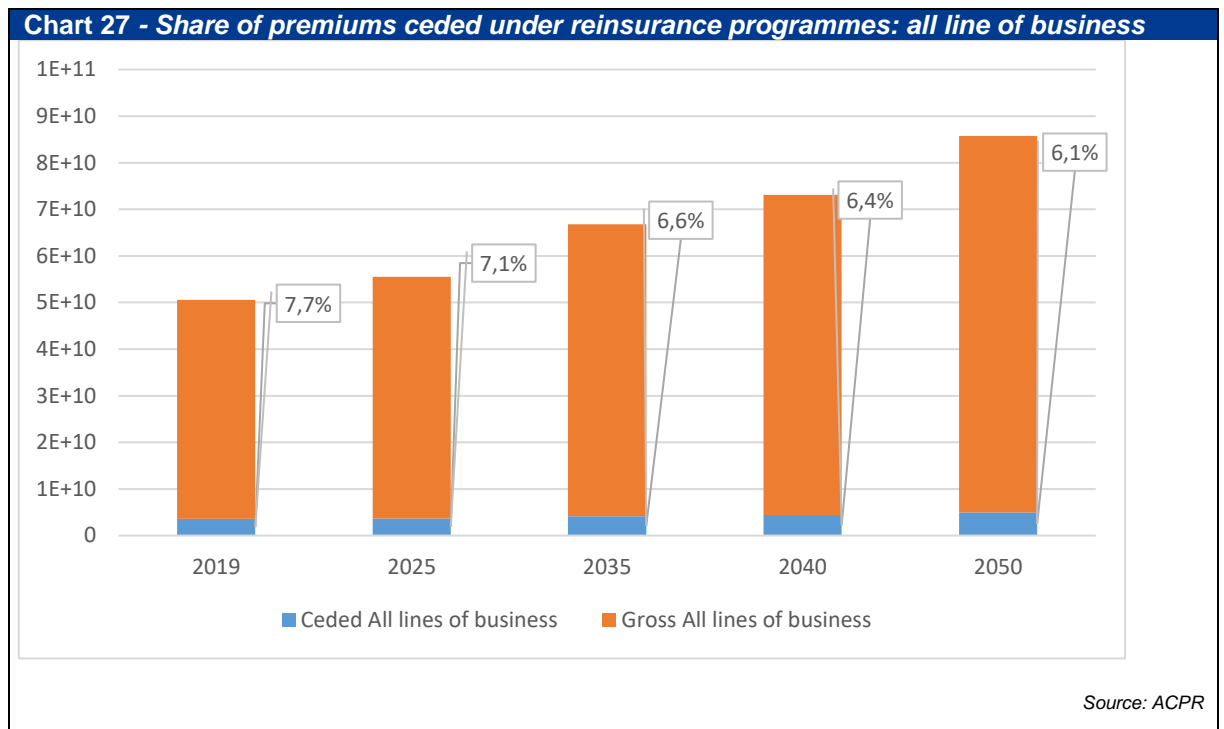
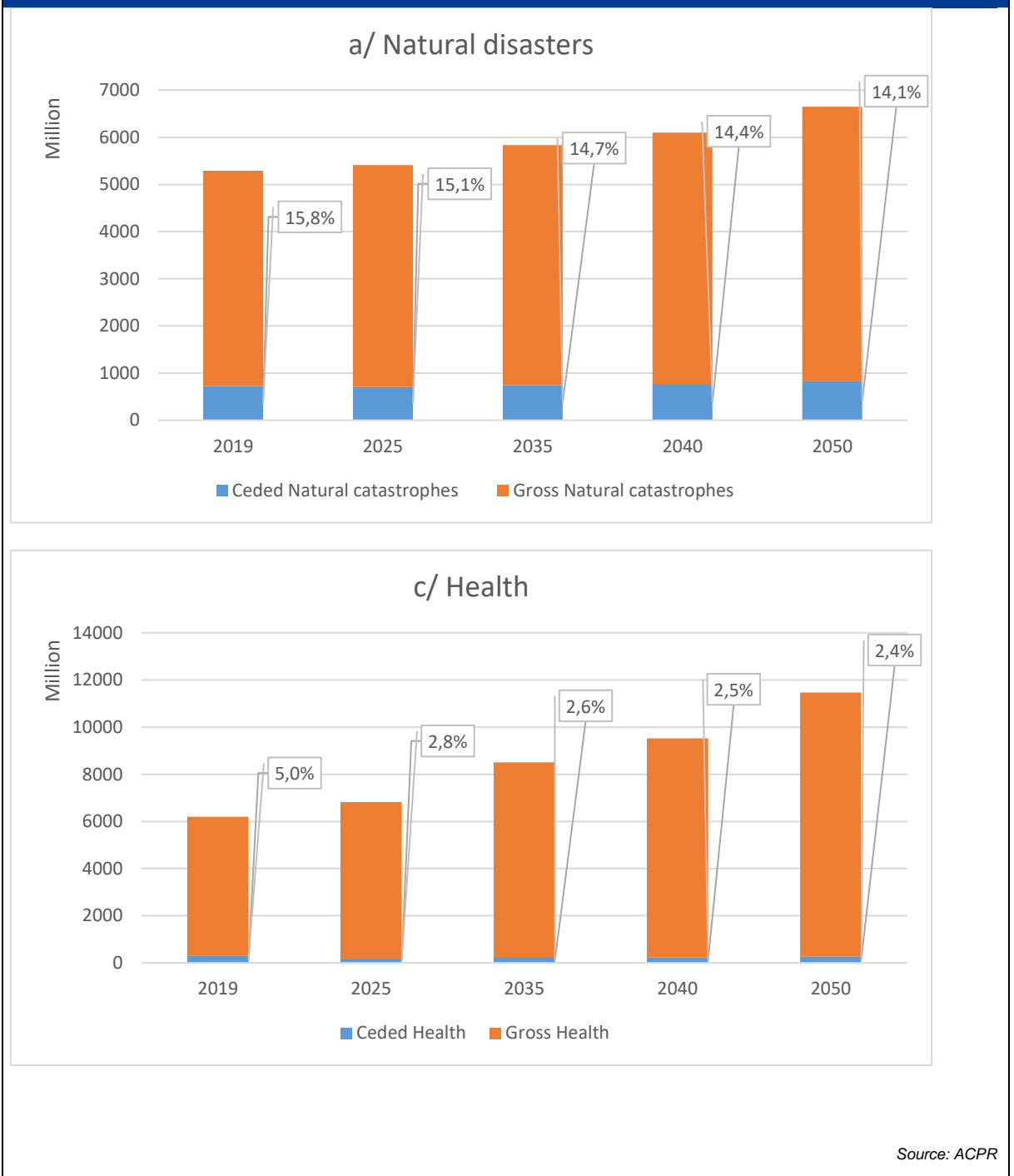


