Copenhagen Economics

A GUIDE TO **CLIMATE TRANSITION RISK SCENARIO ANALYSIS** OF **MORTGAGE PORTFOLIOS**

A hands-on guide for how banks and financial institutions can assess climate-related risks for the mortgage portfolio entailed in a transition to a low-carbon economy

Copenhagen Economics
June 2021

Introduction

Scope and limitations

This document describes a straightforward approach to transition risk scenario analysis for credit risk in mortgage portfolios. The aim of the presentation is to give a set of concrete tools that can be used at an institutional level, to clearly identify the direct transition risks for mortgages.

In addition, we hope to guide the general discussion around climate risks by given a concrete example of how to analyse transition risk for a specific portfolio.

As the focus is on individual banks and institutions, we only consider direct effects from transition-induced policy action. Indirect effects with economy-wide impact, which in turn can affect financial institutions (e.g. labour market composition), are left to transition risk scenarios by supervising entities.

Analytical foundation for the study

The outlined approach is developed as part of the Energy Efficient Mortgage Initiative. The analytical foundation of the guide is the forthcoming study within that initiative: '*Appropriate prudential framework for energy-efficient mortgages*'.

Furthermore, we build on top of recent work by the Bank of International Settlements, the Task-Force on Climate-related Financial Disclosures, and the Network for Greening the Financial System, but with a focus on how these risk assessment tools can be applied concretely in an institutional setting and on actual portfolios.

To make this document even more hands-on, throughout the paper, we take the average EU mortgage portfolio as an example and demonstrate how the estimations can be carried out – and what the results may look like.

EXECUTIVE SUMMARY
CLIMATE RISK ASSESSMENT USING SCENARIO ANALYSIS

Our research shows that transition risks for mortgage primarily affects collateral value, i.e. loan-to-value (LTV), and are less likely to be the direct root cause of credit losses. Therefore, this guide focusses on assessing impact on risk weights.

Our starting point is a risk scenario of increasing CO_2 prices, which can represent a range of transition risks.

This can then be transformed into an increase in energy costs, based on the energy composition, which leads to user costs of owning the building based on the energy efficiency. These higher costs will, in turn, affect collateral value, which eventually increases risk weights.

The approach can be collapsed into four steps, outlined on the right. As a fifth step, we recommend to consider the robustness of the analysis, as assumptions made along the way will have large impacts on the obtained result.

This document has two tracks. First, we describe the methodology, followed immediately by a hands-on illustration which takes the average EU mortgage portfolio as an example.

5 steps to climate transition mortgage risk assessment

1 Choose your scenario

- Consider the objectives of your analysis and define a scenario accordingly
- Estimate transition-implied effects on future energy prices

2 Estimate energy costs

- Discount future incremental user costs over the entire investment horizon
- Ideally mortgage-specific, alternatively portfolio-wide

3 Estimate collateral values

- Estimate the impact on collateral values from the increased energy costs
- But if energy renovations are profitable, base the new collateral value on this instead

4 Estimate capital ratio

- Update risk weights based on the collateral effect on loss given default and probability of default
- Use new risk weights in Tier 1 Capital Ratio calculations to estimate the scenario impact

5 Consider robustness

- Check sensitivity and ensure that assumptions are sound


1
Scenario
2
Energy price
3
Collateral value
4
Risk weight and capital ratio
5
Robustness

METHODOLOGY
1 CHOOSE YOUR SCENARIO

Define the objectives of your analysis	Decide on the scenario for transitioning to a carbon-free economy	Estimate the impact on energy prices across the relevant energy sources

To obtain meaningful insights, the initial step to any scenario analysis is to define the objectives. What do you want to learn?

The transition to a low-carbon economy can take many paths, resulting in many types of transition risks. Do you want to assess the impact of a universal carbon tax that aligns the cost of emissions at a given level? Or is it the impact of raising costs of emissions by a fixed amount, regardless of current implicit taxation?

Decisions like this can completely alter the outcome of the scenario analysis. For instance if you take into account that in some countries, current implicit carbon taxes on e.g. heating is already so high that they are not required to increase as part of the transition[1].

Once your analysis objectives are in place, design a scenario for the climate transition around them.

If you simply want to analyse the impact of higher costs of CO_2 emissions, benchmark scenarios, such as those proposed by the NGFS, may be relevant.

If you want to analyse the impact of a universal CO2 price, you would need to identify existing and implicit local or domestic carbon prices, and estimate how large the required increase would be.

Finally – as an alternative – you could construct specific risk scenarios to test for particular risks, e.g. the impact on certain sectors, or similar.

For mortgages, the relevant credit risk driver under the climate transition is energy costs. To operationalise your scenario, it should thus be converted into impact on energy prices.

