Norges Bank

3 | 2023

Staff memo

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25.06.2024

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ISSN 1504-2596 (online)
ISBN 978-82-8379-329-1 (online)

Firms' transition to lower greenhouse gas emissions and the risk in Norwegian banks*

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Summary

For a period of time, climate change could increase firms' costs and reduce the value of their assets. If we assume that the composition of banks' lending remains constant, the increase in costs could increase the banks' losses. The risk of increased losses is very unevenly distributed between industries, and the increase will probably come at the same time as firms' need for financing to reduce emissions increases.

1 Introduction

In the Climate Act, Norway has committed to reducing greenhouse gas emissions by 55 per cent from 1990 levels by 2030, and to achieving net zero emissions by 2050. To achieve this goal, society will have to go through a significant transition process in the coming years.

The transition will require major investments in new technology and new forms of energy. In addition, the climate transition may lead to cost increases in firms, which may increase the likelihood of losses. Banks are currently a key source of loans for Norwegian firms, and we expect this to continue in the transition to zero emissions. If the transition to lower emissions were to lead to increased losses on bank lending, this could put pressure on lending, while at the same time increasing demand for new loans for the transition.

If banks are able to make good assessments of this risk, they will also be better able to provide credit in a transition phase. Understanding how the transition may affect the magnitude and distribution of losses is useful for assessing how banks can best prepare for the transition to zero emissions. Governments can make the transition for the financial sector more efficient through changes in regulation and supervision.

*The views and conclusions in this publication are those of the authors and are not necessarily shared by Norges Bank. They should therefore not be reported as the views of Norges Bank. We thank Henrik Borchgrevink, Torbjørn Hægeland, Sindre Weme and participants in seminars at Norges Bank for comments and useful input on earlier versions. Any errors and omissions are the sole responsibility of the authors.

Exercises in which climate scenarios are used to assess the risk of bank lending are often referred to as "climate stress tests". Climate stress tests are often characterised by having a long time perspective and less emphasis on serious macroeconomic scenarios than so-called solvency stress tests, which are otherwise widely used by central banks in assessments of financial stability. Most central bank climate stress tests refer to climate scenarios from the Network for Greening the Financial System (NGFS) when making projections.[1] Climate scenarios show trajectories for how the energy transition will materialise under different climate policy assumptions, and can be used to calculate the economic consequences of the transition. NGFS is now also developing short-term scenarios, which are more focused on disruptions that may occur during a transition phase.[2] Some of these scenarios could be used as a starting point for conducting solvency stress tests with a climate perspective.

De Nederlandsche Bank (2018) was the first to present a "climate stress test" in 2018. Since then, Bank of Canada (2022), Bank of England (2021), Banque de France (2021), Deutsche Bundesbank (2021) and Reserve Bank of New Zealand (2024) have followed suit. In addition, climate stress tests have been carried out under the auspices of the European Supervisory Authority, European Banking Authority (2023). The European Central Bank (2023), published its second climate stress test in August 2023. In Norway, Finanstilsynet (Financial Supervisory Authority of Norway) (2021b) conducted a climate stress test of insurance firms in 2020. The IMF published an analysis in 2020 (see Grippa and Mann (2020)), and both Norges Bank (see Haug et al. (2021)) and Finanstilsynet (Financial Supervisory Authority of Norway) (2021a) published climate stress tests in 2021.

The first climate stress tests were announced as pilot exercises and a first step to learn about climate-related risks on banks' balance sheets. The key contribution at this stage has been to raise awareness of climate risk, and to explore access to and use of climate-related data in banks' risk assessment. Some exercises have taken a systemic perspective, focusing on how total losses are expected to develop. Other exercises have taken place in co-operation with the banks and have focused on how the banks assess climate risk. The results from the last type of exercise show that there are still major differences in the extent to which different banks have taken climate into account in their risk assessments. In 2022, the ECB reported that 60 per cent of banks in the eurozone do not have a well-integrated framework for stress testing climate risk. The exercises have helped to set a standard for assessing climate-related risk and can thus act as a guide for banks.

Most climate stress tests have so far concluded that banks should be able to handle the transition to a low-emission society, but that losses in some industries can be large and have an impact on the banks' returns. Reserve Bank of New Zealand (2024) writes:

[1] Bank of England (2024) has a review of the use of scenarios in climate stress tests.

[2] For more information on the short-term scenarios being developed by NGFS to, among other things, assess risk in the banking sector, see NGFS (2023a).

The scenario on its own did not threaten bank solvency or financial stability with banks able to maintain their capital ratios. However, this came at a cost to shareholders with modelled dividends nearly 40 percent lower and profits 25 per cent lower than a base case scenario absent climate-related risks.[3]

Qualitatively, this is in line with the results of our analysis. Estimated bank losses as a result of an orderly climate transition are not a significant threat to financial stability, but if banks do not take into account the impact of such a transition on their corporate customers, it could weaken profitability and the banks' ability to provide new loans. The authorities can help prepare banks by placing sufficient emphasis on climate-related issues in supervision and monitoring, and by considering regulatory measures such as increased capital requirements in order to be better equipped should losses increase.

Note that the analysis in this memo is limited to assessing the consequences of emissions and emission reductions. For some firms, physical climate change will be the biggest risk. We have previously discussed physical risk on property in Haug et al. (2021) and Bjørland et al. (2022). We will cover physical risk in later publications.

2 From scenario to assessment of increased losses in banks

The aim of this exercise is to build a framework for assessing how the transition to reach a specific climate target can affect the risk of losses in the banks and possible effects for the banks' adaptation, see figure 1.

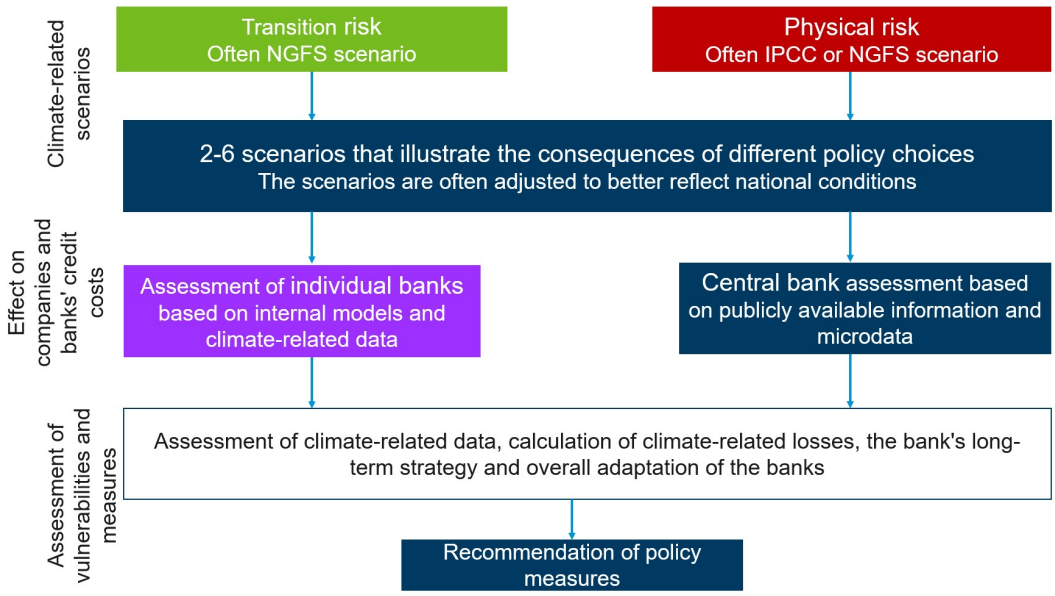
The climate stress test is not a projection of what we believe will actually happen to the banks' balance sheets. In the exercise, we assume that the banks' lending portfolio is fixed (static balance sheet), but climate change is an expected change that takes place over many years. If the banks carry out a similar analysis to us – which there is reason to believe they do to some extent – they will be able to opt out of high-risk customers, and they can change prices to better reflect the risk they take in each individual commitment. Banks can also require customers to change their projects before they get a loan. The exercise must be read as what to be concerned about - not a prediction of how banks will fare in five or ten years' time.

In the autumn of 2023, we asked the banks in Norges Bank Survey of Bank Lending how they would achieve their climate goals, see Johansen and Solheim (2023). All banks had an overall goal of net zero emissions by 2050. The banks responded that they will largely support firms' transition instead of pulling out. The exception was oil, gas and shipping, where several banks wanted to reduce their exposure.

Even though the challenges associated with global warming have been known for a long time, climate analyses are still a fairly new topic and relevant data is often difficult to access. The first

[3] Reserve Bank of New Zealand (2024), page 3.

Figure 1: Building a climate stress test



Source: Norges Bank

task in conducting this analysis is therefore to build up our data bases. We do this in five steps, see also the overview in table 1:

1. First of all, we need to decide what kind of climate target we want to analyse. Here, we have focused on the goal in the Climate Act that Norway should be a low-emission society by 2050.

2. Next, we must have a model projection that shows the consequences of the policy necessary to achieve the target. Here we use the scenarios from NGFS as a starting point for values related to emission taxes, emission cuts and energy production, see section 3.

3. In order to make the scenarios relevant for analysing the firms' accounts, they must be compared with the current situation. Firms already pay significant emissions taxes, and the costs of emissions reductions vary across industries. We retrieve figures for current taxes and the costs of emission reductions from Statistics Norway and the Norwegian Environment Agency, see section 4.

4. If we are to relate the transition to the firms, we must have information about the climate status of the corporate sector. Here we use estimated figures for emissions in scope 1-3 per firm calculated by Menon, see section 5.

5. Finally, we link the emission figures to other firm specific information, such as financial statements and information about loans, see section 6.

