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FINANCING THE TRANSITION? TAKING THE TEMPERATURE OF EUROPEAN BANKS’ CORPORATE LOAN BOOKS

A PILOT STUDY ON BANKS’ ALIGNMENT WITH THE TEMPERATURE TARGET OF THE PARIS AGREEMENT

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ABSTRACT

The Paris Agreement requires policy makers to keep the increase in global average temperature well below 2°C above pre-industrial levels, while pursuing efforts to limit the increase to 1.5°C. Furthermore, it demands finance flows to be consistent with pathways towards low greenhouse gas emission technologies. While prudential supervisory authorities so far primarily focussed on assessing banks' resilience to climate-related financial shocks from a risk-oriented viewpoint, e.g. based on dedicated climate stress tests, we argue in this paper for a complementary perspective beyond prudential supervision, namely banks' own contribution to global warming through their financing of climate-harmful activities. This perspective becomes especially relevant considering the prospective reporting on double materiality according to the EU Corporate Sustainability Reporting Directive (CSRD). With the objective of the Paris Agreement being defined in terms of degrees Celsius, we examine banks' alignment with the temperature target by quantifying the implied temperature rise of banks' (non-SME) corporate loan books. To that end, we propose an innovative alignment methodology, leveraging on the so-called X-Degree Compatibility (XDC) Model developed by right°, which we apply on granular exposure-level information collected from selected EU banks. According to our findings, the average implied temperature rise of banks' (non-SME) corporate loan portfolios ranges between 3.7°C and 4.1°C, depending on the aggregation methodology. While we observe some heterogeneity across banks, none of them is on a pathway compatible with the agreed target. Additionally, we show that the implied temperature rise as per our methodology can also serve as proxy for transition risk, thereby combining the twofold objective from a double materiality perspective in a single metric.

KEYWORDS

EU banks, Paris Agreement, portfolio alignment, climate transition, financed emissions, implied temperature rise

JEL CODES

G21, G28, Q54, Q58

Motivation

On 5 October 2016, the European Union (EU) ratified the Paris Agreement on climate change, which aims at strengthening the global response to the threat of climate change (Council Decision (EU) 2016/1841) by i) holding the increase in the global average temperature to well below 2°C and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels as well as ii) making finance flows consistent with a pathway towards low greenhouse gas emissions and climate-resilient development, among others (UNFCCC, 2015).

As a first step, the European Green Deal, presented by the European Commission (EC) on 11 December 2019, sets the objective of becoming climate-neutral in Europe by 2050 (EC, 2019). In addition to that, a legally binding interim target of reducing net greenhouse gas emissions by at least 55% until 2030 compared with 1990 levels was cast in the European Climate Law (Regulation (EU) 2021/1119). This binding target was also communicated to the United Nations Framework Convention on Climate Change (UNFCCC) in December 2020 as the official EU's determined contribution to meeting the goals of the Paris Agreement (UNFCCC, 2020). In July 2021, the EC adopted a set of proposals to make the EU's climate, energy, land use, transport and taxation policies fit for reaching this objective, so-called Fit-for-55 (FF55) package (EC, 2021a).

One important building block of the European Green Deal consists of the sustainable finance agenda. The EC's renewed sustainable finance strategy published in July 2021 also entails new mandates for the EBA and other European Supervisory Authorities (ESAs) in the field of climate stress testing (EC, 2021b). Among others, ESAs have been requested to conduct a coordinated one-off exercise to substantiate the contribution of the EU financial system to financing an orderly implementation of the FF55 package and to assess the resilience of the EU financial sector against the risk of a disorderly transition to the FF55 target (EC, 2023).

As follows, the focus of the one-off exercise is to better understand how European banks would be affected in their capacity to finance the green transition in line with the FF55 target even under stressed conditions, e.g. due to delayed climate policies (while keeping the FF55 target in 2030 leading to a negative reassessment of transition risks by market participants) or other adverse macroeconomic developments. This objective is in line with traditional climate stress tests conducted by supervisory authorities so far which generally focussed on banks' exposure to climate transition risk from a *resilience* perspective for both micro and macro-prudential purposes.[1] However, banks might in response to any supervisory follow-up simply opt for reducing their transition risk, e.g., by divesting from transition vulnerable activities or by diversifying through additional investments in other, i.e. less vulnerable, activities. As such, a reduction in transition risk at bank level may not necessarily lead to a reduction of total emissions financed and hence global warming.

[1] For instance, EBA EU-wide pilot on climate risk (EBA, 2021a), ECB economy-wide climate stress test (Emambakhsh, 2023), SSM climate risk stress test (ECB, 2022), BoE Climate Biennial Exploratory Scenario (BoE, 2022), DNB energy transition risk stress test (Vermeulen et al., 2018), ACPR climate pilot exercise (ACPR, 2021).

Another objective implied by the one-off exercise has however received only limited attention so far, namely banks' accountability for financing climate-harmful activities thereby indirectly contributing to global warming, which is typically assessed using alignment methodologies in reference to given decarbonisation pathways.[2] This *efficacy* perspective becomes especially relevant in the context of the Paris Agreement, which stipulates a re-direction of financial flows consistent to the prescribed pathways towards keeping the global temperature rise well below 2°C compared to pre-industrial levels.[3] Furthermore, banks still financing climate-harmful activities less able to transition today contribute to the delay and impediment of an orderly transition, which might in turn require more stringent climate policies for reaching the FF55 target, but as a result in a more disruptive fashion. Such disorderly transition might then create additional spillovers to other market participants, e.g. if more stringent climate policies are applied at system rather than the accountable entity level.

Going forward, European regulators will therefore have to assume a dual perspective to ensure that banks are not only resilient and solidly capitalised to finance the transition to a low-carbon economy even under adverse macroeconomic conditions *(resilience)*, but also to monitor the evolution of banks' financed emissions in line with the Paris Agreement and the FF55 target in particular *(efficacy)*. This is also referred to as double materiality perspective under the Corporate Sustainability Reporting Directive (CSRD, Directive (EU) 2022/2464), in which the risks to an undertaking and the impacts of the undertaking each represent a separate materiality perspective. Applicable to all public and a broad set of large private companies in the EU, including banks, mandatory reporting according to the CSRD will start from 2025 for the 2024 financial year. Acting as a catalyst, the 2023 EBA workshop on climate risk stress testing (e.g. Mauderer, 2023) provided a first platform for gathering views from academics, practitioners and policymakers on how to use and potentially adapt the climate risk stress-testing toolkit fit for purpose to capture both *resilience* and *efficacy* aspects.

In this context, it is important to note that the targets prescribed by the Paris Agreement and the FF55 package are expressed in different terms. While the former refers to degrees Celsius by holding the increase in the global average temperature to well below 2°C and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels, the FF55 target corresponds to a reduction of net greenhouse gas emissions by at least 55% until 2030 compared with 1990 levels with the long-term target of reaching climate-neutrality in 2050. Compatibility of the FF55 target with the maximum temperature rise implied by the Paris Agreement will therefore depend on the actual transition pathway, which need to be in line with the remaining emissions budgets for reaching the Paris goals on limiting global warming, even beyond 2030.

[2] According to the ECB, 90% of euro area significant institutions are found to be misaligned with EU climate policies based on the so-called Paris Agreement Capital Transition Assessment (PACTA) methodology, which is seen as an indicator for elevated transition risk (ECB, 2024). Similar findings are documented for the Swiss financial sector (Spuler et al., 2020).

[3] For instance, consider a bank, which invests 5%/95% of its assets into activities contributing to a 4°C/2°C pathway with sector-specific targets of 2°C for both types of activities. From supervisory perspective, the bank might be considered less exposed to transition risk if the bank's loss absorbing capacity, i.e. regulatory capital, is sufficiently high to compensate for potential losses arising from the transition within the 4°C tranche. On average, however, the bank would still finance a transition to 2.1°C, which is not in line with the Paris Agreement.

Expressing the deviation from the target in terms of degrees Celsius comes with several advantages (UNEP-FI, 2021).[4] Not only that it links directly to the globally accepted target defined by the Paris Agreement. It is also easy to compare and aggregate, e.g. across portfolios or entities, and to communicate, e.g. to investors and policy makers (Institut Louis Bachelier et al., 2020).[5] Furthermore, it is largely scenario-agnostic, i.e. reducing the modelling complexity vis-a-vis traditional climate risk assessments mainly focussing on resilience aspects. Nevertheless, besides providing an unequivocal indication on banks' contribution to global warming through their financed emissions, it may also be interpreted as a proxy for transition risk especially for banks with limited loss absorbing capacity (Bingler and Colesanti Senni, 2022), thereby combining the twofold objective on *resilience* and *efficacy* in a single metric.[6]

The objective of this paper is to shed some light on the contribution of European banking groups to climate change through their financing of climate-harmful activities, which might also impede a smooth transition to the agreed temperature target, especially if banks' beneficiaries fail to manage their transition adequately. Using an innovative alignment methodology based on absolute emissions, namely the X-Degree Compatibility (XDC) Model developed by right°, we quantify the implied temperature rise and examine whether banks are actually financing a 1.5/2°C world or not. Assuming compatibility of the FF55 transition pathway with the Paris target, the analysis also provides an indication to which extent the EU banking sector is supporting the implementation of the FF55 package, thereby also complementing the EBA's sectoral contribution to the joint one-off exercise with other ESAs. Furthermore, the project also complements previous analytical projects conducted by the EBA, namely the 2021 EU-wide pilot exercise on climate risk (EBA, 2021a), which mainly focussed on potential losses and capital implications given a number of different transition risk scenarios. Finally, this paper also investigates the suitability of alignment metrics, exemplary based on the implied temperature rise based on the XDC methodology, for the assessment of the two interrelated, but distinct perspectives on *resilience* and *efficacy*. Ultimately, this might also help to interpret and contextualise sectoral banking book exposures as well as alignment metrics which banks have to disclose as part of their Pillar 3 reporting since 2023 (EBA, 2022; Commission Implementing Regulation (EU) 2022/2453).