This can be done at different levels of sophistication.

The minimum viable approach considers heterogeneous carbon intensities across energy sources, implying a price increase proportional to the amount of carbon emissions. To obtain more precise results, formal energy market price modelling that capture general equilibrium effects (or other indirect effects) may be called for.

1 See Copenhagen Economics (2021): Appropriate Regulatory Capital Framework for energy efficient mortgages

METHODOLOGY
2. ESTIMATE ENERGY COSTS

Gather asset-specific data for the portfolio, or make sensible assumptions

As increases in energy costs is the key driver of the portfolio impact, this step is essential for achieving a precise impact.

The first-best approach is to use building-specific data on energy consumption and the sourced energy mix.

If this data is unavailable, use a sensible proxy that brings you as close to the underlying assets as possible, e.g. energy labels, heating technology and local average electricity mix.

Forecast increase in energy costs for property owners and discount to present value

Calculate future energy costs on a mortgage-specific level by combining the energy price increases defined in your model scenario with the actual energy type and usage. Then sum and discount to obtain the present value.

The forecast should be carried out over the full modelling period, which should resemble a typical mortgage investment horizon.

The calculated net present value of future energy costs would be the theoretical decrease of the collateral value in a perfect market (with complete rationality, perfect information, etc.). However, as we demonstrate in step 3, the collateral value is likely to decrease less.

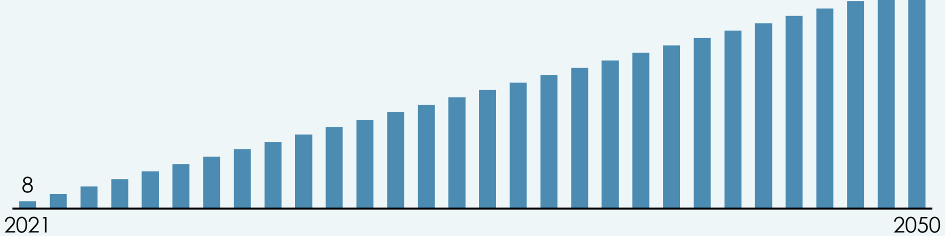
EXAMPLE: AVERAGE EU MORTGAGE PORTFOLIO
1 CHOOSE YOUR SCENARIO AND ESTIMATE ENERGY PRICES

We use average EU energy consumption and the ‘orderly transition’ benchmark scenario by NGFS, which implies a linearly increasing carbon price, shown below. In other words, in this estimation, we do not consider current explicit and implicit carbon prices.

The induced impact on energy prices are calculated on the right. Other scenarios will impact energy prices differently, and you may have to estimate energy prices independently across different sources, using the energy mix from the specific region you analyse.

NGFS scenario: Effective carbon tax 2020-2050

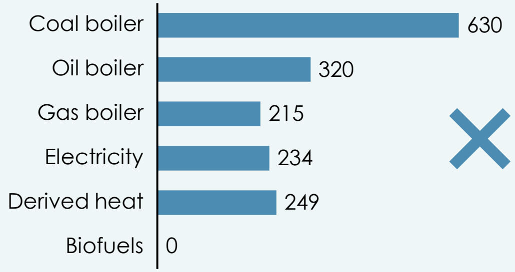
EUR / ton CO2e



> **!** The above scenario is relevant for the EU average. In your organisation you might want to consider a scenario relevant for your jurisdiction. Consult step 5 on robustness checks for details.

