Box 3.1
IMPACT OF CLIMATE CHANGE RISKS ON THE BANKING SECTOR

Climate change and the need to implement measures to move towards a more sustainable economy pose risks to the banking sector. Some stem from the materialisation of physical risks associated with extreme climate conditions, such as rising sea levels and water stress in certain areas. Another set of risks is associated with the transition to a more sustainable economy, since the implementation of measures to prevent or mitigate climate change would entail significant changes to human and economic activity. These two types of risks could materialise simultaneously, as risk mitigation measures may be late or insufficient. In both cases, assessing their impact requires the use of quantitative tools.

This box summarises the first work undertaken by the Banco de España to quantify the impact of transition risks on the banking sector using analytical models. The results should be viewed with caution, as only part of the channels are modelled, with a methodology that captures just some of the adjustment costs. In addition, the box presents a more exploratory study of the potential long-term impact of physical risks on credit risk, comparing them with transition risks, using scenarios from the Network for Greening the Financial System (NGFS). This allows an assessment to be made of the advantages of taking action now to prevent climate change and avoid the costs that would arise if the physical risks materialise.

The scenarios used in this first analysis to assess the impact of climate change-related transition risks were prepared using the Carbon Tax Sectoral (CATS) model.[1] This is a general equilibrium model with a very detailed sectoral structure (51 non-energy and two energy sectors), designed to capture the impact of an increase in the cost of greenhouse gas emissions. The calibration of the model replicates the main characteristics of the Spanish economy in terms of productive structure, energy intensity, emissions by type of technology, etc.

With this model, simulations were carried out to assess the impact on the Spanish economy of four different shocks: 1) an increase in the price of emission allowances (from €25 to €100 per tonne of CO_2 equivalent); 2) an extension of the Emissions Trading Scheme (ETS) to all firms, including those currently excluded for belonging to the so-called non-ETS sectors; 3) a combination of the two foregoing measures; and, additionally, 4) the extension of the ETS to also include emissions generated directly by households. The baseline scenario used to study the implementation of these measures considers an economic trend in Spain that is analogous to that prior to the COVID-19 crisis.

According to the results of the model, the effect of these shocks on economic activity in aggregate terms would be noticeable but not huge (see Table 1). However, there are a number of reasons why these effects might constitute a

Table 1
IMPACT OF SIMULATED SHOCKS ON ECONOMIC ACTIVITY

Differences in accumulated rates of change (t+1, t+2, t+3) vis-à-vis the baseline scenario

		Range of impact on non-energy sectoral GVA (a)	
	GDP	Lower bound	Upper bound
Emissions price increase	-0.6	-5.3	0.1
Extension of ETS coverage	-0.3	-2.1	0.1
Combination	-1.3	-8.4	0.3
Combination incl. extension to households	-1.9	-9.1	0.3

SOURCE: Banco de España.

a The lower bound of the range of impact on sectoral GVA under each scenario is the most negative difference between the accumulated rates of change over the three years of the exercise and the corresponding measures under the baseline scenario. The upper bound represents the analogous most positive difference. The scenarios 1) increase in the price of emission allowances; 2) extension of the ETS coverage; 3) combination (of the two shocks); and 4) combination including extension to households, correspond to those described in the text with the same numbering.

1 See P. Aguilar, B. González and S. Hurtado (2021), “Carbon Tax Sectoral Model (CATS): a sectoral model for climate change stress test scenarios”, *Occasional Paper,* Banco de España (forthcoming).

