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The most significant financial risks from climate change and green transition

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Climate change and the green transition will spill over into the financial sector and may affect the stability of the financial system. But what are the specific events that have the potential to affect financial stability? There is still a great deal of uncertainty about this. This analysis contains an initial mapping of events that *could* lead to higher risks for Danish credit institutions over the next 10 years and that are related to climate change and the green transition. The analysis thus provides a foundation for assessing which risks are important to analyse in more detail, and therefore sets the direction for future work in relation to assessing the consequences for financial stability.

Green transition is necessary to mitigate future climate risks

Climate change is already impacting society, and these impacts will continue to increase in the future. The green transition must protect society from the worst future consequences of climate change. A successful green transition requires, inter alia, that companies and consumers bear the costs of climate damage caused by emissions from their production and consumption themselves and to a greater extent.

The green transition will pose risks for credit institutions over the next 10 years

Over the next 10 years, climate and transition risks for credit institutions will relate mainly to the green transition. Institutions may be affected by this through changes in regulation and market conditions for their customers. Introducing taxes on greenhouse gases can support a transition that is less costly for their customers than other tools. Severe weather events in the most vulnerable parts of the world may also affect institutions.

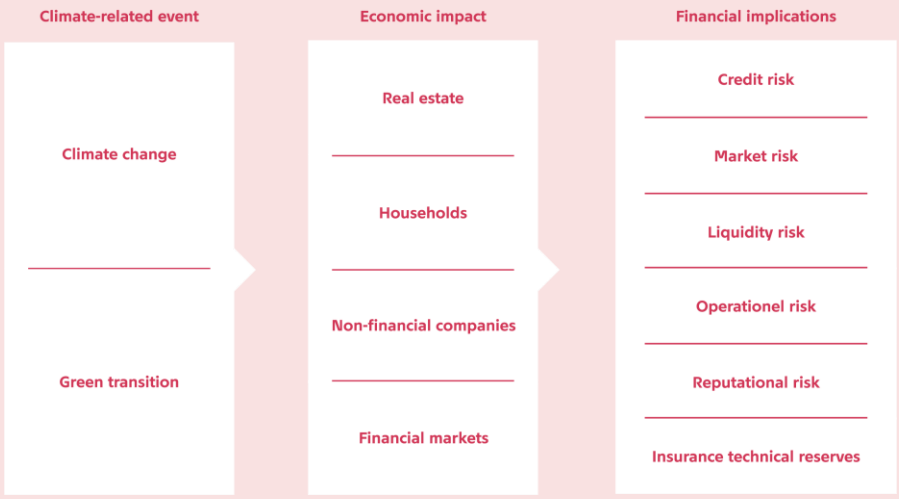
Credit institutions should include relevant climate and transition risks in their risk management

In credit institutions, climate-related risks will materialise in the form of the classic types of financial risks that the sector is already familiar with, such as credit and market risks. It is the responsibility of individual institutions in the financial sector to manage the climate-related risks they face. They should therefore include these in their risk management.

Why is it important?

Climate change is already affecting society today and is expected to have an even greater impact in the future. Therefore, a successful green transition is urgent and requires historic efforts in Denmark and abroad. Both climate change and the green transition could challenge Danmarks Nationalbank's objectives of stable prices and financial stability in Denmark. Therefore, Danmarks Nationalbank needs to increase its knowledge about how and how much climate change and green transition will affect different parts of the economy and the financial system.

Main chart: From climate-related events to financial risks



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01
A green transition is necessary to limit climate change

Climate change is already impacting society today, for example, through the devastation caused by extreme weather events. In the future, the consequences are expected to get worse, cf. the UN Intergovernmental Panel on Climate Change (2023).

The green transition must protect society from the worst future consequences of climate change. If the green transition is not realised and emissions are not curbed, climate change could spiral out of control, with serious consequences for financial stability, cf. ECB/ESRB project team on climate (2022) and Bank of England (2022).

Denmark has joined the Paris Agreement to limit the long-term increase in global temperature to below 1.5-2°C compared to pre-industrial levels, cf. United Nations (2015). The Danish Parliament has also adopted a national climate target for 2030 of a 70 per cent reduction in emissions compared to 1990. Additional targets have also been agreed for both 2025 and 2045.[1]

A successful green transition requires that companies and households bear the costs of the damage to the climate caused by emissions from their production and consumption themselves and to a greater extent. A uniform cost of emissions can ensure an economic incentive to reduce emissions where this can be done most efficiently, cf. Danish Economic Councils (2021a). Governments can best support a cost-effective transition with greenhouse gas taxes or an emissions trading system, such as the EU Emissions Trading System (ETS). Such instruments may have consequences that are relevant to include in the risk management of financial institutions. However, the alternatives are more costly and may lead to higher financial risks, see box 1.

The atmosphere and climate are global issues. International collaboration to ensure a uniform cost of emissions could therefore contribute significantly to an orderly transition. However, no proposal has received widespread support across regions to date.

If the green transition were realised with gradually increasing costs of emissions, the implications for the financial sector could be limited. Danmarks Nationalbank has previously assessed that credit institutions (banks and mortgage credit institutions) are generally well-equipped to absorb credit losses due to vulnerabilities in connection with transition-related risks for emission-intensive business customers and mortgages on low energy efficiency housing, cf. Danmarks Nationalbank (2020). The European Central Bank (ECB) has also assessed that a green transition poses an overall limited risk to banks in the euro area, cf. ECB/ESRB Project Team on climate risk (2021). However, the ECB points out that the local effects of both climate change and the green transition are concentrated in certain geographical areas and in certain industries, and may

[1] For more information, see the Executive Order on the Climate Act *(link* – only available in Danish) and the government platform from 2022 *(link* – only available in Danish).

therefore challenge credit institutions that are particularly exposed to these areas or industries.

BOX 1

Uniform tax on greenhouse gas emissions can help limit risks to financial stability in the green transition

A uniform greenhouse gas tax encourages the green transition to be realised in the most cost-effective way. Consequently, the macroeconomic consequences of the transition are also expected to be fairly limited, and for the vast majority of Danish companies, such a carbon tax will not affect profit significantly.[1] If the revenue from a tax is returned to the taxed industries, the profits of the affected companies will be shielded from the direct effects of the tax.

However, it is still relevant for financial institutions to consider the possible consequences of the tax in their risk management. Even if the revenue from a greenhouse gas tax is returned to the taxed industries, the tax will still increase costs for those companies that continue to emit high levels of greenhouse gases and correspondingly lower costs for the lower emitting companies. Such redistribution may have implications specific to individual companies that are relevant for credit institutions' management of the risk of losses on their financial claims, and therefore potentially for financial stability. Some of the companies that institutions have financial claims against may be lagging behind in the transition, and tax payments may contribute to financial challenges in these companies.

Denmark has adopted a new greenhouse gas tax and participates in the EU Emissions Trading System, ETS

A number of countries have introduced taxes on greenhouse gas emissions associated with various production processes. Such taxes are often referred to as carbon taxes as the emissions being taxed are predominantly CO_2. However, emissions of other greenhouse gases, such as nitrous oxide and methane, are also included in the tax base. The Danish Parliament has decided to phase in a new greenhouse gas tax on emissions from industry and other businesses. The tax rate will increase to kr. 750 per tonne of emissions for companies outside the EU ETS and kr. 375 per tonne for companies within the ETS. In addition, the tax rate has been reduced to kr. 100 for companies in the *mineralogical processes* industry.[2]

A higher price on greenhouse gas emissions can also be introduced by requiring the purchase of emission allowances, which authorise a given volume of emissions. The total number of quotas is determined by the authorities and the quotas can then be traded on a market *(cap-and-trade*). In 2005, the EU introduced the ETS and a number of emission-intensive Danish industries are required to purchase quotas in order to emit. The market price for emitting 1 tonne of CO_2-equivalent greenhouse gases in January 2024 was approximately kr. 520 and the Danish Energy Agency estimates that the price of quotas could rise to kr. 850 per tonne by 2030.

Tax puts a price on emissions so that the cost of emissions is internalised by producers and consumers

According to economic theory, the cost to society of greenhouse gas emissions and climate change should be reflected in the price of emitting greenhouse gases. The tax is intended to solve the economic problem that there is no market price for emissions, even though they are a nuisance to society.

A tax on emissions will make market players recognise the societal cost of these emissions and purchasing emission-intensive goods and services. This provides an economic incentive to reduce emissions where this can be done most efficiently, cf. the Danish Economic Councils (2020). An ETS can provide the same cost-effective solution as a greenhouse gas tax.

Alternative measures, such as subsidies and taxes on products and services, as well as technical requirements, are not as effective and will generally be associated with higher socio-economic costs, cf. International Monetary Fund (2019). For example, taxes on petrol and diesel cars (product taxes) can support a shift towards electric cars, but cannot support less driving and therefore energy consumption. This means that in order to achieve the same emission reductions as a greenhouse gas tax, the state will have to collect more revenue from businesses and households. The revenue consists of the total payments to the state.

Reversal of revenue can reduce the overall cost of the tax for businesses

The revenue from a new tax represents additional funding that authorities can choose how to utilise. If a tax is introduced to reduce greenhouse gas emissions, the authorities could choose to return the revenue to the taxed industry or industries. In this case, the average costs for a company in these industries will remain unchanged and the tax will only lead to a redistribution of costs between companies in the affected industries.[3]

Continues...

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[1]. See, for example, the Danish Economic Councils (2021a), the Danish Economic Councils (2021b) and Ekspertgruppen for en grøn skattereform (2022) for socio-economic analyses of uniform greenhouse gas taxes in Denmark.
[2]. Read more about the green tax agreement for industry, etc., in the relevant political agreement (*link – only available in Danish*).
[3]. The revenue can also be used in other ways to minimise any negative economic effects of the tax. Revenue from the upcoming Danish greenhouse gas tax will be used to subsidise the installation of CCS systems to capture greenhouse gas emissions from point sources. CCS is an acronym for carbon capture and storage and covers technologies where CO_2 is first captured (e.g. from a factory chimney) and then transported to underground storage.

Identification of financial risks related to climate change and green transition

The green transition requires major investment in green technology. As with other investments, the financial sector plays a crucial role in financing green investments, bearing in mind sound risk management.

A robust financial sector is therefore the starting point for the sector to support the green transition and adaptation to climate change. In light of this, it is pertinent to identify the relevant financial risks from both the green transition and climate change.

Financial institutions are at risk of incurring losses on some of their investments and lending. For example, it could be business customers in an industry with technical capabilities to reorganise existing production, but where some of the companies are unable to achieve their goals. It could also be in industries where some of the existing production needs to be reduced or reorganised.

These companies, and the capital stock they use in their production, are at risk of becoming superfluous. There is also talk of capital stock 'stranding' and losing value. Furthermore, climate change itself will cause physical destruction and have economic costs. Expectations of future climate change may also affect the value of vulnerable companies and their capital stock before the changes materialise.

In relation to the green transition, financial risks may be related to both intended consequences of cost-effective initiatives, as well as unintended and unnecessary consequences of delayed or inappropriate initiatives. For example, the introduction of a uniform tax on greenhouse gases would support a cost-effective transition, while tax payments could increase the credit risk of lending to selected business customers, see box 1. Such cost-effective measures could support a positive development in the economy at the same time as involving risks that are relevant to financial institutions. The assessments in this analysis are solely for the purpose of identifying significant financial risks and are not an expression of estimates or predictions of possible macroeconomic effects of climate change and measures to promote green transition.

Focus on risks that may materialise at credit institutions within the next 10 years

The purpose of this analysis is to present an initial identification of climate-related financial risks and an approach to assessing which ones may be the most significant. It can provide a basis for further work on assessing climate-related financial risks and for dialogue with relevant parties in the financial sector.

Based on public analyses and data from national and international authorities and Danish financial institutions, this analysis provides a list of climate-related financial risks that may be relevant in a Danish context. The contribution of this

analysis is then to map and rank these risks based on the available knowledge and a structured methodological framework. Based on this, an assessment is made of which of these risks may currently be the most significant.

Assessing the risk of events that *could* happen in the future is complex. Therefore, the assessment of the individual risks may also change over time and the ranking may look different in the future. Furthermore, risks are only identified and ranked relative to each other. An absolute assessment of how much of an impact they each have on financial stability has yet to be made. This will be included in future work.

The analysis is limited to financial risks that may materialise over the next 10 years. Further into the future, the uncertainty of whether a number of risks may materialise becomes too great to handle in the analysis. Physical climate science is characterised by, among other things, great uncertainty about the underlying physical relationships, and therefore, the long-term scenarios for the climate. This is partly due to so-called tipping points, which can abruptly and irreversibly worsen the climate impact of greenhouse gas emissions and global warming. In the very long term, it must also be assumed that the composition of institutions' exposures will be significantly different than today, which means they will be exposed to different risks than today.

There are also certain risks, or rather complexes of risks, that are not addressed in the analysis. For example, the IPCC points out that increased migration flows and geopolitical tensions over natural resources are key societal risks of climate change, cf. IPCC (2023). Climate change is expected to particularly affect societies in countries that are already fragile, for example, due to poverty or armed conflict. Many of these countries are located in arid regions around the equator, where the number of days in a year with very high temperatures is expected to increase the most, cf. Jaramillo et al. (2023). In such countries, climate change may become a catalyst for further conflict and migration. Although such events and their diverse consequences are globally highlighted as some of the greatest risks, their consequences for Danish credit institutions are considered too uncertain to be included in this analysis.

Although investment funds, insurance and pension companies are major players in the financial sector, the analysis is limited to credit institutions. For credit institutions, risks are primarily limited to credit risk (lending losses) and market risk (losses on securities). However, future analyses should also take a closer look at other financial entities and the climate-related risks they may be exposed to.

02

How can climate-related financial risks be described and assessed?

Risk is about potential and unwanted events, i.e. events that have not yet occurred. This analysis is about *climate-related financial risks,* i.e. financial risks associated with climate-related events taking place. These are events that may potentially affect the stability of the financial system *and* stem from climate change or green transition.

An example of a climate-related financial event could be a reduction in the value of real estate pledged as collateral for loans with a credit institution, for example, due to hurricanes, storm surges or stricter energy efficiency requirements for buildings.

This chapter briefly summarises the methodological approach used in this analysis to describe and assess climate-related financial risks. Appendix 2 explains the methodology and its assumptions in more detail.

Climate-related financial risks are assessed in this analysis by splitting them into three elements

Assessing the likelihood of a climate-related event materialising with consequences for the financial sector is complex. Such an assessment often involves many different contexts, about which there is currently limited knowledge available. However, in some cases, some knowledge is available about some of the sub-elements. It can therefore be beneficial to break down the probability into several individual parts.

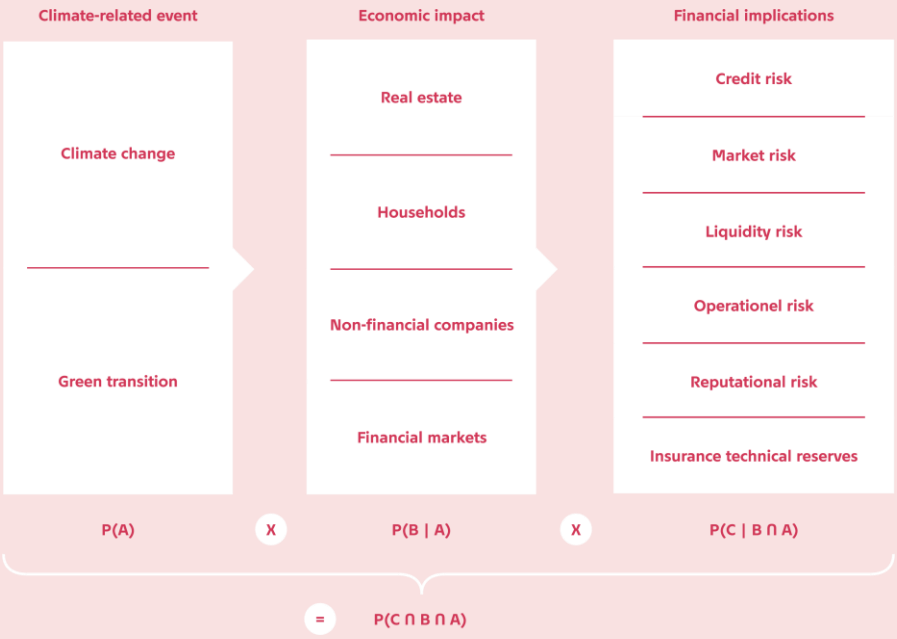
In many cases, a climate-related financial event can be viewed as a sequence of three events: A climate or transition-related event (A), an economic event (B) and a financial event (C). Economic and financial events can be viewed as consequences or implications. Chart 2 provides an overview of this three-way split.