Carbon intensity

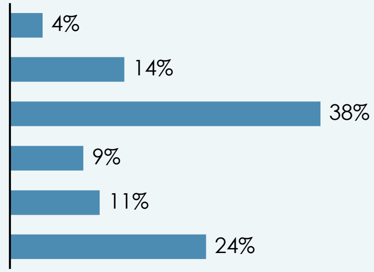
g CO2e / kWh



×

Energy mix

EU average %



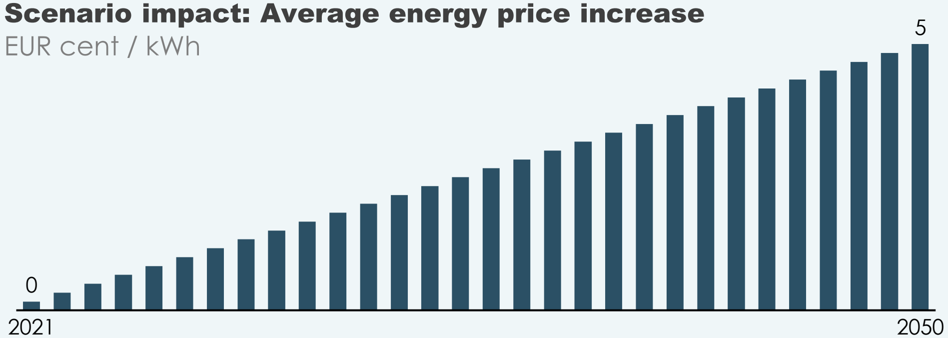
200
Average g CO2e per kWh

×

Carbon tax
For each year given scenario

Scenario impact: Average energy price increase

EUR cent / kWh



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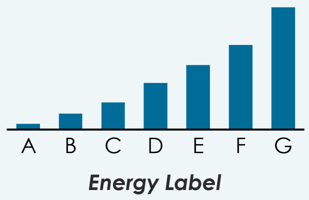
EXAMPLE: AVERAGE EU MORTGAGE PORTFOLIO
2 ESTIMATE INCREASED ENERGY COSTS

In our case, we collapse the data to average European values across energy labels and assume an average size of $100m^2$. Then, we use a 30-year investment horizon and a discount rate of 2.6% to calculate the energy price increase[1]. Assumptions are necessary at this stage, but they should be portfolio-relevant, as well as questioned in the robustness analysis.

Granular consumption data

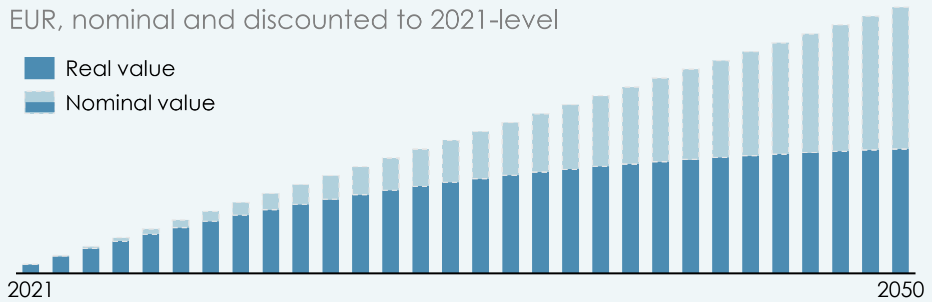
	Belgium	Bulgaria	...	Sweden
Average Energy Label	D	E	...	E
Label A Consumption	31.99	20.48	...	24.55
...	...	...	...	...
Label G Consumption	240.93	154.23	...	184.90

Impact across assets



Average household energy bill increase

EUR, nominal and discounted to 2021-level



EUR 6,600

Energy price increase over 30-year horizon from today's perspective for a representative European household

Since our objective was to estimate the effect on a *representative* European household, we reduce our model to average values across energy labels without losing nuance, as this is enough to capture heterogenous effects in our case. This is generally not possible if the objective is to assess the portfolio-specific risk assessment. Aim at keeping your data as granular as possible at this stage, e.g. by doing asset-specific estimations, in order to properly capture asset- or asset group-specific impacts in the subsequent steps.

1 See Copenhagen Economics (2021): Appropriate Regulatory Capital Framework for energy efficient mortgages for justification of these assumptions under this scenario

METHODOLOGY
3 ESTIMATE IMPACT ON COLLATERAL VALUES

Adjust for the fact that households do not fully price energy costs into house prices

Theoretically, the increase in user costs should decrease property values one-to-one. However, studies have found that this effect is not factored fully into the price of a property.

This is, among other things, due to financial myopia and illusory discounting at the time of purchase.

To combat these imperfections, adjust the impact on collateral values by an appropriate 'irrationality factor'. This can be specific to a region or customer type.

Calculate new collateral value by deducting *the lowest of* future energy costs *or* renovation costs

The impact on collateral value cannot go lower than the cost of renovating the building to a higher energy standard.

Thus, the impact is the lowest of either 1) all future, rationality-adjusted and discounted energy bill increases, or 2) the net costs of energy renovations plus the new (lower) increase in user costs. The lowest of the two is then subtracted from the current collateral value.

The renovation can both decrease energy demand (higher efficiency) or lead to lower CO_2 price from a new (greener) energy source.

The new, and most likely lower, collateral value represents a negative *wealth effect* on credit risks, which is the main risk driver for mortgage portfolios in the context of climate transition. The realized impact is considered in step 4.

Estimate the net costs of performing an energy renovation to escape energy price increases

As an alternative to bearing the increased energy costs, consider – preferably on a consumer level – whether it is profitable to perform an energy renovation that brings energy costs down permanently.

If the net costs of performing an energy renovation is smaller than the future energy costs, it is a profitable deviation to renovate the property, and the collateral value should be devalued by the net costs of the renovation, plus a now smaller increase in energy costs.