Chart 28 - Share of premiums ceded under reinsurance programmes, broken down by business lines impacted by scenarios of the pilot exercise



5. Consideration of the indirect (second-round) effects of physical risk on the banking sector

In the work published by the ACPR in April 2019 on banks' consideration of the risks associated

with climate change, banks did not consider that, beyond the operational risk relating to their own facilities, they were particularly concerned by physical risk, as the latter is handled by insurers. In order to raise awareness of this risk in the banking sector, a plan was made to apply the insurers' reaction function to changes in premiums and coverage policies to banks'

credit risk parameters, in particular loss given default and probability of default. The measurement of this second-round effect targeted two types of exposures in particular: those that are financed or guaranteed by immovable properties (corporate and retail portfolio) and those that are directly related to the corporate portfolio.

The analysis consisted of two steps: (i) institutions were asked to identify, within the abovementioned portfolios, the proportion of exposures at risk due to of their geographical location of the immovable property or the business activities and value chain of a company; (ii) it was then requested of them to indicate orders of magnitude for the impact of both the physical risk scenario and changes in insurance coverage on credit risk parameters. On this second point, institutions were asked to consider, on the basis of available data on the evolution of claims worldwide and of the elements provided by the ACPR, the following transmission mechanisms:

- **Portfolios secured by immovable properties (retail and corporate).** The impact of a higher probability of occurrence of extreme weather events such as marine submersion, floods and droughts -which could affect the value of real estate, for example due to the expansion of clay soils- on credit risk, materialising as the depreciation of a given secured property located in risk areas and therefore as a possible increase in loss given default (LGD). For households, this effect is coupled with a possible increase in the probability of default (and LGD) in the event of restrictions applied to the insurance coverage of households.
- **Corporate portfolio (vulnerable sectors).** In addition to the transmission channels described above, institutions were asked to take into account the impact of such events for businesses (business disruption, crop losses, supply chain disruptions, etc.), which

could lead to a lower turnover and to a decrease in value added for counterparties at risk, which could result in an increase in the probability of default.

Due to timing constraints and the late delivery of assumptions, banks were not able to initiate specific work on these issues³². Banks were therefore asked to provide a description of the state of progress in their internal work on physical risk. Only two institutions (a commercial bank and a public institution) were able to provide an exhaustive template on the basis of *ad hoc* assumptions established by the ACPR. These assumptions are presented in Annex C, as the answers provided by the insurers did not allow for the quantification of risks related to the uninsurable nature of certain exposures.

A first challenge, identified as early as the first stage, consists in identifying exposures sensitive to physical risk with different implications depending on the type of portfolio. In the case of immovable properties, whether as collateral or financed, institutions have at their disposal information such as the address of the property, or at least the address of the client linked to that property. However, such information is not systematically centralised and/or matched with the risk management information systems at the consolidated level, which limits the ability of institutions to perform this type of analysis at the portfolio level with sufficient granularity, without first launching a major data collection exercise within the group's entities. In most cases, the institutions have launched projects aimed at systematising the reporting of information in order to assess the risks associated with climate change, using a component based on the location of funded assets. Recurrent physical risk analyses continue to be performed at country-level and are occasionally accompanied by studies on very localised segments aimed at improving our understanding of the criteria used for the

³² Moreover, the development of the methodology for the analysis of the physical risk was not the subject of a joint reflection with the industry, as was the case for the transition risk.

assessment of the physical³³ risk. For instance, it should be noted that in France housing loans are often guaranteed by specialized financial institutions (“*organismes de caution*”). The final impact of physical risks on credit risk will accordingly depend on the impact on these guarantors.

With regard to the corporate portfolio, the limits encountered concern the availability of information on the location of the production sites of businesses and their value chain. The identification of the geographical location of the counterparty’s head office constitutes an achievable but insufficient approximation. Besides the data issue, the analysis is complex to implement and requires significant resources to analyse even a sample of counterparties representative of the corporate portfolio. As a result, some institutions have initiated work on specific sectors or portfolios, aided by third parties specialising in physical risk assessment to speed up the work.