Table 1: Data included in climate stress test

What are we looking for?	What do we choose?	Sources
Climate targets	Low-emission society (net zero emissions) by 2050.	Climate Act
Projections for how to reach the target	Pathways for shadow price of carbon and greenhouse gas emissions. Composition of energy production. Other production changes.	NGFS scenario portal, REMIND, Net zero
Climate variables, status, macro	Emission prices and costs to clean/remove emissions.	Statistics Norway and the Norwegian Environment Agency
Climate variables, status, micro	Emissions per firm in scope 1, 2 and 3 (upstream and downstream).	Menon
Other firm variables, status, micro	Financial statements per firm. Loan commitments in ten major banks.	The Brønnøysund Register and the Financial Supervisory Authority of Norway

Source: Norges Bank

With a target of net zero emissions and higher emissions taxes, firms are likely to invest in technology that produces fewer emissions in production. We want to analyse an adaptation in which firms are both burdened with increased emissions taxes and change technology so that they gradually cut emissions, see table 2.

Table 2: Analyses included in climate stress test

Who is affected?	Variables we estimate	Methodology
Effects on the firms' income statement and balance sheet	Expenses for emission taxes.	Assumptions about the distribution of emission taxes between different frameworks.
	Costs of emission reductions. Need for new bank loans.	Assumptions about the distribution of emission reduction costs.
	Change in the value of property, plant and equipment.	Estimated impairment if the cost increase is permanent.
Effects on the firms' creditors	Change in the probability of bankruptcy as a result of increased costs and fall in capital values.	Projections based on the bankruptcy probability model KOSMO.*
Effect for the banks	Estimates of new loss provisions resulting from the restructuring. Assumes static balance.	Calculation of PD and LGD. Calculation of new loss provisions given the current loan portfolio.

**See Hjelseth and Raknerud (2016).*
Source: Norges Bank

We use the combined cost estimate from increased taxes and investments in new technology (emission cuts) to project the change in bankruptcy probability using Norges Bank's bankruptcy probability model, KOSMO.[4] The change in bankruptcy probability and information about the banks' lending to firms allows us to calculate the increase in loss provisions as a possible consequence of the climate-related cost increase. This is the method used by the central banks of the Netherlands, Canada and New Zealand, among others, and in the previous Norwegian stress tests.

The alternative would have been for the banks to assess the risk themselves on the basis of a common scenario from the authorities, as was done in the climate stress tests conducted by the EBA, Bank of England and Banque de France. In such analyses, there is a particular focus on how the banks work with climate risk. The analysis therefore takes a supervisory perspective to a greater extent. The advantage of this type of analysis is that it involves the banks and can therefore have a direct impact on how credit ratings are carried out. At the same time, this type of exercise is more resource-intensive.

3 Emissions will go down and emission taxes and investments in emission reductions will go up - climate scenarios from NGFS

Since the late 1990s, attempts have been made to model the transition to lower emissions by combining insight into the relationship between emissions and temperature with insight into technology and economics in so-called "integrated assessment models" (IAM models). The IAM models calculate the shadow price of carbon.[5] The shadow price of carbon provides a measure of what emissions must cost in order for emissions to be reduced sufficiently quickly to fulfil a set emissions reduction target. Climate scenarios of this type play an important role in the work of the UN's Intergovernmental Panel on Climate Change (IPCC).

Different model projections give an impression of the uncertainty resulting from possible misspecification of the models. Since 2019, NGFS has published a set of projections that outline the possible consequences of various choices in climate policy, see NGFS (2023b). In the latest version, they have seven different scenarios from three different model providers that extend up to 2100, see figure 2.[6] The NGFS endeavours to publish figures at the national level, but these are based on regional projections that are typically compiled according to geopolitical constellations.[7]

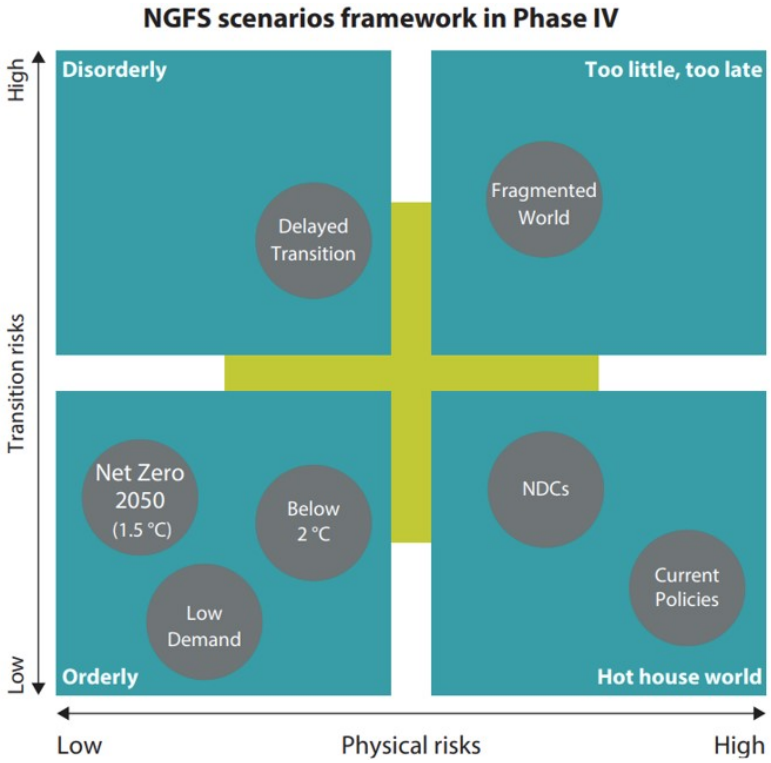
[4] See Hjelseth and Raknerud (2016) for a presentation of KOSMO.

[5] The shadow price is a measure of the general intensity of government climate policy. In practice, governments are likely to pursue a range of policy measures, not just tax increases, to maximise adaptation to an emissions reduction target.

[6] In choosing between the three models published by NGFS, we use figures from REMIND. This model is used in the ECB's analyses, among others. REMIND has a slightly lower level of the shadow price of carbon than the other two models in our scenario.

[7] Norway tends to be grouped with "European countries outside the EU", a diversified group that can include

Figure 2: NGFS scenarios in version 4



Source: NGFS

In this analysis, we choose to focus on the "net zero 2050" scenario, which aims for the world to achieve the goal of becoming a low-emission society by 2050 and for global temperature increases to stabilise below 1.5 degrees. The scenario is the most ambitious among the NGFS scenarios. "Net zero 2050" has been chosen because it is the scenario that comes closest to fulfilling the objective in the Climate Act that Norway should be a low-emission society in 2050. It is also the scenario that in practice has the highest costs for Norway up to 2050. Norway already has fairly high climate taxes in many industries, so a less ambitious target than "net zero 2050" will result in small tax increases. It is also in such a net-zero scenario that the production of oil will fall most markedly, and thus have the greatest effect on Norwegian exports.

To take into account the cost of having less ambitious climate targets, the NGFS scenarios also incorporate some types of physical risk. In our perspective, looking ahead to 2050, the effect of a slightly higher temperature increase on Norway is still assumed to be moderate. If the world manages to achieve the goal of net zero emissions, the effect of physical climate change for Norway will be relatively small.

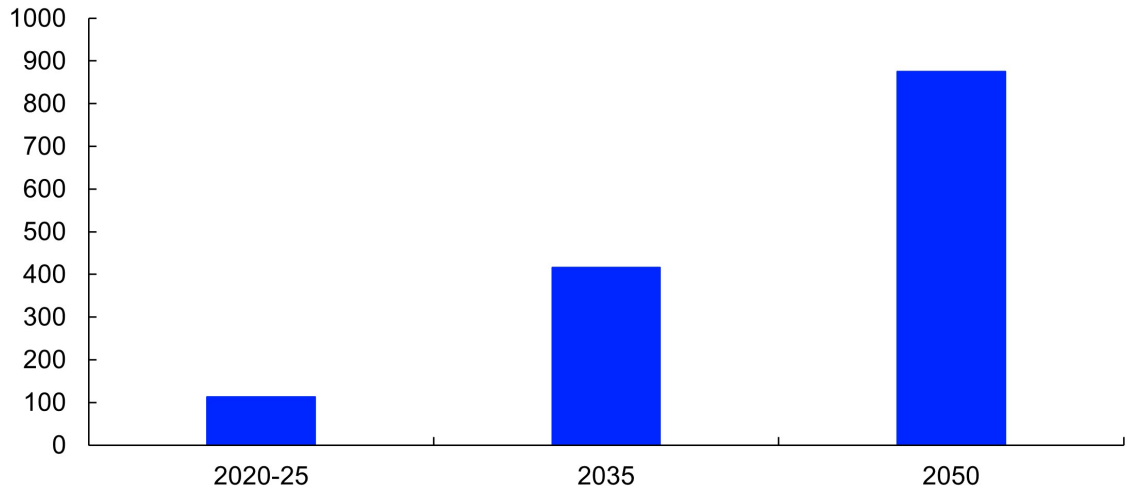
countries such as Turkey, Switzerland and Iceland. See Johansen et al. (2023) for a discussion of several different NGFS scenarios.

3.1 Key variables from the NGFS scenario

We derive three main variables from the NGFS scenario "net zero 2050" - the shadow price of carbon, the level of emissions and developments in oil and gas production. These variables are central to the scenarios and largely capture the pace of climate policy tightening.

We use the shadow price as an indicator for the development of the carbon price. The projection shows that the shadow price will rise to USD 416 in 2035 and USD 875 in 2050, see figure 3.[8]. Ministry of Finance (2023b) publishes carbon price trajectories for use in socio-economic analyses. The development in the shadow price in the NGFS scenario "net zero 2050" is in line with the development in the high price path estimated by the Intergovernmental Panel on Climate Change (IPCC) to be needed to limit warming to 1.5 degrees (median estimate).