The split into sub-events enables splitting the probability of the climate-related financial event occurring, $P(A \cap B \cap C)$. The first element is the probability of the climate or transition-related event occurring, $P(A)$. The second element is the probability of the economic impact assuming the climate/transition-related event has occurred, $P(B \mid A)$. The third element is the probability of financial implications assuming the first two events have occurred, $P(C \mid B \cap A)$.

An example of a possible climate-related financial risk is the probability of a credit institution having the value of its real estate collateral significantly reduced in the event of a hurricane. One can imagine that the probability of some buildings dropping significantly in value, given that a major hurricane has actually occurred, is high. The impairment can be due partly to the direct damage, but also expectations of further similar hurricanes in the future. Since borrowing against real estate collateral is widespread, it is also likely that a credit institution will have its collateral value reduced, given that buildings have lost value. However, since hurricanes are rare, the overall risk of a bank having the value of its collateral reduced as a result of a hurricane is modest.

CHART 1

From climate-related events to financial risks



Assessments are based on the probability of change relative to the current situation

The assessment of risks related to climate change and the green transition differs from the typical way of assessing risks in the financial sector. This is because the scale and frequency of climate-related events are changing and are expected to grow to unprecedented levels where the consequences are unknown, cf. Ingholt et al. (2021). Identifying these risks can therefore not exclusively be based on historical data, but also on more forward-looking scenarios where the probability of incidents occurring may be significantly different than today.

A climate-related risk is considered significant in this analysis if the event is expected to have a significantly greater extent in the future. Today's situation is the starting point against which future risks are assessed. The focus is on risks for credit institutions, regardless of whether the risk stems from a possible event that is favourable to the green transition or for mitigating climate change.

There is great uncertainty associated with the assessment of risks in future scenarios for climate change and the green transition

Since risk assessments are forward-looking, they are often subject to a high degree of uncertainty. A high level of uncertainty about an assessment may mean that the risk in question may later turn out to be greater than assessed.

In a number of cases, the data is insufficient for assessing the probability of the individual sub-elements. There could be several reasons for this. For some risks, there may be a lack of source material (e.g. absence of analyses or relevant data), while for other risks, sources are available, but the conclusions in the sources are indicated as being very uncertain.

Uncertainty about the individual elements determines the uncertainty in the assessment of overall probability, P(A ∩ B ∩ C). Specifically, uncertainty in assessing a risk is indicated by looking at whether the overall probability can change if the uncertain sub-elements change. When combining the individual elements this implies that even if there is great uncertainty about one of the individual elements, such as the probability of economic impact, it does not necessarily affect the overall assessment of the risk.

Expectations are often important for the economic and financial consequences

It is not always the actual physical damage associated with a climate-related event that has the greatest impact on credit institutions. Often, it is rather the expectations of future similar (or worse) events that arise as result of the event. For example, a home that has been flooded, despite relatively limited and/or fully repaired damage, can become unsellable in the worst case scenario simply due to potential buyers' concerns about future flooding, coastal protection and insurance options.[2] To limit the range of possible outcomes, we have assumed that expectations of future events only change in the wake of actual physical events.[3] This means that when we look at storm surge risks for the Danish coasts, for example, the probability of expectations of future storm surges changing is equal to the probability of a storm surge event occurring.

It is not only expectations of the physical climate event itself that have an impact on credit institutions' risks. For example, potential home buyers' expectations in relation to future climate adaptation, protection against extreme weather events and insurance options can also play an important role. So, while forward-looking expectations of the climate events themselves may already be widespread, there may also be expectations that in the future society will be able to take care of the problems, so that losses in value may be more limited.[4]

Risks are prioritised based on the probability of the climate-related financial event and the uncertainty in assessing it

For each risk, the probability of event A ∩ B ∩ C occurring over the next ten years is assessed. In the prioritisation, high uncertainty in an assessment constitutes an aggravating circumstance. The risks that are most important to analyse are those that are considered most likely to occur and those that are most uncertain.

This analysis identifies 28 climate-related financial risks. The preliminary assessment of each risk does not provide a sufficient knowledge base for determining the absolute level of probability, P(A ∩ B ∩ C). Instead, the individual risks are assessed in relation to each other.

The assessment of the probability of climate-related events is based on sources such as Technical University of Denmark (DTU), the Danish Meteorological Institute (DMI) and the Danish Energy Agency. The assessment of the economic impact and financial implications is based on existing data and calculations. To assess the probability of derived economic impact, we look at, for example, the economic size of individual industries, their energy consumption and greenhouse gas emissions. The assessment of financial implications is based on data on institutions' exposures and risks, as well as published analyses.

[2] Expectation effects can generally be of great importance if the market does not already expect such events to occur and, in other words, has not priced the risk adequately. In general, there seems to be evidence that climate-related risks are only partially priced in many financial and real assets, including real estate, cf. Egemen et al. (2022). However, there is evidence that risks associated with storm surges in Denmark are to some extent, priced in the housing market, cf. Mirone and Poeschl (2021).
[3] This assumption is supported by previous evidence that the prices of homes exposed to storm surges typically fall in the period after actual physical storm surges have occurred, cf. Mirone and Poeschl (2021). This is even true for homes in areas that have not been affected, emphasising that it is the shift in expectations that matters in terms of the decline in value.
[4] Many economic losses caused by extreme weather are already not covered by non-life insurance. However, according to the European Environment Agency (2023), in 2020 Denmark was one of the European countries with the highest proportion of events covered by insurance (56 per cent).

03
The green transition entails certain risks for credit institutions in the coming decade

This chapter presents an overview of the climate-related financial risks that have been identified, see table 1, and which of these are considered to be the most significant. Finally, the uncertainty of the assessments and the possibility of multiple risks materialising simultaneously are described. A further description of each risk can be found in the catalogue of risks in appendix 1.

Identified climate-related financial risks

In table 1, the risks are first ranked according to how great the risk is considered to be (risk assessment) and then according to how uncertain the assessments are (see the section on uncertainty later in the chapter). The biggest risks have a risk score of 1 and the smallest risks a score of 4. Where there is a particularly high level of uncertainty and a lack of source material, the assessment is marked with an asterisk (*). Risks with the same risk assessment and uncertainty are considered to have approximately the same probability of materialisation. Most climate or transition events can each lead to several different risks for the financial sector.[5] The individual risks in table 1 are listed with an ID number for reference in the following sections.

Overall, it is considered that the most significant risks to financial stability over the next 10 years are linked to the following climate or transition events (ID number in brackets):

- Prolonged periods of high electricity prices (ID 1-2)
- Higher costs of emitting greenhouse gases in Denmark (ID 3)
- Green transition abroad (ID 4-6)
- Climate change abroad (ID 7-8)
- Higher energy efficiency requirements for buildings (ID 9)
- Misleading green marketing (ID 10-12)
- Unsuccessful investments in green technologies (ID 13-14)

Nearly all of the most significant financial risks arise from initiatives related to the green transition and are, to some extent, necessary consequences of this. These can be cost-effective measures to achieve politically agreed climate targets. Such measures may also have consequences that are relevant for credit institutions to include in their risk assessment.

[5] As an example, two of the risks relating to prolonged periods of high electricity prices (losses on loans to businesses and households, respectively) rank as the two highest risks in the overview, while the third risk relating to the same event (losses on investments in corporate securities) is rated in the lowest category. This is because lending losses pose a greater risk to credit institutions, and therefore financial stability, than investment losses.

According to DMI, many of the changes in the Danish climate will not materialise until later this century. Consequently, these are generally not considered to be among the most significant risks over the next 10 years, although they may become serious in the longer term. For example, coastal flooding will reach further and further inland as sea-level rise accelerates from the second half of this century onwards.

The overview of the most significant events in the next 10 years also includes the consequences of climate change in the parts of the world that are expected to be hit the hardest in the next 10 years. Natural disasters abroad can also affect businesses in Denmark through trade patterns, value chains and migration.

TABLE 1

Climate and transition risks to financial stability in 2024-2034

ID	Climate/Transition event	Economic impact	Financial implications	Risk assessment
1	Prolonged periods of high electricity prices	Declining profits for non-financial companies with high electricity consumption	Credit institution losses on lending to businesses and households	1
2		Financial stress on households with high electricity consumption		2
3	Higher costs of emitting greenhouse gases in Denmark	Declining profits for non-financial companies that emit large amounts of greenhouse gases	Credit institution losses on lending to emission-intensive customers	2
4	Transition abroad*	Declining profits for non-financial companies that are closely linked to international value chains*	Credit institutions lose on lending	2*
5			Credit institution losses on securities	3*
6		Falling value of real estate used as collateral for corporate lending*	Credit institution losses on lending collateralised by corporate assets	3*
7	Climate change abroad	Declining profits for non-financial companies that are closely linked to international value chains*	Credit institution losses on lending	2*
8		Falling value of real estate used as collateral for corporate lending*	Credit institutions losses on securities	3
9	Higher energy efficiency requirements	Decreasing value of buildings with low energy efficiency	Credit institution losses on mortgages and housing loans	3*
10	Misleading green marketing		Credit institutions suffer reputational loss*	4*
11			Credit institution losses on lending*	4*
12			Credit institution losses on securities*	4*
13	Unsuccessful investments in green technologies*	Declining profits for green technology non-financial companies*	Credit institution losses on lending*	4*
14			Credit institution losses on securities*	4*
15	Critical minerals*	Declining profits for green technology non-financial companies*	Credit institution losses on lending to new green projects	4*
16			Credit institution losses on securities	4
17	Higher costs of emitting greenhouse gases in Denmark	Financial stress on households*	Credit institution losses on lending to households	4*
18		Declining profits for non-financial companies that emit large amounts of greenhouse gases*	Credit institution losses on securities	4
19	More violent storm surges in Denmark	Declining profits for some non-financial companies	Credit institution losses on lending to land-intensive industries (e.g. agriculture)	4
20		Falling real estate values	Credit institution losses on mortgages and housing loans	4
21	Major flooding due to extreme rainfall in Denmark	Declining profits for some non-financial companies	Credit institution losses on lending to land-intensive industries (e.g. agriculture)	4
22		Falling real estate values	Credit institution losses on mortgages and housing loans	4
23	Drought periods in Denmark	Declining profits for some non-financial companies	Credit institution losses on lending to land-intensive industries (e.g. agriculture)	4

Continues ...

... continued

24	Rising groundwater levels in Denmark	Falling real estate values	Credit institution losses on mortgages and housing loans	4
25	More violent storms and hurricanes in Denmark	Falling real estate values	Credit institution losses on mortgages and housing loans	4
26	Climate change abroad	Declining profits for companies that are closely linked to international value chains*	Credit institution losses on securities	4
27	Prolonged periods of high electricity prices	Declining profits for non-financial companies with high electricity consumption*	Credit institution losses on securities	4
28	Higher energy efficiency requirements	Decreasing value of buildings with low energy efficiency	Credit institution losses on securities*	4

Note: 28 climate-related financial risks are addressed in this analysis. The risks are first categorised according to the assessment of their significance to financial stability and then the uncertainty of that assessment. Where there is a particularly high level of uncertainty and a lack of source material, the assessment is marked with an asterisk (*). The scale is an ordinal scale, which means that only the order or ranking of the risks is meaningful, while the scale does not say anything about the absolute level. The bold line indicates that risks 1-14 are considered to be the most significant risks. Probabilities and uncertainties are based on the assessments in the last column of tables 2-7 in appendix 1.

Prolonged periods of high electricity prices may increase the risk on credit to businesses and households (ID 1-2)

An important element of the green transition is the electrification of energy consumption and that electricity production is increasingly based on renewable energy sources such as wind, water and solar. This may lead to greater fluctuations in electricity prices, increasing the probability that electricity prices may remain high for a longer period of time. This could affect the profits of electricity-intensive companies in particular, and to a lesser extent the rest of the business community and households. Insofar as credit institutions' customers become less financially robust as a result, this may lead to losses for credit institutions both on lending to households and the affected companies and on securities issued by the latter.

Long-term fluctuations in electricity prices may be due to the fact that electricity production is increasingly dependent on weather conditions. In 2022, a dry and windless summer led to lower European electricity production from hydropower and wind turbines, as well as problems with water cooling of nuclear power plants and transporting coal to power plants.

Fluctuations in fossil fuel prices may also continue to contribute to fluctuations in the electricity market. Today, the marginal generation unit in the electricity market is often based on natural gas, and fossil fuels will continue to play a significant role in electricity generation in Europe for years to come. As renewable electricity production in 2022 was lower than normal, gas-based electricity production had to take over. The price of electricity subsequently increased as gas prices were very high due to Russia's invasion of Ukraine. Going forward, the reduction in the number of emission allowances may contribute to rising fossil fuel prices in the EU.

Finally, challenges related to the expansion of the European energy system may also affect prices over longer periods of time. For example, a delay in new offshore wind and solar farms may reduce the expansion of electricity production and lead to higher electricity prices.

Some institutions' business customers have to pay a larger share of the cost of their emissions (ID 3)

The transition of business and industry could be supported by measures that increase its cost of continued emissions. These may include new and/or stricter greenhouse gas taxes and emission allowances that increase the price of emissions, as well as other taxes and stricter technical standards.

In particular, sea transport, aviation, agriculture and horticulture, as well as the concrete industry and brickworks, currently emit large amounts of greenhouse gases. The existing capital stock of emission-intensive companies is in danger of 'stranding', i.e. falling in value. The loss in value is due to an expectation that the capital stock cannot be utilised profitably or sold for other purposes in the future. If credit institutions have a lien on such assets, their credit risk may increase.

The EU has already agreed to a gradual reduction in the number of emission quotas for companies participating in the ETS, and all quotas are currently planned to be phased out by 2045. Denmark has also adopted a tax on greenhouse gas emissions for industrial companies from 2030, and an expert group has recently published a report on a tax on emissions from agriculture and transport. Due to large loans to the agricultural sector, credit institutions already have a significant credit risk with emission-intensive companies.

The above types of measures are the most cost-effective. If they are not phased in, alternative measures such as subsidies, other taxes and technical standards will be used to reduce emissions from business activities. If so, the societal costs of the transition, and the potential for financial risks, will increase. For example, the energy sector is to some extent regulated through such measures, and the expansion of renewables has previously been driven by subsidies. Subsidies will not initially affect company finances. However, through the financing of subsidies, e.g through distortionary taxes and duties, this can also indirectly increase companies' costs.

Green transition abroad may rub off on Danish credit institutions (ID 4-6)

A large part of Danish business and industry is connected to foreign companies through trade patterns and global value chains. Just as the green transition in Denmark can affect credit institutions and their customers, the transition in other countries can also have indirect consequences for them.