The second stage, which concerns the assessment of the impact in terms of credit risk, is therefore constrained by the limited availability of the data needed to differentiate risks within portfolios, particularly in the corporate portfolio (excluding SMEs). Nonetheless, banks have undertaken significant work in this area, mainly *ad hoc* work (at a local level) on very localised portfolio segments or for specific risks (e.g. coastal floods). The objective is to gain a better understanding of how physical risk is transmitted to credit risk and to define the key criteria for modelling, for example, the impact of natural disasters on credit risk. Thus, studies aimed at reconciling the evolution of defaulted loans (retail and business- VSEs/SMEs) and the occurrence of past natural disasters are first steps in this direction. In the end, this second-round exercise points to the need for institutions as well as supervisors to carry this work forward.

³³ For example, one institution points out that the analysis of flood risk at the level of the address of a financed property is imperfect as this information has to be cross-checked with data on altimetry, etc. Accordingly, ACPR requests on the identification of exposures at risk at a department level was not granular enough.



Methodological lessons from an exercise with unprecedented characteristics

The pilot exercise provides insightful lessons but also raises a number of methodological issues on which additional work will be carried out in the coming quarters. This work will enrich discussions within financial institutions as well as among European and international supervisors. Three main areas of development were identified concerning: i) the design of long-term scenarios and the identification of vulnerable sectors; ii) consideration of the physical risk; and iii) improvements to the models used by the participants and the issue of the data needed to carry out this type of exercise.

1. Assumptions used in scenario building and identification of sensitive sectors

The challenges associated with a long-term horizon

The first difficulty encountered by financial institutions relates to the time horizon of the exercise. The covered time span, 30 years, exceeds by far the usual horizon over which institutions conduct their stress tests, whether those implemented by supervisors or their own risk assessment testing (usually over 3 to 5 years). The scenarios provided in the framework of the pilot exercise take the form of a set of macroeconomic and financial variables projected over the long term, in five-year intervals. These scenarios reflect long-term trends. However, the models used by banks to quantify risks are not adapted to incorporate smoothed trends in macroeconomic and

financial variables over a long period. The same applies to non-life insurance companies, which are used to dealing with extreme climate shocks but not with the smoothed-out deterministic effects over a long period of time which are typical of chronic physical risk.

The very long time horizon also implies costly work in projecting credit risk parameters. This cost is multiplied by the number of sectors considered in the analysis, the number of scenarios and the number of geographical areas to be covered.

The second difficulty encountered by the institutions that participated in the exercise was the low variability between the different scenarios provided by the ACPR. This issue had already been identified by the ACPR, which led the authority to add a sudden transition scenario to the scenarios published by the NGFS in order to increase the level of macroeconomic and financial stress. However, the nature of this exercise differs from traditional stress-testing practices. The objective here was not to ensure that financial institutions are sufficiently capitalised in the event of an extreme but plausible shock, but rather to make those institutions aware of the risks induced by climate change and their transmission channels. Hence, unlike the stress tests conducted by the European Banking Agency, which require scenarios based on three consecutive years of GDP contraction, the pilot exercise is based on a set of plausible transition scenarios, none of which induce an economic recession.

Finally, another innovative aspect of the exercise was the implementation of the dynamic balance sheet assumption. The latter provides very interesting results and information on the strategies of financial institutions. However, the building of the transition scenarios, whether orderly or not, results in achieving the carbon neutrality target by 2050, except in the case of the scenario underlying the physical risk analysis. In this context, the absence of feedback effects between the management decisions of financial institutions and the dynamics of the economy, including the evolution of sectoral structures, does not necessarily encourage them to implement an active risk reduction policy despite the dynamic balance sheet assumption.

Identification of sensitive sectors

A second challenge associated with this type of exercise is the identification of sectors that are sensitive or exposed to climate risk: identification is firstly contingent on the method used. It then requires assumptions on the evolution of the energy mix, the intensity and the energy efficiency of production, which have not been satisfactorily integrated into this exercise. Finally, there is the matter of sectoral granularity and the incorporation of exposures or counterparties into a given nomenclature or taxonomy. Some supervisors identify these sectors solely on the basis of their greenhouse gas (GHG) emissions. In the pilot exercise, the choice was made to take into account the financial risk associated with the implementation of transition policies in the form of a carbon tax. The analytical framework underlying the production of the scenarios is based, in its sectoral part, on input-output matrices which make it possible to take account of sectoral interactions. Thus, even though its direct GHG emissions are limited, the manufacture of coke and refined petroleum products sector is the most affected, its value added being about 58% lower in 2050 in the abrupt transition scenario than in the baseline scenario. This sectors is particularly impacted due to the fact that its production emits large

quantities of GHG. Indeed, the consumption of oil and coke is highly taxed, prompting players to invest in cleaner energy sources and to reduce their demand significantly. As a result, oil production in France in 2050 fell by 47% compared to the baseline scenario in the delayed transition scenario and by nearly 60% in the transition scenario. This demand effect is also transmitted to the French mining sector, with value added dropping by 25% in the case of a sudden transition. Similarly, sectors upstream of the production network also tend to be more impacted. Hence, these methodological choices are not neutral in terms of scenario narrative and impact assessment.