Figure 3: Shadow price in net zero 2050 (1.5°)



Per tonne of CO2 equivalents in USD.
Source: NGFS (REMIND)

The increased taxes come alongside cuts in emissions. Emissions are expected to fall the most at the beginning of the period, with about 3/4 of the emission cuts made by 2040, and a target of zero emissions in 2050, see figure 4.[9]

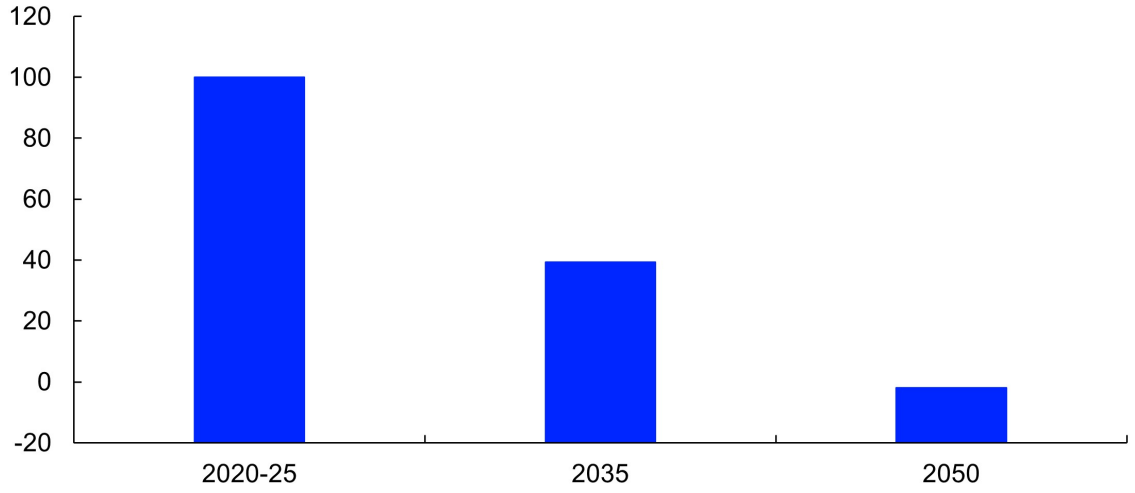
NGFS has also incorporated the results of its scenarios into a macro model[10] which provides projections of the macroeconomic effects of implementing the scenario. This analysis also attempts to quantify the macroeconomic effects of physical risk given the temperature increase in the scenario. The reduction in GDP growth up to 2050 for Norway is very moderate compared to a

[8]We use the shadow price for carbon for the EU, since this is a more realistic region than the region Norway is part of in REMIND. In the following, we operate with an exchange rate of 10 NOK = 1 USD

[9]For emission cuts, we use the projection for the region Norway is part of, "non-EU Europe". The projections here are more in line with a reasonable trajectory for countries that initially have moderate carbon emissions in their energy production, such as Norway.

[10]NGFS uses the National Institute Global Econometric Model (NiGEM), which has been developed by the National Institute of Economic and Social Research (NIESR), see Home Page - NIESR

Figure 4: Emissions in net zero 2050 (1.5°)



Index=100 in 2020-2025
Source: NGFS (REMIND)

trajectory without corresponding climate policy.

Ideally, a projection should say something about changes in the composition of production that are consistent with the changes in taxes and cuts in emissions. The models underlying the NGFS scenarios do not have such a level of detail. To provide a more realistic production projection, one could, for example, use a so-called C-GE model.[11]. In Norway, Statistics Norway's SNOW model is an example of such a model.[12] Norges Bank does not have results from this type of model available for this analysis.

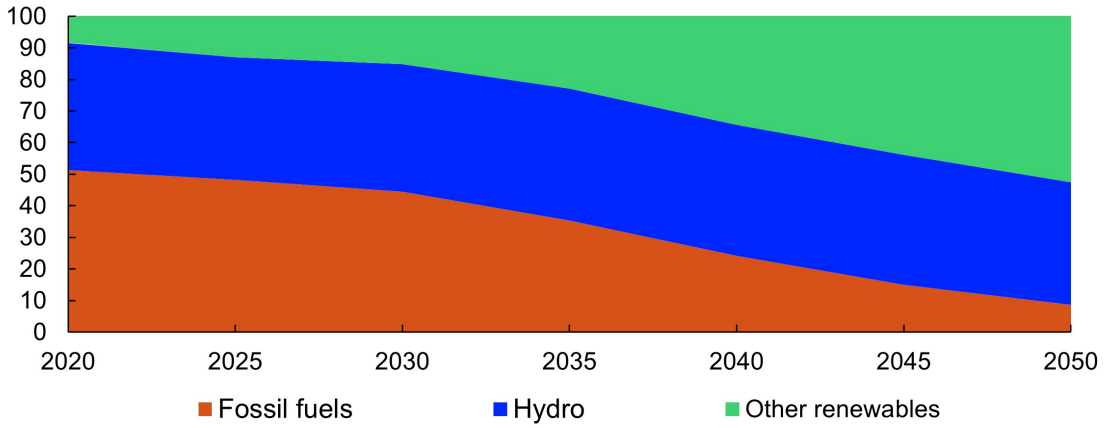
We make one exception from the assumption of constant production in real terms. For industries with oil and gas activities[13], we assume that production falls in line with the fall in oil production in the NGFS scenario. Here we use the figure from the region that Norway is part of, see figure 5. Oil and gas is the only single sector of importance to Norway where we can obtain such detailed information from the scenario.

[11] C-GE stands for Computational General Equilibrium

[12] See Statistics Norway (2019) for more information about the SNOW model.

[13] By oil and gas, we mean both the extraction of oil and gas and industries that either supply such extraction or further develop oil and gas

Figure 5: Energy composition in net zero 2050 (1.5°)



In per cent of total energy production.
Source: NGFS (REMIND)

4 Level of current emissions taxes and costs of cutting emissions

The NGFS scenario "net zero 2050" assumes that the price of emissions over time will be the same for all emissions. In practice, emission taxes vary across industries and it will not cost the same to cut emissions in all industries. When we use the scenario for an assessment of risk for specific industries, we must take into account that the starting points are different.[14] We are assuming that all industries will be brought up to the same emissions price over time. This means that industries that currently have low taxes appear to be more exposed, and industries that currently have high taxes appear to be somewhat less exposed.

4.1 Current price of emissions

Norway has had an explicit carbon tax since 1991. However, what firms actually pay for emissions varies widely across industries. Some industries only pay a Norwegian carbon tax. Firms covered by the European Emissions Trading Scheme (ETS) are allocated a number of free allowances based on historical production and industry (allocation in Norway is done by the Norwegian Environment Agency). The firms must purchase emission allowances to cover emissions that exceed this allocation. The extraction of oil and gas is covered by both the Norwegian carbon tax

[14] Grippa and Mann (2020) analyses the effects of both a shift to a uniform price (increases to the same tax in all industries) and a parallel shift (tax has the same increase in all industries) for Norwegian firms. To a large extent, industries with a high emissions intensity are affected by both types of shift, but in the case of a shift to a uniform price, some industries with an already high emissions tax will only be affected if a very sharp increase in the tax is assumed.

and the ETS. In addition, parts of the export directed industry have a compensation scheme to cover carbon taxes as a result of Norway being part of a European electricity market.

In addition to the direct carbon tax, other taxes are also differentiated according to carbon emissions. For example, electric cars are exempt from road pricing taxes that are added to the price of fuel. One consequence is that the tax imposed on a gasoline car compared to an electric car is much higher than what the explicit carbon tax alone would suggest.

Statistics Norway has endeavoured to take all these factors into account in a calculation of effective carbon prices in various industries, see Langdal (2023). It is this effective carbon price that we refer to as the "emissions tax" in our analysis. The calculation documents major differences across industries. Statistics Norway's classification is not as detailed as the industry grouping in the national accounts, but we have used Statistics Norway's classification as a starting point to make an estimate of what firms in different industries are likely to pay in emissions tax in 2022, see figure 6. The service sector has the highest taxes. However, the emissions in this sector are small relative to the sectors' economic importance. The process industry, which still receives free allowances under the ETS, pays a significantly lower emissions tax than the service sector. International shipping has so far been shielded from all emissions taxes.

4.2 Cost of emission reductions

The point of climate action is to reduce emissions over time. At the same time, emission reductions are not free. When emissions are eliminated, you don't have to pay emission taxes, but you have to pay to remove the emissions instead.[15]

In the spring of 2023, the Norwegian government presented a plan for how Norway can achieve its 2030 emissions target. In this plan, they have also outlined the socio-economic costs of cutting emissions in various industries. The estimates are not linked to industries, but to processes. The processes could, for example, be the electrification of transport or the use of carbon capture and storage (CCS).