There is currently no international collaboration to ensure consistent costs of emissions across countries. Standardising the cost of emissions across countries would support a cost-effective transition and international trade. In the absence of international collaboration, the transition becomes less orderly and Danish companies have to navigate different approaches in different countries. Some countries are making greater use of subsidies and government support to promote the green transition, which may challenge the position of some Danish companies in certain markets. As value chains often cross several national borders, it is not only the transition in Denmark's largest trading countries, such as Germany, the US, Sweden and the UK, that matters, but also in countries further down the chains.

Credit institutions have large-scale corporate lending that may be affected by the transition abroad in these ways. For example, the energy supply and agriculture industries are highly export and/or import-orientated, while also having relatively large loans with Danish banks. Furthermore, some institutions are exposed to foreign transition risks as a result of lending collateralised by foreign assets used in oil and gas extraction and related industries.

Climate change abroad may affect institutions' Danish business customers via global value chains (ID 7-8)

In many countries, climate change is already having a significant economic impact due to the devastation caused by extreme weather events. The summer of 2023 was the hottest ever in the northern hemisphere, with wildfires spreading across large areas in places like Greece and Canada, while Italy and Norway experienced widespread flooding. Over the next 10 years, the consequences are expected to worsen in many parts of the globe, cf. UN Intergovernmental Panel on Climate Change (2023). In countries that are already fragile, for example, due to poverty or armed conflict, climate change may be a catalyst for both new conflicts and increased migration flows, cf. Jaramillo et al. (2023).

As is the case with the green transition, climate-related events abroad may also negatively impact Danish companies' profits via international trade and production links. This may lead to increased credit risk for these institutions.

Higher energy efficiency requirements for buildings may reduce the value of collateral behind some housing loans (ID 9)

Energy efficiency improvements can help reduce emissions in Denmark without the use of new technology. Among other things, there is continued potential for energy renovations of the building stock, where a large part of the energy consumption takes place. The European Commission has a goal for EU building stock to be carbon neutral by 2050, and has initially proposed national requirements for energy improvements in buildings with the lowest energy labels by 2033. It is also likely that additional requirements will come into force over time.

However, in many cases, energy renovations of buildings can pay for themselves through lower energy bills. If owners have access to financing to carry out the profitable renovations, additional energy renovation requirements are not expected to negatively impact the market price. However, in other cases where energy renovations are not economically viable and/or the owner does not have access to sufficient financing, there is some risk that increased requirements could put downward pressure on market prices.

New national requirements from the EU must be implemented into Danish law. The extent to which the requirements may affect the market value of some buildings depends on the actual implementation of the stricter technical standards for buildings. In the event that the implementation is done by ordering the individual owner to carry out the necessary renovations at their own expense, it must be assumed that until the renovations are completed, the market price of the real estate may decrease by the total cost of the necessary renovations. However, implementation can probably be supported by subsidies, for example, in the form of new and/or expanded grant schemes.

The value of buildings is the collateral behind a large part of credit institutions' lending, and if this falls in value, it increases the institutions' credit risk. Stakeholders' expectations of rising energy costs and requirements for energy efficiency in buildings may result in value reductions on some buildings even before the measures are implemented.

Misleading green marketing may damage the reputation of credit institutions (ID 10-12)

Credit institutions and other financial companies have developed a raft of new financial services that integrate sustainability and green transition goals into traditional services, such as lending and investment products, in different ways. Such goals to contribute to sustainable development entail risks for institutions if

they are not met. If so, this is misleading green marketing – also known as *greenwashing*.

The most significant risk associated with misleading green marketing is damage to an institution's reputation. Materialisation of reputational risks can have major economic consequences in terms of increased costs and/or loss of profits. In the past, cases of money laundering have weakened the reputation of some Danish institutions and had significant economic impact. Sustainability is still a relatively new area for credit institutions, and while the demand for green services is growing, the data to ensure compliance with green guarantees is still lacking.

Financing unsuccessful investments in green technologies may create risks for institutions (ID 13-14)

The green transition involves major investment projects in areas such as energy. In Denmark, investments in renewable energy sources and infrastructure based on new technology are planned to ensure a multiplication of green electricity production. However, there are several technical aspects of the expansion that have yet to be fully clarified. In addition, the return on projects is sensitive to future changes in government subsidies and taxes.

As with investments in other emerging technologies, there is a risk that investments in these technologies may not yield the expected returns**.** This may be because the technologies are not immediately scalable to a commercial level, because international competition will be fierce, or because there will be a lack of capacity, for example, in the form of qualified labour, to carry out projects as planned.

If the major investments in the energy system turn out to be less profitable than expected, the value of the investments may fall and it may become more difficult for investors to maintain high credit standards. It's worth noting that this risk is largely related to loan portfolios that could grow large in the coming years, but are still limited for now.

Uncertainty about the financial implications of a climate event constitutes an aggravating factor

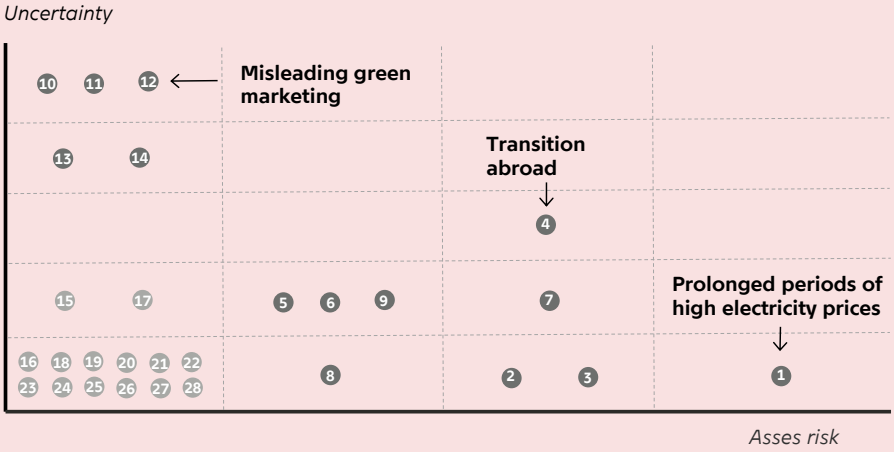
The actual work with the risk assessments in this analysis has in many cases been subject to great uncertainty. Uncertainty may be due to a lack of detailed knowledge about the climate-related event, for example, or because the existing sources point to a high degree of uncertainty in the conclusions.

In most cases, however, this is because there is no basis for assessing the economic impact of an event. For example, there is not a sufficient knowledge base to assess the extent to which international companies' real estate may strand as a result of initiatives in the green transition. In some cases, there is also uncertainty about the size of credit institutions' exposure to certain activities. This applies, for example, to the major investment projects in the Danish energy sector that will be realised in the coming years.

19 of the 28 risks are placed in the category with the lowest risk rating based on best judgement and estimates, see chart 2. However, five of these risks are still labelled as some of the most important climate-related financial risks to further work on understanding better. This is because high uncertainty about the assessments constitutes an aggravating circumstance. The categorisation of the most significant and other risks reflects the risks above and below the horizontal line in table 1.

CHART 2

Some risks can be assessed with relative certainty, while other assessments are more uncertain



Note: The X-axis indicates how highly a climate-related financial risk is rated with a score from 1-4 (see chapter 2 and appendix 2). The ranking is ordinal, which means that only the order or reciprocal ranking of the risks is meaningful, while the scale does not say anything about the absolute level. The Y-axis indicates the level of uncertainty in the risk assessment (see chapter 2 and the introduction in appendix 1). If the assessment is uncertain, which means that the risk may be higher or lower than estimated, the risk is placed further up the y-axis. Risks in the first category are rated as not being able to be higher, while risks in the second category are rated as being able to increase one score, and so on. The number in each circle indicates the ID of the given risk. For the risks that are considered most significant, the circle is dark grey, while the other circles are light grey.

Interplay between risks may exacerbate the consequences for credit institutions

In this analysis, climate-related risks have been assessed individually. This means that the potential materialisation of each risk is assessed based on the assumption that one risk materialises at a time. For some risks, however, it is possible that they occur simultaneously with others. Simultaneity is thus an amplifying risk factor because the financial consequences of the individual risks are 'added up'. When a number of risks are combined, the result can be referred to as a so-called composite risk.

Simultaneity of risks can occur in several ways. For example, transition-related events can happen simultaneously if several emission reduction measures clump together towards the same 'deadline' linked to a climate target, e.g. 2030.

Certain industries are particularly vulnerable to simultaneous risks. Agriculture, for example, can be affected by simultaneous climate events. The industry is vulnerable to prolonged droughts, for instance. The summer of 2022 showed that drought in the rest of Europe could drive up electricity prices, which will also affect agricultural profits, as the industry's production is electricity-intensive. Agriculture also emits relatively large amounts of greenhouse gases, and a tax on its emissions could lead to structural adjustments in the industry. Furthermore, agriculture is already highly indebted, and some credit institutions have a significant credit risk as a result of their lending to the industry, cf. Danmarks Nationalbank (2018).

Moreover, individual consequences can be amplified by the interaction of risks that materialise simultaneously. Technologies such as PtX and CCS/CCU, for

example, may prove less efficient and/or difficult to utilise on a larger commercial scale. This in itself may pose a risk to credit institutions that have loans to and securities in companies that produce and sell such technologies. However, if these technologies prove insufficient to reduce emissions, other measures, such as taxes on greenhouse gas emissions or energy efficiency requirements, may need to be adjusted. In this way, risks are amplified through their interconnectedness.

04

Credit institutions must include the most relevant climate-related risks in their risk management

It is the individual institutions in the financial sector that are responsible for managing the relevant risks they face. This also applies to climate-related financial risks. Institutions should therefore include relevant climate risks in their risk management. Climate-related risks will eventually materialise in the form of the classic types of financial risks that the sector is already familiar with, such as credit and market risk.

The largest Danish credit institutions are building competences and data to assess climate-related risks. With this in mind, they have already identified some of the risks highlighted in this analysis. In addition, all of the largest institutions have published estimates of the emissions that their loans and investments help to finance, and they have all announced more or less specific targets for reductions in their own emissions and the emissions they finance.[6]

Climate-related risks require institutions to expand their risk management

Financial institutions' management of traditional risks is based on historical experience and data. How have risks materialised in the past and could similar risks occur in the future? If the underlying economic and financial mechanisms are stable, institutions can quantify future risks based on historical data.[7] This means that they can make useful estimates of, for example, the size and likelihood of a potential future loss.

Climate-related risks are not new as such. Financial institutions have suffered losses from natural disasters before, and in 2022 they experienced the consequences of rapidly rising energy prices. However, the scale and frequency of climate-related events are changing, and they are expected to become more frequent and severe, which means that previous experience and data cannot be used as the only source when managing risks. This also requires the use of tools such as model-based scenario analyses and plans for the institutions' transition.

Climate-related risks fall within already well-known risk categories

While credit institutions have to deal with extreme weather events or changes in energy systems to a greater extent than before, the potential consequences are more familiar to institutions. Once climate-related risks have been identified and assessed, it will often be well known how financial institutions can mitigate their impact. For example, a bank with housing loans in an area at risk of storm surge can limit lending collateralised by exposed properties, charge higher interest rates, allocate impairment charges for expected future losses or increase the

[6] In early 2022, the European Banking Authority (EBA), set out the first binding reporting requirements on the climate-related risks of major banks. In their reporting, banks must report a number of key figures in the best possible way – including their own emissions and the emissions they finance. Medium-sized banks are expected to eventually be subject to the same reporting on an annual basis.
[7] For instance, banks must use the standards from the Basel Committee to calculate their risk-weighted exposures, which determine how much equity they need to build up, cf. Basel Committee (2017).

capital tied up behind the loans to cover unexpected losses in the future, cf. Poeschl (2022).

Risks are incorporated into supervisory requirements for credit institutions' resilience

The Danish authorities' requirements for credit institutions and their robustness are based on a number of international standards. These include the so-called microprudential regulatory pillars. Pillar 1 contains minimum capitalisation requirements for all institutions, Pillar 2 contains additional institution-specific requirements and Pillar 3 contains public reporting requirements.

The Basel Committee, which developed the international standards behind the regulation, believes that the standards can also be applied to climate-related risks. The climate-related financial risks can be accommodated within the existing pillars of bank regulation, and in 2022 the Committee published a set of principles on how credit institutions should do this, cf. Basel Committee (2022). The EBA also considers that the Pillar 1 requirements for European credit institutions already contain elements that can capture some of the climate-related risks and can be complemented by forward-looking methodologies in the Pillar 2 institution-specific assessment (European Banking Authority, 2023). In addition, they point out that the focus should be on climate risks in supervisory practices and more and better reporting by institutions. A number of reporting requirements have been implemented in the EU and more are on the way. For example, the so-called disclosure regulation requires that a range of information on climate and sustainability must be published for investment products offered by financial institutions.

The EU is also looking at whether macroprudential measures may be relevant to limit the climate-related risks of financial companies. Macroprudential measures aim to limit systemic risks in the financial system as a whole, and therefore, focus on the overall financial system and its interaction with the economy. Specific macroprudential measures can be either capital-based, for example, systemic capital buffer, or borrower-oriented, for instance, rules for maximum loan-to-value ratio or debt-to-income ratio. The European Systemic Risk Board (ESRB) has identified the macroprudential instruments that may be available to mitigate climate-related financial risks, cf. ECB/ESRB Project Team on climate risk (2023). For example, the Board mentions sector-specific systemic risk buffers as a measure that, with a few adjustments, could be used to limit institutions' exposures to physical risks in certain geographical areas and/or in relation to emissions-intensive industries.

Appendices

Appendix 1:
Risk catalogue

This appendix contains a catalogue of the identified risks and the analyses that form the basis for the prioritisation of risks in chapter 3. The 28 individual risks are summarised in the following six groupings of climate-related events, where numbers in brackets refer to risks in table 1:

- Prolonged periods of high electricity prices (ID 1-2, 27)
- Higher costs of emitting greenhouse gases in Denmark (ID 3, 17-18)
- Climate change and green transition abroad (ID 4-8, 15-16, 26)
- Higher energy efficiency requirements for buildings (ID 9, 28)
- Misleading green marketing (ID 10-12)
- Unsuccessful investments in green technologies (ID 13-14)
- Climate change in Denmark (ID 19-25)

Chart 3 identifies the 28 risks. For each of the climate and transition-related events, the probability of the event having economic consequences for some businesses or households is assessed through at least one of three main channels: companies' profits, real estate values and financial stress on household finances. Events can often impact through more than one channel and different events can also affect credit institutions through the same economic channel. The analyses focus on three main types of risks for credit institutions: credit risk, market risk and reputational risk. For a more detailed description of the approach to analysing the individual risks, see box 2 and chapter 2.