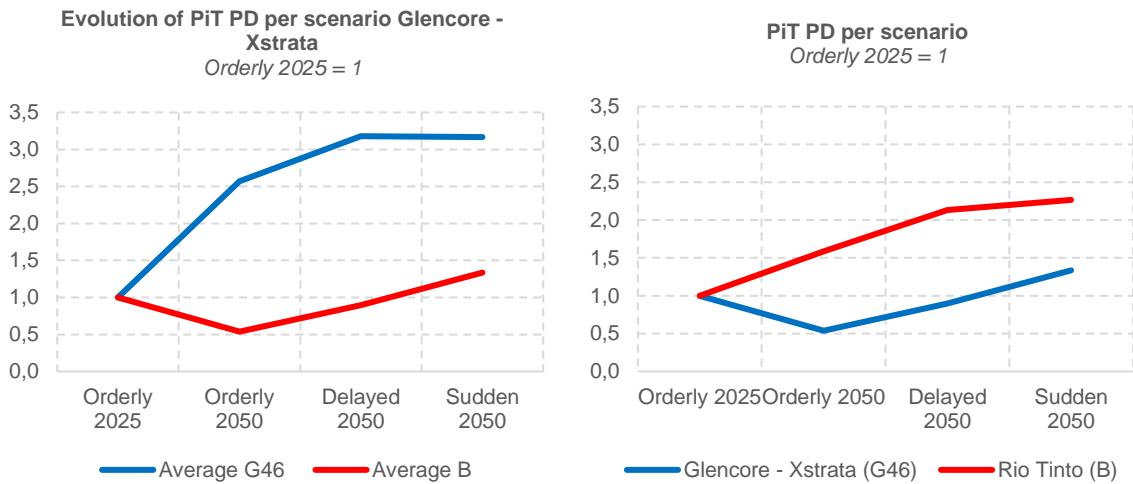
The limits of the NACE code segmentation

One of the features of the pilot exercise was asking institutions to analyse credit risk by disaggregating the impacts by economic activity applying the statistical classification of economic activities in the European Community, NACE rev2 level. The institutions had to start by allocating each counterparty to one of the various NACE codes. The corporate exposures (often VSEs / SMEs) that were not allocated usually represented a relatively small share of the corporate portfolio (15.2% of the portfolio for all the participating banks). The institutions were therefore able to allocate the vast majority of their corporate exposures to economic activity sectors, usually because they already have this information available in their information systems or because they had an internal sectoral classification system that was compatible with NACE codes. In the case of multiple-activity companies, however, this sectoral allocation process may have posed difficulties³⁴. Indeed, a company in which part of its economic activity is little exposed to transition risk but of which another part is more vulnerable so can be assigned to one or other of these NACE sectors, with the risk of underestimating exposure to transition risk (see box below). Though it is difficult to assess the extent of this issue, further work will be needed to standardise the process by which establishments categorise exposures.

³⁴ Each counterparty had to be allocated in full to a single NACE code in the exercise.

Box 3 - Case study: Glencore - Xstrata

A practical example encountered during the pilot exercise helps to illustrate this issue. Originally a trading company, Glencore merged with Xstrata to become a major mining company³⁵. As a trading company, Glencore Xstrata can be allocated to the 'wholesale trade' sector (G46), but the scale of its extraction activity can also justify its allocation to the mining and quarrying sector (sector B). Thus, out of the five institutions that submitted data on Glencore Xstrata, three allocated the company to sector B and two allocated it to sector G46, the latter being much less impacted in the various scenarios of the pilot exercise. When the company was allocated to the 'wholesale' sector, the associated probability of default remained close to its 2025 level (before the increase in the price of carbon) over the entire period considered. Conversely, for institutions that categorised this company as belonging to sector B, a sharp increase can be observed in the probability of default over the 2025-2050 period. This observation was the result of the approaches retained by banks to project parameters as the same banks that allocated the company into the G46 economic activity projected very different PD paths for the sector B.



Note: The evolution of the probability of default (PD PiT stands for for point in time Probability of default) compared to 2025 in the orderly transition scenario is presented as a ratio relative to the starting point. On the left-hand side, the graph represents the average default probability for institutions assigning Glencore - Xstrata to NACE code B and institutions assigning the same company into the NACE code G46. On the right-hand side, the chart focuses on the institutions assigning Glencore Xstrata into the NACE code G46 and compares the evolution of the PD PiT with another company assigned in the NACE code B.

Another identified methodological limitation stems from the fact that the breakdown of sectoral impacts using NACE at 2-digit level codes does not allow for account to be taken of the heterogeneity of exposures to the transition risk among companies within the same economic sector. Indeed, companies with varying degrees of exposure to the transition risk can be found in the same sector. For

example, the value added of the “electricity and gas” sector is growing significantly in the scenarios of the pilot exercise, and institutions project slightly increasing probabilities of default for this sector in the three transition scenarios. However, when considering four companies that are assigned to this specific NACE code (Enel, EDF, Engie, and RWE), companies that use very different technologies and therefore

³⁵ According to the Global Coal Exit List, more than 20% of Glencore - Xstrata's revenues are derived from the coal mining business

have, at first glance, very different transition risk exposures themselves. The same dynamics regarding probabilities of default can be seen in Table 2 below, although in the case of RWE, for example, about 30% of its electricity production is generated by coal³⁶. This example confirms

the need for a more granular approach for key transition sectors. Another example commonly presented to illustrate this heterogeneity is that of the automotive industry, which includes companies that are more or less advanced in the development of electric transport.