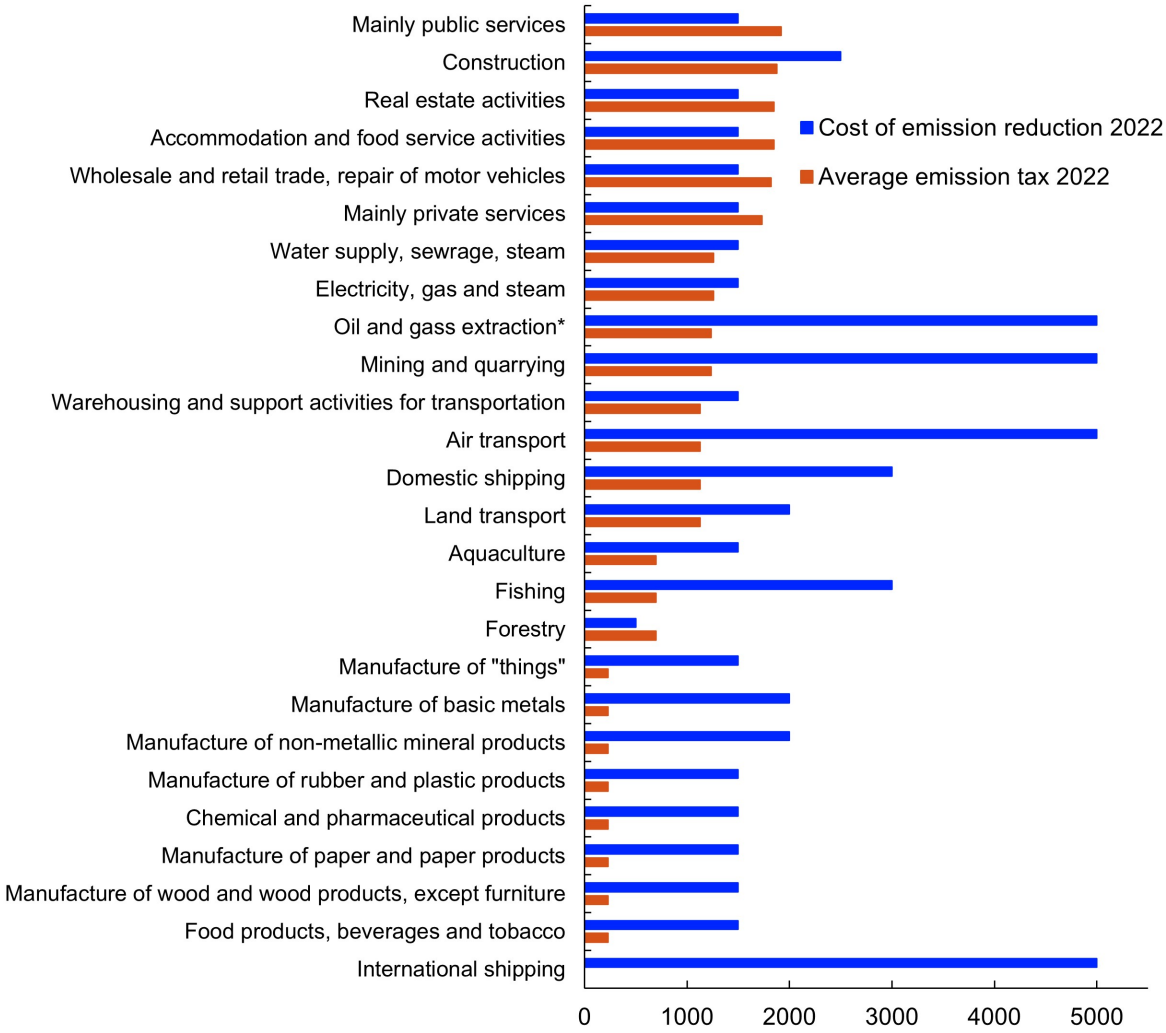
Estimates of the pricing of emission reductions show that there are major differences in what it will cost to cut emissions in different industries. In some industries, such as international shipping, it can be very expensive to cut emissions. In other industries, such as the service sector, the cost of cutting emissions may already be lower than the current average tax on emissions, see figure 6.

Such figures are intended to give an indication of the level in different industries. The cost of cutting emissions for individual firms will vary widely. In some cases, it is also conceivable that the investments have positive effects that reduce the overall cost. A firm that replaces an internal combustion engine with an electric motor may experience an efficiency gain - electric motors have

[15]Note that we assume here that the activity continues as today. Emission cuts mean that you can continue with the same activity, but now without emissions. The alternative is that you change your behaviour. This means reducing activities with high emissions and increasing activities with low emissions. One example is a transition from the production of goods to the production of services.

higher energy efficiency and are more reliable than internal combustion engines.[16]

Figure 6: Average emission tax and estimated cost of emission reductions in the same industries



**Including services, pipe transport and oil refining.*
Average emission tax and estimated cost of emission reductions. Per tonne of CO2 equivalents in NOK. 2022.
Sources: Norwegian Environment Agency, Statistics Norway and Norges Bank

[16]In some industries, such as agriculture and forestry, there are also benefits from emission reductions in the form of positive external effects, including those related to nature conservation, health and nutrition, which do not benefit the firm to any great extent.

5 Emissions in scope 1, 2 and 3

Requirements for calculating and reporting emissions from firms are changing, and in the years ahead, more firms will report emissions.[17] So far, only a small number of large firms report figures for their own emissions. In this analysis, we therefore use figures for emissions calculated by Menon for Norges Bank.[18] Emissions are divided into three "scopes", where the last scope is again divided into two:

- **Emissions in scope 1 are direct emissions from own operations.** Emissions in scope 1 can, for example, be calculated by combining information about purchases of fossil fuels and other input factors that are converted to greenhouse gases with knowledge about production processes and emission reductions in the firm. In practice, simplifying assumptions must be made. A number of large firms, particularly those that have to buy emission allowances under the ETS, have long reported their direct emissions. Statistics Norway reports estimated emissions from Norwegian firms at industry level. In our analysis, emissions are calculated per firm based on the firm's industry code, turnover and gross product.

- **Emissions in scope 2 are emissions in the production of electricity and heat that the firm purchases**. Calculations of such emissions are based on electricity consumption by industry from Statistics Norway. Electricity consumption is further broken down by firm in the same way as the breakdown of emissions in scope 1. Emissions associated with the production of electricity are calculated either based on the composition of energy sources in energy production in the area in which the firm is located (location-based) or in the market in which it is sold (market-based). We assume market-based emissions. This means that scope 2 emissions reflect emissions from the production of electricity in northern Europe, and thus to a large extent from production in Germany, which has far higher emissions per kWh than production in Norway.

- **Emissions in scope 3 upstream are indirect emissions from the production and processing of input factors in operations**. Emissions are calculated based on the exchange of goods between industries, so-called input-output tables, for Norway and Europe. There is great uncertainty associated with this type of calculation.

- **Emissions in scope 3 downstream are indirect emissions in the processing and treatment of products sold by the firm**. Emissions are calculated based on input-output tables for Norway and Europe. There is even greater uncertainty associated with

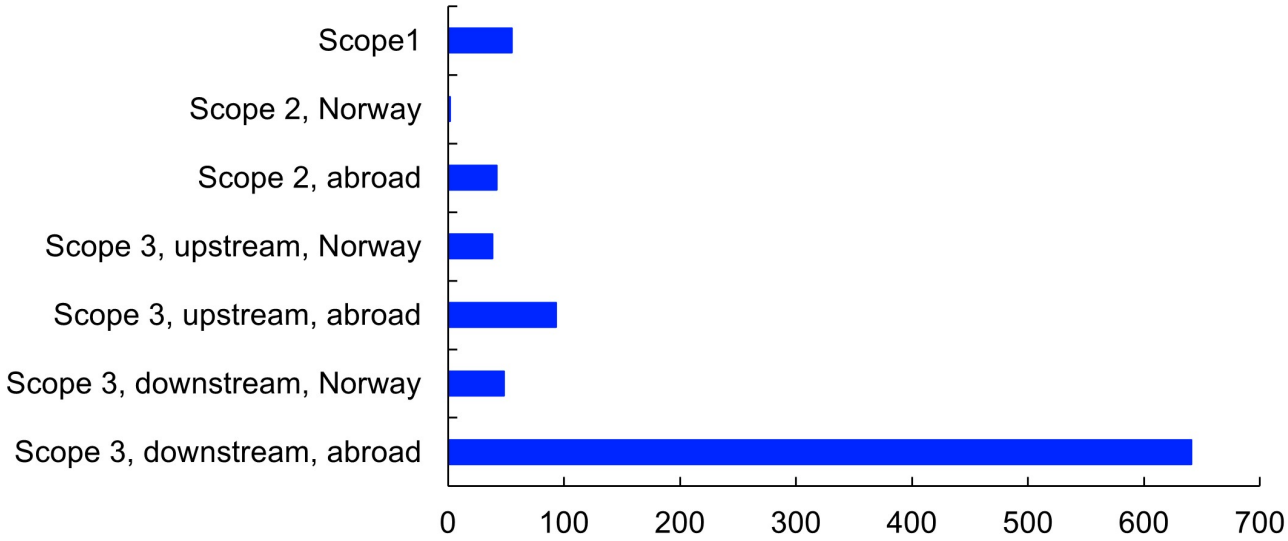
[17] For Norway, this means that we incorporate the EU's CSRD regulations into Norwegian law, see Ministry of Finance (2023a). Reporting requirements will apply to emissions in several different frameworks.

[18] See Menon (2024) for documentation of methodology. The figures do not cover emissions in agriculture because accounting figures are used here to allocate emissions per firm, and many farmers are not required to keep accounts.

the calculation of scope 3 downstream than for scope 3 upstream. The figures must be interpreted with caution.

The sum of scope 1 emissions is the sum of direct emissions, and thus the sum of all emissions. Scopes 2 and 3 are indicators of how exposed the firm is to emissions in the value chain. Since scope 3 counts the same emissions many times, it is natural that the total will be higher than emissions in scope 1. For Norway, emissions in scope 3 downstream are particularly high because we have a high export of fossil fuels, see figure 7.[19]

Figure 7: Emissions broken down by scope and emission point



Emissions in millions of tonn CO2 equivalents. 2022.
Sources: Menon and Norges Bank

The calculated emission figures show that there is a high correlation between emissions per firm in scope 1 and firms' exposure to emissions in scope 3, see table 3. Production processes with high emissions often require large machines, which in turn are energy-intensive to produce. Many of the most emission-intensive industries are also early in the value chain, and therefore also have large downstream emissions.

[19]Menon has calculated emissions in scope 3 downstream for emissions in the corporate sector. However, between 30 and 40 per cent of fossil fuel combustion takes place in households. We have therefore increased emissions in scope 3 downstream for oil and gas extraction by 1/3 to reflect the household share, see United Nations (2007).

