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Unpacking banks' response to societal expectations: An NLP analysis of European banks' discussion of climate change

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ABSTRACT

We employ Natural Language Processing (NLP) to analyze how climate change is discussed in the annual sustainability reports of the 35 largest EU banks (2015–2021), assessing alignment with four societal expectations: decarbonizing financial products and services, addressing climate-related risks, reducing operational emissions, and enhancing transparency. These expectations stem from governments, regulators, and civil society. Analyzing over 1.5 million statements, we find that about 7% of content pertains to climate change. Banks increasingly focus on decarbonizing consumer products and their own operations, but devote less attention to financed emissions, transition risks, and concrete commitments. Our study contributes to the application of NLP in climate finance by qualitatively interpreting how banks, in their own words, engage with societal expectations around the climate transition. This complements quantitative studies by contextualizing disclosure patterns and highlighting reporting gaps and under-emphasized but material issues, offering insights that can inform policymakers in designing disclosure requirements.

1. Introduction

To meet the goals of the Paris Agreement, significant amounts of capital must be mobilized and redirected away from climate-intensive activities. The EU alone faces a substantial investment gap of up to 3.7% of 2023 GDP annually to achieve its target of 55% reduction in greenhouse gas (GHG) emissions from 1990 levels by 2030 (Andersson et al., 2025). The banking sector is expected to have a key role in closing this gap, but a lingering question pertains to whether banks' approaches to climate change align with societal expectations regarding their role in the transition. The aim of this study is to investigate this question by applying natural language processing (NLP) to European banks' annual sustainability reports, examining how banks describe their climate-related activities in relation to societal expectations.

To contextualize this analysis, we distinguish between two perspectives on societal expectations: those of governments and regulators on one side, and those of the general public and civil society on the other.

From a governmental and regulatory perspective, one critical aspect that shapes expectations is the impact of climate risks on the financial system. Banks are particularly exposed to risks through their lending activities (Battiston et al., 2017). Moreover, climate change poses systemic risks to the financial system by exacerbating physical and transition risks,[1] with the potential to destabilize capital markets, depress asset values, trigger correlated defaults, and erode trust in the financial sector (Birindelli et al., 2024).

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Given their central role in financial intermediation, banks are especially exposed to these risks, which has direct implications not only for financial stability but also for their ability to mobilize and redirect capital needed to close the investment gap.

To address these challenges, and to mitigate the effects of banks and other financial actors not fully accounting for climate risks, the EU has since 2015 introduced a series of policies and regulations to promote sustainable finance. A central aim of these initiatives is to reduce uncertainty about what constitutes a sustainable investment and to improve the transparency and comparability of disclosures, thereby steering capital flows toward low-carbon activities. The *EU Action Plan: Financing Sustainable Growth* (European Commission, 2018) includes the 2019 Sustainable Finance Disclosure Regulation (SFDR), the 2020 Taxonomy Regulation, the 2020 Climate Transition and Paris-Aligned Benchmarking Regulation, and the 2023 Green Bond Regulation. Together, these regulations aim to establish a framework to promote transparency and accountability in sustainable finance, guide financial flows toward sustainable development goals and enhance trust in sustainable financial products. The SFDR requires banks and financial institutions to disclose how they integrate sustainability risks into investment decisions and provide details about the environmental or social characteristics of their products (European Parliament, 2019a). The Taxonomy Regulation sets criteria to determine whether an economic activity is environmentally sustainable and requires banks to assess and report on the alignment of their economic activities with these criteria (European Parliament, 2020). The Green Bond Regulation outlines voluntary standards for issuing green bonds that pursue activities which meet the Taxonomy standards (European Parliament, 2023).

These regulations and accompanying guidelines from the European Central Bank indicate that regulators and supervisory bodies expect the banking industry not only to decarbonize their own operations but, more importantly, to decarbonize their products and services and appropriately evaluate and account for climate risks in their financing decisions (European Parliament, 2019a, 2020; European Central Bank, 2020). By factoring in climate considerations, banks are expected to shift credit away from high-emission investments and to transparently disclose how they are decarbonizing their financial products as well as how they account for climate risks.

In addition to the regulators' and governments' perspectives, there are also expectations from the public. The role of banks in mitigating and exacerbating climate change have been frequently discussed in media, calling out the industry for its continued investment in fossil fuels (Lewis, 2021; Jolly, 2022; Greenfield, 2019; Ambrose, 2023; Limb, 2023; Flatt, 2023; Merleaux et al., 2023). *The Global Call on Banks to Stop Financing Fossil Fuels*, created by Banktrack and supported by over 260 organizations, calls on banks to immediately end financing fossil fuel expansion and any projects that abuse human rights, publish how they plan to phase out financing for current fossil fuel projects, require their clients to publish their phase-out plans, make specific commitments to net-zero targets, and publicly and thoroughly report on these actions (Fossil Banks No Thanks, 2021). We see this call as a concise summary of what NGOs and civil society ultimately expect banks to do about climate change. Activists and civil society organizations have further solidified the need for banks to address these expectations through, for example, protests outside of banks, filing complaints under the OECD Guidelines, and taking legal action (Sims, 2023; Sabin Center for Climate Change Law, 2023a,b).