Table 2: PiT PD evolution per Electricity and Gas sector (D35) counterparty
Normalized at 1 in 2025

Counterparty	Disorderly			
	Orderly 2025	2050	Delayed 2050	Sudden 2050
Engie	1.0	1.4	1.4	1.4
EDF	1.0	1.5	1.5	1.5
ENEL	1.0	1.3	1.2	1.2
RWE	1.0	1.9	1.8	1.8

The impact of financial assumptions on insurers' and banks' results

The pilot exercise reveals an overall "moderate" exposure of French banks and insurance companies to the risks associated with climate change. For the insurance sector, and in a regulatory framework such as Solvency 2, the valuation of insurers' balance sheets depends to a large extent on the level of interest rates. Additional assumptions could be developed to better take into account, in the scenarios, the link between interest rates and climate change or to better differentiate the impact of variations due to climate change from that resulting from other factors.

For banks, market risk assessment applied to portfolios managed over a very short-term in the framework of an exercise aimed at assessing long-term risks also poses significant methodological problems. The assessment provided in this exercise is similar to a sensitivity exercise on which progress needs to be made in order to have a better appreciation of the vulnerability of banks to market adjustments generated by the implementation of transition policies or by the default of major stakeholders due to the lasting impact of extreme weather events on economic activity.

2. Consideration of the physical risk

In order to assess the impact of a natural disaster, insurers have highly granular information at their disposal on the geographical location of insured assets. In order to do so, they also need to know the geographic coordinates of the climate event. However, this exercise required a different approach, based on an increase in the frequency and intensity of natural disasters to be simulated according to a given temperature trajectory. As mentioned above, the public reinsurer CCR played a very important intermediary role by applying the Météo France climate model to insurers' exposures at a very granular geographical level. For undertakings that did not wish to go through CCR, the ACPR, in collaboration with the NGFS, has made available a database projecting the main climate variables at the global level, each of them being consistent with one of several climate scenarios, including RCP 8.5. However, insurers have found it very difficult to use this data to derive the impacts of an increase in the claims on their portfolios, due to the incompatibility of the data with internal models and assumptions. Further work on the nature and quality of the data to be made available to insurers during an exercise is therefore necessary to enable them to use this

³⁶ <https://www.group.rwe/-/media/RWE/documents/05-investor-relations/2020-Q4/2021-03-16-rwe-annual-report-2020-tables.xlsx?la=en&hash=D00D131952E8DF428475BEE69D7AEA2F>

data in their model and guarantee the comparability of results.

The pilot exercise also included a second round, following on from the estimates made by the insurers to assess the impact of changes in insurance coverage on banks' credit risk. In the absence of management decisions by insurers, ad hoc assumptions were provided to banks, but only two institutions were able to submit full statements. Further work is also needed on this topic in order to allow for an assessment of the physical risk on exposures relating to the financing or guarantee of property and those of the corporate portfolios of credit institutions. The first necessary step is for banks to integrate the geographical location of their exposures into their information systems. The second one is the identification of the geographical location of suppliers and customers in order to identify potential vulnerabilities resulting from a lasting disruption of supply chains.

3. Improving models and methodologies used by participants

Projecting results over a 30-year horizon

On the insurance side, participants did not necessarily have the skills or tools necessary to make projections over a 30-year period. Out of the 15 insurance groups that took part in the exercise, six used an external service provider, who created dedicated projection tools. Others adapted existing tools, most often assuming a stable market share over time. Overall, the ability of ALM tools to manage the time horizons inherent to climate change scenarios remains limited and the adaptation of these tools is more complicated than recursive calculations over consecutive periods.

As a result, insurers, who usually perform projections over a horizon comprised between 3 and 5 years, have not fully taken advantage of the room for adaptation allowed under the dynamic balance sheet assumption:

- On the assets side, only one participant conducted a strategic reallocation in response to the transition risk scenarios provided for the exercise. It is true that banks and insurers were not severely impacted by the shocks included in the scenarios, especially given their low ex ante exposure to sensitive sectors and equities (subject to higher losses than bonds), as French financial players have already made commitments to exit polluting sectors - especially coal-producing and coal-intensive industries.

- On the liabilities side, in the absence of decisions on the geographical reallocations in the insurers' portfolio, the exercise failed to show the potential emergence of an insurability risk. Insurers continued to provide coverage in all regions independently of the differential exposure to extreme weather events, considering that customers would be able to financially absorb the increased premiums. During the dynamic balance sheet assumption phase, insurers have generally chosen to maintain a stable claims/premiums ratio, essentially maintaining a static balance sheet by increasing premiums in proportion to the increase in claims. Similarly, insurers did not appear to be sensitive to the assumption of a proposal of reform of the French CATNAT scheme, which was incorporated into the exercise to ensure the stability of the natural disaster scheme. This triggered an adjustment from 12% to 18% of the reinsurance of certain non-life insurance premiums required to fund the public scheme. However, despite this assumption, no participant modified its reinsurance strategy.