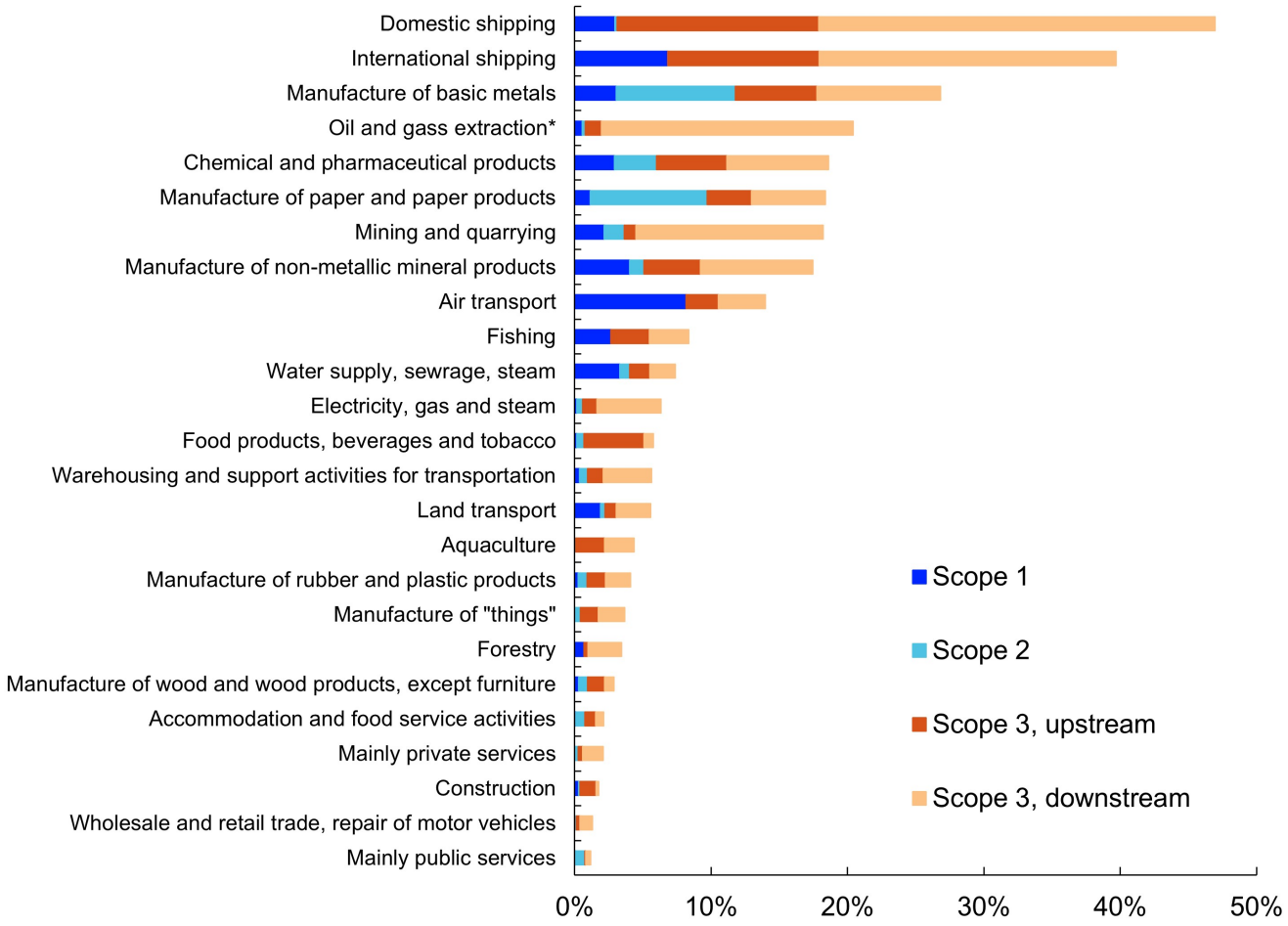
Table 3: Correlation between emissions in the different scopes of emissions

	Scope 1	Scope 2	Scope 3, upstream
Scope 2	6 %		
Scope 3, upstream	52 %	15 %	
Scope 3, downstream	33 %	2 %	64 %

Correlation across firms.
Sources: Menon and Norges Bank

Emissions intensity, measured as emissions over turnover, is unevenly distributed across industries, see figure 8. Extraction of oil and gas, domestic and international shipping have large emissions in scope 1 and scope 3. The metals industry has large emissions in scope 2 when we assume emissions in electricity production that correspond to emissions from the production of electricity in northern Europe.

Figure 8: Emission intensity by scope and industry



**Including services, pipe transport and oil refining*
Emissions in per cent of turnover for the industry.
Sources: Menon, Brønnøysund Register Centre and Norges Bank

6 Sample selection and loans covered by the analysis

We use the firms' annual accounts for 2022 and retrieve figures for turnover, various types of costs, operating income, tangible fixed assets and total assets. From the Norwegian Financial Supervisory Authority's credit exposure database (ENGA), we retrieve the banks' loan exposures to each individual firm at the end of 2023.

We limit the analysis to corporate loans from DNB Bank, Nordea, Danske Bank, Handelsbanken, SpareBank 1 SR-Bank, SpareBank 1 SMN, Sparebanken Vest, SpareBank 1 Nord-Norge, SpareBank 1 Østlandet and Sparebanken Møre. The focus of this analysis is on non-financial firms and we therefore exclude all financial firms. We also exclude lending to the self-employed, as only a small proportion of these submit accounts and therefore have emission data. The self-employed account for only 3 per cent of these ten banks' lending to non-financial firms.

At the end of 2023, according to ENGA, these ten banks had loans to non-financial firms (excluding the self-employed) totalling NOK 1,710 billion. This represents around 80 per cent of total loans to non-financial firms in the Norwegian banking sector.

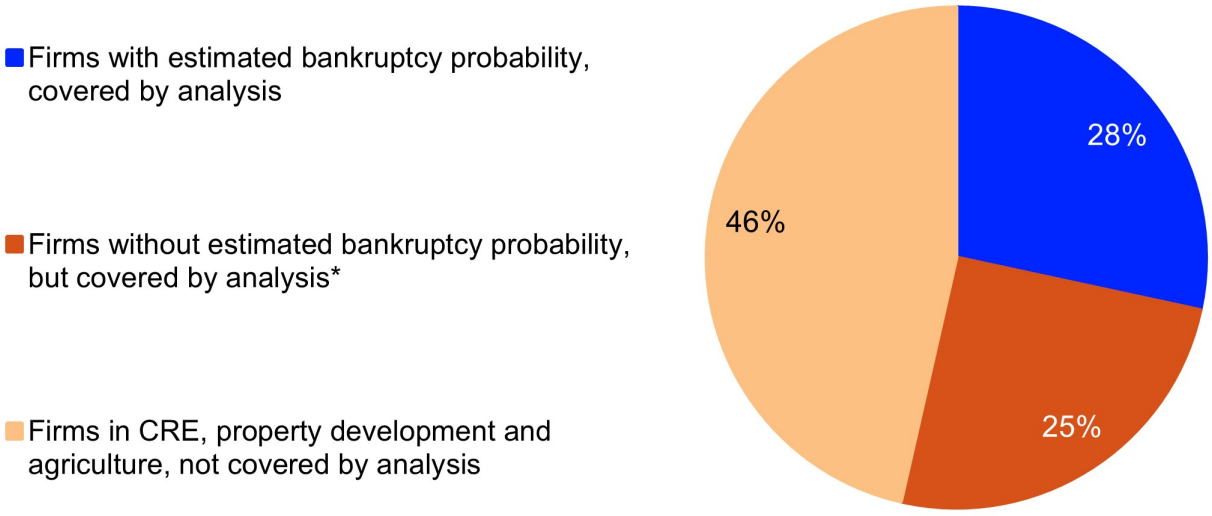
To achieve as consistent an analysis as possible, we further narrow the sample. We exclude all loans to agriculture because we do not have emission figures for this industry. In addition, we choose to exclude loans to firms in commercial property and property development. We believe that the risk associated with property is of a different nature than for other firms, with more emphasis on physical risk and specific requirements for energy efficiency. This requires other types of analyses than the emissions analysis we are conducting here. Climate risk associated with commercial property is discussed in Haug et al. (2021) and Bjørland et al. (2022), and we are planning new analyses in the future. Commercial property, property development and agriculture account for 46 per cent of the corporate loans of the ten banks we look at, see figure 9.

The analysis thus covers 54 percent, or 916 billion NOK, of the corporate loans of the ten banks. From this, we have been able to estimate the probability of bankruptcy for just over half of the loan volume. The main reason we could not estimate the probability of bankruptcy for the rest is that the banks have a significant loan volume to foreign firms for which we do not have emissions or accounting data.[20] Nevertheless, we want to include these firms in the analysis, and therefore they are assigned a probability of default based on the calculated industry average they belong to.

The distribution of loans covered by the analysis varies widely across the banks we look at. Overall, the analysis covers from 12 to 67 per cent of the banks' corporate loans. If we only look at the portion of loans for which we have our own bankruptcy probabilities, the analysis covers between 10 and 57 per cent of corporate loans.

[20] There is also a small proportion of Norwegian firms for which we do not have estimated bankruptcy probabilities. Menon assumes that firms without turnover do not have emissions. The banks may nevertheless have loans to some of these firms. It may also occur that the banks have loans to firms that started up after the 2022 financial year, and there are also firms that, for other reasons, have not yet submitted annual accounts for 2022.