BOX 2

Catalogue of climate-related financial risks – here's how we did it

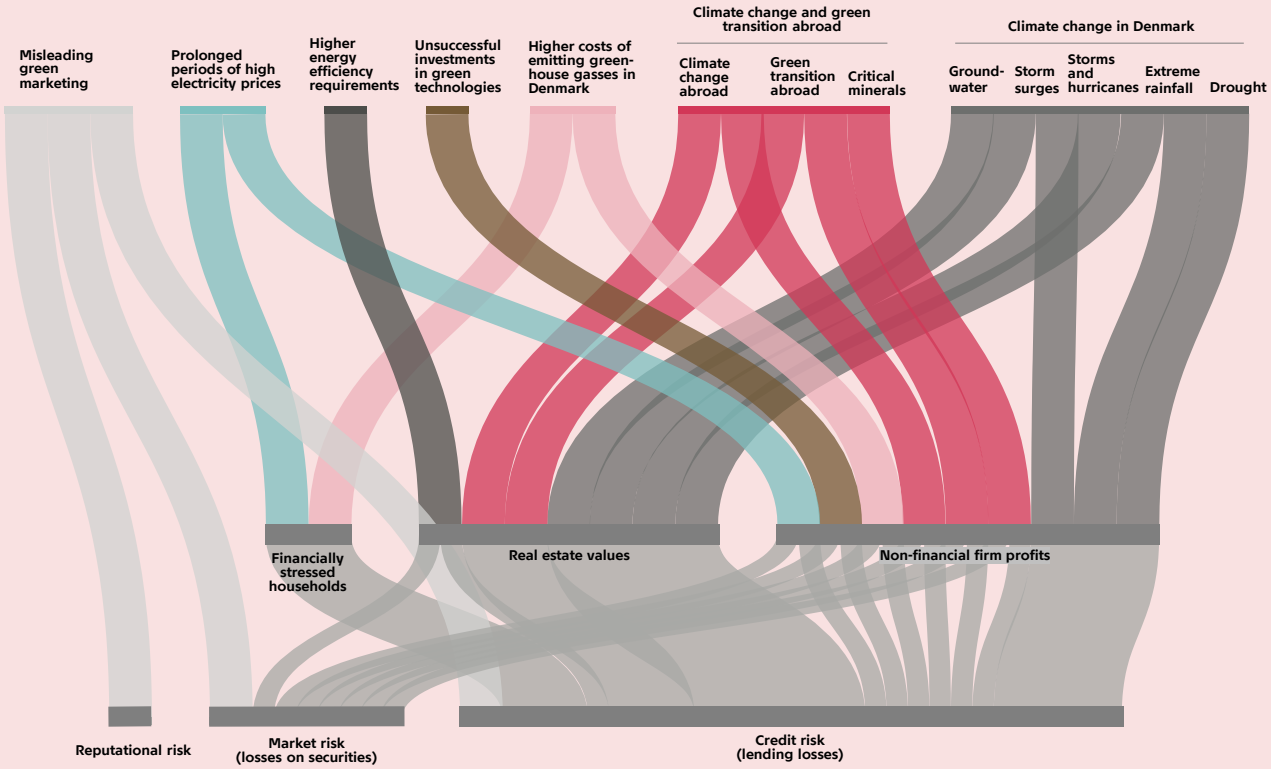
The probability of each of the climate-related events occurring with the mentioned economic and financial consequences is assessed in the following sections. The assessed probabilities are all stated qualitatively on a 5-point scale from *lowest* to *highest*. Each section first describes the climate-related events (A) and the probability of them materialising within the next 10 years. Then the economic impact (B) and its conditional probability of occurring are described, assuming that the climate-related event has occurred. Finally, the financial implications (C) and their conditional probabilities are described, given that both the climate-related and economic events have occurred. The product of the assessed probabilities from the three sub-elements together gives the probability that the climate-related financial risk will materialise and is the basis for the assessment of the individual risks in table 1. This product is described in the conclusion of each section.

The assessed probabilities are best estimates, but may be subject to a high degree of uncertainty. In the following sections, the sub-elements, i.e. the assessed probabilities P(A), P(B I A) and P(C I A ∩ B), for which there is the greatest uncertainty are marked with an asterisk (*). All three sub-elements of an identified risk can potentially be marked as uncertain. Uncertainty about the probability of the overall climate-related event follows from the uncertainty about the sub-elements. The overall probability is marked as uncertain if the product of the three probabilities is considered to be subject to change due to uncertainty about the sub-elements.

See chapter 2 and appendix 2 for more information on the methodology and assumptions used.

CHART 3

Identifying climate-related events and their transmission to the economy and credit institutions



Note: Illustration of the 'paths' that begin from a climate/transition-related event and end in a type of financial risk (credit, market or reputational risk). 28 paths corresponding to the 28 climate-related financial risks are analysed in the following sections. With the exception of misleading green marketing, the paths go through economic consequences for businesses or households. The colours of climate events indicate the groupings in the following sections.

Prolonged periods of high electricity prices

(ID 1-2, 27)

The transition from fossil-based energy sources to electricity based on renewable energy sources is an important part of the green transition. The transition will likely mean greater short-term fluctuations in electricity prices that reflect variation in solar and wind. However, there is also a risk that it could lead to more prolonged periods of high prices. Prolonged periods of high energy prices increase energy costs for many businesses and households, which may materialise as an increased risk of losses on credit institutions' lending and investments.

The possible events associated with prolonged periods of high electricity prices and the assessment of the probability of their materialisation are described below. A summary can be seen in table 2.

TABLE 2

Risks of prolonged periods of high electricity prices

ID	Climate-related event (A)	Economic impact (B)	Financial implications (C)	Probability of climate-related event P(A)	Probability of economic impact P(B I A)	Probability of financial implications P(C I A∩B)	Probability of a climate-related financial event P(A∩B∩C)
1	Prolonged periods of high electricity prices	Declining profits in trades and industries	Credit risk (lending losses)				
2		Financially stressed households					
27		Declining profits in trades and industries	Market risk (loss on securities)		*		

Highest | Second highest | Moderate | Second lowest | Lowest

Note: P(A) indicates the probability of the climate-related event materialising over the next 10 years. P(BIA) indicates the conditional probability of a significant economic impact, B, given that climate event A has occurred. P(C | B ∩ A) indicates the conditional probability of a significant financial consequence given A and B. See chapter 4 and appendix 2 for the approach to assessing climate-related financial risks. An asterisk * indicates high uncertainty about the assessed probability.

Climate-related event (A)

Since the early 1990s and until 2021, European electricity production has become more dependent on imported natural gas. This is part of a political desire to phase out coal and oil-based production and reduce the extraction of fossil fuels in Europe. When production from wind and solar energy is low in the current system or overall demand is high, the price of natural gas in particular determines the electricity price, as gas-fired power plants often represent the marginal production capacity in the grid, cf. Branner and Ingholt (2023).

Russia's war of aggression against Ukraine and subsequent European sanctions against Russia have led to a reduction in Russia's natural gas exports to Europe. A drop in the supply of natural gas caused prices to rise in 2022 and resulted in high electricity prices in the European market. Subsequently, the supply disruption has been partially offset by increased imports of liquefied natural gas (LNG) from the US and Qatar, among others, as well as measures to limit gas consumption in Europe.

The price of electricity based on gas and other fossil fuels has also increased due to higher market prices for emission allowances in the ETS. Taxes on emissions from fossil fuel-based energy production are expected to increase over the next ten years, which can contribute to higher electricity prices during periods when these sources are crucial to price formation in the electricity market.

In the long term, the expansion of renewable energy is expected to reduce the dependence on natural gas in the European electricity market. In Energinet's latest calculations, their main scenario is a decrease in the average annual electricity price up to 2030 from a still high level after Russia's invasion of Ukraine, see Energinet (2023). However, the level will remain higher than in the years leading up to 2021.

Increasing dependency on wind and solar energy can increase the risk of electricity production not being able to cover consumption during periods of unfavourable weather conditions, i.e. especially cold weather when the sun is not shining and the wind is not blowing, and when electricity consumption for heating is high. During such periods, electricity prices can rise significantly. The ability to import power produced in the rest of Europe is determined by the capacity of the connections to our neighbouring countries. Capacity can be

utilised during periods of both high domestic consumption and low domestic production of renewable energy.

Short-term price fluctuations are not a significant problem for businesses and households. Weather fluctuations can also potentially be present for longer periods of time. This happened, for example, during the summer of 2021, when drought and lack of wind affected production based on hydropower and wind turbines. In addition, heat and drought also affected the ability to cool nuclear power plants and transport coal to other power plants. Energinet found that the average electricity price in 2030 will be more than twice as high in an unfavourable weather year as in a favourable one, cf. Energinet (2023).

Electricity prices can also be affected over longer periods of time by challenges related to the green transition. Business organisation Green Power Denmark estimates that a delay in new renewable production plants[8] could reduce the expansion of electricity production sufficiently to increase the electricity price throughout the entire period of transition of the energy sector, cf. Green Power Denmark (2023).

Based on the above, the probability that prolonged periods of high electricity prices will occur during the period 2023-2033 is rated in the *highest* category of the events identified in this analysis.

Economic impact (B)

Prolonged periods of high electricity prices result in higher costs for many industries and businesses and can lead to a *decline in companies' profits*.

Access to large amounts of power is important for a wide range of Danish businesses and industries. The most electricity-intensive industries are oil refineries, retail and agriculture, see chart 4. These industries generally represent a limited part of the total value creation in the business world. In addition, companies in the mineralogical processes industry and the transport sector currently have a significant consumption of fossil fuels, which may be converted to some extent to electricity-based energy over the next few years.

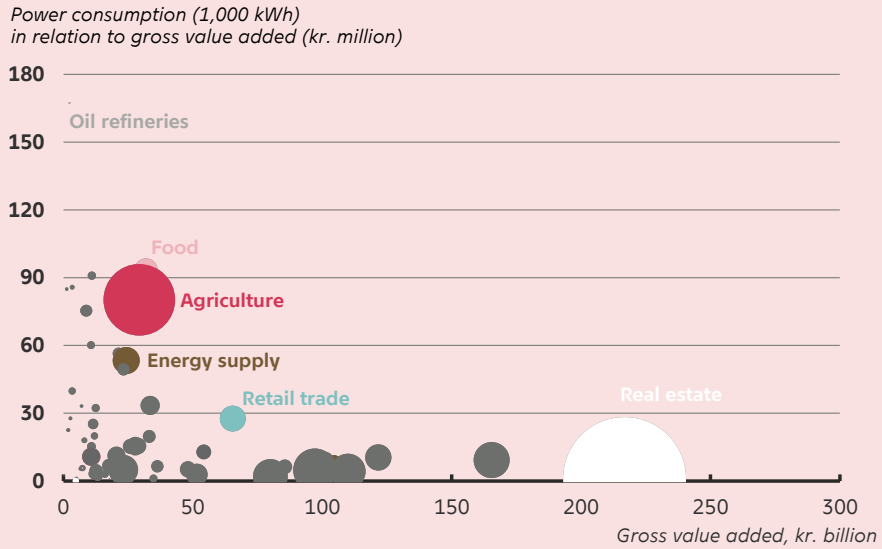
Danmarks Nationalbank has previously found that the war in Ukraine and the dry summer in 2022 had a negative impact on the profits for many companies due to rising energy and commodity prices, cf. Danmarks Nationalbank (2022). During this period, some farms and fishing companies chose to limit or stop their activities as costs outweighed expected profit.

Overall, we rate the probability of a decline in some businesses' and industries' profits due to prolonged periods of high electricity prices as one of the *highest of* the climate-related financial risks in this analysis.

[8] In Green Power Denmark's scenario, all offshore wind installations are delayed by 2.5 years, while the delay is one year for onshore wind and solar PV installations. At the same time, the increase in demand for electricity, especially in relation to PtX capacity expansion, continues as expected.

CHART 4

Several Danish industries have high power consumption



Note: Danish non-financial industries broken down by power consumption (1,000 kWh) per GVA (kr. million), industry GVA (kr. billion) and Danish credit institutions' lending and credit institutions' exposures in the industries (size of bubble). Data for power consumption and GVA is for 2021, while credit institution exposures are from the end of December 2023.
Source: Danmarks Nationalbank, Statistics Denmark and own calculations.

Higher electricity bills can also put a *strain on some households' finances*. An analysis by the business organisation Finans Danmark estimates that two out of three Danish families were facing a significant additional bill as a result of higher energy prices, as well as interest rate increases in 2022, cf. Finans Danmark (2023). This was especially true for families who had both an expensive heating source and high interest rates on their variable rate mortgages. Based on the above, the probability of a significant decrease in households' disposable income during the period 2023-2033 is rated in the *second highest* category compared to the other climate-related risks.

Financial implications (C)

Declining company profits and financial pressure in some households may increase credit institutions' *credit risk* on lending to them. Some institutions' lending is to companies in industries with high electricity intensity. The 25 per cent most electricity-intensive industries account for almost 22 per cent of credit institutions' lending to non-financial companies. Danmarks Nationalbank has previously found that some of these companies have a lower debt servicing capacity when interest rates, energy and commodity prices rise, cf. Danmarks Nationalbank (2022). On this basis, the probability that the credit quality of these could be weakened if energy prices rise is placed in the *highest* category of climate-related financial risks.

Danmarks Nationalbank also pointed to a relatively high probability that the creditworthiness of households could be significantly worsened by rising energy costs.

Institutions' investments in securities issued by energy-intensive companies – both domestic and foreign – may also lose value as a result of higher energy

prices. Sufficient source material is not available for a full assessment of this risk. However, the best estimate is that the probability of a significant increase in the sector's *market risk* is in the *second lowest* category. There is uncertainty about the economic impact due to a lack of source material, but this is not considered to affect the overall assessment of the risk.

Conclusion

The risk due to prolonged periods of high electricity prices is assessed to be relevant for credit institutions' credit management. The risk of increased credit risk due to declining profits for some businesses (product of the three sub-elements) is rated in the *second highest* category. This is partly due to a relatively high probability that the price of electricity will rise, but also because if this happens, it is very likely that it will have both significant economic and financial consequences.

Higher costs of emitting greenhouse gases in Denmark

(ID 3, 17-18)

Taxes on greenhouse gas emissions and emission allowances should be central elements of the green transition, so that emitters are more likely to pay for the costs that their emissions cause to society.

This section describes the possible events related to higher costs of greenhouse gas emissions and the assessment of the probability of their materialisation. A graphical summary can be seen in table 3.

TABLE 3

Risks of a higher price on greenhouse gas emissions in Denmark

ID	Climate-related event (A)	Economic impact (B)	Financial implications (C)	Probability of climate-related event P(A)	Probability of economic impact P(B I A)	Probability of financial implications P(C I A∩B)	Probability of a climate-related financial event P(A∩B∩C)
3	Higher costs of emissions in Denmark	Declining profits in trades and industries	Credit risk (lending losses)				
17		Financially stressed households			*		*
18		Declining profits in trades and industries	Market risk (loss on securities)		*		

Highest	Second highest	Moderate	Second lowest	Lowest

Note: P(A) indicates the probability of the climate-related event materialising over the next 10 years. P(BIA) indicates the conditional probability of a significant economic impact, B, given that climate event A has occurred. P(C | B ∩ A) indicates the conditional probability of a significant financial consequence given A and B. See chapter 4 and appendix 2 for the approach to assessing climate-related financial risks. An asterisk * indicates high uncertainty about the assessed probability.

Climate-related event (A)

The transition of trades and industries could be supported by measures that increase its cost of continued emissions. These include new and/or stricter greenhouse gas taxes and emission quotas that increase the price of emissions, as well as other taxes and stricter technical standards.

The probability of companies having to pay a larger share of the social costs of their emissions is categorised as the *highest* compared to the other climate-related risks. This is because specific actions have already been taken and more are on the way.

Most large emission-intensive companies are already required to purchase emission quotas. In 2022, the European Council and the European Parliament reached an agreement to gradually reduce the number of emission quotas, phase out free quotas and include power plants and shipping in the ETS.[9] In addition, a new emissions trading system was created for emissions from the construction sector and road transport. The market price for emitting one tonne of CO_2-equivalent greenhouse gases has increased significantly in recent years, and was around kr. 520 at the beginning of January 2024 compared to around kr. 150 at the end of 2020. The Danish Energy Agency estimates that the price of quotas in 2030 could rise to kr. 850 per tonne of CO_2-equivalent greenhouse gases emitted, cf. Danish Energy Agency (2022c).