Most of these management actions were carried out in a concerted manner within the participating undertakings, leading to the convergence of methods used. The choice of more elaborate management decisions, such as portfolio reallocation or a change in reinsurance programmes, would require the involvement of the management bodies of insurance groups, which, contrary to what was done in several banking institutions, were not involved in this exploratory exercise. Further reflection is needed to develop methods

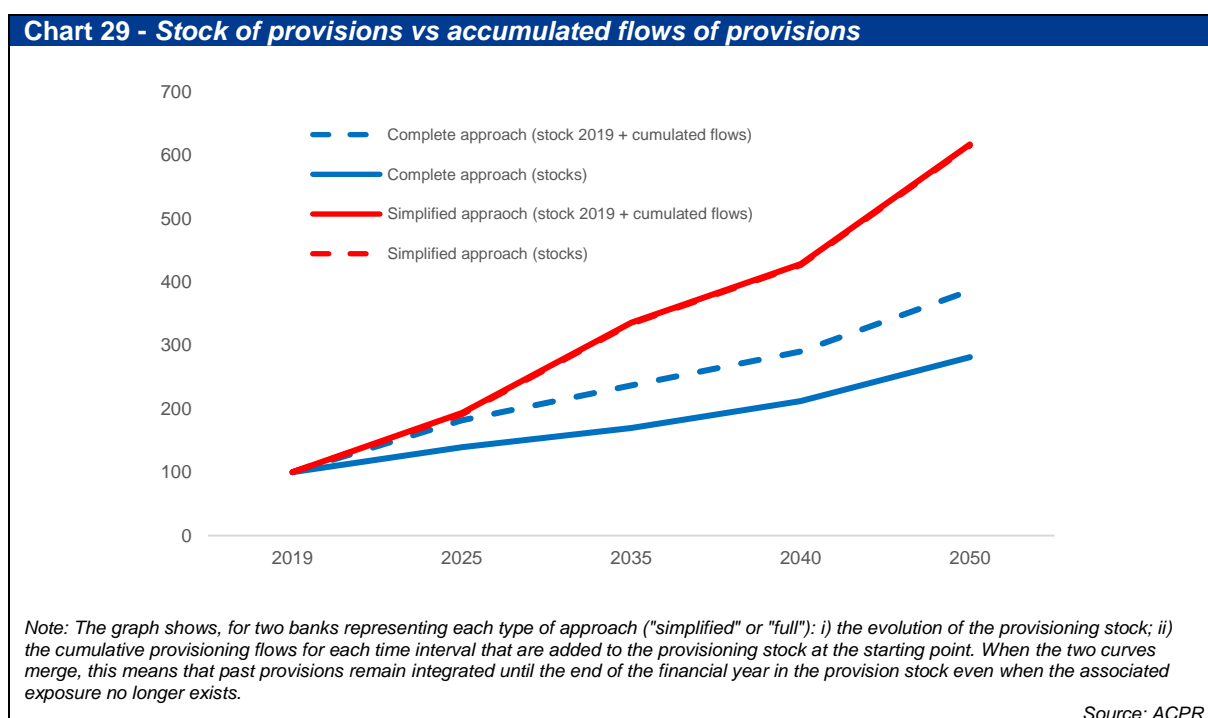
allowing for the assessment of the actual impact of scenarios on insurers' practices, notably to better understand the insurability risk related to climate change.

30-year projection and re-issuing as performing of the exposures at default of banking institutions

Due to the long-term horizon of the exercise, significant adaptation was required to the methodology used in the biannual stress tests organised by the European Banking Agency. In these exercises, as the projection horizon is limited to three years, it is assumed that exposures at default reaching their maturity are reissued as defaulted. As the pilot scenarios of the ACPR cover 30 years, this assumption becomes problematic as it creates an artificial build-up of defaulted exposures. In its pilot exercise, the ACPR therefore makes the assumption that exposures at default reaching their maturity were reissued as performing ones.

With the exception of one institution, banks were able to apply this methodological principle in more or less sophisticated ways depending on the tools they had available. Several approaches were observed that aimed at dealing with this issue: (i) a "simplified" approach, similar to the methodology presented by the ACPR and based on the use of a residual maturity at the entry of default; (ii) a more "comprehensive" (but more cumbersome) approach to differentiating between survival in default, write-off and repayment with specific calibrations. Some institutions also modified survival in default in response to the shock applied to the sector.

Chart 29 shows that these methodological differences make it difficult to compare provision stocks across institutions. However, they only have a moderate impact on the projections of provision flows. It is therefore the main metric retained and discussed in this publication.



Treatment of sectoral impacts

While insurers simply applied the assumptions provided in the portfolio valuation scenarios according to the business sector considered, various approaches were retained by credit