Figure 9: Banks' corporate loans covered by the analysis

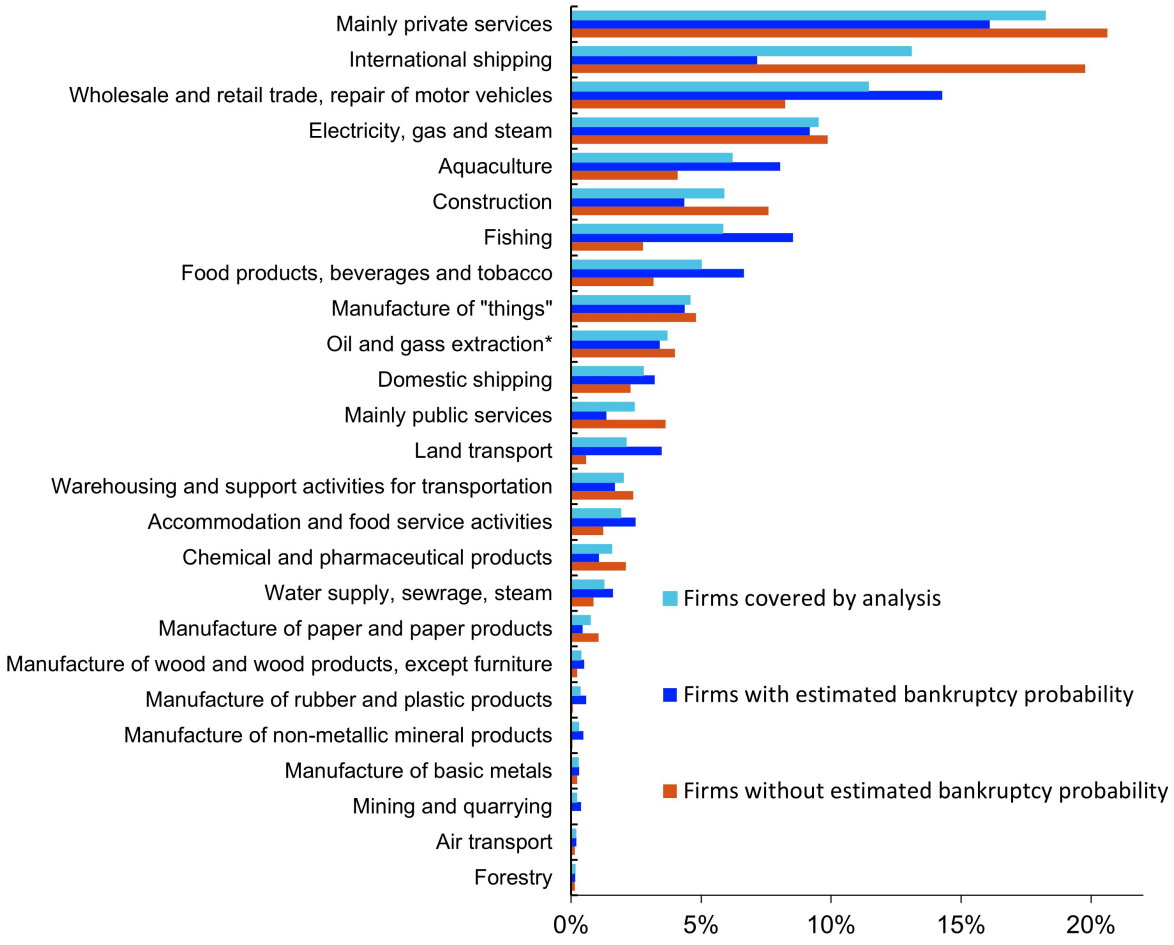


**Covered by the analysis using the estimated average probability of default of the industry to which the firm belongs.*
Corporate loans grouped by loans covered and not covered by the analysis. Self-employed and financial firms are not part of the population.
Per cent. As of 31 December 2023.
Sources: Financial Supervisory Authority of Norway and Norges Bank

The share of loans covered by the analysis varies between 12 and 67 percent of the different banks' corporate loans. If we only consider the portion of loans for which we have estimated the probability of bankruptcy, the analysis covers between 10 and 57 percent of the banks' corporate loans.

The loans covered by the analysis are well dispersed among industries, with most lending to private services at 18 per cent, see figure 10. Other large individual industries are international shipping, wholesale and retail trade, electricity, gas and steam, construction and aquaculture. There is variation in the industry composition between the proportion of corporate loans that have estimated probabilities of bankruptcy and the proportion of loans that use the industries' average probabilities of bankruptcy. The biggest difference is international shipping. This is because some banks have a lot of lending to foreign-registered firms in international shipping. Some foreign branches have also transferred much of their shipping portfolio to the Norwegian branch.

Figure 10: Industry composition of banks' lending to firms covered by the analysis



**Including services, pipe transport and oil refining.*
The industry's share of total corporate loans covered by the analysis. Per cent. As of 31 December 2023.
Sources: Financial Supervisory Authority of Norway and Norges Bank

7 Consequences of climate change adaptation for firms' costs, capital values and probability of bankruptcy

Based on the figures described in chapters 5 and 6, we can now assess how developments in the NGFS climate scenario may affect firms and banks.

7.1 Effect on firms' costs

The first step is to determine the projection of emission taxes. The taxes are initially paid by the firms responsible for the direct emissions in scope 1. However, it is reasonable to assume that the firms pass on the taxes down the value chain in the same way as for other taxes. How much they can pass on will depend on how sensitive supply and demand are to changes in price and will vary between industries. We assume a schematic distribution where the firms pay a fixed share

of the tax per unit of emissions in each scope, see table 4. The distribution is calibrated so that Norwegian firm pay net for emissions corresponding to 70 per cent of the emissions in scope 1. At the same time, through the effects on the pricing of imported products with emissions and exported products with emissions, Norwegian firm must pay almost three times as much related to emissions outside Norway as for emissions in Norway.[21]

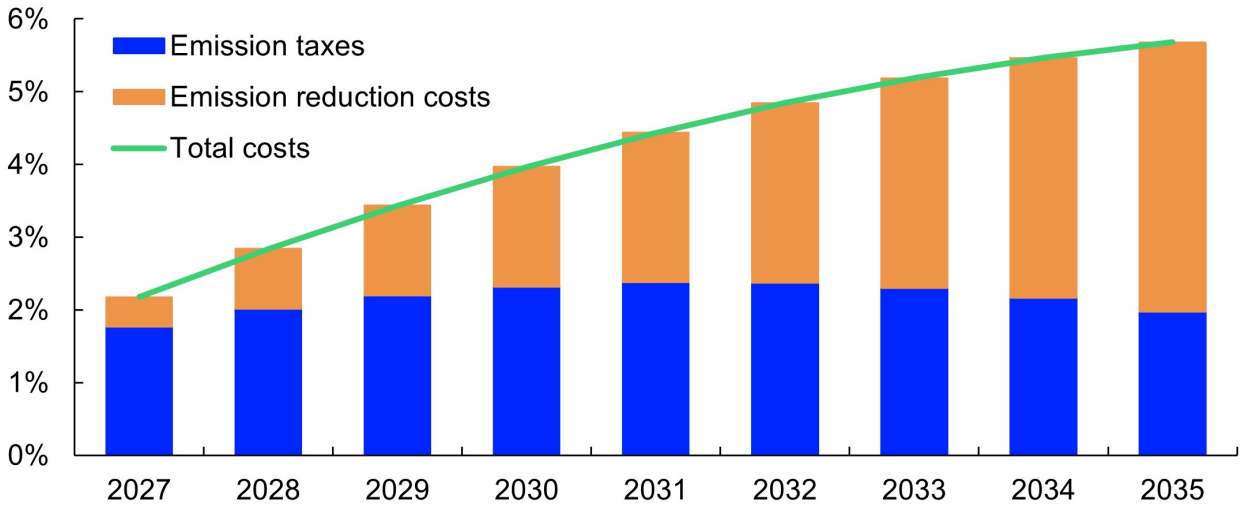
Table 4: Share of emission tax allocated to emissions in different frameworks

	Share of emission tax paid by the firm	Emissions in Norway mill. tonnes CO2 eq.	Imported emissions mill. tonnes CO2 eq.
Scope 1	50 %	55	
Scope 2	50 %	2	42
Scope 3, upstream	12.5 %	39	93
Scope 3, downstream	12.5 %	49	641

Sources: Menon and Norges Bank

At the same time as the emissions tax increases, emissions are likely to be reduced. To achieve the climate target of net zero in 2050, the climate models signal that the biggest emission cuts must come early in the period. Around three quarters of the emission cuts must be made before 2040. In the early 2030s, the emission cuts will be large enough for total emission taxes as a proportion of turnover to fall, even if the tax increases, see figure 11. Towards 2050, total emissions taxes as a proportion of turnover will gradually approach zero as emissions are cut.

Figure 11: Distribution of climate-related costs in net zero 2050 (1.5°)



In per cent of total turnover. 2027-2035.
Sources: Menon, Brønnøysund Register Centre and Norges Bank

Cutting emissions come at a cost. However, there are many ways in which emissions can be

[21]Note that this is not based on an assessment of how much emissions taxes Norwegian firms pay for, but follows from our assumptions about tax distribution.

cut. Here we assume that firms cut emissions gradually, in line with the emission reductions in the scenario.[22] For simplicity, we assume the following sequence: Emission reductions require a one-off investment. We assume that the investment increases in proportion to the emissions being cut. We assume that the investment cost is kept constant in real terms. The investments are fully financed by non-amortising loans with a fixed interest rate, and each loan is repaid after ten years.

From such a simple story, we derive two types of information: the volume of new loans and the cost of cutting emissions (the amortisation of the investment). For each year, the firm adds new investments. This increases the loan and depreciation, but after ten years each investment is fully depreciated and the loan repaid. Furthermore, we assume that the borrowing changes in line with the need for further investments.

The sum of total emission taxes and costs for emission reductions increases most in the first few years. This is when emissions are still high, emission prices increase markedly and investments in emission cuts are large. In subsequent years, cost growth will slow down. We emphasise that there is a great deal of uncertainty here, not least in relation to how much it will cost to cut emissions over time. The cost may be both higher and lower than we have assumed here.

7.2 Effect on turnover and value of assets

In the analysis, we keep income per unit produced constant in real terms and allow production to develop in line with the NGFS scenario "net zero 2050". To reach net zero in 2050, the use of fossil fuels must fall in line with the scenario. Turnover in oil and gas extraction and in oil-related industries must therefore fall markedly over time.[23]

Since emission cuts are intended to be permanent, we assume a permanent effect on the value of existing tangible fixed assets. The effect for the individual firm reflects the fall in operating profit resulting from increased costs and reduced turnover. We calculate the size of this effect by first calculating a net cash flow on the current tangible fixed assets, which is reduced in line with the increase in operating costs as a proportion of total turnover. We assume that the required rate of return in the future is affected by the relative transition risk of the firm compared with the rest of the industry.[24]

Note that, as mentioned, we do not take into account the potential benefits of climate and energy transition. The focus of this work is on the potential costs associated with climate and energy transition.

[22] One possible way to think about this is that each firm has a large number of combustion engines used in daily operations, each emitting a known number of tonnes of carbon equivalents. Each year, the firm will replace a portion of these engines with electric motors and access to clean electricity to meet its emission target.