According to our findings, the average implied temperature rise of EU banks' (non-SME) corporate loan portfolios ranges between 3.7°C and 4.1°C, depending on the aggregation methodology. Also, we find only minor heterogeneity across banks with each of the considered (partial) loan book clearly deviating from the Paris target. Additionally, we show that the implied temperature rise as per our methodology also bears significant explanatory power for loan losses modelled under different scenarios at bank level as part of the 2021 EU-wide pilot exercise on climate risk (EBA, 2021a), which generally supports its use also for the assessment of transition risk.

[4] For an overview on different portfolio warming approaches, see Portfolio Alignment Team (2020 and 2021).

[5] For instance, investors/depositors might find it easier to make their investment decision between >/< 2°C portfolios/ banks than based on targets expressed in terms of emissions or emission intensities against a given timeline.

[6] The EBA report on management and supervision of ESG risks for credit institutions and investment firms (EBA, 2021b) provides examples on how portfolio alignment methodologies can support the identification, evaluation and assessment of ESG risks.

The remainder of the paper is structured as follows. In the next section, we first introduce the employed XDC methodology in more detail, including an overview on the underlying calculation steps as well as a brief discussion on challenges and limitations. Afterwards, we describe the dataset as well as the necessary data treatment, before presenting results and an interpretation thereof. Given the exploratory character of this study, we conclude by also hinting at possible analytical extensions going forward.

Methodology and data

The XDC Model by right°

The X-Degree Compatibility (XDC) Model is an economic climate impact model, calculating the temperature alignment of an economic entity, such as a company, a building, a sovereign, or a financial portfolio. It analyses the degree of global warming that an economic entity is compatible with under various scenarios, answering the question: "How much warming could we expect if the entire world exhibited the same climate performance as this particular entity until 2100?" The XDC Model was chosen for this particular analysis as it offered the highest coverage in terms of economic sectors for the dataset at hand when compared with alternative (temperature) alignment methodologies.

Climate performance under the XDC Model is measured in relation to sector-specific economic emission intensity (EEI) benchmarks, which reflect the remaining emission budget allocated among sectors in the One Earth Climate Model (OECM) (Teske and Guerrero, 2022) mitigation scenario (the XDC Model also supports other mitigation scenarios, e.g. by the International Energy Agency (IEA)). By mapping the measured performance at EEI level to a global scale, it is possible to derive the amount of global emissions that would reach the atmosphere every year until 2100 under the assumptions being used. Finally, the calculation draws on a climate model to compute the resulting effect on global warming in a tangible degree Celsius (°C) number: the XDC.

The XDC Model represents a unique temperature alignment methodology that uses an iterative climate model, the Finite Amplitude Impulse Response (FaIR) (Smith et al., 2018), i.e. one that updates the state of the climate system for each year of input emissions and considers multiple different greenhouse gases (GHG) explicitly. There are many advantages to this approach, one of which is the ability to quantify the different impacts of early mitigation of emissions versus later use of negative emission technologies. A further benefit is that the effect of climate uncertainties on the temperature calculation can be quantified.

The XDC Model was developed by *right. based on science*, hereafter right°, as a science-based, forward-looking, scenario- and data-agnostic temperature alignment model. The basic methodology is available as open-source application. The XDC Model allows companies, both financial and non-financial, to conduct climate impact analysis, manage their portfolio alignment, simplify sustainability reporting, set sound and science-based emission reduction targets, conduct forward-looking scenario analysis, guide climate-conscious investment and engagement decisions, and communicate effectively with stakeholders.

At its core, the XDC Model focuses on the decoupling of value creation from greenhouse gas emissions. This is the same logic that underpins the European Green Deal as "a new growth strategy […] where economic growth is decoupled from resource use" (EC, 2019). In this paper, the XDC Model is applied to analyse banks' loan portfolios by calculating the temperature alignment of the companies therein. Gross Value Added (GVA) is used as the parameter for value creation.[7]

The XDC Model calculation steps

The calculation logic behind the XDC Model can be decomposed into four separate steps, which are as follows:

Step 1 - Company EEI

In the first step, the Economic Emissions Intensity (EEI) for a certain company in a given base year is determined as the quantity of GHGs that the company emits, across scope 1, scope 2, and scope 3, to generate EUR 1 million in GVA. GVA is adjusted for inflation and differences in purchasing power parity.[8] EEI evolution from the base year until 2100 is projected along the assumptions derived from a chosen scenario. For this paper, a baseline scenario based on the Shared Socio-Economic Pathway 2 (SSP2 – Middle of the Road)[9] (O'Neill et al., 2017) with a Representative Concentration Pathway (RCP) of 6.0 (Fujino et al., 2006 and Hijioka et al., 2008) is applied. Thereby, the baseline scenario explicitly accounts for the amplification in radiative forcing due to the specific behaviour of short- and long-lived emissions in the atmosphere as well as land use (e.g. deforestation).

Step 2 - Sector median EEI / benchmark pathways

Afterwards, the EEI for the sector in a given base year is calculated as the median EEI of the companies in the sector. Various sector median EEI pathways are then projected from the base year until the end of the century along the assumptions derived from a baseline scenario (based on

[7] A more detailed description of an earlier version of the XDC model is provided by Helmke et al. (2020). The XDC model is also available as open source via GitHub or via the 'right. open' project.

[8] To control for internationally diversified business models, the GVA is adjusted for differences in purchasing power and inflation at country, regional and global level based on the respective World Bank Indicators. The baseline adjusted GVA pathways are subsequently determined based on economic growth rates implied by the underlying baseline SSP2 scenario.

[9] The SSP2 scenario is called „Middle of the road" and widely used as baseline scenario. It assumes that the world follows a path in which social, economic, and technological trends do not shift markedly from historical patterns. Development and income growth proceeds unevenly, with some countries making relatively good progress while others fall short of expectations. Global and national institutions work towards, but make slow progress in achieving sustainable development goals. Environmental systems experience degradation, although there are some improvements and overall, the intensity of resource and energy use declines. Global population growth is moderate and levels off in the second half of the century. Additional analyses based on other SSP narratives that assume more progress in terms of technical innovation, and thus a faster decarbonisation, could theoretically be implemented, but are considered out of scope for this type of exercise.

SSP2/RCP6.0, as above) as well as decarbonisation pathways from the OECM mitigation scenario. Among its main features, OECM considers the target temperature of 1.5°C, without allowing for overshoot, with a likelihood of its pathways of 66%.

Sectors are defined according to NACE codes; normally at 1 or 2-digit level, but higher granularity may also be used.[10] The minimum data requirement to define the sector median EEI of a particular sector is set at 30 companies according to the 30-sample size rule. If the sector does not have enough data, a lower granularity NACE code is used (e.g. the 1-digit in lieu of the 2-digit level).

Step 3 - Climate performance / upscaling to global emissions

By comparing the position of the company EEI (step 1) to the sector benchmark pathways (step 2), the relative climate performance of the company is determined for every year until 2100. This annual performance is then mapped to the global scale through a normalisation process, by assuming that the world GHG contributors perform the same relative to their equivalent global benchmarks. This yields the global GHG emissions that would reach the atmosphere if the entire world exhibited the same climate performance as the company under consideration until the end of the century. In doing so, the XDC metric enables comparability of results among different sectors.

Step 4 - From emissions to degrees Celsius

The annual globally mapped GHG emissions from the base year until 2100 (step 3) are used as input to the FaIR climate model, which calculates the resulting global temperature. The company's XDC value is the calculated global mean temperature anomaly in 2100 relative to the pre-industrial level. It can hence be interpreted as the global temperature rise implied by the respective company's business model or the company's temperature alignment.

Challenges and limitations

This analysis uses the XDC Model as a forward-looking methodology for assessing the climate impact of an economic entity. Forward-looking methodologies rely on assumptions; consequently, their results are prone to some uncertainty. Most important assumptions refer to the remaining carbon budget for reaching the 1.5°C target and the emission intensity of a sector.

As the 1.5°C-aligned carbon budget shrinks every year, in which the world does not decarbonize with a 1.5°C-aligned rate, XDC-values change naturally with new base years over time. The question of how to handle this issue of "moving targets" for a single entity is still subject to clarification.