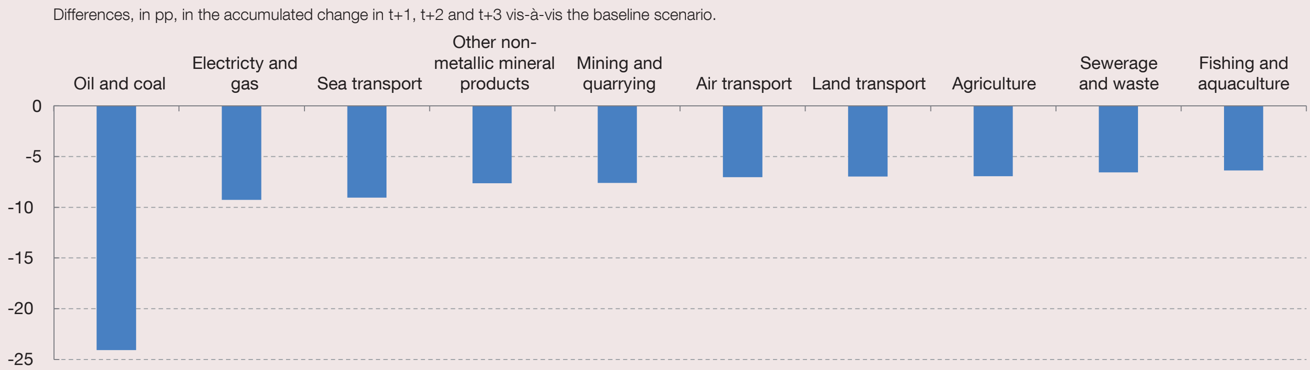
lower bound. First, reallocating resources between sectors, as envisaged by the model, could be difficult in practice because of, for example, the high specialisation of human capital. In addition, the model does not consider the reallocation of physical capital, meaning that technological obsolescence costs are excluded by construction.

Second, the model treats households homogeneously, underestimating the costs of climate change, as its impact is greater on lower-income families. Moreover, in the model the Spanish economy is not open to external trade. Thus, it only captures climate change effects through domestic demand, while those stemming from lower external demand are not considered. Lastly, the simulations are conducted under the assumption that the rise in energy prices in the scenarios is insufficient to cause permanent increases in inflation that are passed through to interest rates or that translate into sharp financial market corrections or significant shocks to house prices. A stronger influence of these nominal factors could generate more adverse scenarios.

Despite these limitations, the model's detailed sectoral structure makes it possible to identify some sectors where this shock has a greater impact. The clearest example is energy sectors, whose value added is substantially reduced. But the effects also extend not only to the more directly affected non-energy sectors (e.g. the chemical sector) but even to those most closely related to them via their purchases (e.g. the manufacture of machinery and equipment) or sales (e.g. the waste treatment sector). Through these mechanisms, under the more severe scenarios, the sectors most exposed to such shocks would be significantly impacted, directly or indirectly (see Chart 1).

To model the impact of these scenarios on the banking sector, a framework of comparable granularity for measuring corporate default risk is needed.[2] That is why sectoral granularity has been increased in the probability of default (PD) projection of the Forward Looking Exercise on Spanish Banks (FLESB) model used for stress testing. These sectoral PDs (50 sectors) vary according to the size of the firm and sector-specific and aggregate economic and financial variables.[3]

Chart 1
EFFECT ON THREE-YEAR SECTORAL GVA GROWTH OF THE INCREASE IN THE EMISSIONS PRICE AND THE EXTENSION OF THE SCHEME TO ALL FIRMS AND HOUSEHOLDS IN THE TEN MOST AFFECTED SECTORS



SOURCE: Banco de España.

2 A broad sectoral sensitivity is central to transition risk modelling (see "Guide to climate scenario analysis for central banks and supervisors", NGFS, June 2020).

3 Each model by sector and size is estimated for a panel of banks, drawing on data for the 2000-2020 period. Its final specification is selected using an algorithm that identifies a PD projection model from all the possible combinations of explanatory variables with valid specifications, and according to statistical and economic criteria. For more information, see A. Ferrer, F. J. García, N. Lavín, I. Pablos and C. Pérez (2021) "Un primer análisis de los riesgos de transición energética con el marco de pruebas de resistencia FLESB del Banco de España", forthcoming in the Banco de España's Autumn 2021 Financial Stability Review.

It should be noted that this framework captures transition scenarios' sectoral heterogeneity in two ways: i) by including economic and financial variables in all models, and ii) by constructing separate models by sector and size, providing different elasticities whenever the available information so allows.[4] Considering sectoral financial ratios makes it possible to analyse PD sensitivity to firms' hypothetical responses aimed at reducing their emissions (e.g. increasing borrowing to acquire new, greener technologies).