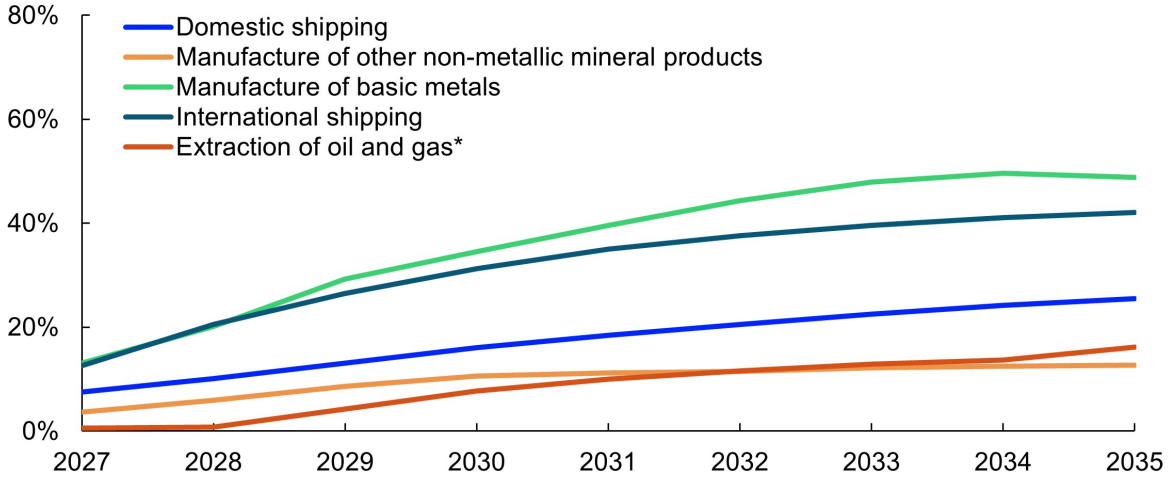
[23] Please note that the path for a global decline in the use of fossil fuels implies a faster phasing out of Norwegian oil and gas extraction than the projections from Norwegian Offshore Directorate (2024) currently assume.

[24] Firms with a maximum increase in operating costs receive a risk premium of up to 2 percentage points on the required rate of return. With reduced net cash flow and a new required rate of return, we can calculate an updated value of tangible fixed assets. Relative transition risk is calculated as the deviation in total cost increase as a proportion of operating income relative to the average for all firms in the industry plus 2 standard deviations.

8 Climate adaptation has a major impact on some industries, but for banks as a whole the effect is moderate

A fall in earnings and capital values reduces firms' ability to continue profitable operations. This can trigger losses on the banks' loans. Using the bankruptcy probability model KOSMO, we calculate the expected change in bankruptcy probability for each individual firm as a result of climate change. We use the increase in the probability of default as the basis for estimating the banks' probability of default (PD).[25] We then calculate the "loss given default" (LGD).[26] The sum of outstanding loans multiplied by PD and LGD provides an estimate of cumulative loan loss provisions as a result of the climate transition. The change in loan loss provisions between years gives the increase in new loan loss provisions. The cumulative loan loss provisions provide a measure of how much climate-related losses may weigh on the banks' earnings throughout the scenario.[27]

Figure 12: Cumulative loan loss provisions in the industries with the highest provisions



**Including services, pipe transport and oil refining.*
Static balance sheet with no write-offs. In per cent of loans to the industry. 2027-2035.
Sources: Menon, Norwegian Environment Agency, Statistics Norway and Norges Bank

There is a big difference in the estimated increase in cumulative loan loss provisions between different industries, see figure 12. Five industries stand out in particular: international and domestic shipping, the process industry, divided into the production of metals and the production

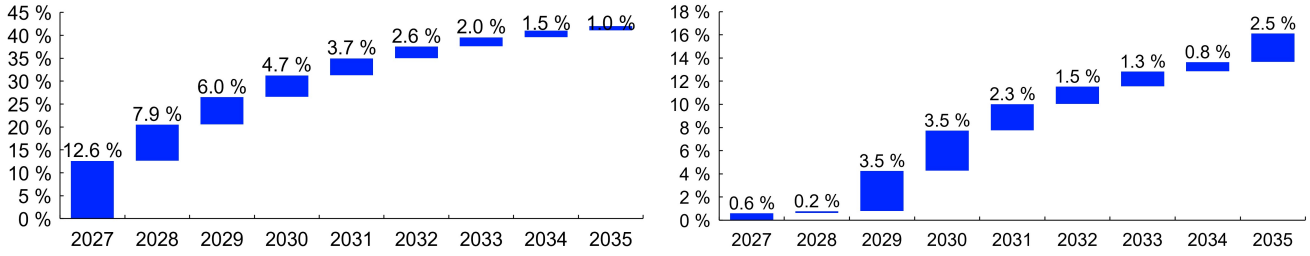
[25] Bernhardsen and Syversten (2009) has calculated that the probability of default on corporate loans is about twice as high as the probability of the firm going bankrupt. We therefore assume that the PD is twice as high as the probability of bankruptcy for each individual firm.

[26] LGD stands for "loss given default". LGD is initially set at 25 per cent, but increases additionally with the percentage impairment of the value tangible fixed assets. We limit the calculation of LGD not to exceed 80 per cent for the individual firm. It is common practice in such climate stress tests to use higher LGD for industries perceived as brown, which are likely to have a greater reduction in collateral values.

[27] We assume that there are no write-offs. Any change in the stock of loan loss provisions therefore reflects new loan loss provisions that generate loan losses in the income statement.

of other non-metallic mineral products, and the extraction of oil and gas. These industries are characterised by large emissions, often in all scopes, see figure 8. With the exception of oil and gas, current emission taxes are low in these industries, since they have largely been shielded through quota regimes and exemptions. Here, we assume that shielding from taxes will be phased out over time. Some of the industries, such as shipping, also have high estimated costs for cutting emissions. In our analysis, shipping is therefore hit hard by both increased taxes and investment costs for emission cuts.

Figure 13: *Cumulative loan loss provisions as a result of climate-related costs*



(a) *International shipping* (b) *Extraction of crude oil and gas*

In per cent of loans to the industry. 2027-2035.
Sources: Menon, Norwegian Environment Agency, Statistics Norway and Norges Bank

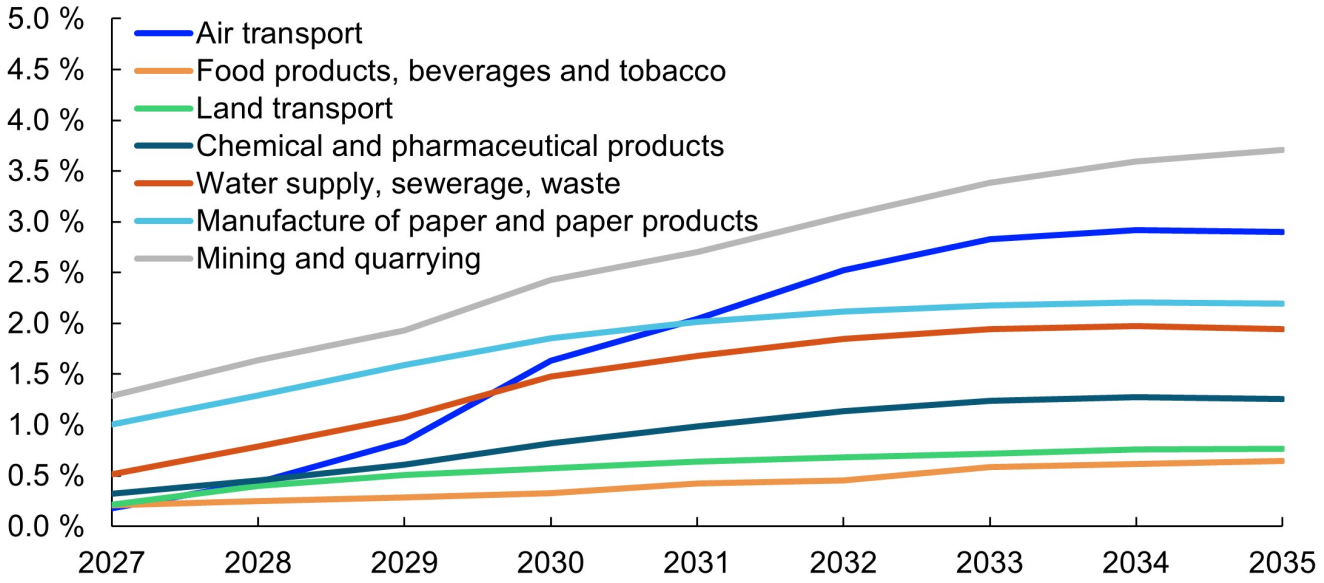
The development in loan loss provisions throughout the scenario also varies between the different industries. For international shipping, much of the increase comes early in the period, see figure 13a. This is due to the fact that the industry currently has very low emission taxes, which we assume here will increase rapidly. For oil and gas extraction, which currently has very good operating margins and already pays fairly high taxes, there is little effect in the first few years, see figure 13b. However, from 2030, when the production of oil and gas begins to fall, the estimated loss provisions increase.

For the vast majority of industries, loan loss provisions are moderate. If we look at various industries within transport and manufacturing, the cumulative increase in loan loss provisions as a result of climate change is less than 4 per cent of gross lending even if we extend the perspective all the way to 2035, see figure 14. This indicates that for industries with moderate emissions, the cost of climate change is of little significance for the continuation of further operations.

8.1 Risk on banks' balance sheets

The five industries most exposed to climate change together account for 20 per cent of lending to firms covered by the analysis, see figure 10. 16 per cent is to domestic and international shipping and 4 per cent to oil-related industries, while lending to the production of metals and other non-metallic mineral products is very low.