The emission-intensity of a sector is determined by the median of emissions intensities of all companies in the sector in the underlying database. Statistical rules are applied that control this approximation to a certain extent. With increasing levels of data quality, especially with regards to Scope 3 emissions, median emissions intensities will change, which also affects XDC-values for

[10] For the purpose of this exercise, NACE Rev. 2 terminology was used for the classification of individual counterparties to economic sectors. The NACE framework including sectors, divisions (2 digit level), groups (3 digit level), and classes (4 digit level) is established by Regulation (EC) 2006/1893).

single companies. At the moment, NACE sector A (agriculture) cannot be covered due to the peculiarity of GHGs emissions in that sector. The extension of the XDC Model for NACE A companies is planned to be released by 2025.[11]

As any model, the XDC Model is subject to ongoing fine-tuning in terms of logic, tuning of parameters and functionalities. Apart from that, planned model developments include additional quality assurance processes with the aim of catching and deeper investigating edge cases, the introduction of more recent benchmarks to be used for the climate performance calculation, the switch to a new version of the climate model to improve the performances and the temperature calculation part.

Data

The analysis builds on a unique dataset compiled from various sources combining exposure-level information from selected EU banks with granular emissions data. This section provides a detailed overview on the various data sources used and the composition of the final dataset.

Data description

Banks' exposure-level data

The dataset on which the XDC Model is applied was collected as part of the 2021 EBA pilot exercise on climate risk.[12] This dataset includes information provided by 29 volunteer banks and focuses on non-SME corporate exposures under both standardised (SA) and internal rating based (IRB) approaches (i.e. financial obligors were excluded from the sample). In terms of geographical coverage, the scope of the sample is narrowed to EU-domiciled obligors. The reference date of the collected data is end-2019.

Among the 29 banks that took part in the 2021 EBA pilot exercise on climate risk were seven global systemically important institutions (G-SIIs) and 15 other systemically important institutions (O-SIIs) covering 50% of the EU banking sector's total assets and 47% of total risk-weighted assets (RWA).

Apart from exposure values, collected data points also include selected risk parameters as well as and climate risk-related information (e.g. economic sector, GHG emissions intensity). In total, the data reported by participating banks comprises information on more than 477,000 unique obligors located in 29 countries, covering 78% of total non-SME corporate exposures to obligors domiciled in EU countries, which accounts for approximately 28% of total loans and advances at amortized cost and 16% of the total assets of the participating banks.[13]

[11] As the share of agricultural exposures in the underlying dataset is only marginal due to its scope being limited to non-SME corporate exposures (EBA, 2021a), the effect from excluding of the agricultural sector in the following analysis is considered limited.

[12] For more information on the sample, the data collection process as well as data limitations, please refer to EBA (2021a).

[13] As the dataset at hand does not differentiate loans by the use of proceeds, e.g. whether loans are explicitly linked to transition finance, it is assumed for the following analysis that all loans are provided as general purpose loans. For

Emissions data

Emissions data is used to compute the base year EEI for both the individual counterparties and their respective sector references. More precisely, emissions data is needed for scope 1, 2 and 3 separately and expressed as tons of CO2e. For the individual counterparties, the information provided as part of the 2021 EBA pilot exercise is used while for the sector references emissions data is extracted from the S&P Trucost.

Financial data

The other main component for the EEI calculation is the GVA. For those counterparties where an identifier is available, the GVA data is extracted from FactSet. Furthermore, the NACE sector or the country information is collected to adjust the GVA for purchasing power and inflation.

Data processing and mapping

Filtering

The 2021 EBA pilot dataset included a total of 577,232 observations adding up to a total exposure volume of 2,346.53 EUR bn. From its initial status, several filters were applied to align with the data requirements of the XDC Model, which itself was adjusted too in order to maximise coverage of the given dataset, as described above.

The first filter excluded observations for which no NACE code was available. The lack of this relevant information caused the exclusion of 144,159 observations, which accounts for the 25% of the initial dataset.

From the remaining 433,073 observations, banks provided information on ISIN codes for 27,372 observations (4.7% of the initial dataset). For these observations, the ISIN was used to map financial information needed for the aggregation from asset to portfolio level. The mapping resulted in a further reduction of the dataset to 8,303 observations, for which the XDC calculation could be run without additional data adjustments. Moreover, these observations were used to determine the sector references needed for XDC Model calculation step 2 as well as for cross-filling in case of missing input data, as described below in more detail.

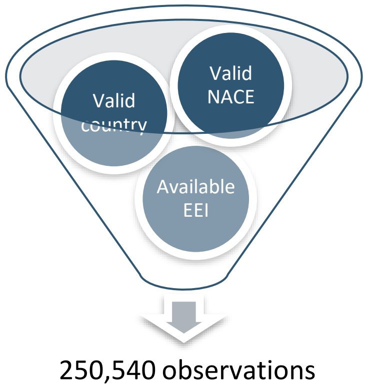
Further filtering caused the exclusion of 18 observations due to unavailable country information and 221 observations due to a non-applicable asset type (not a listed or a private equity).

After applying these filters, a total of 432,834 observations remained for the XDC calculation. However, due to the inability to provide sector median EEIs in every non-standard case following the above methodology, an XDC could eventually only be calculated for 294,279 (51%) observations corresponding to 69% of the initial total exposure volume. From this set, the counterparties from

companies falling under the scope of the CSRD, the upcoming disclosure of more detailed information on their individual transition activities will help to address this shortcoming going forward. Moreover, banks' pillar 3 disclosures will provide some information on mitigating actions supporting their counterparties in the transition to a carbon neutral economy and in the adaptation to climate change based on breakdowns of (accounting) portfolios.

the financial sector (NACE 2 sectors K64, K65, and K66) have been excluded, similar to the 2021 EBA pilot exercise. The result is a calculation for 250,540 observations (43%) and 60% of the initial total exposure volume. This corresponds to 19% of the total loans and advances at amortized cost and to 11% of the total assets for the banks participating in the exercise.

Figure 1: Stylised illustration of filtering logic

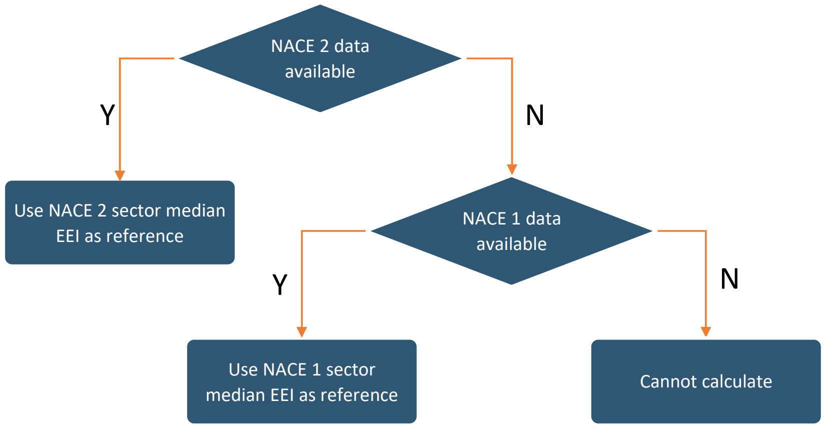


Sector median EEI

As described above, the sector median EEIs serve as a starting point for the determination of sectoral reference pathways by combining, to the extent available, emissions data (scopes 1-3) with information on the GVA for those companies operating in that particular sector.

Following this approach, the EEIs are calculated for individual companies, where possible, and subsequently grouped by NACE codes at 2-digit level in order to determine the sector median EEIs when those (sub)sectors included more than 30 companies. Otherwise, grouping is performed at NACE 1-digit level.

Figure 2: EEI at sectoral level

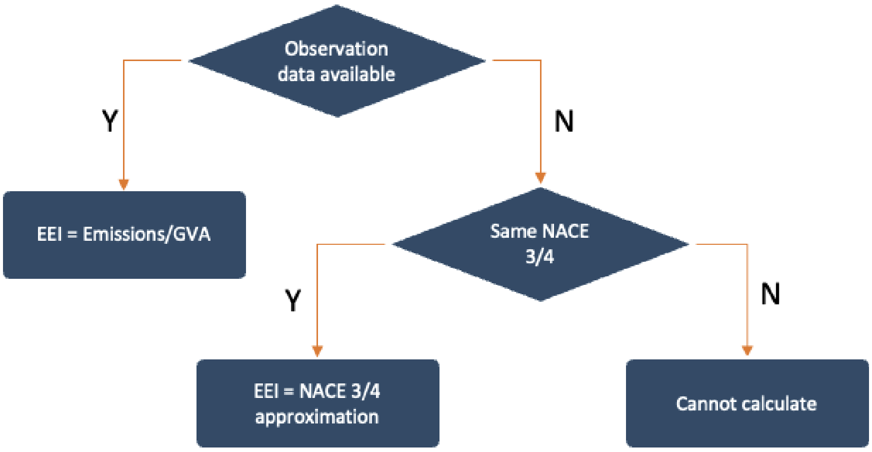


Furthermore, sector median EEIs are also determined for groups with at least 10 companies at more granular levels, i.e. NACE 3 or 4-digit levels, to facilitate the approximation of missing company data at single obligor level, as described in the following.