In addition, last year the Danish Parliament passed a tax on emissions from industrial companies, etc., to be implemented in 2027-2030.[10] The tax rate will increase to kr. 750 per tonne of emissions for non-ETS companies and kr. 375 per tonne for ETS companies. Furthermore, the tax to reduce so-called leakage has been reduced to kr. 100 for companies working with activities in the mineralogical processes industry, cf. Expert Group for a Green Tax Reform (2022). Leakage is when activities and their associated emissions move abroad due to higher costs. The revenue from the tax is used mainly for a subsidy

[9] The agreement includes one-off reductions in the number of quotas in 2024 and 2026, and an annual reduction in quotas of 4.3 per cent in 2024-27, and 4.4 per cent in 2028-30. The agreement also includes a new separate ETS for road transport and heating of buildings. The ETS sets the rules for greenhouse gas emissions in the EU and already covers around 40 per cent of greenhouse gas emissions. Find out more about the ETS (*link*).
[10] Read more about the green tax agreement for industry, etc., in the political agreement (*link* – only available in Danish).

programme for the establishment of CCS plants at point sources with particularly high emissions. This means that the revenue is used to reduce emissions, and thus tax payments, for some of the companies with high emissions.

In February 2024, the expert group presented proposals for a carbon tax for agricultural businesses, which can form the basis for political negotiations on a tax later in the year.[11]

Economic impact (B)

Higher costs of emitting can either be the result of market economy incentive to reduce emissions or from imposing new technical requirements to certain activities and processes. This could lead to higher costs for businesses and households that fail to convert their activities.

A uniform greenhouse gas tax encourages the green transition to be realised in the most cost-effective way. The macroeconomic consequences of the transition are therefore expected to be quite limited, and for the vast majority of Danish companies, such a tax will not affect profits significantly. If the revenue from a tax is returned to the taxed industries, the profits of the affected companies will on average not be negatively impacted. Alternative instruments, such as other types of taxes and stricter technical standards, are more costly to implement.

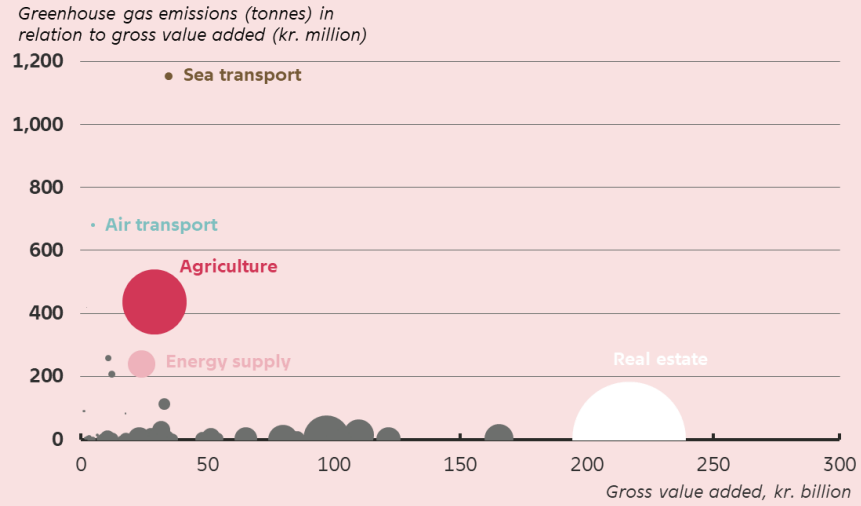
However, it is still relevant for financial institutions to include possible economic consequences of greenhouse gas taxes, for example, in their risk management. The tax may lead to a redistribution within the taxed industries and have negative company-specific consequences in emission-intensive industries, see chart 5. Activities within maritime and air transport, agriculture and energy supply account for a significant part of industries' total emissions in Denmark.

The Expert Group for a Green Tax Reform has assessed that the upcoming tax for industrial companies, etc., will increase costs for fisheries and refineries, for example, and lead to some shutdowns of production and/or relocations in certain industries, cf. Danish Expert Group for a Green Tax Reform (2022).

[11] Read more about the expert group's work and terms of reference here (*link* – only available in Danish). The expert group's second interim report on, inter alia, agricultural emissions has been delayed and is expected to be published early in 2024.

CHART 5

Some industries emit large amounts of greenhouse gases



Note: Danish non-financial industries broken down by greenhouse gas emissions (tonnes) per GVA (kr. million), industry GVA (kr. billion) and Danish credit institutions' lending and credit institutions' exposures in the industries (size of the bubble). The *Agriculture* industry represents the total figure for agriculture, forestry and fisheries. Data for greenhouse gas emissions and GVA are for 2021, while credit institution exposures are from the end of December 2023.
Source: Danmarks Nationalbank, Statistics Denmark and own calculations.

Agriculture is expected to be covered by a future political agreement based on proposals in a report by the expert group from February 2024, cf. Expert Group for a Green Tax Reform (2024). The Danish Council on Climate Change considers that a tax at the same level as manufacturing industry, etc., could lead to structural adjustments in agriculture, including less cattle-based agriculture, cf. The Danish Council on Climate Change (2023). However, the expert group's terms of reference state that the revenue from the agricultural tax must be returned to the industry as a whole, which will limit the cost increase for the average farm.

Overall, for some companies, there is estimated to be a *high* probability of negative economic impact due to higher costs of emissions over the next 10 years.

If expectations for a company's future profits are negatively affected, this may result in a lower pricing of its share capital and other issues. As a result, the existing capital stock of emission-intensive companies may be in danger of 'stranding'. Some studies have found that financial market valuations of companies exposed to increased costs of greenhouse gas emissions or other climate-related risks do not fully reflect such negative expectations, cf. Faccini and Matin (2021). However, there is considerable uncertainty about this, and overall, the existing knowledge base must be considered insufficient for a full assessment of the loss in value of issues by emission-intensive companies in the event of rising allowance prices in the EU, for example. Best estimate is that the probability of this risk should be placed in the *second highest* category.

Taxes and quotas on companies' greenhouse gas emissions may also lead to some *financial strain for some households*. If some companies do not adapt, they may either pass on the higher costs to consumers by raising prices or by

reducing employee or owner remuneration. How the higher costs of emissions can be financed depends, among other things, on the competitive situation in the market and the price sensitivity of consumers. As above, there is not a sufficient knowledge base for a true assessment of the degree to which households' finances may be stressed, but the best estimate is that the probability of this is low (*lowest* category).[12]

Financial implications (C)

Businesses and households under financial stress due to higher costs of emissions can contribute to both increased *credit risk* and *market risk* in credit institutions.

In terms of *credit risk*, institutions have significant lending to companies in some of the industries with the highest average emission intensity. This is especially true for *agriculture, forestry and fisheries* (approx. 7 per cent of their total lending to non-financial companies), but also in relation to *energy supply* (approx. 2.5 per cent). In contrast, they have limited lending to the *sea and air transport* and *refinery* industries. Given that emission-intensive companies experience a decline in their profits, the probability of significantly increased credit risk in credit institutions is rated in the *second highest* category. The probability of increased credit risk as a result of some households' finances being stressed is rated in the *moderate* category.

In terms of market risk, institutions have more limited exposures to Danish companies in their securities portfolio. In light of this, the probability of significantly increased risk due to loss of value on issues by emission-intensive companies is rated in the *lowest* category.

Conclusion

Best estimate is that the probability that taxes and allowances, that increase the cost of emissions could result in significant climate-related financial risks for credit institutions is in the *moderate* category. Although there is uncertainty about the economic impact, the uncertainty does not directly affect the overall assessment.

Climate change and green transition abroad

(ID 4-8, 15-16, 26)

The Danish economy is closely integrated into international production chains and developments in the Danish economy are highly dependent on international economic conditions. This also applies to risks related to climate change and the green transition. Just as the green transition and climate adaptation in Denmark can affect credit institutions and their customers, changes in other countries can also have indirect consequences for them.

The most significant events and the assessment of the probability of their materialisation are listed below. A graphical summary can be seen in table 4.

[12] The Expert Group for a Green Tax Reform assesses that the tax on industrial companies, etc., will not have significant distributional consequences for households, cf. Danish Expert Group for a Green Tax Reform (2022).

TABLE 4

Risks related to climate change and green transition abroad

ID	Climate-related event (A)	Economic impact (B)	Financial implications (C)	Probability of a climate-related event P(A)	Probability of economic impact P(B I A)	Probability of financial impact P(C I A∩B)	Probability of a climate-related financial event P(A∩B∩C)
26	Climate change abroad	Declining profits in trades and industries	Market risk (loss on securities)		*		
5	Transition abroad			*	*		*
16	Critical minerals			*	*		
7	Climate change abroad		Credit risk (lending losses)		*		*
4	Transition abroad			*	*		*
15	Critical minerals			*	*		*
8	Climate change abroad	Decline in real estate values			*		
6	Transition abroad			*	*		*

Highest	Second highest	Moderate	Second lowest	Lowest

Note: P(A) indicates the probability of the climate-related event materialising over the next 10 years. P(BIA) indicates the conditional probability of a significant economic impact, B, given that climate event A has occurred. P(C | B ∩ A) indicates the conditional probability of a significant financial consequence given A and B. See chapter 4 and appendix 2 for the approach to assessing climate-related financial risks. An asterisk * indicates high uncertainty about the assessed probability.

Climate-related event (A)

There are several climate-related events based on international conditions that could have an impact on the economy and credit institutions in Denmark. This analysis focuses on climate change in the most vulnerable parts of the world, green transition abroad and shortages of critical minerals on the international market.

In many countries, *climate change* is already having a major economic impact, for example, as a result of damage caused by extreme weather events. The summer of 2023 was the hottest ever in the northern hemisphere, causing extreme drought, wildfires and rainfall resulting in flooding. In the future, the consequences are expected to get worse, cf. the UN Intergovernmental Panel on Climate Change (2023). In Europe, European Commission experts expect more severe droughts, floods and wildfires, see ECB/ESRB Project Team on climate risk (2021). In light of this, these risks are considered to be in the *highest* category compared to the other events identified in this analysis.

The *green transition* must safeguard against the worst of climate change in the future. According to the UN Intergovernmental Panel on Climate Change, the transition must be realised internationally over the next 10 years in order to achieve the Paris Agreement targets and slow down the worst climate change.

There is currently no international collaboration to ensure consistent costs of emissions across countries. Standardised costs across countries would support a cost-effective transition and international trade. In the absence of international collaboration, the transition becomes less orderly and Danish companies have to navigate different approaches in different countries.

The fragmented development is reflected in a published climate scenario from NGFS. In this scenario, severe climate change materialises while at the same time

the transition entails significant costs. Climate change is not mitigated because many large countries are not transitioning their economies. For those countries, such as Denmark, that continue the transition, it will incur significant costs, cf. Network for Greening the Financial System (2023).

At present, sufficient source material is not available for assessing the extent to which the green transition will be realised and whether the Paris Agreement's climate targets can be achieved. However, the best estimate is that the risk that the international perspectives of the green transition will affect Danish companies is in the *highest* category.

Green technologies require access to a series of specialised input, including a range of *critical metals and minerals*. There may be some probability that a lack of metals and minerals, which are particularly critical in the green transition in connection with the production, transport and storage of energy, for example, may hamper the green transition. A particular concern is the geographical concentration of the extraction of these minerals. This is the case, for instance, in the production of lithium batteries, where the majority of both mining and processing is controlled by a few countries, particularly China, cf International Energy Agency (2022). Sufficient source material is not available to assess the probability of this risk materialising. Best estimate is that the risk should be placed in the *moderate* category.

Economic impact (B)

The materialisation of climate-related risks abroad is considered to lead to both a *fall in companies profits* and a *fall in real estate values*. There are no sources offering sufficient information on the magnitude of such consequences in Denmark and the assessment below represents a best estimate. Additional economic analysis and research is needed on the local impacts of international climate change and transitions.[13]

The starting point for the assessments is that climate-related events abroad can affect the Danish economy via international trade and production links and, first and foremost, lead to a *decline in companies' profits*. Differences in the approach to the green transition in international markets may challenge the position of some Danish companies in certain markets. As value chains often cross several national borders, it is not only events that are geographically anchored in Denmark's largest trading partner countries, such as Germany, the US, Sweden and the UK, that are important, but also in other countries further up or down the chains.[14] Danish companies may also be dependent on semi-finished goods from foreign subcontractors that are exposed to natural disasters related to climate change

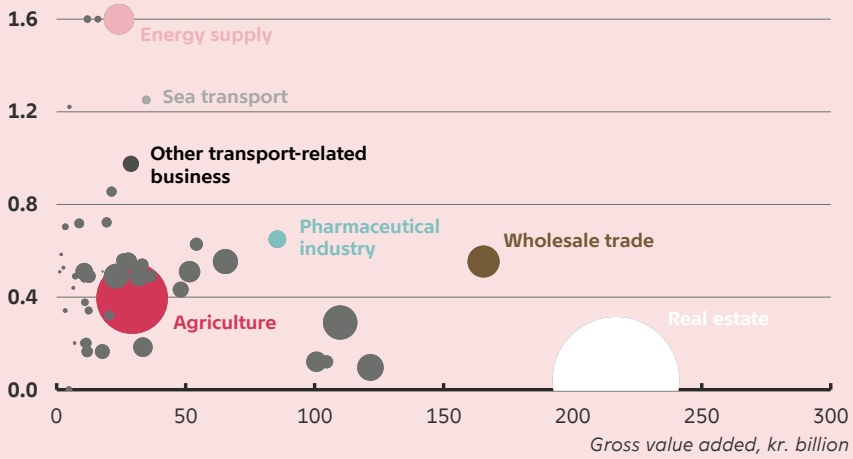
In some industries, companies are particularly closely connected to international value chains, and therefore, exposed to climate-related events in other countries, see chart 6. This applies to some of the industries that make up a significant part of Danish business and industry such as transport companies and the pharmaceutical industry. Best estimate is therefore that the probability of significant reductions in business and industry profits given the materialisation of significant climate and transition risks abroad is in the *highest* category.

[13] More generally, Feng and Li (2021) examine the cross-border impacts on the market value of securities from the materialisation of physical climate-related risks in other countries. They find that globalisation increases the interconnectedness of countries' global exposure to risks. Natural disasters in major trading partner countries reduce valuations in the home country's equity markets.
[14] For around half of Denmark's exported added value, the final destination country is outside the EU/EEA, cf. Højbjerre Brauer Schultz (2019).

CHART 6

International trade in goods and semi-finished goods is crucial for a number of industries

Exports and imports share of gross value added



Note: Danish non-financial companies summarised by industry and broken down by export and import share of gross value added (GVA), industry GVA (kr. billion) and Danish credit institutions' lending and credit institutions' exposures in the industries (size of the bubble). Data for exports, imports and GVA are for 2021, while credit institution exposures are from the end of December 2022. The *Agriculture* industry represents the total figure for agriculture, forestry and fisheries. The energy supply and film, TV and radio production industries have very high values for exports and imports as a share of GVA (around 28.5 and 5.5 respectively). To show the industries, the figures are set at 1.6 in the chart.
Source: OECD TiVA database, Statistics Denmark, Danmarks Nationalbank and own calculations.

There may also be a *fall in real estate values* if the aforementioned climate-related risks cause assets to 'strand' and decrease in value. This could, for example, be physical capital stock used in oil refineries that has no immediate use if a decision is made that fuels will remain in the subsoil. If the value of a company's assets depreciates, this will immediately weaken the company's solvency and resilience. Another example could be the falling market value of government bonds issued by some of the countries that are expected to be hit hardest by climate change, such as desert and island states.

Financial implications (C)

Credit institutions may be affected by the repercussions of international climate-related risks in the form of increased *credit risk* and, to a lesser extent, increased *market risk*.

A decline in profits for Danish companies that are vulnerable to climate-related events abroad may lead to increased *credit risk* in the credit institutions where they are customers. As a large part of Danish business and industry is connected via global value chains, institutions also have a relatively large amount of corporate lending that could be affected via this channel. For example, the energy supply and agriculture industries are highly dependent on the ability to trade in products and semi-finished goods, while at the same time they have taken out relatively large loans from credit institutions. In light of this, the risk of institutions experiencing increased credit risk as a result of a decline in profits

from their business customers is considered relevant. Business customers with significant lending are assessed to be most exposed to transition risks abroad *(second highest*), then international climate change (*moderate*) and finally unsuccessful investments and lack of critical minerals *(second lowest*).