The reduction in energy costs from an energy renovation should be discounted and adjusted for irrationality in the same manner as future energy costs.

EXAMPLE: AVERAGE EU MORTGAGE PORTFOLIO
3 ESTIMATE COLLATERAL VALUES

Scale the price impact from increased user costs through the energy bill by an irrationality factor to account for the fact that future costs are not fully priced into the current price. In a previous study[1], we estimated an average rationality factor of 58%, though heterogenous across geography and energy labels. Deduct the irrationality-scaled price impact, or the cost of a relevant energy renovation – whichever gives the highest collateral value.

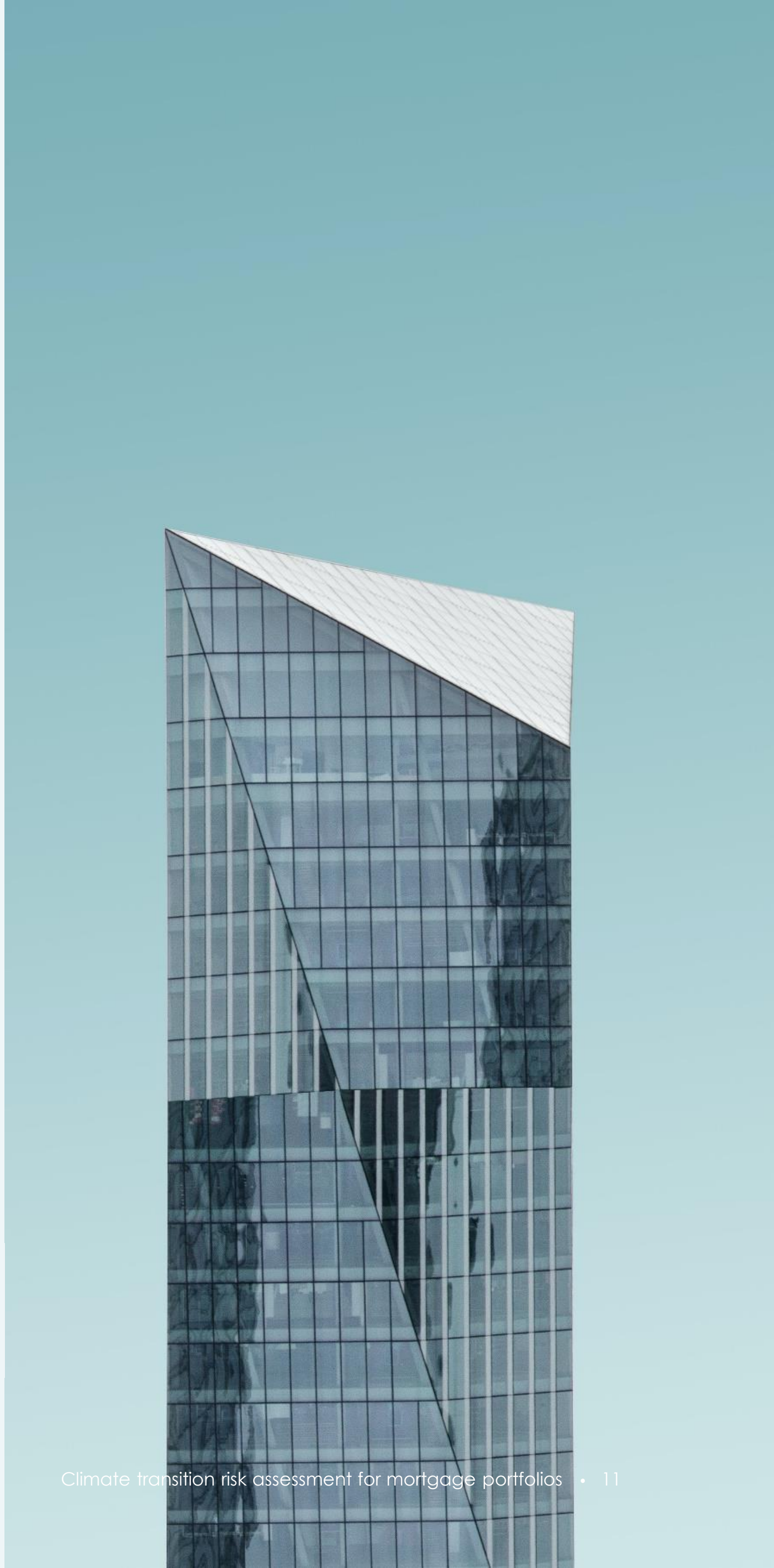
EUR 6,600 Average theoretical price impact × **58%** Average rationality factor = **EUR 3,900** Average actual price impact

EUR 128,700 Collateral value pre-scenario – **EUR 3,900** Average actual price impact = **EUR 124,800** Collateral value post-scenario

What about energy renovations in this example?