Single obligor level

In the standard application, the XDC Model calculations take place fetching all the required data from the internal database of right°. However, to apply the model to the 2021 EBA pilot dataset, the supporting data infrastructure had to be adapted to leverage the specific structure of this dataset and to account for the varying degree of completeness. Accordingly, in the cases where emissions and GVA data were available for the individual observation, the standard XDC application could be adopted. This has been the case for 8,303 (3.3%) observations (also see filtering section above). Otherwise, an approximation based on sectoral information at highest possible granularity, i.e. at NACE 3 and 4-digit level, was used as a proxy for the missing company data in order to increase the number of assets, which could be covered by the XDC calculation.

Figure 3: EEI at single obligor level



More specifically, for exposures for which either emissions or GVA data was missing, the EEI was approximated by

- the sector median EEI of the corresponding 4-digit NACE sector, if the sector contained at least 10 companies, which has been possible for 115,840 (46.2%) observations, or
- the sector median EEI of the corresponding 3-digit NACE sector, if the 4-digit sector contained less than 10 companies and the 3-digit sector contained at least 10, which has been possible for 126,397 (50.5%) observations.

The threshold of 10 companies is determined based on a bootstrapping analysis performed on the dataset, which aimed at balancing the accuracy of the sector EEI values and the coverage at 4-digit level.[14]

[14] For each sector, a bootstrap sampling is utilised with varying the sample size from 5 to 40 companies. The 95% confidence interval is computed for the sector median of the scope 1 emission intensity. For the interpretation of the results, two additional variables are calculated: i) Index: upper end of confidence interval divided by lower end and ii) range: Difference between upper and lower end of interval. Acknowledging the heterogeneity of some sectors, it is simplified that minimum 10 companies are needed in to calculate the approximation. If the sector does not have enough data, a lower granularity NACE code is used (e.g. the 3-digit NACE code in lieu of the 4-digit NACE code).

From single obligors to portfolios

The calculation of portfolio-level XDCs relies on so-called "attribution factors" as an estimate for the share of emissions an investor is actually responsible for having invested in a certain asset. In this analysis, two approaches for calculating the attribution factors are considered (Portfolio Alignment Team, 2021):

1. Portfolio-weight approach: The ratio between the amount of loans provided to a company, by a single bank, and the sum of loans provided to all the companies in the considered portfolio of that bank. Hence, the analysis is made from the perspective of the individual bank, where the portfolio consists of the (partial) loan book being considered.
2. Aggregated-budget approach: The ratio between the amount of loans provided to a company, by a single bank, and the sum of total funding available to that company including from other sources (both equity and debt), following the definition of financed emissions by the Partnership for Carbon Accounting Financials (PCAF, 2022).

For the bank-level calculation, aggregated XDCs were calculated based on the two attribution factor approaches discussed above. Under the portfolio-weight approach, based on the relative contribution of loans to the considered loan book, an XDC could be calculated for all banks, while under the aggregated-budget approach, relying on PCAF financed emissions, an XDC could only be calculated for 17 banks due to lacking data. In the following, bank-level results are therefore presented according to the portfolio-weight approach to maximise coverage of banks at the cost of sacrificing some scientific robustness, unless otherwise stated (Portfolio Alignment Team, 2021).

Descriptive statistics

After applying the filtering and cross-filling logic, 250,540 observations remain in the final dataset corresponding to 19% of total loans and 11% of total assets for the banks participating in the exercise. In terms of exposure volume, loans to the manufacturing sector (C) contribute most representing 39.6%, followed by wholesale and retail trade (G) and real estate activities (L) representing 14.8% and 13.1%, respectively. Overall, sectors that highly contribute to climate change amount to 83.1% of total exposures in the final dataset.

Table 1: Descriptive statistics by NACE sectors

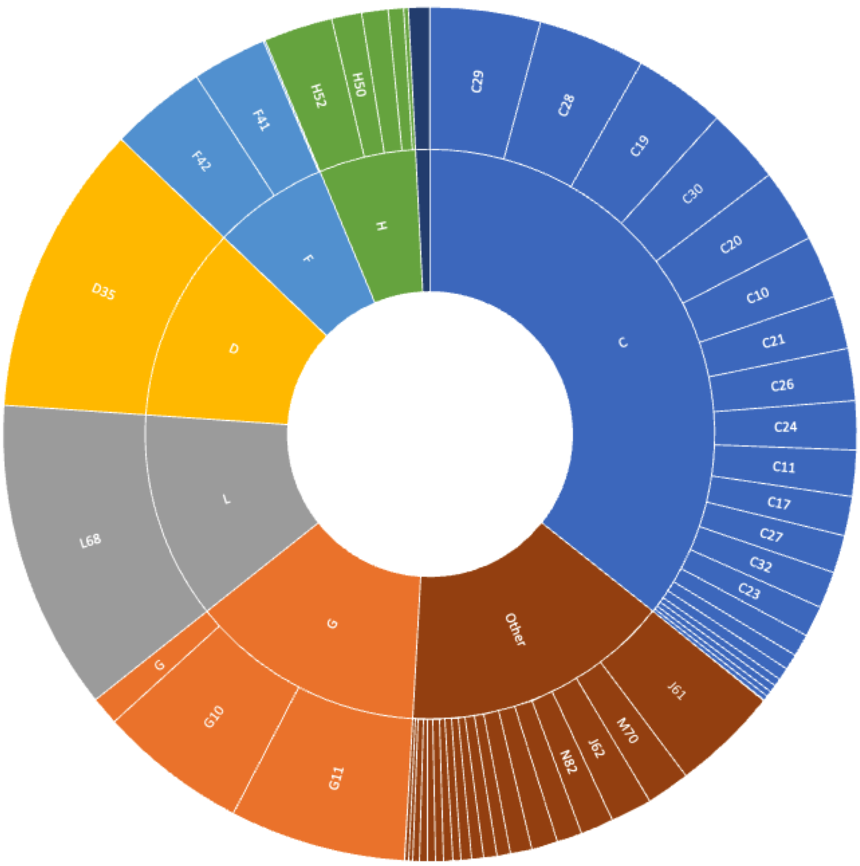
NACE		Number of observations	Exposures in EUR mn		
			Total	Mean	Std. deviation
C	Manufacturing*	61,771	503,712	8.15	53.26
D	Electricity, gas, steam and air conditioning supply*	7,407	155,880	21.04	78.44
E	Water supply; sewerage, waste management and remediation activities*	1,525	11,363	7.45	31.75
F	Construction*	15,121	92,586	6.12	28.69
G	Wholesale and retail trade; repair of motor vehicles and motorcycles*	60,631	188,714	3.11	38.68
H	Transportation and storage*	14,351	77,704	5.41	29.96

NACE		Number of observations	Exposures in EUR mn		
			Total	Mean	Std. deviation
I	Accommodation and food service activities	6,107	19,326	3.16	27.52
J	Information and communication	12,201	110,945	9.09	69.07
L	Real estate activities*	31,082	165,971	5.34	24.26
M	Professional, scientific and technical activities	20,623	51,157	2.48	28.37
N	Administrative and support service activities	10,297	22,044	2.14	11.58
Q	Human health and social work activities	2,461	5,422	2.20	9.86
R	Arts, entertainment and recreation	6,963	6,543	0.94	7.88

* Sectors that highly contribute to climate change in accordance with Commission Delegated Regulation (EU) 2020/1818 supplementing Regulation (EU) 2016/1011 as regards minimum standards for EU Climate Transition Benchmarks and EU Paris-aligned Benchmarks (Climate Benchmark Standards Regulation).

As even individual sectors can be quite heterogeneous, figure 4 provides an additional breakdown of total exposures in the final dataset by NACE divisions, i.e. at 2-digit level. Nevertheless as mentioned above, the analysis relies on the most granular sectoral information available.

Figure 4: Breakdown of total exposures by NACE sectors at 1 and 2 digit level



Results

The following section is divided in two parts. First, the results for the XDC calculation are presented for individual exposures, but also bank and sector-level aggregates. Afterwards, bank-level XDCs are compared with individual results from the 2021 EBA pilot exercise on climate risk.

XDC calculation

Exposure-level XDCs

As a first step, XDC values for each counterparty are calculated. Figure 5 shows the distribution of individual XDC values across the number of counterparties. The peak of the distribution is located around 3.5°C, while the mean is slightly higher at 3.7°C. Notably, these values are considerably higher than the current temperature increase under baseline assumptions (SSP2-RCP6.0), which are projected at 3.2°C.