The impact on PDs of the transition scenarios varies among sectors. It is summarised in Chart 2, which presents a scatter plot, with each point representing a sector, showing the differences in GVA growth (three-year average, X axis) and in PD (average for 2021-2023, Y axis) between different scenarios and the baseline scenario. Specifically, the left-hand panel shows these differences for the emissions price increase scenario, while the right-hand panel depicts those for the scenario that also envisages extending ETS coverage to all firms and households (severest scenario). As is to be expected, the sectors hit hardest by the climate transition (those with the largest falls in GVA vis-à-vis the baseline scenario) tend to present higher PD increases.

As shown in Chart 3, these higher probabilities of default would impact cumulative bank profitability. To illustrate this impact, the ratio of accumulated profit after tax divided by the volume of average risk-weighted assets (RWAs), both as per the scenario, is considered. The difference in this ratio

Chart 2
EFFECT OF TRANSITION COSTS ON PROBABILITIES OF DEFAULT (PD) (a)

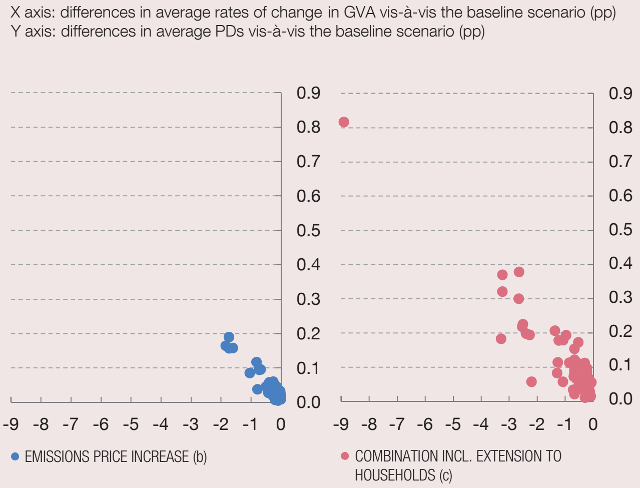
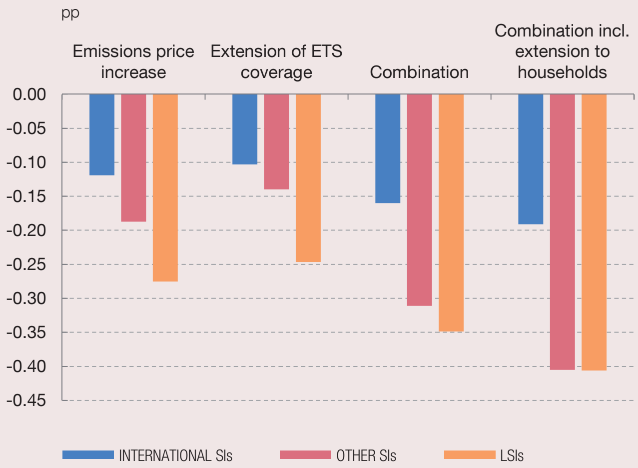


Chart 3
EFFECT OF TRANSITION COSTS ON THE RATIO OF PROFIT AFTER TAX TO RWAs (d) (e) (f)



SOURCE: Banco de España.

a Each point on the chart relates to a sector of business activity in accordance with the Spanish National Classification of Economic Activities and depicts the difference in that sector's average PD, weighted by the number of borrowers, over a three-year horizon between a trend-based baseline scenario (under which no measures are applied) and adverse scenarios resulting from different extensions of the CO_2 emission allowances trading scheme. See Box 3.1 for further details.
b This adverse scenario considers an increase in CO_2 emission allowance prices from €25 to €100.
c This adverse scenario considers a combination of the scenario described in (b) and an extension of the requirement for allowances to other productive sectors and to households.
d The bars show the difference in the ratio of profit after tax to RWAs between the corresponding scenario and the baseline scenario, for each of the three groups of institutions.
e The effects of the transition costs are calculated under four alternative scenarios. The first scenario, "emissions price increase", considers an increase in CO_2 emission allowance prices from €25 to €100. The second scenario, "extension of ETS coverage", considers the extension of the ETS coverage to all firms. The "combination" scenario simultaneously considers the CO_2 emission allowance price increase and the extension of the ETS coverage to all firms. Lastly, the "combination including extension to households" considers the ETS coverage also being extended to households.
f To calculate the ratio, the numerator (profit after tax) is cumulative for the three years in the exercise, while the denominator reflects the value of average RWAs in the same period.