The credit risk of institutions may also increase due to a decrease in the value of the collateral behind their lending. For example, some institutions are exposed to foreign transition risks as a result of lending collateralised by assets used in oil and gas extraction and related industries.

Loss of profits by foreign companies can also have repercussions for institutions through investments in equities or corporate bonds. The potential materialisation of such events can pose a *market risk* for institutions. However, the institutions only have limited investments in foreign companies' issues, and therefore, the risks are considered to be small. The risk is therefore placed in the *second lowest* category for transition-related events and in the *lowest* category for other events.

Conclusion

In the assessment of risks related to climate change and green transition abroad, the risk for credit institutions is considered to be *moderate* in relation to the green transition abroad. This is mainly due to the risk of increased credit risk as a result of lower profits for both Danish and foreign business customers. However, there is a lot of uncertainty around the estimates. Since the best estimate of risk is relatively high, the uncertainty may also impact whether the overall risk might be higher.

Similarly, the risk related to climate change abroad may increase institutions' credit risk as a result of lost profits from both Danish and foreign business customers *(second lowest*).

The other risks are all rated in the *lowest* category. However, there is great uncertainty about the risk of lack of international access to minerals that are critical for green technology. This risk may therefore turn out to be greater than best estimate.

Higher energy efficiency requirements for buildings

(ID 9, 28)

Energy consumption inside buildings accounts for a large part of total energy consumption, and therefore, emissions in Denmark. Increasing energy efficiency requirements can put pressure on the price of buildings where the necessary energy renovations are not carried out. This section assesses the possible consequences of higher requirements and the probability of their materialisation. A summary is provided in table 5.

Climate-related event (A)

Almost 40 per cent of total energy consumption in Denmark is used in connection with buildings.[15] The energy is used primarily for heating, and to a lesser extent, for cooling, ventilation and lighting. Energy renovations can contribute to reducing emissions in Denmark.

[15] Read more on the Construction and renovation page of the Danish Energy Agency's website (*link – only available in Danish*).

While energy renovations of buildings are in many cases both economically viable and can contribute to lower emissions, there is a risk that new requirements may push down market prices for the part of the building stock that is currently the least energy efficient and where no energy renovations have been carried out.

The EU has a common goal for building stock to be emissions neutral by 2050, and to contribute a significant share of the reductions by 2030. This will be achieved by, among other things, carrying out energy renovations of existing building stock and expanding energy production in buildings with, for example, solar cells on roofs.[16]

TABLE 5

Risks from higher energy efficiency requirements for buildings

ID	Climate-related event (A)	Economic impact (B)	Financial impact (C)	Probability of climate-related event P(A)	Probability of economic impact P(B I A)	Probability of financial implications P(C I A∩B)	Probability of a climate-related financial event P(A∩B∩C)
9	Higher energy efficiency requirements for buildings	Fall in real estate values	Credit risk (lending losses)				
28			Market risk (loss on securities)			*	*

Highest | Second highest | Moderate | Second lowest | Lowest

Note: P(A) indicates the probability of the climate-related event materialising over the next 10 years. P(BIA) indicates the conditional probability of a significant economic impact, B, given that climate event A has occurred. P(C | B ∩ A) indicates the conditional probability of a significant financial consequence given A and B. See chapter 4 and appendix 2 for the approach to assessing climate-related financial risks. An asterisk * indicates high uncertainty about the assessed probability.

In December 2023, a political agreement to update the Buildings Directive was reached in Brussels. In light of this, the probability that requirements for energy improvements in the least efficient buildings will be realised during the period to 2033 is rated in the *highest* category. However, there is still uncertainty about how the national requirements of the directive will be implemented into Danish law.

Economic impact (B)

Higher energy efficiency requirements may affect pricing for the part of the building stock that has low energy efficiency according to the current energy label scale. Buildings with the three worst energy labels, E-G, accounted for 23 per cent of all buildings with a valid energy label in 2022, see chart 7.

According to an analysis by Danmarks Nationalbank, it will in many cases be possible to carry out energy renovations to improve a building's energy label *and* the renovation can pay for itself through lower energy bills, cf. Martinello and Møller (2022). Of the buildings with a valid energy label in 2022, only around

[16] In December 2023, political agreement was reached on an updated Buildings Directive. According to the agreement, publicly owned buildings and commercial buildings will be subject to a minimum energy efficiency requirement as early as 2027, which will be further tightened in 2030. For residential buildings, requirements for improving average energy efficiency will be introduced in 2030 and 2033 respectively. See the press release about the agreement (*link*) and an analysis of the proposed agreement previously presented by the European Commission in Danmarks Nationalbank (2022).

3 per cent of buildings with an energy label of E-G could *not* profitably improve their energy label.

Profitable renovations may end up not being carried out because owners are unable to finance the project. According to business organisation Finans Danmark, profitable renovations and thermal rehabilitation are carried out to a lesser extent in municipalities such as Lolland and Vordingborg compared to relatively wealthy municipalities such as North Zealand, cf. Finans Danmark (2023).

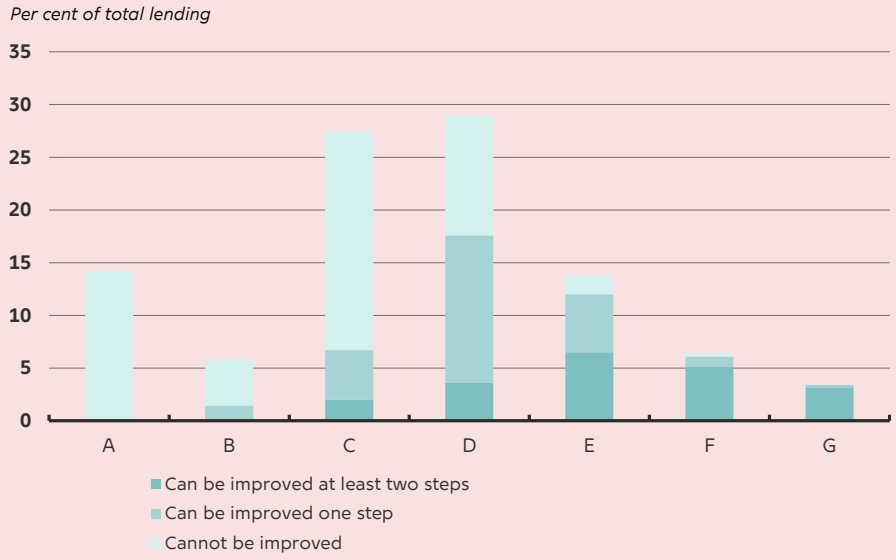
In cases where energy renovations of buildings are both economically viable and owners have access to financing for the renovation, additional energy renovation requirements are not expected to negatively affect the market value. However, in other cases where energy renovations are not economically viable and/or the owner does not have access to sufficient financing, there is some risk that the increased requirements could drive down the market price.

The extent to which national requirements from the EU may affect the market value of some buildings depends on the specific implementation. The largest price correction is likely to materialise if the implementation happens solely by instructing individual owners to carry out sufficient renovations at their own expense. Then the market price of the real estate may drop by up to the total cost of the necessary renovations. However, there are many other measures that can help implement the requirements, such as the creation of new and/or expansion of existing grant schemes.

Based on the above, the probability of the introduction of higher energy efficiency requirements for buildings or expectations thereof leading to a significant decrease in overall real estate values is rated in the *second lowest* category.

CHART 7

Most buildings with poor energy labels have profitable energy saving opportunities



Note: Lending collateralised by buildings with a valid energy label by current energy label. The categories show how many steps a home can advance on the energy label scale through profitable renovations, according to the energy report. A profitable renovation is when the homeowner's total savings over the useful life of the installation equal or exceed the cost of the renovation. Energy label data were collected in 2021 and lending data are for the end of Q4 2022.
Source: Spareenergi.dk, Danmarks Nationalbank and own calculations.

Financial implications (C)

Many building owners have taken out loans secured by mortgages on their buildings. Therefore, if higher energy efficiency requirements for buildings were to lead to a decrease in the market value of buildings, it could reduce the value of the collateral behind a large part of institutions' lending and thus increase their *credit risk* on these loans. Mortgaging ensures that the institution can take possession of the property and sell it if the borrower is unable to repay the loan. If the value of the property falls (or is at risk of falling) to less than the outstanding debt on the property, the institution can no longer expect to recover the borrower's debt through repossession. In this case, the institution's credit risk on the loan will have increased. This means, inter alia, that the institution must set aside more funds for expected losses and possibly more equity to cover losses. In light of this, the probability of significant lending losses is rated in the *highest* category.

In the event of a general decline in real estate values, credit institutions may also experience *increased market risk*. Institutions often invest in mortgage bonds issued by other institutions against collateral in the mortgaged buildings. If the collateral behind the bonds decreases in value, the market value of the bonds may fall. However, credit institutions typically invest in short-term mortgage bonds. The market value of short-term bonds falls less in comparison when the value of collateral decreases than for bonds with a long residual maturity. In light of this, the best estimate is that the probability of a significant increase in the sector's *market risk* as a result is in the *lowest* category.

Conclusion

There are likely to be new requirements for increased energy efficiency in some of the building stock. However, the probability of the requirements posing significant risks to credit institutions is low, and therefore, the overall assessment of the risk of increased credit risk is in the *second lowest* category, while the risk of increased market risk is *lowest*. However, with regard to market risk, the uncertainty of the assessment is sufficient for the risk to be higher.

Misleading green marketing

(ID 10-12)

Credit institutions and other financial companies have marketed a raft of new financial services that integrate sustainability and green transition targets into traditional services, such as loan types and investment products, in different ways. Including such targets of contributing to sustainable development in their products carries risks for companies if the targets are not met. If so, this is misleading green marketing – also known as *greenwashing*. This section reviews the potential consequences of misleading green marketing and our assessment of the probability of their materialisation. A summary is provided in table 6.

The consequences of misleading marketing for the financial system are not transmitted through the economy and banks' non-financial customers, as is the case for the other risks in this analysis. Therefore, this climate-related financial risk is only divided into two sub-elements (A and C).

TABLE 6

Risks of misleading green marketing

ID	Climate-related event (A)	Financial impact (C)	Probability of climate-related event P(A)	Probability of financial implications P(C I A)	Probability of a climate-related financial event P(A∩C)
11	Misleading green marketing	Credit risk (lending losses)		*	*
10		Market risk (loss on securities)		*	*
12		Reputational risk		*	*

Highest	Second highest	Moderate	Second lowest	Lowest

Note: P(A) indicates the probability of the climate-related event materialising over the next 10 years. P(BIA) indicates the conditional probability of a significant economic impact, B, given that climate event A has occurred. P(C | B ∩ A) indicates the conditional probability of a significant financial consequence given A and B. See chapter 4 and appendix 2 for the approach to assessing climate-related financial risks. An asterisk * indicates high uncertainty about the assessed probability.

Climate-related event (A)

In recent years, consumers and institutional investors have increasingly demanded sustainable and green financial products and services. Many financial institutions want to market and offer products that reflect this. This also applies to credit institutions that market green loans, bond issues and investment products. These products are traditional financial services with a goal of fulfilling specific sustainability and climate requirements.

Situations with asymmetric information can often arise in both issues of green securities and investment products, where the issuer knows more about compliance with guarantees than the customer and/or investor. If a financial product does not fulfil the guarantees, it is misleading green marketing.

In relation to the issue of green bonds and lending, credit institutions must ensure that the proceeds are used to finance activities that promote the green transition, such as energy renovations for homes or the installation of heat pumps. A green bond standard has recently been adopted in the EU that can provide greater clarity on what issuers' bonds should fulfil and how issues can comply with the EU green taxonomy.

In terms of green investment products, institutions must ensure that customer funds are invested in assets that either promote the green transition and/or do not contribute to emission-intensive activities. In the EU, green investment products must comply with the Sustainable Finance Disclosure Regulation. The Disclosure Regulation sets out the disclosure obligations of financial market participants and financial advisors in connection with, inter alia, climate-related matters.[17] Requirements for providers of sustainability ratings (ESG ratings) for securities have also recently been agreed in the EU.

According to the European Banking Authority, the number of cases of misleading green marketing has increased significantly since 2012, European Banking Authority (2023). The EBA points out that increased public awareness of climate change has led to companies being held more accountable for their environmental policies and climate impact. The Danish Consumer Ombudsman has also received cases of credit institutions being accused of misleading marketing of sustainable investment products.

The probability that one or more Danish credit institutions will be involved in or accused of misleading green marketing over the next 10 years is rated in the *highest* category.

Financial impact (C)

The most significant risk for each financial institution is in relation to its reputation. Materialisation of reputational risks can have major economic consequences in terms of increased costs and/or loss of profits. For example, money laundering cases over a number of years have weakened the reputation of some Danish institutions and had significant economic consequences. Sustainability is still a relatively new area for credit institutions, and while the demand for green financial services is growing, the data to ensure compliance with green guarantees is still lacking.[18] In 2023, according to the European Banking Authority, European banks assessed the risk of misleading green marketing as low, but expected it to increase in the future. In light of this, there is currently no sufficiently specific source material to assess the risk up to 2033, but the best estimate is that the probability that misleading green marketing will lead to serious reputational risk for the credit sector as a whole, should be placed in the *second lowest* category.

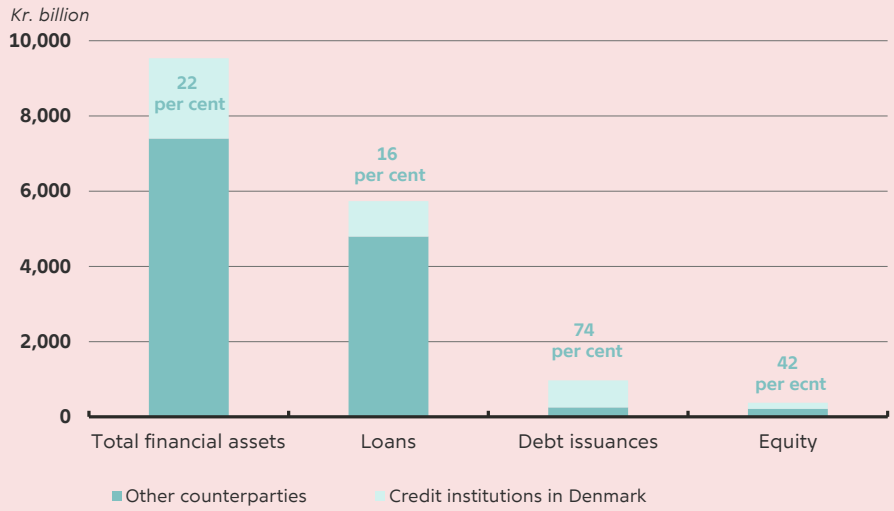
Materialisation of reputational risks may negatively affect the market value of the institution's equity (shares) and other issued securities (e.g. bonds). Credit institutions have large investments in each other's issues, see chart 8. Therefore,

[17] See the Regulation of the European Parliament and of the Council on sustainability-related disclosures in the financial services sector, CELEX No. 32019R2088.
[18] See, for example, the Danish Financial Supervisory Authority's thematic study on sustainability disclosures for funds that have sustainable investments as a target from June 2023 (*link*). The study found that the investment management companies of the funds included in the study have not ensured that the funds disclose sustainability in a clear, comprehensive and understandable way. In several significant areas, the Danish Financial Supervisory Authority pointed out that the sustainability disclosures were inadequate.

there is also a limited risk that the materialisation of reputational risks in one institution may spill over to other institutions via market risk (the probability is rated in the *lowest* category).