While there are notable differences between regulators' expectations and expectations from the public,[2] there are also clear overlaps between these expectations. Summing up, we argue that there are (at least) four prominent societal expectations regarding banks' role in the climate transition: banks are expected to (1) decarbonize their products and services (including end their financing of fossil fuel industries), (2) appropriately account for climate risk and the impacts their financing has on society, (3) decarbonize their own operations, and (4) improve their transparency to regulatory bodies and to the public in their disclosures, especially as it relates to their evaluation of climate risks, their plans to transition their financing, and their climate-related commitments. In this study, we aim to investigate whether banks' discussion about climate change aligns with the four societal expectations outlined above. Our analysis is based on the 35 largest EU banks' annual sustainability reports between 2015–2021, employing NLP to discern trends and qualitatively analyze clusters and topics relevant to the climate transition. Specifically, we build on an existing NLP model and framework developed to detect latent information about how banks discuss their activities related to climate change (Yu et al., 2024).

Of particular relevance to our study is the expanding literature that applies NLP techniques to analyze climate-related disclosures by companies and financial actors (see e.g. Friederich et al., 2021; Bingler et al., 2022, 2024; Villacampa-Porta et al., 2025; Moreno and Caminero, 2022; Clarkson et al., 2020; Gorovaia and Makrominas, 2025; Cenci et al., 2023).[3] While there are well-grounded arguments for mandating climate disclosures (Carattini et al., 2022; Hoepner and Rogelj, 2021; Battiston et al., 2017), there is a lack of both data availability and standardization in how climate-related information is reported (Jona and Srivastava, 2025; Porenta and Rant, 2025). This lack of data availability and standardization, combined with increasing societal pressure to report on climate-related issues, creates a challenge when firms and banks use vague or non-specific language in their annual reports. This reduces accountability and can result in misleading information, raising concerns about greenwashing. NLP offers a possibility to still extract insights from current company disclosures and assess their performance based on the content of their climate-related communication, often in terms of readability, length, or quantitative assessment by sentiment analysis (Clarkson et al., 2020; Gorovaia and Makrominas, 2025). Indeed, as shown by Bingler et al. (2024), voluntary disclosures are more often associated with

[1] Physical risk in relation to climate change refers to the direct financial impacts stemming from the increasing severity and frequency of climate-related weather events and other natural disasters. Transition risk pertains to the financial risks associated with the shift towards a low-carbon economy, including policy changes, technological advancements, and shifts in market preferences and social norms.

[2] For example, civil society to a larger extent pushes immediate action and phase out of fossil fuel financing, while the government and regulators emphasize the importance of an orderly transition in relation to the market.

[3] For an overview of climate finance research and the growing use of NLP and machine learning, see Alonso-Robisco et al. (2025), Tian et al. (2025).

'cheap talk' than with concrete, targeted commitments. Voluntary disclosure initiatives such as the Task Force on Climate-Related Financial Disclosures (TCFD) have also shown limited effectiveness in improving the quality of climate-related disclosures (Bingler et al., 2022). Furthermore, NLP has been used to assess the implementation of various disclosures laws, like the EU Non-Financial Reporting Directive, highlighting the regulation's influence on corporate disclosures (Villacampa-Porta et al., 2025).

Our study contributes to this growing literature by applying NLP to analyze how banks, in their own words, respond to societal expectations regarding their role in the climate transition. Our data-driven, qualitative approach highlights trends in discussions found in sustainability reporting, which complements more quantitative analyses by revealing patterns in climate disclosures and offering insights into banks' priorities and constraints. By examining societal expectations, we interpret our empirical findings in relation to broader questions of accountability and legitimacy in banks' responses to climate change. We recognize the banking industry as a particularly interesting actor to understand their climate-related disclosures given their key but differentiated role in promoting a sustainable economy.

The paper is structured as follows: following this introduction, Section 2 provides detailed information on the data and methodology used in our study. Section 3 then presents the results of the cluster and topic analysis. It offers a comprehensive view of the evolution in banks' discourse from 2015 to 2021 and identifies specific clusters and topics crucial for exploring banks' responses to societal expectations. This section also critically examines the alignment of banks' responses to these expectations in the context of our findings. The paper concludes with final remarks that summarize our key insights.

2. Data and methodology

2.1. Data

Our data is comprised of statements parsed from the annual sustainability reporting of large EU banks. We focus specifically on annual sustainability reports because these documents serve as representations of how banks, and businesses more broadly, disclose their strategy, activities, and risks in relation to issues like climate change. That being said, there is a lot of discretion in how businesses and banks can disclose this information. Unlike responses to reporting standards, such as the Global Reporting Initiative (GRI) or TCFD, which prompt disclosures with specific questions and in a template format, sustainability reports are developed and published by the company itself. Therefore, we see these reports as promoting a narrative as written in banks' own words.