Figure 5: Distribution of individual XDCs across counterparties

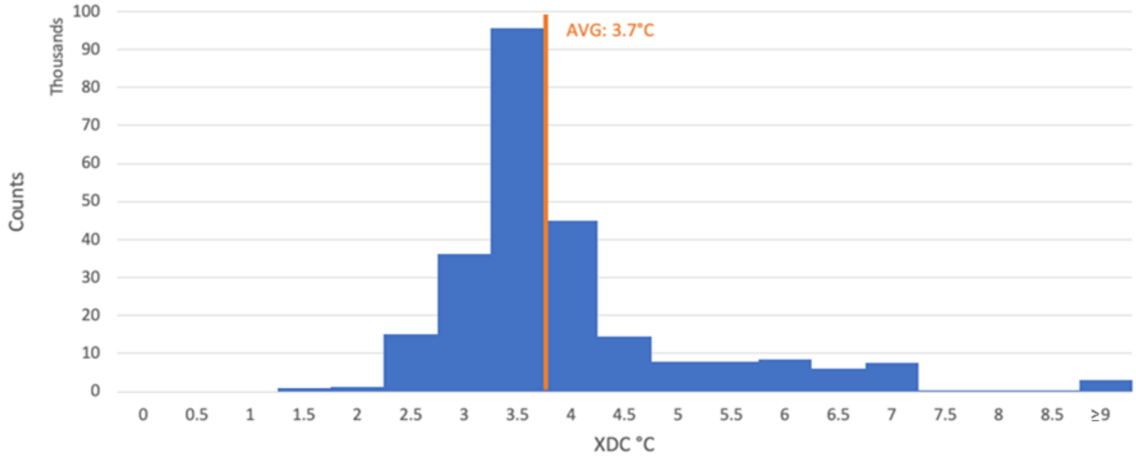
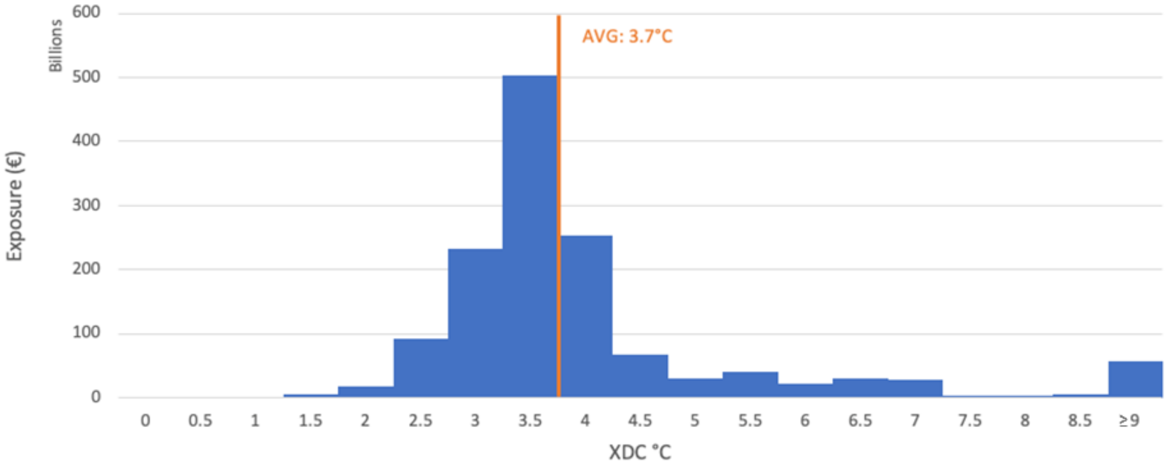


Figure 6 shows again the distribution of XDC values, but in terms of exposure volumes, thereby illustrating the amount of invested capital that is associated with a certain range of temperature increase. When compared to the distribution of individual counterparty-level XDCs above, it becomes apparent that both distributions appear similar having the same average of 3.7°C and the peak in the same temperature range. However, the somewhat lower peak of the distribution across exposures indicates that exposure volumes are spread more across the various intervals than the count of observations.

Furthermore, both distributions show a considerable range of XDCs, with only a non-material fraction in the range of 1.5°C to 2°C, which would be in line with the Paris Agreement. At the same time, both distributions exhibit material tails for higher XDCs of up to 7°C and more.

Figure 6: Distribution of XDCs by exposure volumes



XDCs at bank level

As a next step, the XDCs are aggregated across exposures at bank level, i.e. representing the degrees of warming associated with the (partial) loan book considered for each bank. Applying the two aggregation mechanisms explained before, portfolio-level XDCs are calculated according to the portfolio-weight approach and, where possible, also according to the aggregated-budget approach following the PCAF logic.

Figure 7: Aggregated portfolio-level XDC per bank

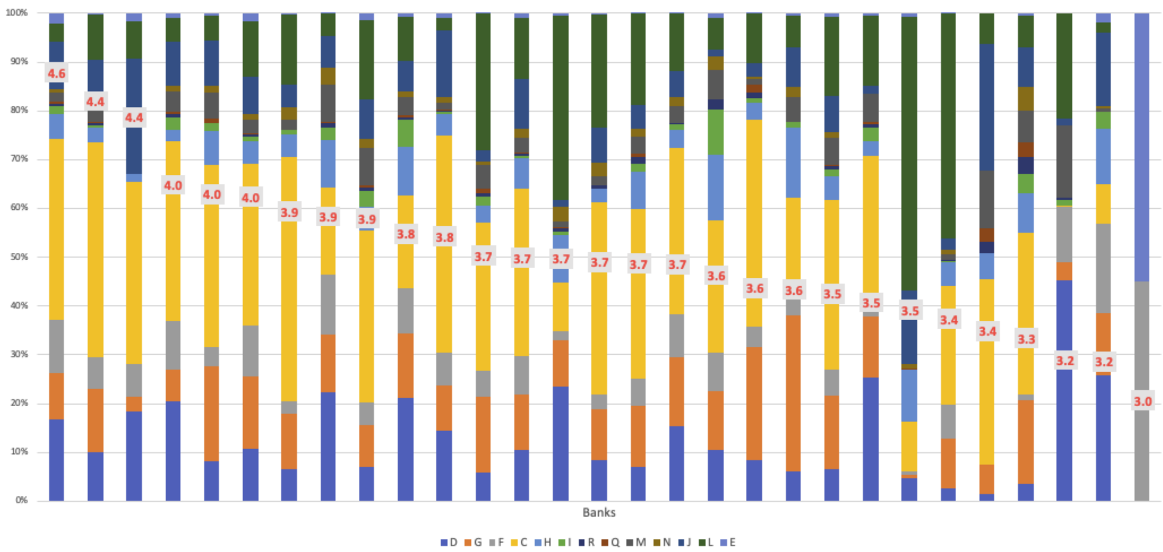
Considering the portfolio-weight aggregation approach, the system-wide average of the portfolio-level XDCs across all sampled banks is 3.7°C, which is in line with the one obtained through the individual calculations. Overall, there is only minor heterogeneity across banks, ranging from 3.0°C to 4.6°C. As such, none of the considered (partial) loan books has been in line with a pathway compatible with the Paris Agreement at the reference date (end-2019), but rather financing activities that on average contribute to further global warming. This is consistent with recent findings by the ECB indicating that 90% of euro area significant institutions' corporate loan portfolios are misaligned with EU climate policies (ECB, 2024).

Under the aggregated-budget approach following PCAF logic, bank-level XDCs are for most banks higher when compared to the portfolio-weight aggregation approach, resulting in a system-level average of 4.1°C with a range from 2.9°C to 5.1°C. The slightly different XDCs resulting from the two approaches can be partially explained by the fact that the portfolio-weight approach tends to underestimate the contribution of high-emitting counterparties with relatively small outstanding amounts by construction (Portfolio Alignment Team, 2021). Since the aggregated-budget approach could only be implemented for a sub-sample of banks, as explained above, with most banks showing relatively higher XDCs, the resulting system-level contribution is also somewhat higher. Nevertheless, the directional result under both aggregation approaches seems largely consistent with a correlation of XDCs across banks, for which both aggregation approaches could be implemented, of 0.88.

Bank-level XDCs and portfolio composition

Following the calculation of XDCs at bank level, a potential relationship with the underlying portfolio composition in terms of NACE sections is investigated. Figure 8 presents both the average XDC by bank, aggregated according to the portfolio-weight approach, and the corresponding relative composition of the considered loan book by NACE sections with sectors being stacked according to the average sectoral EEI from highest (bottom) to lowest (top).

Figure 8: Bank-level XDCs and portfolio composition by sectors



However, from figure 8 it seems there is not necessarily an evident relationship between the sectoral composition and the XDC for a given portfolio. A plausible explanation for this is that the XDC calculation is generally anchored at counterparty level, i.e. relying on company-specific emissions data to the extent possible, while only reverting to (sub-)sectoral information where such company-level information is missing. Furthermore, if cross-filling is applied, this is generally done at higher levels of sectoral granularity to account for the heterogeneity even within NACE sections. Another reasonable explanation may be that large exposures to climate-relevant, i.e. emission intense, sectors may not per se lead to higher XDCs as the underlying methodology is built around sector-specific pathways. In other words, some banks may simply do relatively better compared to their peers in financing companies within a certain sector that are closer to the respective sectoral targets, which would positively affect and lower the resulting XDC. In any case, this may be interpreted as supporting evidence that granularity matters not only for the XDC calculation, but also for any type of alignment and climate risk analyses in general.