CHART 8

Credit institutions have invested large amounts in each other's issuances



Note: Value of the assets held by Danish banks and mortgage credit institutions. The proportions stated show the percentage of assets issued by other Danish banks and mortgage credit institutions. Data are for the end of Q4 2023
Source: Danmarks Nationalbank and own calculations.

Conclusion

Incidences of credit institutions with misleading green marketing are considered highly likely to occur over the next 10 years. However, the best estimate is that these incidences are only slightly likely to have large overall financial implications for the sector. However, the reputational damage that may be caused by misleading marketing is extremely uncertain. In light of this, the uncertainty of the estimate is so great that the risk due to misleading marketing may be significantly higher.

Unsuccessful investments in green technologies

(ID 13-14)

The green transition involves major investment projects in areas such as energy. In Denmark, investments in renewable energy sources and infrastructure based on new technology are planned to ensure a multiplication of green electricity production. Such investments involve a certain amount of risk. Credit institutions can be affected insofar as they provide funding for these projects.

The most significant events and the assessment of probability of their materialisation are listed below. A graphical summary is provided in table 7.

TABLE 7

Risks related to unsuccessful investments in green technologies

ID	Climate-related event (A)	Economic impact (B)	Financial implications (C)	Probability of a climate-related event P(A)	Probability of economic impact P(B I A)	Probability of financial impact P(C I A∩B)	Probability of a climate-related financial event P(A∩B∩C)
14	Unsuccessful investments	Declining profits in trades and industries	Market risk (loss on securities)	*	*	*	*
13			Credit risk (lending losses)	*	*	*	*

Highest	Second highest	Moderate	Second lowest	Lowest

Note: P(A) indicates the probability of the climate-related event materialising over the next 10 years. P(BIA) indicates the conditional probability of a significant economic impact, B, given that climate event A has occurred. P(C | B ∩ A) indicates the conditional probability of a significant financial consequence given A and B. See chapter 4 and appendix 2 for the approach to assessing climate-related financial risks. An asterisk * indicates high uncertainty about the assessed probability.

Climate-related event (A)

There may be a growth potential in the green transition for a number of industries. However, there are also a number of circumstances which entail a certain risk that some of the major investment projects will fail.

As with investments in other emerging technologies, there is a risk that investments in these technologies may not yield the expected returns**.** This may be because the technologies are not immediately scalable to a commercial level, because international competition will be fierce, or because there will be a lack of capacity, for example, in the form of qualified labour, to carry out projects as planned. In addition, the returns on projects are sensitive to future changes in government subsidies and taxes.

Specifically, the green transition plans involve major investment projects – especially in the energy sector, cf. the Government's climate partnerships – Energy and Utilities (2020) and the Danish Energy Agency (2022a). With these projects, green electricity production will multiply over the next 10 years and Denmark will increase its green energy exports, cf. Danish Energy Agency (2022b).

Exporting electricity to the rest of Europe depends on sufficient capacity in the European transmission grid. Secondly, a significant portion of the remaining green power in new PtX plants must be converted to hydrogen and possibly further to green fuels. Thirdly, Denmark has plans to develop new technologies and extensive infrastructure for carbon capture, transport and storage to be deployed on a large scale, cf. Danish Energy Agency (2021). Sufficient source material is not available to assess the probability that some of these investment projects will be unsuccessful.

Overall, the best estimate is that the probability of one or more of these events happening within the next 10 years is in the *second lowest* category.

Economic impact (B)

The materialisation of risks from unsuccessful investments in new, green technology is estimated mainly to lead to a *decline in companies' profits*. There are no public sources with sufficient information on the magnitude of such consequences in Denmark, and the assessment below represents a best estimate.

Denmark is among the EU countries contributing the highest revenue from green goods and services to the economy, see chart 9. Danish companies are major players on the global market in both the development and production of renewable energy and resource-saving technologies. Furthermore, as already mentioned, the government has drawn up plans for major investment projects to move forward with the green transition. As a result, companies are investing heavily in the development of new, green solutions.

Overall, huge resources are being invested in new technologies. However, the probability of these being unsuccessful is estimated to be quite low. Therefore, the best estimate is that the probability of major negative economic consequences is in the *second lowest* category. However, there is a lot of uncertainty around the estimate.

CHART 9

Green goods and services make up a larger share of production in Denmark than in most other EU countries

Note: Green goods and services cover the production of market-oriented goods and services that contribute to the protection of the environment or the conservation of resources. EU is calculated as an unweighted average of the Member States. Data are for 2020.
Source: Eurostat.

Financial implications (C)

If the large investments in the energy system and other parts of the economy turn out to be less profitable than expected, the value of the investments may fall. Insofar as the investments are financed in collaboration with credit institutions, this may entail risks for the institutions.

For example, it is possible to take out mortgage loans collateralised by, for example, wind farms, both onshore and offshore, as well as solar parks. In addition, the government will make it possible to use mortgage financing for the establishment of existing and future offshore wind farms located in the parts of Denmark's exclusive economic zone that lie outside Danish territorial waters (more than 12 nautical miles or approx. 22 kilometres from the coast).

Such financing is to some extent related to potential loans that have not yet been issued. This represents an additional uncertainty in the assessment of the risk involved. Overall, it is estimated that the risk of credit risk due to a fall in real estate values is greater for events related to the green transition *(second lowest*) than climate change *(lowest*).

Conclusion

Best estimate is that the financial risk to credit institutions from unsuccessful investments in green technologies is in the *lowest* category. However, the risk is considered to be highly uncertain and may turn out to be greater than estimated.

Climate change in Denmark

(ID 19-25)

Over the next 10 years, the IPCC expects climate change to hit many other countries harder than Denmark, cf. IPCC (2023) and ECB/ESRB project team on climate risk(2021).[19] Denmark's geographical position (northern location) and topological conditions (low-lying and long coastline) make us vulnerable primarily to certain changes that will only really take effect in the latter half of this century.

Table 8 provides an overview of all estimated probabilities of climate change in Denmark and its consequences.

[19] Also see the dashboard prepared by the European Commission Disaster Risk Management Knowledge Centre (*link*) and the DRMKC Risk Data Hub (*link*).

TABLE 8

Risks related to climate change in Denmark

ID	Climate-related event (A)	Economic impact (B)	Financial implications (C)	Probability of climate-related event P(A)	Probability of economic impact P(B I A)	Probability of financial implications P(C I A∩B)	Probability of a climate-related financial event P(A∩B∩C)
19	More violent storm surges	Declining profits in trades and industries	Credit risk (lending losses)		*		
21	Major flooding due to extreme rainfall				*		
23	Drought periods						
20	More violent storm surges	Decline in real estate values					
24	Higher water table				*		
22	Major flooding due to extreme rainfall						
25	More violent storms and hurricanes						

Highest	Second highest	Moderate	Second lowest	Lowest

Note: P(A) indicates the probability of the climate-related event materialising over the next 10 years. P(BIA) indicates the conditional probability of a significant economic impact, B, given that climate event A has occurred. P(C | B ∩ A) indicates the conditional probability of a significant financial consequence given A and B. See chapter 4 and appendix 2 for the approach to assessing climate-related financial risks. An asterisk * indicates high uncertainty about the assessed probability.

Climate-related event (A)

There are a number of physical climate events that could occur in Denmark over the next 10 years. These include *more severe* coastal *storm surges*, *higher groundwater levels*, *greater flooding due to extreme rainfall*, *more violent storms and hurricanes* as well as *droughts*.

Such events are already happening today, and although they are expected to increase in intensity and frequency, especially towards the end of the century if emissions are not reduced, according to DMI, their development will be relatively slow, see chart 10.

The probabilities of events over the coming decade are assessed based on projections for 2011-2040 under the high emissions scenario (business-as-usual). On this basis, the probabilities of *drought*, *high groundwater levels* and *storms/hurricanes* of a magnitude significantly greater than experienced historically are rated in the *lowest* category. For example, the uncertainty interval in chart 9 (D) shows that 90 per cent of DMI's projections for summer droughts either indicate a decrease or increase to a maximum of 17.6 days compared to the reference period level of 15 days.[20] Only 10 per cent of DMI's projections indicate that drought periods will increase by more than 2.6 days and therefore a significant change in drought periods must be considered less likely. However, the effect of *higher water levels* during storm surges, see chart 3 (A), and to some extent *extreme rainfall*, see chart 3 (C), may be more significant in the next 10 years. The probability of significant incidents is therefore rated slightly higher *(low)*.

Economic impact (B)

Climate events are estimated to result in two economic consequences: *declining profits in trades and industries* and *decline in real estate values*.

[20] The uncertainty interval describes the differences in projections across DMI's different models. See the note in chart 3.

Declining profits in trades and industries can be caused by both storm surges and extreme rainfall, which reduce the industries' production and consequently profits when, for example, cropland, facilities, farm buildings and infrastructure are flooded. Crop yields can also decrease as a result of droughts. One example is the drought in the summer of 2018, which affected agricultural profits, cf. Schou (2019).

Industries that rely on physical natural assets in particular may experience a decline in profits when the above events materialise. Agriculture, forestry and horticulture are particularly at risk. In 2016, these covered around 82 per cent of land area in Denmark. In terms of floods and droughts, declining profits in the industries will therefore mainly be a result of agricultural cropland and other land-intensive activities being affected. As profits in these industries only make up a small part of the total value creation in Danish industry as a whole, the probability of a significant decline in the industries' total profits will be limited. In terms of flooding due to extreme rainfall and storm surges, the probability of a significant loss of profit is rated as the *second lowest* and *lowest*, respectively. The difference is that storm surges only affect coastal farmland, while flooding due to extreme rainfall affects a wider area. However, there is a general lack of analyses of these economic effects, which is why the assessment of the probability is subject to great uncertainty (marked with asterisks). Drought is often even more widespread geographically and the probability of a drop in yield is therefore higher. On this basis, the risk is assessed as *moderate*.

Decline in real estate values can occur due to *flooding*, *rising groundwater levels* and *severe storms and hurricanes* that reduce the value of buildings (including homes) and arable land, for example. When it comes to real estate values, expectations of future climate events are important. A study has shown that both homes with a current flood risk and homes with an expected future flood risk are already being sold at a discounted price as a result, cf. Mirone and Poeschl (2021).

The probability of a significant reduction in the total value of real estate as a result of a storm surge event is rated in the *second lowest* category. Even if the housing market is dominated by forward-looking expectations, for example, based on the assumption that emissions will remain high for many decades to come and that the handling of climate events in the future will be inadequate, the number of buildings and facilities that are expected to be affected is still relatively limited, cf. Larsen et al. (2021). Around 1 per cent of Danish single-family homes are currently at risk of flooding from storm surges and if greenhouse gas emissions continue as they are today, the number could be around 2 per cent in 50 years, cf. Mirone and Poeschl (2021).[21]

Rising groundwater levels will give rise to episodes of water in cellars and rising ground moisture, which will also lead to reductions in real estate values (see, for example, Niras (2021)). As with storm surges, the decline in value of individual buildings is also affected by expectations. However, despite the fact that rises in groundwater level are geographically more widespread than storm surges, the loss of value per building is estimated to be limited. In addition, individual homeowners have a financial incentive to protect themselves using available measures such as drainage. The impact on real estate values also depends on the ability of potential buyers to find alternatives to buildings at risk of high groundwater. Overall, the probability of a significant decline in real estate values as a result of *rising groundwater levels* is rated in the *lowest* category. However, this assessment is uncertain due to a lack of source material and data.

[21] However, there is great uncertainty about sea level rise and the possibility that the trend will accelerate as tipping points are exceeded, cf. UN Intergovernmental Panel on Climate Change (2023). In the long term, there is some probability of a worst-case scenario with significantly greater consequences. See the appendix and calculations in Mirone and Poeschl (2021).

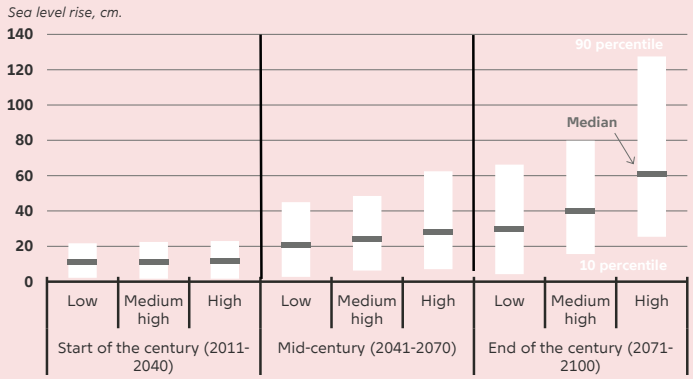
Flooding along rivers and around depressions due to *extreme rainfall* is relatively common.[22] The risk associated with this type of flooding will often vary on a very localised level. Often only the first row of houses down towards a local river, for example, will be at risk of flooding. This gives potential buyers a better chance of finding alternatives, and thus the risk can be better reflected in the price of the property. Therefore, the probability is rated slightly higher, i.e. in the *moderate* category.

Hurricanes and severe storms can also affect a wide geographical area and cause material damage.[23] However, it is estimated that the effect on the market value of buildings is limited, partly due to the limited availability of alternatives and that in many cases the damage is relatively limited compared to flood damage, for instance. Overall, the probability of a significant decline in the value of the total real estate stock as a result of storms and hurricanes is rated in the *lowest* category.

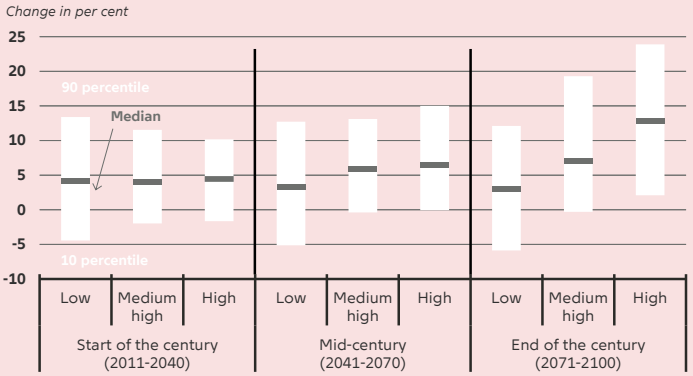
[22] See, for example, the Central Denmark Region and the consultancy firm SCALGO's analysis of the risk of real estate flooding *(link*: DK – only available in Danish).
[23] The material damage as a result of the hurricane in 1999 is estimated at approx. kr. 13 billion, cf. the Danish Emergency Management Agency (2022).

CHART 10

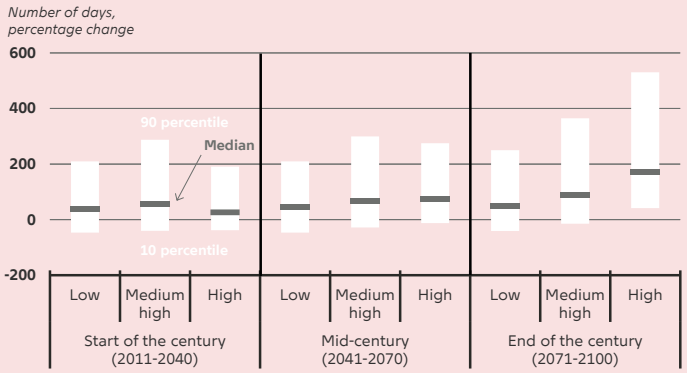
A - Increase in sea level during storm surges



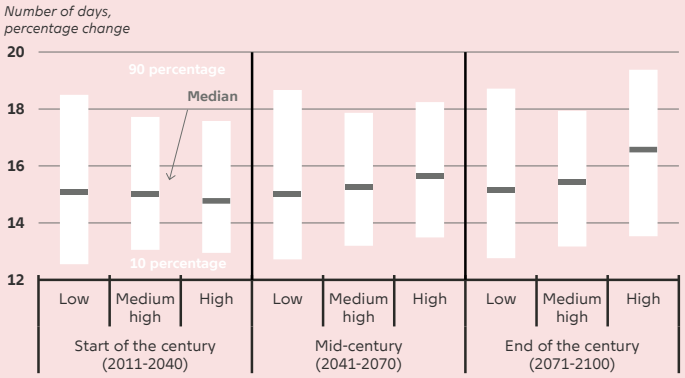
B - Average annual rainfall



C - Number of rainy winter days



D - Longest dry period in the summer months



Note: For each period, we look at projections in three different scenarios: a low level of greenhouse gas emissions (RCP2.6), a moderately high level (RCP4.5) and a high level (RCP8.5). The latter scenario is also considered business-as-usual. The reference period is 1981-2010. For each scenario, the grey line shows the median projection in DMI's models. The uncertainty interval around the median projection (marked in white) describes the model uncertainty. The lower (upper) limit of the interval corresponds to 10 per cent (90 per cent) of the models projecting a level that is lower (higher) than this limit.