Figure 14: Cumulative loan loss provisions in a selection of industries with moderate loss provisions



In per cent of loans to the industry. 2027-2035.
Sources: Menon, Norwegian Environment Agency, Statistics Norway and Norges Bank

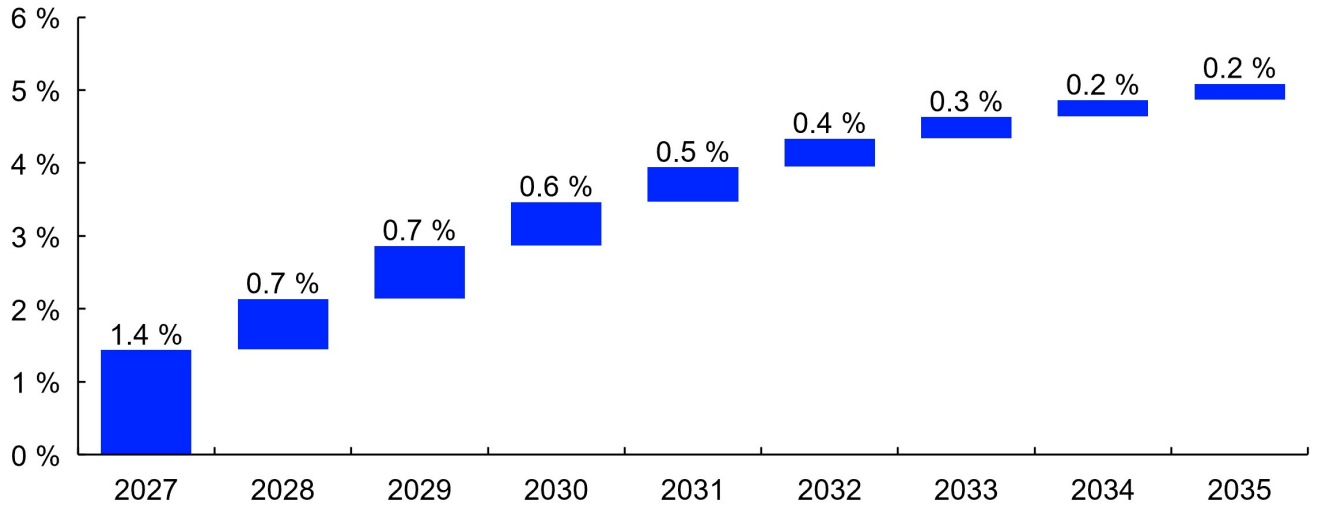
Overall for the ten banks we look at, the increase in new loan loss provisions is relatively moderate, see figure 15. Loan loss provisions rise towards 2035 to an cumulative level of 5 per cent of lending to firms covered by the analysis, with an annual increase averaging close to 0.5 per cent. Even if banks take the entire cumulative loss provision over a shorter period than the scenarios suggest, losses would be significantly lower than during the banking crisis and comparable to the periods of elevated losses we have seen over the past 25 years. These are losses that the banks can handle, but they will affect the banks' profitability for a period of time. Based on the major banks' balance sheets and earnings in 2023, such an annual increase in loan losses means that the return on equity in isolation will be reduced by just over 0.5 percentage points per year.

Including the banks' lending to foreign firms means that the calculated loss provisions are higher than they would have been by only looking at Norwegian firms. This is due to the fact that the foreign portfolio has an industry composition that is inherently more exposed to climate risk than the Norwegian corporate portfolio. The risk is particularly linked to a large proportion of loans to international shipping in the foreign portfolio, see figure 10 and the discussion in chapter 6.[28]

Another observation is that exposure to climate-exposed industries can change rapidly. From 2022 to 2023, banks have reduced lending to the most exposed industries in both absolute and relative terms. We find that the cumulative increase in loss provisions in 2035 is reduced by 22

[28]This is based on the foreign firms having the same probability of default as the average estimated probability of default for the Norwegian firms in the same industry. Since we have neither emissions nor accounting data for foreign firms, we cannot assess the risk beyond this.

Figure 15: Cumulative loan loss provisions as a result of climate-related costs



In per cent of total corporate loans covered by the analysis. 2027-2035.
Sources: Menon, Financial Supervisory Authority, Brønnøysund Register Centre and Norges Bank

per cent (just over 1 percentage point) when we change the composition of the banks' loans from the 2022 portfolio to the 2023 portfolio. This is because exposure to international shipping and oil-related industries has decreased from 2022 to 2023.

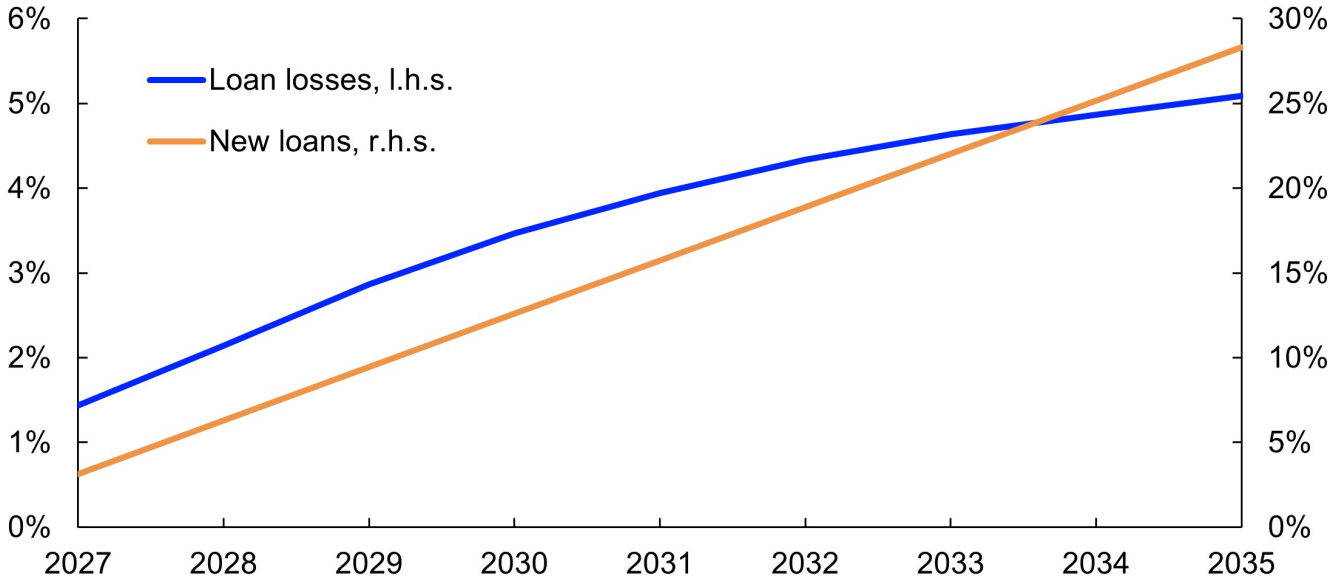
8.2 Consequences for banks' adaptation

We have assumed that the banks' balance sheets and loan terms remain unchanged. In practice, banks can change the terms on loans that are exposed to climate costs. Financial markets have already started to take climate risk into account in pricing and credit ratings.[29] Banks can also reduce their share of lending to exposed industries. A survey in connection with Norges Bank Survey of Bank Lending in the autumn of 2023 shows that banks are already making changes to loan terms and lending volumes to industries exposed to transition risk. The banks themselves say that their first choice is to support firms in the transition, and not to reduce their exposure to industries with high emissions.[30]

Loan losses in the banks can affect the banks' ability to provide new loans. Increased loan losses as a result of increased climate costs in firms may come at the same time as firms need new loans to implement the climate transition. Our simple analysis indicates that, in isolation, the largest banks will need to increase corporate lending by 20 per cent above normal lending activity over the next ten years to cover investments in emission reductions, see figure 16.

[29] See for example Bandt et al. (2023) for a comprehensive review.
[30] The exception is oil, gas and offshore, where several banks want to reduce their exposure

Figure 16: Cumulative loan loss provisions as a result of climate-related costs and new loans to cover investments in emission reduction measures



In per cent of total corporate loans covered by the analysis. 2027-2035.
Sources: Menon, Financial Supervisory Authority, Brønnøysund Register Centre and Norges Bank

9 Summary and further work

Norwegian banks are exposed to industries that must implement major climate-related changes. In the Climate Change Act, Norway has committed to becoming a low-emission society by 2050. In the analysis, we use information from the NGFS "net zero 2050" scenario to project the climate transition and the consequences of the transition. The sum of increased taxes on corporate emissions and investment costs for emission reductions affects both firms' profitability and the value of their assets. We estimate the increase in the banks' loan losses as a result of increased emission taxes and the costs of emission reductions the firms must pay through the scenario.

We find that several industries can experience large cost increases. However, these individual industries only account for a limited proportion of banks' lending to Norwegian firms. Total loan loss provisions on corporate loans will therefore increase significantly less than the estimations of the most exposed individual industries would indicate. Even if the banks had to take the entire loan loss provision over a shorter period of time than the scenarios suggest, the loan losses would be significantly lower than during the banking crisis and comparable to the periods of elevated loan losses we have seen over the past 25 years. On the other hand, financing emission-reducing measures will become an increasingly important reason for taking out new loans towards 2035. If losses occur at the same time as major investment needs, it may become more demanding for banks to contribute to the financing of emission reduction measures.

We can further develop this analysis along several dimensions. We do not yet have a firm-

based analysis of the banks' lending to foreign registered firms, although the industry composition of these loans may indicate that the transition risk is relatively high in these loans. Here, it is possible to obtain more detailed data. It is also possible to make the analyses more realistic by using a richer set of models to assess the composition of production in a climate scenario. To develop this issue, there is room for increased cooperation between various Norwegian government agencies. Such models may also be better suited to analysing short-term scenarios, which can take greater account of the interaction between the climate, the real economy and the financial markets. The analysis of the consequences of emission cuts for firms must also be linked to an assessment of possible losses in other industries, particularly the real estate sector. This will also provide a better picture of the risks associated with physical climate change. The goal is to put together an analysis of potential losses on all the different elements of the banks' assets. Having done this, is also natural to make a full assessment of the overall effect on the banks' balance sheets.

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