4 The estimation algorithm assesses whether the number of observations is sufficient to estimate a separate model for each sector and firm size. When the available data are insufficient for estimation at the highest level of disaggregation in a sector, the estimated elasticities of the broader industry to which it belongs are assigned to it overall.

vis-à-vis the baseline scenario is presented for three groups of institutions: Spanish institutions directly supervised by the Single Supervisory Mechanism (SSM) that have significant international activity (International SIs), the rest of the institutions supervised directly by the SSM (Other SIs) and institutions supervised directly by the Banco de España (LSIs). The emissions price increase has a larger impact for the three groups than the extension of ETS coverage, with the worst deterioration in smaller institutions with no significant international presence, as the scenario analysed only considers policy changes in Spain. Insofar as the emission allowance scheme is also implemented in other jurisdictions, the impact on International SIs' profitability can be expected to be more similar to that for the other groups.[5] Under the scenario that combines both effects, the differences in terms of profit generation as a percentage of RWAs are -0.16 pp, -0.31 pp and -0.35 pp for the three groups of institutions, respectively. If the extension of ETS coverage to households is also included, the declines with respect to the baseline scenario stand at -0.19 pp, -0.41 pp and -0.41 pp, respectively. In terms of ROE,[6] the difference in the adverse scenarios compared with the baseline scenario for the aggregate of institutions (i.e. all three groups) would be in a range of between approximately 0.9 pp and 1.5 pp. The institutions would not incur significant capital charges under any of the scenarios, which shows that the transition costs can be considered acceptable.

If the transition to a more sustainable economy is not completed or carried out in time, climate change will lead to the materialisation of physical risks. These can be expected to have potentially much stronger implications for the economy, the financial sector and society as a whole than those estimated in respect of transition risks in the first part of this box. Should climate change occur, the environmental fallout of a temperature rise (desertification, floods, fires, rising sea levels, etc.) would generate asset losses for institutions through various channels, in particular in respect of exposures subject to credit, market or operational risks.

Quantification of this risk is currently at an incipient stage owing to the challenges it poses: uncertainty about the future emissions and temperature trajectories, limited data, and forecast horizons that are much longer than usual, requiring new methodological developments,[7] as it is normally assumed that, in such long time frames, agents will react. Nevertheless, studying physical risk is unavoidable in order to understand and assess the future effects that climate change could have on the financial system if no action to adopt measures is taken.

To illustrate the possible impact of physical risk, a simplified example of the effect on credit risk is presented below. For this purpose, the NGFS long-term risk scenarios have been considered.[8] These scenarios reflect transition risk and also physical risk, especially in the later years of the horizon. They consider a horizon up to 2070 and two pathways: an Orderly Transition scenario, where the shift to a net-zero emission economy is swift and effective (similar to that considered in the previous exercise), and a Hot House World scenario, where no measures are applied and environmental degradation is therefore pronounced. A statistical model was then constructed for the aggregate 12-month PDs for households and for firms, and the two figures were projected up to 2070 under each scenario.[9]

Chart 4 depicts the difference in annual GDP growth under the scenario with larger materialization of physical risks (Hot House World) with respect to the Orderly Transition scenario. At the start of the pathway, when the transition costs predominate over physical costs, the difference is slightly positive, but the trend reverses in the longer term when the environmental costs of inaction materialise to their full extent. By 2070 annual GDP growth under the Hot House World scenario is 2.1 pp lower than under the Orderly Transition scenario. In the long term, physical risks would thus entail a high deterioration in activity, far exceeding the cost of the Orderly Transition.

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5 By construction, the scenarios exclude these costs, as they derive from a closed economy model (where the Spanish economy does not have an external sector).