In our European average case, and for the specific scenario, the cost of relevant energy renovations exceeded the increase in energy costs for all energy labels. In other settings and scenarios, this may not be the case, in particular when looking at asset-specific estimations. If the option of performing an energy renovation is not taken into account, the risk weights assessment may be upward biased.

1 See our forthcoming EeMMIP project



METHODOLOGY
4 ESTIMATE CAPITAL RATIOS

Use the new collateral value to update the LTV, which in turn increases the PD and LGD

Recalculate risk weights and capital rations

The increase in the loan-to-value (LTV) ratio implies larger loss given default (LGD) and probability of default (PD), which increases risk weights.

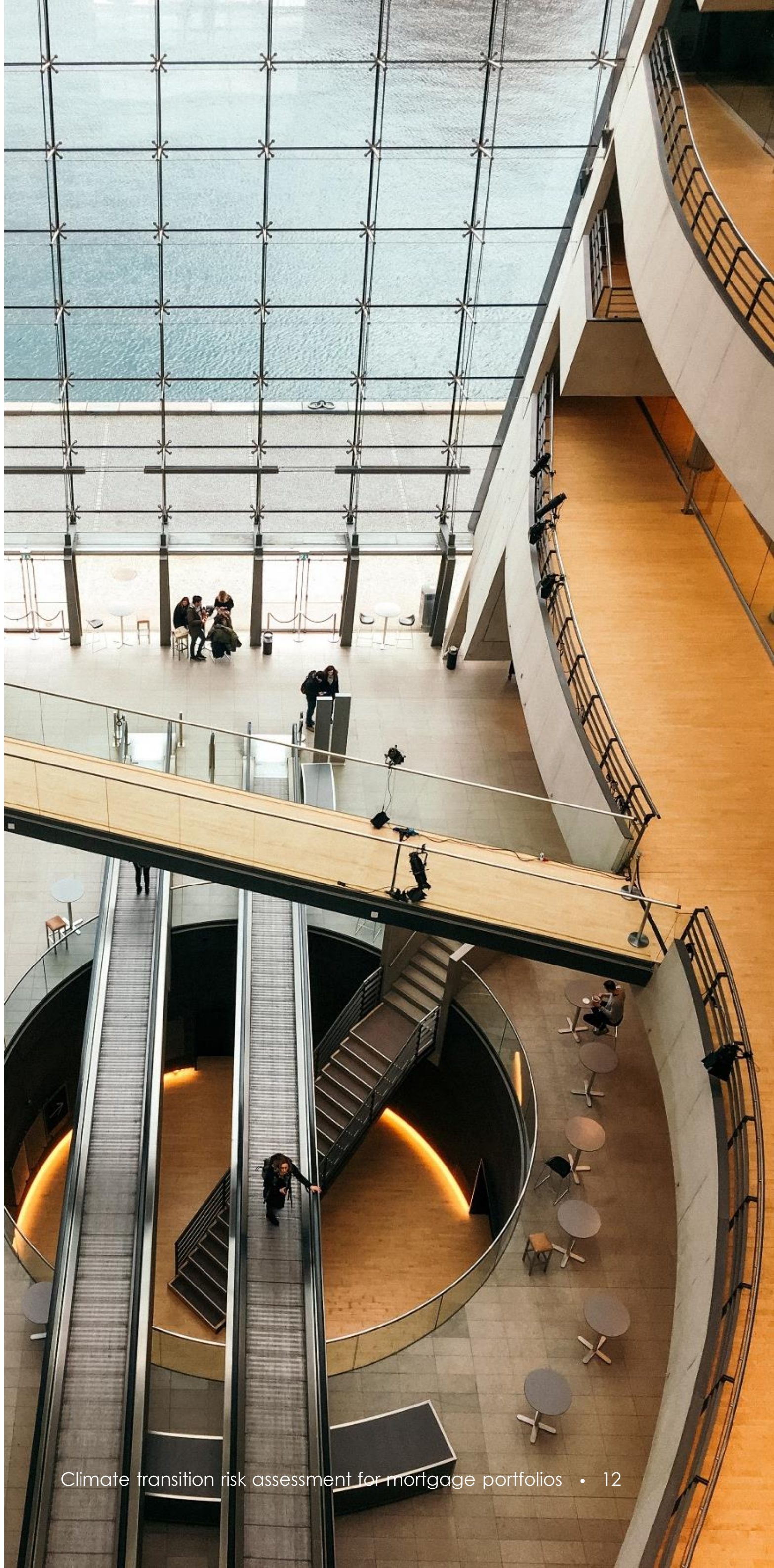
As the collateral values decreases, the LTV ratio of each mortgage increases, leaving financial institutions exposed to greater credit risk on the mortgage portfolio.