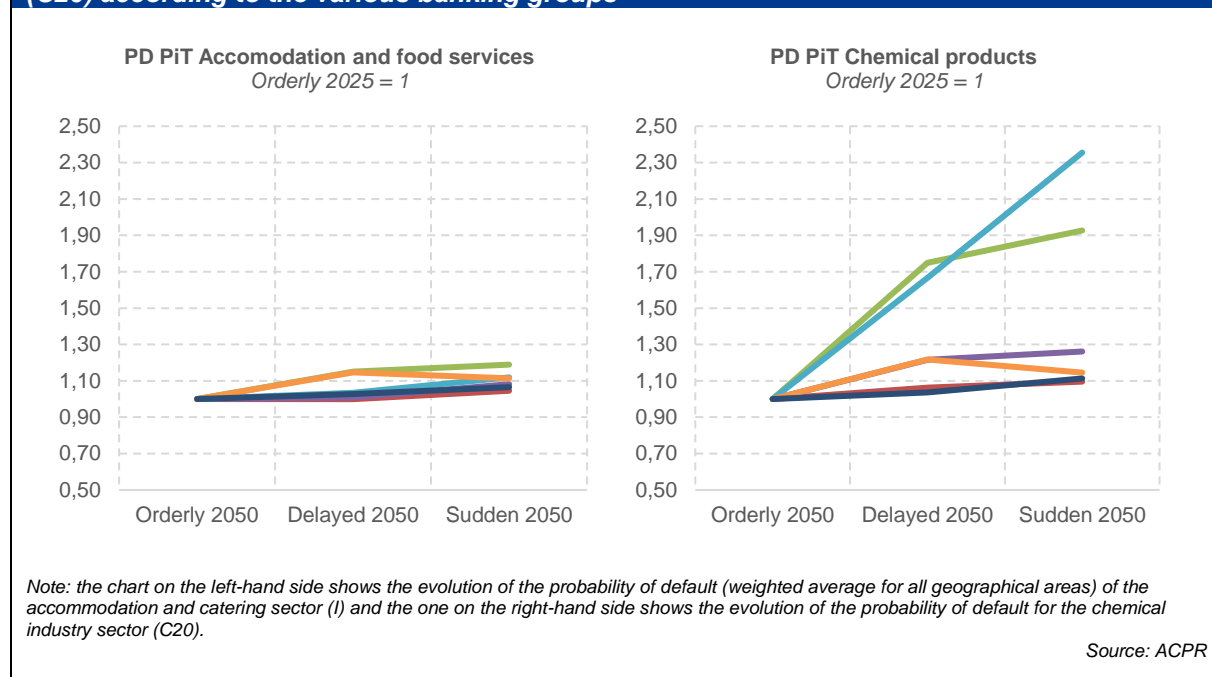
institutions to deal with the differentiated nature of impacts depending on economic activities. Some have integrated sectoral differentiation by substituting, in existing models, and for a given business activity, the GDP shock for the


corresponding sector's value-added shock. For other banks, a sectoral overlay was added, often using a multiplier (or a change upfront in the IFRS9 buckets distribution for a given sector) that were applied to the output of existing models. These multiplier factors can be produced using a quantitative model or by sector experts. Finally, some institutions simply differentiated the starting points but applied a common stress factor across sectors. It should also be noted that projections for SMEs were not always differentiated on a sectoral basis.

To some extent, differences in methodology may explain variations across institutions. Chart

30 below shows that relatively unaffected sectors have growth rates for probabilities of default, projected by different institutions, which are quite similar. Conversely, the sectors most affected by the scenarios have very different dynamics depending on the institution that projected them. The methodological approach used in the calculation of sectoral impacts is therefore likely to have an impact on the level of projections on probability of default. One action to be carried out as a follow-up to this exercise will therefore be the assessment of the various approaches taken by institutions and the issue of methodological recommendations.

Chart 30 - PiT PD developments - Accommodation and food services (I) and Chemical Industry (C20) according to the various banking groups





Annexes

ANNEX A - List of institutions that participated in the ACPR pilot exercise

1. Banking groups participating in the 2020 climate pilot exercise

Banking Group	Business model
AGENCE FRANÇAISE DE DÉVELOPPEMENT	Public Development Bank
BNP PARIBAS	Universal Bank
BPCE	Universal Bank
CAISSE DES DÉPÔTS	Public Development Bank
CREDIT AGRICOLE	Universal Bank
CREDIT MUTUEL	Universal Bank
LA BANQUE POSTALE	Public retail bank
SOCIÉTÉ GÉNÉRALE	Universal Bank
SOCIÉTÉ DE FINANCEMENT LOCALE	Public Development Bank

2. French insurers that participated in the 2020 climate pilot exercise

Insurance organisations	Life/non-life/mixed
ACM IARD	Non-life
ACM Vie	Life
AESIO	Non-life
ALLIANZ IARD	Non-life
AXA	Mixed
BNP PARIBAS CARDIF	Life
BPCE Assurances	Non-life
BPCE Vie	Life
CCR	Reinsurer
CNP	Mixed
CREDIT AGRICOLE ASSURANCE	Mixed
GMF Assurances	Non-life
GROUPAMA	Mixed
MAAF Assurances	Non-life
MAAF Santé	Non-life
MACIF Apivia	Mixed
MACIF SAM	Non-life
MAIF Non Vie	Non-life
MAIF Vie	Life
MMA IARD	Non-life
SCOR	Reinsurer
SOGECAP	Life

Source: ACPR

ANNEX B - NACE sectoral grouping

The ACPR's pilot exercise is based on a detailed segmentation of the corporate portfolio. Institutions were asked to carry forward credit risk projections for 22 sectors or groups of sectors deemed relevant for the transition risk analysis. These sectors are identified within the meaning of the European economic activities classification NACE rev2. With the aim of isolating the contribution of sectors depending on their vulnerability to transition risk, the ACPR in this publication grouped the sectors as follows:

- **Sensitive sectors**

The sectors sensitive to transition risk correspond to the seven sectors or groups of NACE sectors whose value added deteriorates significantly in the scenarios provided by the Banque de France / ACPR. These sectors correspond to the following economic activities:

Sensitive sectors	NACE code
Crop and animal production, hunting and related service activities	A01
Mining and quarrying	B
Manufacture of coke and refined petroleum products	C19
Manufacture of chemicals and chemical products	C20
Manufacture of other non-metallic mineral products	C23
Manufacture of basic metals	C24
Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	E37-39

- **Other interest sectors**

The other interest sectors correspond to 13 other NACE sectors which are not classified as sensitive but which were selected on the basis of their importance in the institutions' portfolio and also taking into account that the scenarios might not fully reflect the vulnerability of some sectors to the transition risk (e.g. air transport).