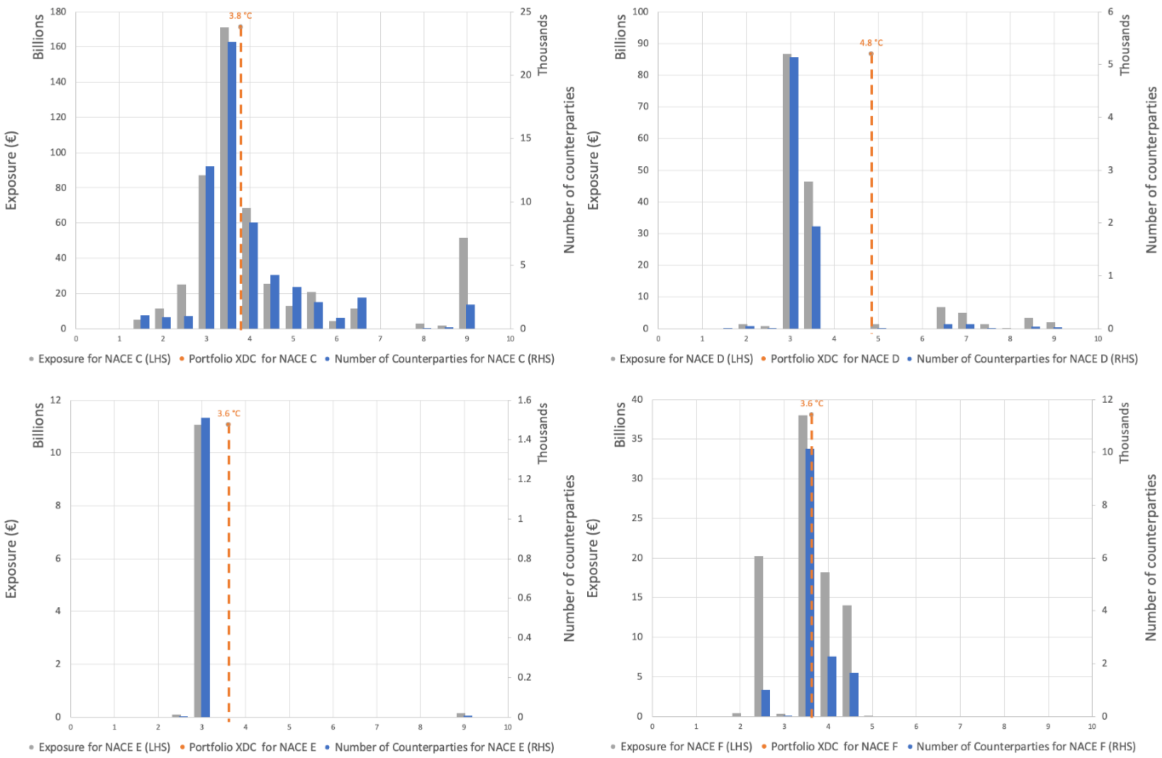
Exposure-level XDCs by NACE sections

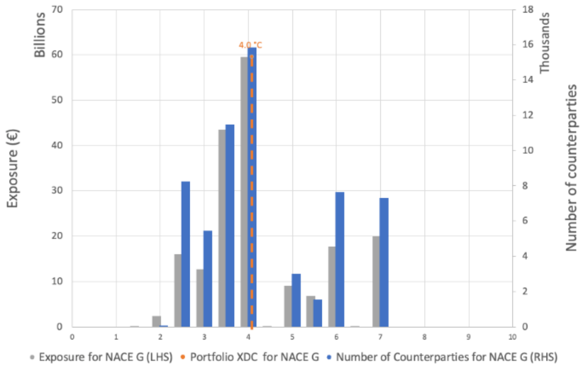
Instead of aggregating at bank level, the following analyses provide an additional perspective regarding the calculated XDCs for individual NACE sections (1-digit level), which are aggregated across banks. Apart from the average sector XDCs, figure 9 also shows the distributions of XDC values both in terms of number of counterparties and exposure volume.

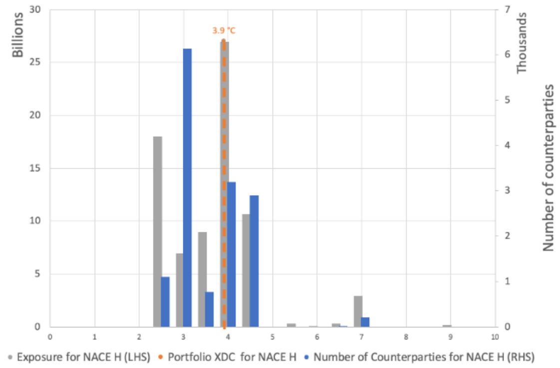
For instance, of the largest sectors in terms of exposure volume, sector C (manufacturing) exhibits an average XDC of 3.8°C, sector G (wholesale and retail trade) 4.0°C, sector L (real estate activities) 4.1°C, sector D (Electricity) 4.8°C, sector J (information and communication) 3.8°C, and construction 3.6°C.

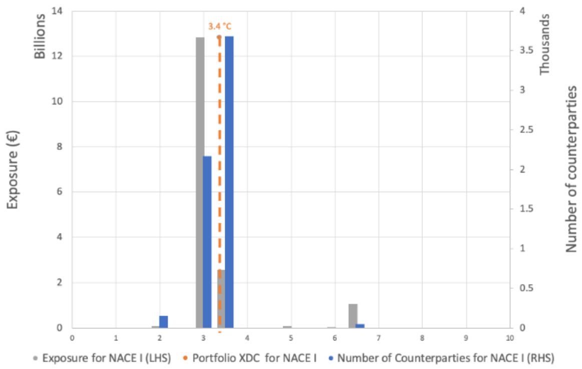
Furthermore, figure 9 also allows for a comparison of the distributions in exposure volumes and the number of counterparties at sectoral level. Regarding sector C (manufacturing), for example, the sector average XDC is substantially influenced by exposures with an XDC of 9°C or higher that however only relate to few counterparties.

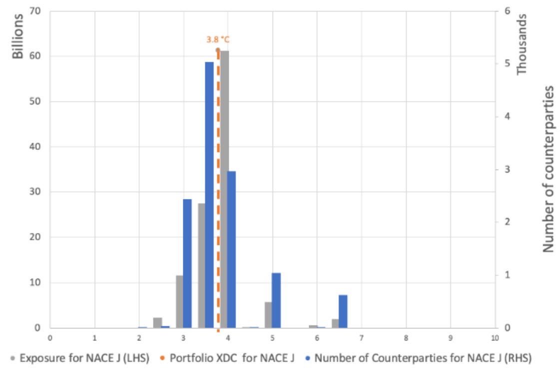
Figure 9: Exposure-level XDCs by NACE sections

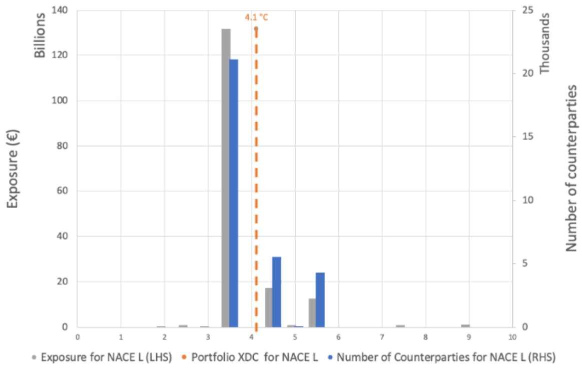


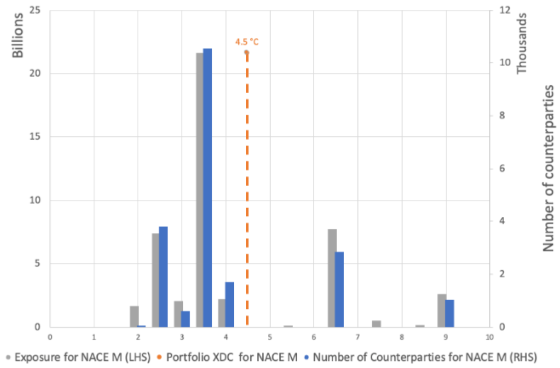

Billions
Exposure (€)
Thousands
Number of counterparties
4.0 °C
Exposure for NACE G (LHS) Portfolio XDC for NACE G Number of Counterparties for NACE G (RHS)

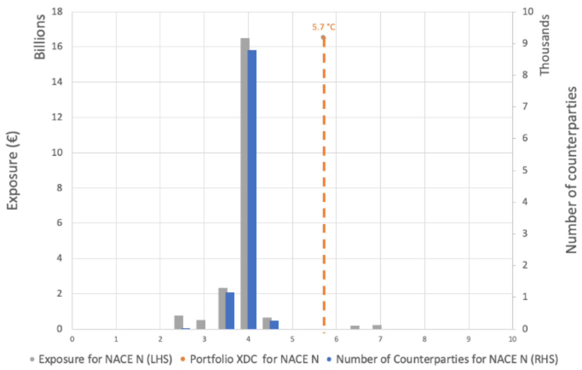

Billions
Exposure (€)
Thousands
Number of counterparties
3.9 °C
Exposure for NACE H (LHS) Portfolio XDC for NACE H Number of Counterparties for NACE H (RHS)