The increased credit risk can be decomposed into two effects. The LGD decreases as the collateral value decreases. Additionally, the PD increases, as the smaller equity stake leaves the debtor with less skin in the game, and thus less of an incentive to avoid defaulting on the mortgage.

If using the IRB approach, recalculate risk weights based on increased PD and LGD, or place mortgages into new risk buckets based on LTV, if using the Standardised Approach.

This final step to credit risk assessment should follow the approach used for the original risk assessment to ensure comparability.

Ultimately, capital ratio can be recalculated based on the updated risk weights, to arrive at the capital shortfall, i.e. impact of the scenario.

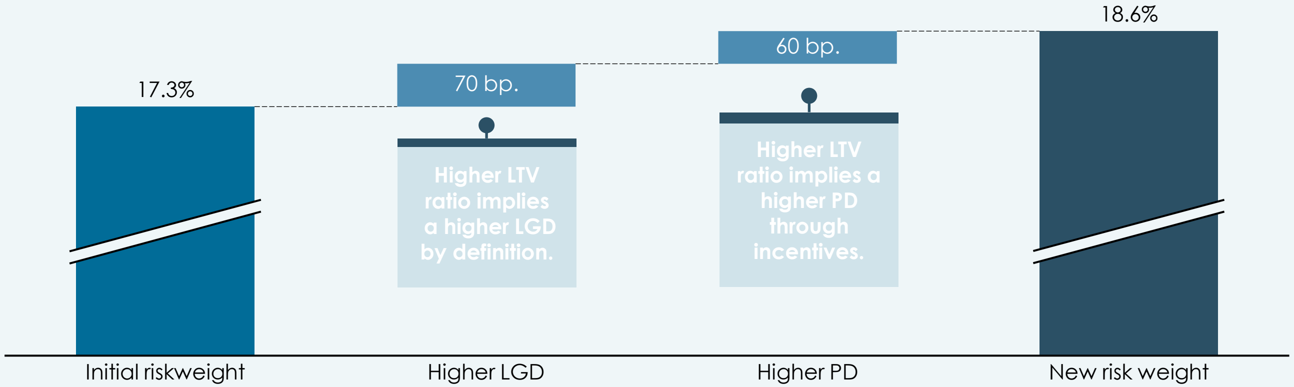


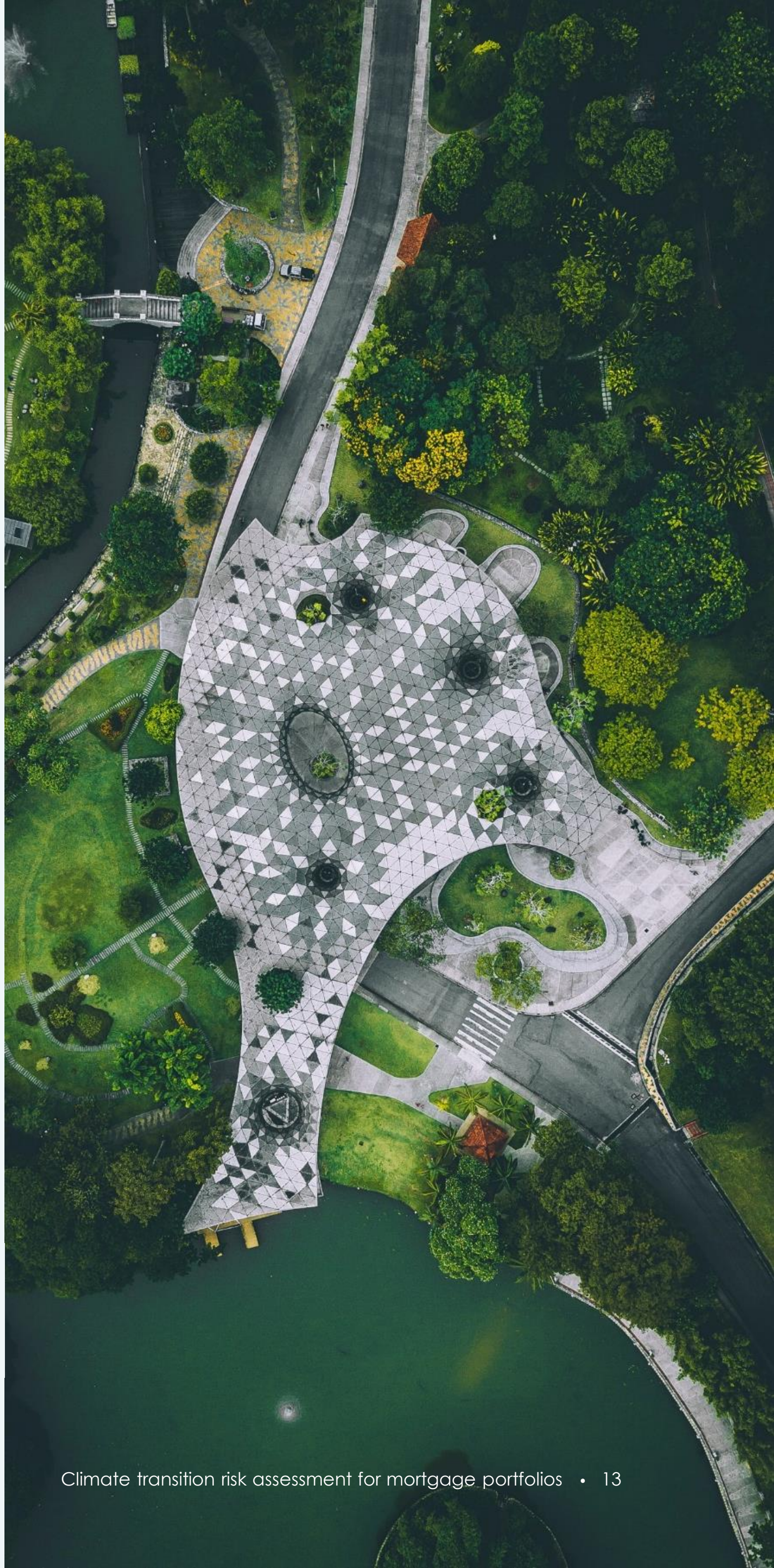
EXAMPLE: AVERAGE EU MORTGAGE PORTFOLIO
4.1 ESTIMATE RISK WEIGHTS

Use the current value of the loan and the new lower collateral value to recalculate the loan-to-value ratio. Then, use the new LTV ratio to recalculate risk weights, keeping all other values constant, if using internal calculation methods. If using