Other sectors of interest	NACE code
Manufacture of food products, beverages and tobacco products	C10-C12
Manufacture of rubber and plastic products	C22
Manufacture of fabricated metal products, except machinery and equipment	C25
Manufacture of motor vehicles, trailers and semi-trailers	C29
Electricity, gas, steam and air conditioning supply	D35
Construction	F
Wholesale and retail trade and repair of motor vehicles and motorcycles	G45
Wholesale trade, except of motor vehicles and motorcycles	G46
Retail trade, except of motor vehicles and motorcycles	G47
Land transport and transport via pipelines	H49
Air Transport	H51
Accommodation and food service activities	I
Administrative and support services activities	N

- **Other sectors**

The residual corporate exposures assigned to a NACE code were then grouped into a common segment ("other business activities").

- **Unallocated exposure**

Corporate exposures not assigned to a NACE code (often SMEs/VSEs) were grouped in a common segment ("not allocated").

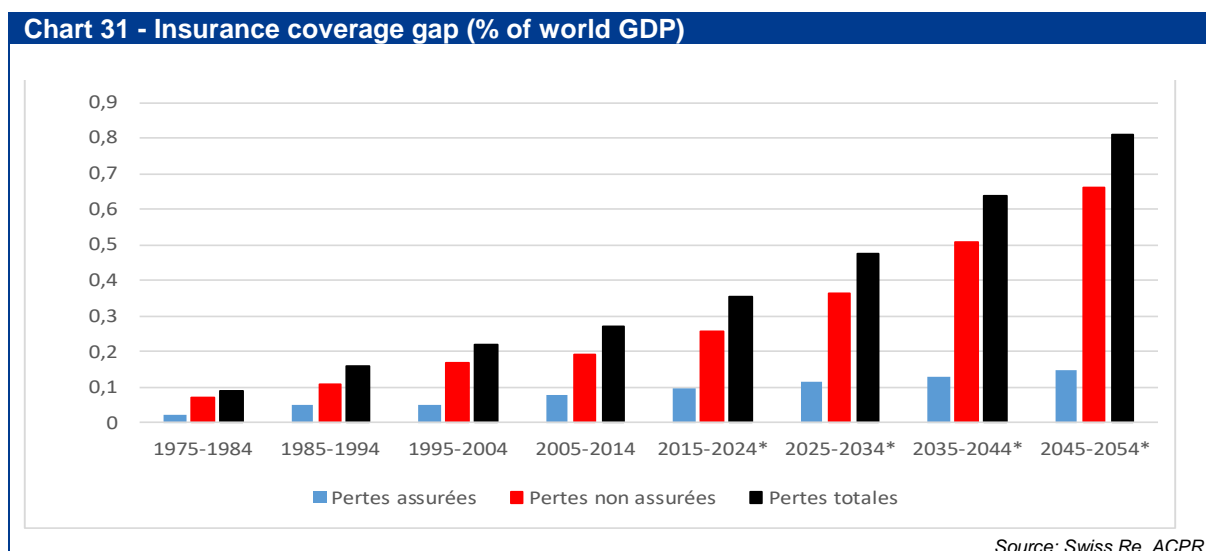
ANNEX C - Assumptions for the evolution of the insurance coverage gap

The assumptions used to calibrate the evolution of the gap between the total economic losses due to climate change scenarios and the losses covered by insurance are based, on the one hand, on *ad hoc* assumptions on the evolution of claims at the global level by 2050, established on the basis of external data and, on the other hand, in the case of France, on the evolution of claims (drought, floods, marine submersion) by 2050, based on the IPCC's RCP 8.5 scenario and on simulations by Météo-France and the JRC.

1. Assumptions regarding the evolution of the global insurance gap

The assumptions are based on data published by the reinsurer Swiss-Re. In particular, it is assumed that past trends will continue, namely:

- A tripling of total losses due to natural disasters between 2014 and 2054, as observed over the previous four decades, resulting in an exponential evolution of losses to reflect the nonlinear impact of climate change on the frequency and cost of extreme weather events;
- A continuation of the trend observed over the last four decades in the evolution of insured amounts.
- The insurance coverage gap is the difference between the two (see Chart below).



2. Assumptions on the evolution of the protection gap in France

For France, which has a ratio of uncovered losses to total economic losses close to the European average, it is assumed that this ratio also increases by almost 4 points between 2019 and 2050. Covered losses include the recourse to the natural disaster scheme.

The evolution of this protection gap by department is assumed to be a function of the relative dynamics of losses compared to the national average, based on the IPCC RCP 8.5

scenario and the exercise carried out by the Caisse Centrale de Réassurance in 2018.

The distribution between households and businesses is based on 2018 data, with agricultural losses reallocated to the household sector. This allocation is assumed to be constant over time.

The assumptions for the variation in the insurance protection gap by department between 2019 and 2050 are presented in the chart below. This variation corresponds to the difference in the ratio of uncovered losses to total economic losses between 2019 and 2050.

Chart 32 - Ad hoc assumptions on the evolution of the insurance protection gap (2019 - 2050)