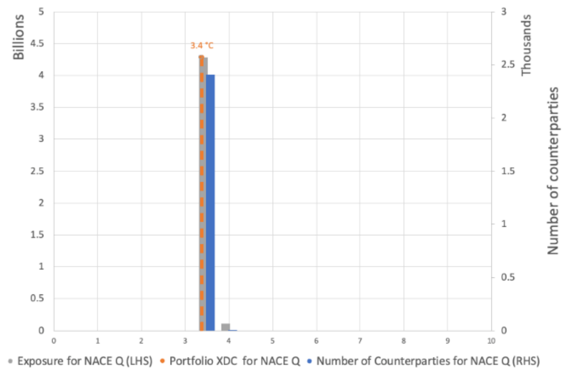

Billions
Exposure (€)
Thousands
Number of counterparties
3.4 °C
Exposure for NACE I (LHS) Portfolio XDC for NACE I Number of Counterparties for NACE I (RHS)

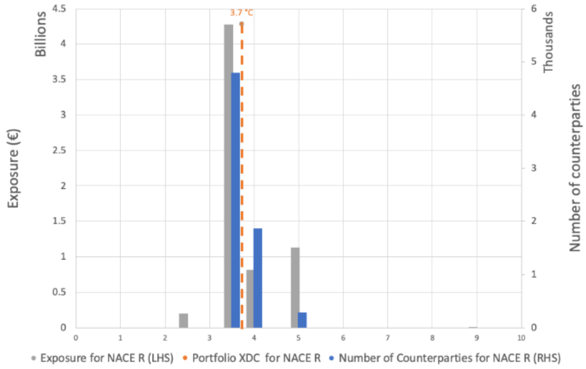

Billions
Exposure (€)
Thousands
Number of counterparties
3.8 °C
Exposure for NACE J (LHS) Portfolio XDC for NACE J Number of Counterparties for NACE J (RHS)


Billions
Exposure (€)
Thousands
Number of counterparties
4.1 °C
Exposure for NACE L (LHS) Portfolio XDC for NACE L Number of Counterparties for NACE L (RHS)


Billions
Exposure (€)
Thousands
Number of counterparties
4.5 °C
Exposure for NACE M (LHS) Portfolio XDC for NACE M Number of Counterparties for NACE M (RHS)


Billions
Exposure (€)
Thousands
Number of counterparties
5.7 °C
Exposure for NACE N (LHS) Portfolio XDC for NACE N Number of Counterparties for NACE N (RHS)

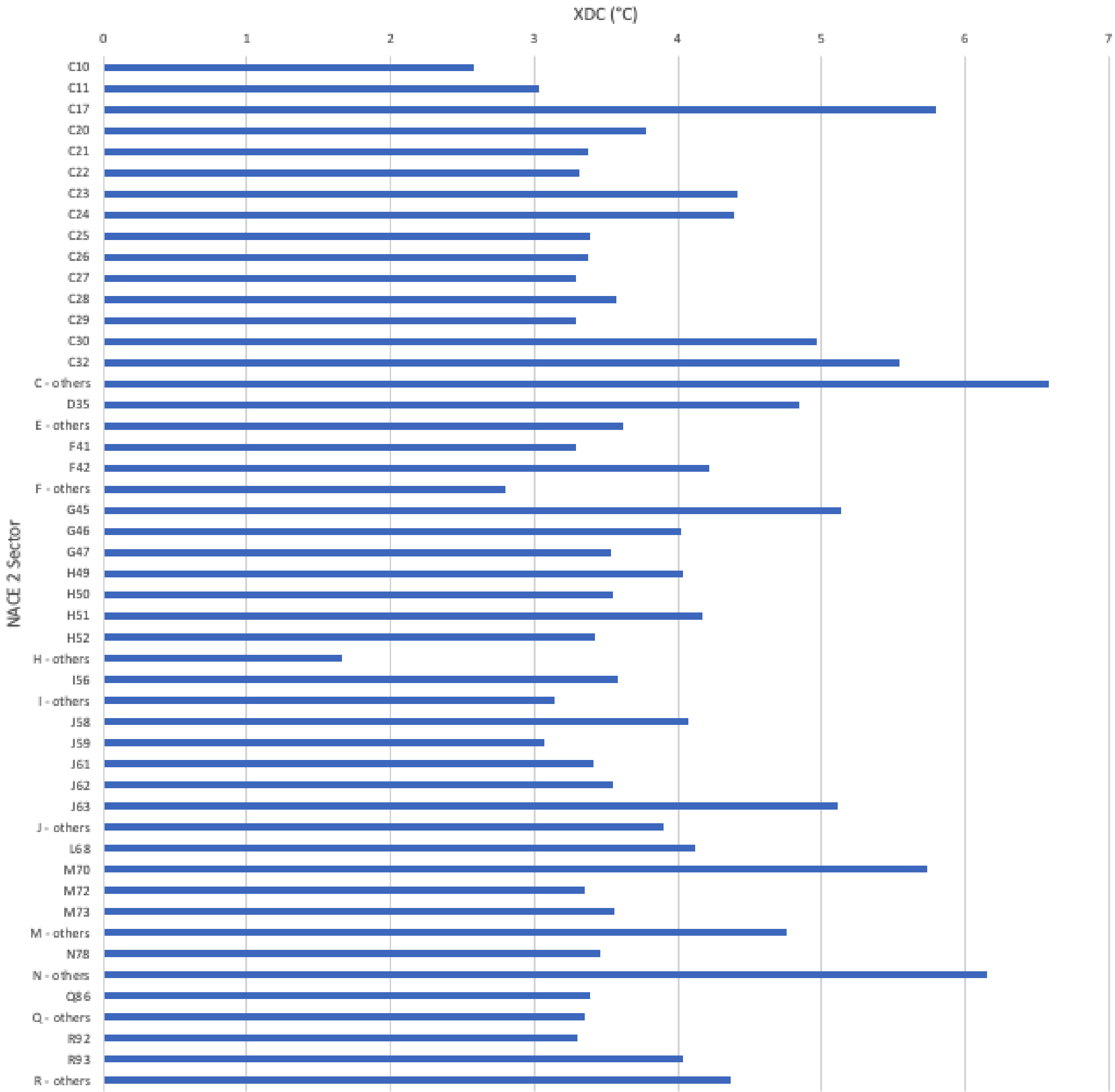

Billions
Exposure (€)
Thousands
Number of counterparties
3.4 °C
Exposure for NACE Q (LHS) Portfolio XDC for NACE Q Number of Counterparties for NACE Q (RHS)



XDCs by NACE divisions

Complementing the above distributions at NACE section level, figure 10 shows the average sector-specific XDCs by NACE divisions (2-digit level). It should however be noted that due to missing observations the 2-digit level could not be exploited for all counterparties represented in the dataset. As explained above, the corresponding NACE section (1-digit level) was used as a reference for these cases. In figure 10, the respective observations are nevertheless shown separately, but aggregated as residual 'others'.

Figure 10: Average XDCs for selected NACE divisions (2-digit level)



XDC as proxy for transition risk

The following high-level analysis aims at contributing to the ongoing debate regarding the potential usability of alignment metrics as a proxy of transition risk, in particular when expressed as implied temperature rise with the possibility of aggregating individual counterparty scores. The analysis is especially motivated by the dual perspective on both *resilience* and *efficacy* aspects that can be derived from the Paris Agreement, but which is also reinforced by the CSRD via the concept of double materiality. Guiding the transition of companies towards 1.5°C-alignment, the concept of double materiality shall thus also provide a base for banks to better understand the transition capacity of their loan portfolios as well as other investments. The concept of double materiality stresses that climate-related transition risks emerge from both a lack of resilience against climate-related factors shaping the business environment of a company and its efficiency to reduce its very own climate impact. Due to the high plausibility of the double materiality concept, climate-related regulation is already increasingly demanding transparency on both *resilience* and *efficacy* aspects. The question, whether, and if yes to what extent, these two perspectives are intertwined, has been largely debated, but was never quantified for the EU banking sector so far.

While previous peer reviews of different alignment methodologies found little consistency and correlation across the resulting metrics (Institut Louis Bachelier et al., 2020), establishing more robust approaches will be needed not only for effective decision-making regarding portfolio alignment, but also when proposing certain alignment metrics as proxy for transition risk (Rydge, 2020). In the below analysis, the XDC estimated at bank level, when aggregated across counterparty-level XDCs following the portfolio-weight approach, serves as the candidate metric.

To that end, bank-level XDCs are compared against loan loss provisions that were estimated as part of the 2021 EBA pilot exercise on climate risk under the NGFS disorderly scenario. While the 2021 EBA pilot exercise also featured the orderly and hot house world scenarios from the NGFS, the disorderly scenario is considered most relevant for this analysis as it entails the highest degree of transition risk. Furthermore, the assumptions underlying the disorderly scenario are consistent with the baseline scenario employed for the XDC calculation, i.e. as per current policies it is also considered most realistic. As the XDC calculation also relies on loan-level data collected as part of the 2021 EBA pilot exercise, the reference date for the two calculations is consistent and given as end-2019.