the Standardised Approach, recategorize assets into the appropriate risk weight bucket. Note that this approach may mute the effect on a customer level, as only LTV ratios relatively close to a cut-off point will be affected.

$$\frac{90{,}000 \text{ (Current loan, EUR)}}{124{,}800 \text{ (Collateral value post-scenario, EUR)}} = 72\% \text{ (Loan-to-value ratio post-scenario)}$$

Average EU mortgage risk weight increase in our scenario





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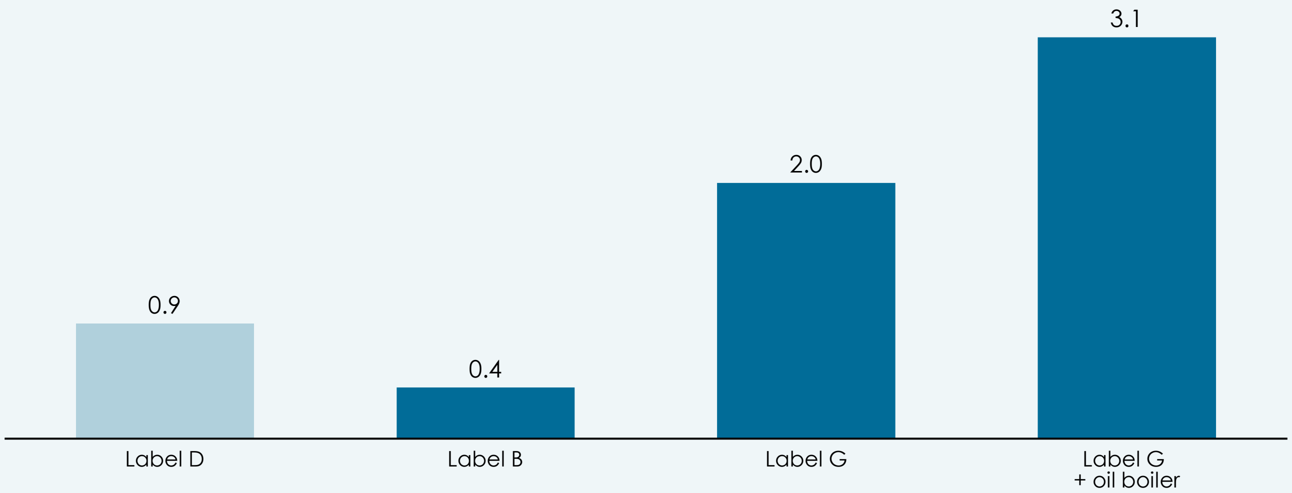
EXAMPLE: AVERAGE EU MORTGAGE PORTFOLIO
4.2 ESTIMATE CAPITAL RATIO

As a final step, use the updated risk weights and original asset values to update capital ratios. In this example, we focus on the Core Equity Tier 1 (CET1) capital ratio for a generic mortgage institute holding average EU mortgages, as defined previously. In this case, the risk from climate transitions seems manageable for portfolios with relatively good energy labels, but it may warrant an increased buffer if the portfolio has a disproportionally large share of low-energy efficient houses reliant on fossil fuel-based heating.