6 ROE has been estimated as accumulated three-year profit after tax as a percentage of average equity in the same period. Equity is estimated assuming a trajectory proportional to that of RWAs.

7 See "Climate-related risk and financial stability", ECB/ESRB Project Team on climate risk monitoring, July 2021, for further discussion of these difficulties.

8 The pathways are obtained using the REMIND-MAgPIE 2.1-4.2 model, see "NGFS Climate Scenarios Database", June 2021.

9 The exercise has limitations, such as not considering the potential deterioration of some assets (e.g. housing) that are used as loan collateral. Events such as sea-level rises or widespread torrential rain could substantially affect the value of such collateral in Spain, as highlighted in Box 3.2.

Chart 5 shows the difference in the projected PD paths for households and firms under each scenario, in the same terms as in Chart 4.[10] Similar to the case of GDP growth, at the start of the pathway, credit default risk is somewhat higher under the Orderly Transition scenario (as reflected in the previous exercise) but, in the longer term, this situation is reversed owing to the materialisation of physical risk, and much higher probabilities of default are observed in the Hot House World scenario. In 2070 the PD for households is 0.57 pp higher under the Hot House World scenario than under the Orderly Transition scenario, with this difference increasing to 1.11 pp for firms. Even if these differences could be interpreted as being contained in marginal terms, they are relevant since they reflect permanent deteriorations in credit quality, which have a significant impact when accumulated over the life of the loan.

These findings show that ignoring the costs of the materialisation of climate change would lead to an underestimation of the costs of credit risk, and that investing in an orderly transition is clearly favourable in the medium and long run, in terms of mitigating economic and financial risks.

Despite its simplifications, this second exercise is useful for highlighting that, depending on how swiftly and intensely the transition to a net-zero emission economy is carried out, the long-term economic deterioration caused by the effects of climate change could have a significant and sustained impact on credit quality. The economic authorities, including the Banco de España, are working to overcome the aforementioned methodological challenges and have begun to develop regulatory frameworks for data collection, analyses and tools to improve the measurement and modelling of its impact.

Chart 4
DIFFERENCES IN GDP GROWTH (SPAIN) (a)

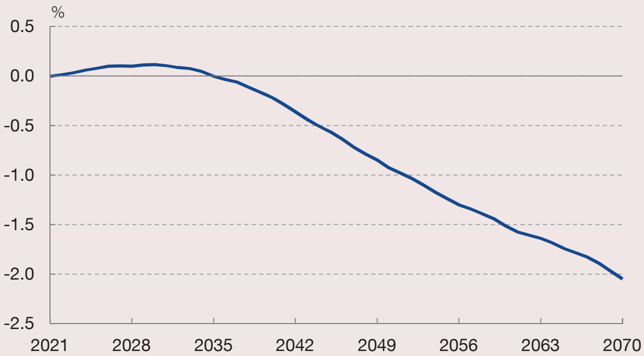
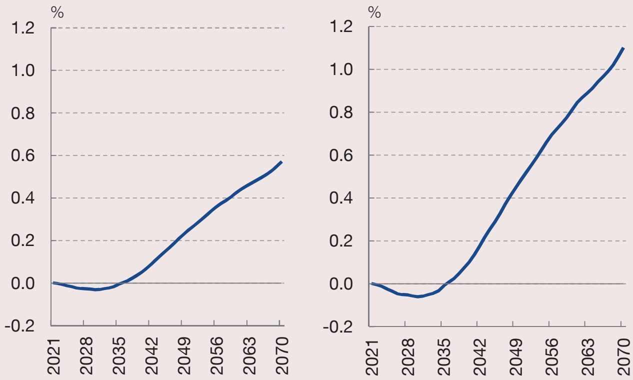


Chart 5
DIFFERENCES IN PROBABILITY OF DEFAULT (a)
Households (left) and firms (right)



SOURCES: NGFS and Banco de España.

a Differences in the Hot House World scenario with respect to the Orderly Transition scenario.

10 PD is projected by sequentially applying the model estimated using historical data. The model depends on GDP growth (the path of which up to 2070 is taken as given) and on the PD lag, such that it is possible to predict, from period to period, the PD up to 2070.