The comparison of the two analyses is also supported from a methodological perspective. Both analyses are based on the Shared Socioeconomic Pathways (SSP) as regards the forward-looking components, i.e. they are largely consistent in the way they model the future. The difference between the two analyses lies in what they measure: XDC, or implied temperature rise metrics in general, measure the climate impact of a certain portfolio from an efficacy standpoint, while the calculation of the expected loss differential anticipating the materialisation of transition risk provides an assessment of banks' resilience under different climate scenarios.

Figure 11: Comparision of bank-level XDCs and modelled loan loss provisions under the disorderly scenario

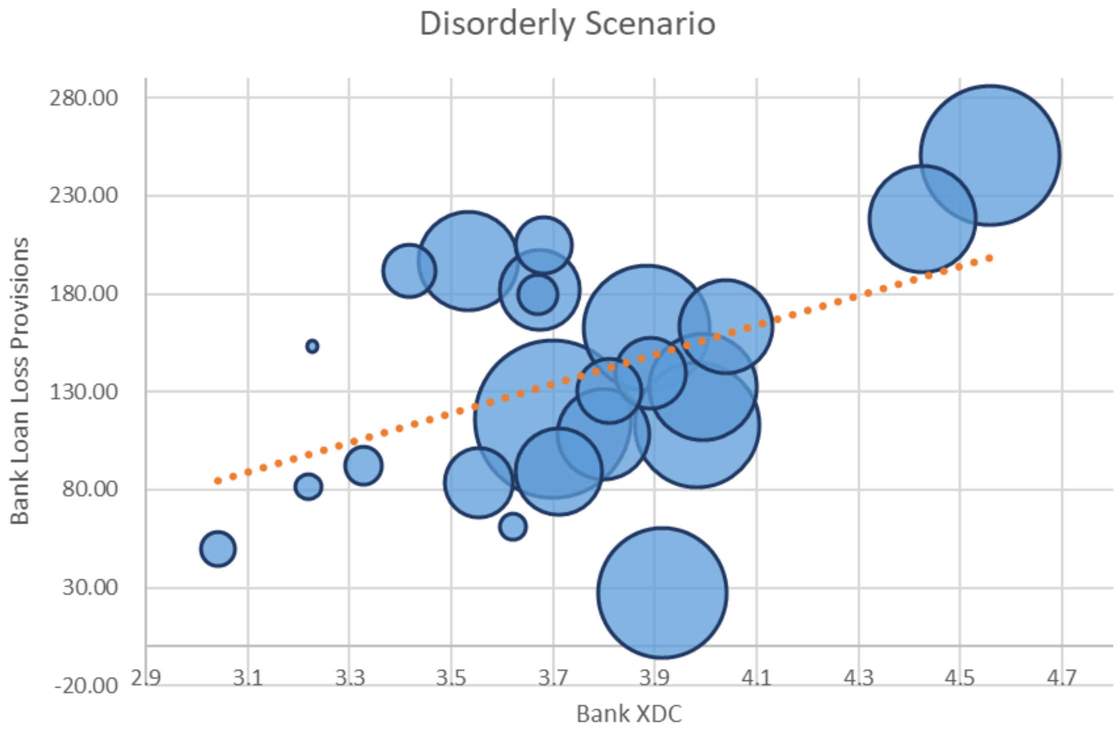


Figure 11 plots the additional expected loan losses modelled as part of the 2021 EBA pilot exercise (expressed as share of the risk exposure amount relating to submitted exposures, i.e. deviation from starting points in bps) against the XDC calculated for individual banks under the disorderly scenario. Bubbles represent individual banks with the bubble size corresponding to the banks' total assets.[15] As expected, figure 11 suggests a positive relationship between the two metrics.[16] Running a simple OLS regression with the additional expected loan losses from the 2021 EBA pilot exercise as dependent variable on banks' XDC (also controlling for size via ln(total assets)) yields an adjusted R^2 of 20.5% with the coefficient on the XDC value being significant at the 1% level (p-value of 0.0089). Accordingly, a difference in XDC of 1°C corresponds to an additional expected loan loss of 162.13 bps on average.[17]

As follows, comparing bank-level XDCs with the results of 2021 EBA pilot exercise on climate risk yields interesting insights about the double materiality of climate-related risks. The moderate, but statistically highly significant correlation of the XDC climate impact of banks via their loan portfolio and the forward-looking expected loan losses estimated as part of the 2021 EBA pilot exercise on climate risk is notable and plausible at the same time given the distance from the transition target

[15] From the initial sample of 29 banks, three banks did not provide expected loan losses as part of the 2021 EBA pilot exercise.

[16] Replicating figure 11 for the orderly and hot house world scenarios from the NGFS leads to very similar results.

[17] Size and significance of the XDC coefficient are almost insensitive to the inclusion of the ln(total assets) as control. The specification was chosen in order to represent the same level of information as depicted in Figure 11. Additional controls, such as the sectoral concentration, the relative REA density or the coverage of the submitted loan-level data against total loans, were disregarded, as their inclusion would have further reduced the sample size by a non-tolerable degree.

increases with higher XDCs. Our findings are also deemed plausible given the consistency in underlying assumptions regarding the baseline scenario, as explained above. As such, we provide evidence that implied temperature rise metrics, such as the XDC, can also serve as an indicative proxy for transition risks. Despite the current limitation of not capturing transition abilities and plans at company level, upcoming CSRD disclosures will facilitate the assessment of transition capacities for individual counterparties, further strengthening implied temperature rise metrics for the purpose of signaling transition risks.

Conclusion

When assessing banks' role in combating or adapting to climate change, prudential supervisory authorities have so far primarily focused on assessing banks' *resilience* to climate-related financial shocks from a risk-oriented viewpoint, e.g. based on dedicated climate stress tests. In this paper, we argue for a complementary perspective beyond prudential supervision on *efficacy*, which can be derived from the Paris Agreement, namely banks' own contribution to global warming through their financing of climate-harmful activities. This perspective becomes especially relevant considering the mandatory disclosures on double materiality according to the CSRD going forward.

With the key objective of the Paris Agreement being defined in terms of degrees Celsius, the objective of this paper is to shed some light on banks' alignment with the temperature target. To that end, we propose an innovative alignment methodology, leveraging on the so-called XDC model developed by right°, which we apply on granular end-2019 non-SME exposure-level information collected from selected EU banks as part of the 2021 EBA pilot exercise on climate risk in order to quantify the implied temperature rise of the considered loan books. Eventually, this allows us to answer the question whether banks are actually financing a 1.5/2°C world or not taking as a reference the XDC baseline scenario. Furthermore, we also examine the suitability of the XDC metric for the assessment of the two interrelated, but distinct perspectives regarding *resilience* and *efficacy*.

Our findings suggest an average implied temperature rise of the considered large banks' non-SME end-2019 corporate loan portfolios between 3.7°C and 4.1°C, depending on the aggregation methodology. While we observe some heterogeneity across banks, none of them would be on a pathway compatible with agreed target. Additionally, we provide evidence that the implied temperature rise as per our methodology can also serve as an indicative proxy for transition risk, thereby allowing to combine both *resilience* and *efficacy* considerations against the backdrop of double materiality in a single metric.

Nevertheless, we suggest that the potential usability of implied temperature metrics for the assessment of transition risk should be subject to further research, also acknowledging the case study nature of the above analysis, such as the relatively small sample of banks and the portfolio being restricted to corporate (non-SME) loans, and this as of end-2019. As such, future studies should rely on a more comprehensive dataset, covering both significant and non-significant institutions and a larger share of banks' balance sheets, e.g. extending to retail loans and debt securities. Additionally, an update based on more recent data, which is currently not available to the EBA unless when collected ad-hoc, would also allow the assessment of banks' progress since end-2019. As a starting point, this type of analysis could be performed on a regular basis based on the sectoral banking book exposures, which banks have to disclose as part of their Pillar 3 reporting. Going forward, however, the benefits of granular counterparty-level data should form the basis for any type of emission-based analysis.

If further substantiated, implied temperature rise metrics, such as the XDC, could provide an effective and easy to use approximation of transition risk inherent to financial portfolios, which could complement the more targeted and sophisticated modelling of expected loan losses under various scenarios. For example, they could serve as an early-warning indicator to identify critical portfolios upfront and steer management actions by banks and supervisory priorities accordingly. Apart from supporting the assessment of transition risks, implied temperature rise metrics would additionally enable the monitoring and steering towards the third sub-target of the Paris Agreement, i.e. ensuring that financial flows are consistent with the agreed temperature target. Put simple, low risk does not (necessarily) mean Paris-aligned: A bank could have sufficient loss absorbing capacity to remain resilient in case of materialising transition risks, but at the same time deviate from the Paris Agreement by financing activities that are not compatible with the agreed temperature target.

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