Decline in CET1 ratio for a generic mortgage institute in transition risk stress
Percentage points decline



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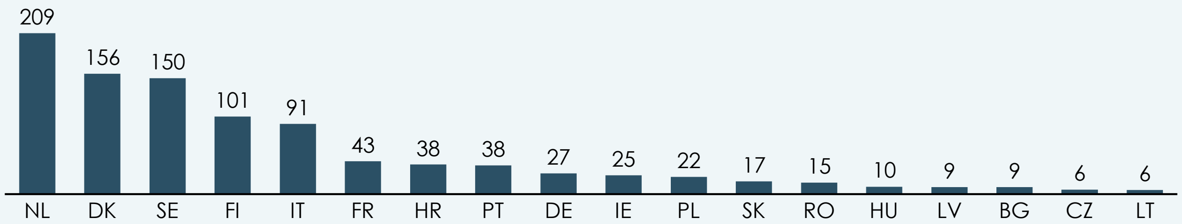
5 CONSIDER ROBUSTNESS

When considering robustness, it is relevant to gauge both the effect of the chosen scenario, as well as the assumed asset characteristics, if non-granular data is used. In our case, as shown on the right, we found that the chosen scenario has a large effect on risk weights, as does the heating source in the household. However, the effect across energy label was less significant. These are only examples, and a robustness check could also consider irrationality, discount factors, etc.

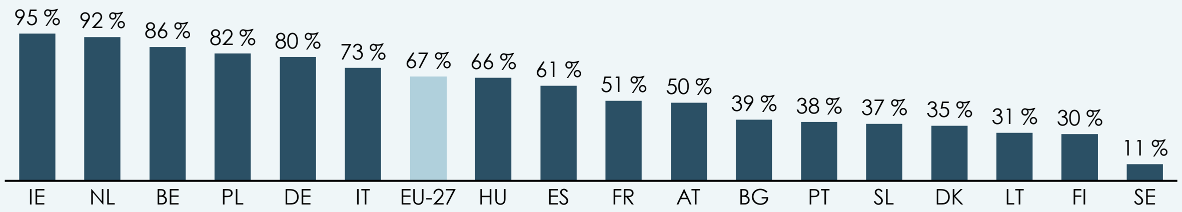
Additionally, it is critical to keep geographical and political heterogeneity in mind when choosing a scenario and estimating price impact. As shown below, the chosen scenario – e.g. an increase to explicit carbon taxes – will hit very differently across EU countries due to diverse country characteristics, which is why analysis should be done on a carefully selected domestic level.

Implicit carbon tax on energy across EU (selected countries)

EUR per ton CO_2

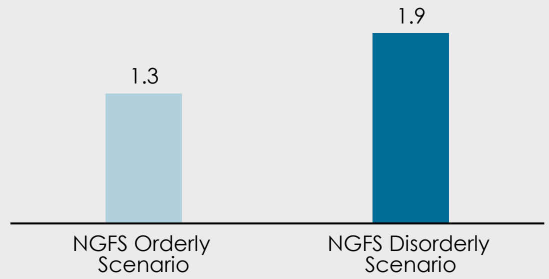


Share of fossil fuel based heating across EU (selected countries)



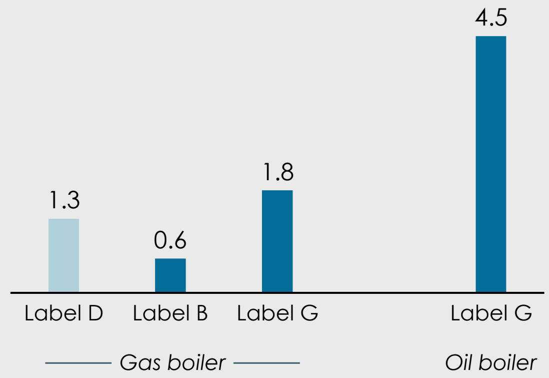
Sensitivity to scenario

Change in risk weight, %-point



Sensitivity to asset characteristic

Change in risk weight, %-point



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