Chart A: Sea level during a storm surge in cm above normal. For the Start of century period, an average of the projection for all years and coastlines is calculated. Chart B: Percentage increase in annual rainfall. Chart C: Percentage change in the number of days in the winter months (Dec-Feb) with more than 20 mm of rainfall. Chart D: Duration (in days) of longest continuous period during summer (Jun-Aug) with less than 1 mm of rainfall.

Source: DMI Climate Atlas and own calculations.

Financial implications (C)

Events due to climate change in Denmark may primarily affect credit institutions as a result of increased *credit risk*.

Declining profits in trades and industries affect the quality of credit institutions' lending due to higher probabilities of default, especially for their agricultural customers. Institutions have lent around kr. 280 billion to agriculture, forestry and fisheries, which represents around 7 per cent of their total lending to non-financial companies, the majority of which is to agricultural businesses. In addition, lending to agriculture has been characterised for a number of years by relatively low, albeit improved, credit quality due to the poor financial situation of many farms, cf. Buchholst et al. (2014), Danmarks Nationalbank (2018) and Bramsen et al. (2022). Many institutions have already allocated significant impairment charges for future lending losses. Overall, the probability of

significant lending losses due to floods and droughts is rated in the *moderate* category.

A large proportion of the buildings in Denmark are mortgaged and pledged to credit institutions and the buildings constitute a significant part of the collateral behind the institutions' lending. When a credit institution grants a loan to finance a property, it often requires the provision of collateral in the form of property. Mortgaging ensures that the institution can take possession of the property and sell it if the borrower is unable to repay the loan. If the value of the property falls (or is at risk of falling) to less than the outstanding debt on the property, the institution can no longer expect to recover the borrower's debt through repossession. In this case, the institution's credit risk on the loan will have increased. This means, inter alia, that the institution must set aside more funds for expected losses and possibly more equity to cover losses.

If the collateral values behind the loans fall significantly, it can have a major impact on the credit quality of the institution's loans. The probability of significant lending losses through this route is therefore rated in the *highest* category in relation to the climate events mentioned. Several banks are looking at the proportion of their exposures where there is a risk that the collateral may decrease in value as a result of selected climate changes. For example, some banks have published estimates of how many homes behind their lending collateralised by real estate may be at risk of flooding in connection with storm surges, cf. Nykredit (2022). According to an analysis by Danmarks Nationalbank, banks do not seem to include storm surge risks in the credit rating of housing loans. When homes at risk of flooding are compared to other similar homes, no differences can be found in the prevalence of lending, loan-to-value ratios or interest rates on housing loans, cf. Poeschl (2022).

Conclusion

The probability of the climate-related financial events due to climate change in Denmark is rated in the *lowest* category for all risks. In other words, the financial risks due to physical climate change in Denmark over the next 10 years are considered to be limited. This is due mainly to the fact that the probability of physical events of a magnitude significantly beyond historical levels is considered to be low. However, there is some uncertainty associated with these assessments, especially with regard to the economic impact and is mainly due to a lack of source material.

Appendix 2: Assessment of climate-related financial risks

This appendix elaborates on the methodological approach used in the analysis to describe and assess climate-related financial risks. Assumptions behind the approach are explained and challenges to be aware of are highlighted.

An event, E, associated with a climate-related financial risk is seen as a compound event and is defined as $E = A \cap B \cap C$, where A is a physical or transition-related event, B is an economic event and C is a financial event. Using the definition of conditional probability, the probability associated with a climate-related financial risk, $P(A \cap B \cap C)$, can therefore be written as a product,

$$P(A \cap B \cap C) = P(A) \times P(B \mid A) \times P(C \mid B \cap A)$$

for $P(A \cap B) > 0$, where P(X) denotes the probability of event X and $\cap$ denotes the intersection (to be read as 'and'). Breaking down the probability $P(A \cap B \cap C)$ provides a better understanding of how the probability associated with a risk is structured and how it can potentially be influenced.

As an illustrative example, consider the probability of a credit institution having the value of its real estate collateral significantly reduced in the event of a hurricane causing widespread damage to buildings. The lower value of the collateral increases the bank's credit risk, especially at high loan-to-value ratios and can thus affect financial stability. One can imagine that the probability of some buildings decreasing in value given that a major hurricane has actually occurred, i.e. P(B I A), is high. The decrease in value may be partly due to the direct damage, but in particular also to expectations of further similar hurricanes in the future. Since mortgage lending is widespread, it is also realistic that the probability of a bank having its collateral value reduced, given that a lot of buildings have lost value due to the hurricane, P(C I B ∩ A), is high. However, since hurricanes are rare (P(A) is low), the overall risk of the bank having the value of its collateral reduced as a result of a hurricane is modest.

As the example illustrates, the advantage of breaking it down is that the probability is expressed as a product of well-defined probabilities that are easier to interpret and assess. For example, P(A) has to do with meteorological and climate conditions, while P(C I B ∩ A) depends on the bank's exposures to the real estate market.

Choice of threshold values for economic and financial variables

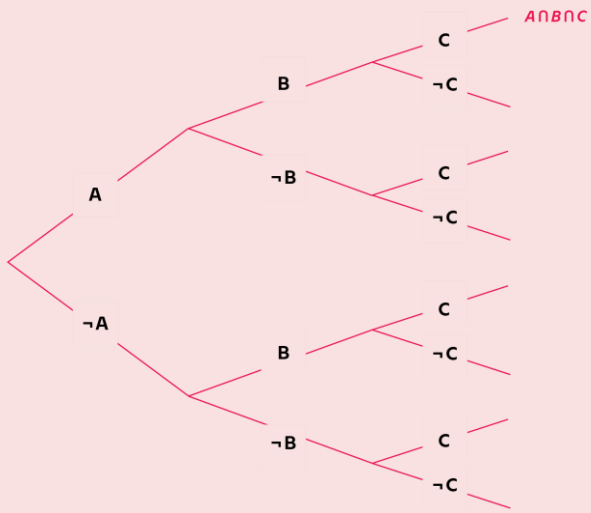
When defining economic and financial events (consequences), two cases can be distinguished. In the first case, the economic/financial variable is discrete and binary, and in the second case, the economic/financial variable is continuous. In the binary case, for example, we can think of an economic event, B, as the event 'economic impact' (e.g. a loss of a given size), and ¬B is therefore equivalent to 'no economic impact' (i.e. a loss of zero). However, when the variables are continuous, as is the case here, thresholds are chosen for these variables. Events B and C now correspond to the thresholds being exceeded.[24]

[24] Several of the climate variables are also continuous (e.g. wind speed, height of storm surge, etc.), but here the thresholds (e.g. when we refer to a hurricane) are often easier to select.

Regardless of whether the variables are discrete or continuous, if E is divided into events A, B and C, there are a total of eight possible events, see chart B1. In two of these, A ∩ B ∩ C and A ∩ ¬B ∩ C, the financial event (C) takes place after the climate/transition-related event (A) has occurred. As a point of departure, we are therefore interested in the probability that either A ∩ B ∩ C or A ∩ ¬B ∩ C takes place, equivalently that A ∩ C taking place.[25] However, as shown above, we only focus on A ∩ B ∩ C, while we disregard A ∩ ¬B ∩ C. This is justified by the assumption that there cannot be a financial consequence without an economic consequence, meaning that P(A ∩ ¬B ∩ C) = 0, such that P(A ∩ B ∩ C) = P(A ∩ C).[26]

CHART B1

For discrete outcomes in the three sub-events there are a total of eight possible events



Note: Illustration of how the division of E into the three events A, B and C gives a total of eight possible outcomes. ¬ is the logical symbol for negation, and, e.g. ¬A means that event A has not happened.

When the economic variable is discrete and binary (e.g. B = 'economic effect' and ¬B = 'no economic effect'), the interpretation of this assumption is straightforward and means that P(A ∩ ¬B ∩ C) = 0. On the other hand, when the variables are continuous (e.g. a decline in profits or a decline in real estate values), such that the events are defined by exceeding selected thresholds, ¬B implies actual economic consequences, e.g. a positive loss. The loss is simply below the selected threshold. In this case, it can happen that P(A ∩ ¬B ∩ C) > 0. It is therefore important how we select the thresholds, as we may now have risks for which P(A ∩ ¬B ∩ C) is significantly above zero, while it may be practically zero for others. Ignoring such differences by only prioritising by P(A ∩ B ∩ C) would give a misleading picture of the relative significance of risks. Choosing thresholds is therefore now discussed in greater detail.

[25] This is because A ∩ C = (A ∩ ¬B ∩ C) ∪ (A ∩ B ∩ C).
[26] Namely, P(A ∩ C) = P((A ∩ ¬B ∩ C) ∪ (A ∩ B ∩ C)) = P(A ∩ ¬B ∩ C) + P(A ∩ B ∩ C) = P(A ∩ B ∩ C), where the first equality sign results from the equation in footnote 25, the second equality sign results from (A ∩ ¬B ∩ C) and (A ∩ B ∩ C) being disjoint, while the third equality sign results from P(A ∩ ¬B ∩C) = 0.

Since it is the financial event that is of interest here, a threshold for the financial variable is chosen first and the economic threshold is determined from this. The financial threshold, which can be labelled x*, is chosen based on expert knowledge and experience, and the threshold should reflect the level at which it starts to be non-negligible in terms of impact on financial stability.

Given x*, a threshold, y*, is also chosen for the economic variable. The economic variable is often a reduction in value or a loss, and therefore y* must be positive (the same is typically true for the financial variable). If $y^* = 0$ is chosen, then for all the risks we look at, $P(B|A) = P(y \geq y^*|A) = 1$, where y is the random variable that measures the economic loss. In this case, we do not use the information on whether the economic variable is above the threshold ('economic impact') or below the threshold ('no economic impact') when assessing the probability of the financial event given the climate/transition-related event.

In line with the above, it is appropriate to choose y* such that the probability of the climate/transition-related event occurring (A), y* being exceeded (B) and x* being exceeded (C), as far as possible describes the probability $P(A \cap C)$ completely. As shown in footnote 26, the latter probability can be written as $P(A \cap B \cap C) + P(A \cap \neg B \cap C)$, and the choice of y* should therefore minimise $P(A \cap \neg B \cap C)$ for all risks. Therefore, if y* is set too high, there will be risks for which $P(A \cap \neg B \cap C)$ is relatively large and therefore should not be ignored in our prioritisation, as we effectively do when we only look at $P(A \cap B \cap C)$.

Prioritisation of risks is not affected by the choice of thresholds

The specific choice of the above thresholds is crucial if the aim is to assess the absolute level of the different probabilities. In this analysis, however, the purpose is to assess the levels of the individual risks in relation to each other. More precisely, the purpose here boils down to determining whether one probability is higher than another, but not how much higher or how high each one is.

We assume that the distributions (densities) underlying the probability assessments are such that changes in the thresholds do not change the prioritisation. Hence, for example, we do not allow risk X to imply a higher probability than risk Y that a loss exceeds a certain threshold, while the reverse applies when a different threshold is chosen. We refer to this assumption as the assumption of 'well-behaved probability distributions'.

When this assumption holds and the thresholds otherwise fulfil the principles above, the actual choice of thresholds will not change the prioritisation. Hence, we do not specify the thresholds further in this analysis.

Prioritisation can be based on probability alone (relation to heat maps)

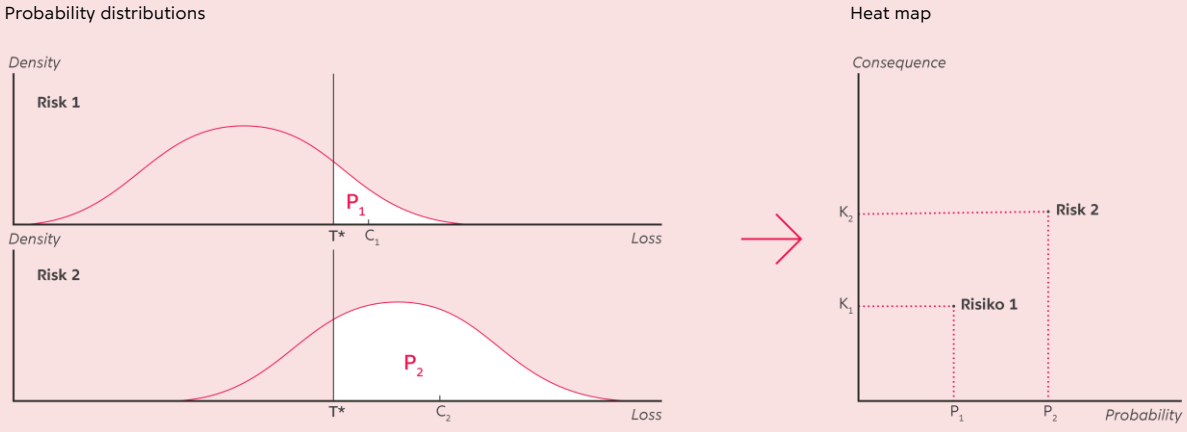
Therefore, we prioritise climate-related financial risks based on their probability of exceeding economic and financial impact thresholds. The higher the probability of exceeding these thresholds, the greater the risk. However, in principle, there can be large differences, for example, between two risks, in terms of how large a loss (consequence) can be expected to be, given that the threshold value is exceeded. This expected loss is often referred to as expected shortfall and should generally be taken into account when comparing risks. This is what is done in principle in a heat map, although the consequences of materialisation are often treated as deterministic. For example, if the risk with the lowest probability has the largest expected shortfall, prioritising the risks can be difficult. In this analysis, we abstract from differences in expected shortfall, which can be justified by the above-mentioned assumption that the probability distributions describing the economic and financial losses are 'well-behaved'. This assumption therefore also implies that the higher the probability of exceeding a given threshold (T*), the higher is the expected consequence (given

an exceedance), measured as expected shortfall. Therefore, we do not consider consequences as irrelevant, but they are implicitly taken into consideration when we look at the probability alone, which is why we can ignore them when prioritising.[27] If you plot risks in a diagram with the probability and expected consequence along the respective axes, the result is the equivalent of a heat map.

Chart B2 shows how we prioritise two risks based on probability alone (left part of the chart) and how this can be translated into a heat map (right part). Under our assumption that the distributions are well-behaved, we see that the consequence (expected shortfall) is proportional to the probability, which means that we get the same order of priority whether we use the probability axis or the consequence axis. We have chosen the former axis.

CHART B2

Prioritisation based solely on the probability of an event can, under certain assumptions of 'well-behaved distributions', translate into a heat map



Note: Illustration of how two risks can be prioritised based solely on their probability of materialisation (left part of the chart), and how this can be translated into a heat map (right part), assuming 'well-behaved distributions'.

[27] Our prioritisation of risks therefore corresponds in principle to a value-at-risk approach, which also means that we abstract from differences in expected shortfall.

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