We focus our analysis on the largest banks in the EU, ranked by total assets based on the 2021 edition of the 50 largest European banks published by Business Insider (Business Insider, 2022). We manually searched each bank's website for their annual reports in English related to sustainability, corporate social responsibility, non-financial reporting, and climate change at the group level. This process resulted in a dataset of 513 reports from 35 of the largest EU banks (see Table A.1), covering the period 2015–2021.

2.2. Method

Given the set of bank reports, we first extracted all text strings from each report. These texts were then split into individual sentences. Each sentence represents a statement. In total, we extracted 1,584,626 statements from our given set of reports. These statements were then further classified into two subsets depending on whether or not they were relevant to climate change. This classification step was done automatically by applying the pretrained classification model, climateBUG-LM (Yu et al., 2024). After this step we found 109,800 statements to be classified as related to climate change (corresponding to 6.9% of the total number of extracted statements). When benchmarking on classification performance in relation to other NLP models currently available such as FinBert (Araci, 2019) and ClimateBert (Webersinke et al., 2021; Bingler et al., 2022), Yu et al. (2024) demonstrates that the climateBUG-LM model surpasses similar or even larger deep learning models in performance when working with data from the nexus of these specific domains.

To further analyze the semantics of banks' narratives in relation to the societal expectations of banks, we apply a two-stage partitioning strategy. Specifically, we partition the climate-related statements, denoted as $\mathcal{S}$, into mutually exclusive subsets $\mathcal{S}_m$ based on a partitioning strategy, where $\mathcal{S} = \bigcup_{\forall m} \mathcal{S}_m,\ m \in \mathbb{N}$. We then perform topic analysis within each partition independently.

2.2.1. Partitioning strategy

Overall, the two-stage partitioning strategy consists of classifying the statements into three predefined categories (risk, products & services, and general) and then clustering the statements for a data-driven (exploratory) analysis within each category. These two stages are discussed in detail below.

Stage 1: Classification. In the first stage, we used a supervised classification approach to assign each climate-related statement uniquely to one of three categories. We fine-tuned the deep learning model climateBUG-LM (Yu et al., 2024) to perform the classification. The categories build on the distinctions outlined in Elliott and Löfgren (2022), who identify four ways banks discuss climate change: risks, opportunities, general discussions, and commitments. In our adaptation, we map their 'risks' to our risk category and align 'opportunities' with products & services. We then merge their 'general' and 'commitments' into a single general category.

To support accurate classification, we manually annotated a large number of statements. Annotators followed detailed guidelines to ensure consistency (see Appendix A.3). In total, 36,201 statements were manually annotated. These annotated statements were then split into a training dataset of 32,580 statements and a test dataset of 3621 statements for fine-tuning the classification model.

The training dataset was used to train the classifier to automatically identify the category for each statement. The hyperparameters, which include design choices in the training process such as batch size and learning rate, were determined through 10-fold validation. This standard method involves dividing the training data into 10 parts, where each part is subsequently used to validate and optimize design choices.

To evaluate the performance of the classifier, we calculated standard evaluation metrics used in discriminative machine learning (Godbole and Sarawagi, 2004), namely: precision, recall, and F1 score. More precisely, for each category, the precision is defined as $p = \frac{\text{True Positives}}{\text{True Positives + False Positives}}$, whereas recall is defined as $r = \frac{\text{True Positives}}{\text{True Positives + False Negatives}}$. Precision and recall provide an overview of how sound and complete the classification model is, respectively. Precision measures the proportion of actual positives among the statements classified as positive by the model. Recall measures how many of the actual positive statements the model correctly identifies. It evaluates the model's ability to find all relevant statements in the dataset. The F1 score is an aggregation of these two metrics, which is defined as $2\frac{p \times r}{p+r}$. Finally, for each metric across the categories (risk, products & services, general), the overall performance measure was calculated as the arithmetic mean over the three categories. The resulting macro-averaged precision is 0.67, macro-averaged recall is 0.84, and macro-averaged F1 score is 0.71. These numbers indicate that the model is relatively balanced in identifying relevant content, with a notably higher ability to correctly identify relevant statements (recall of 0.84) compared to its precision (0.67). This suggests that, on average, the model misses about 16% of the relevant content but also includes about 33% of irrelevant content in its identifications. This balance points towards a model that is more inclusive at the expense of some precision, indicating a preference for capturing most relevant content, even at the expense of including some irrelevant content.

Stage 2: Clustering. In the second stage, we applied a clustering model within each of the three categories to group statements based on their semantic similarity. While the classification stage relied heavily on supervision from experts (for example by providing the categories of the statements), this stage was data-driven and unsupervised. The purpose of this second partition is to explore topics and patterns within each category that are inherently difficult for a human to detect systematically. To achieve this, we chose to employ a three-step clustering strategy:

Step (1) Sentence embedding ($S \to \mathbb{R}^{384}$) We used the Sentence-Bert model[4] to create embeddings that effectively transform sentences into a semantically meaningful metric space, thereby facilitating meaningful clustering based on sentence similarity. We mapped a statement $s \in S$ into a 384-dimensional embedding vector space. The model was trained using a triplet objective function to enforce similar sentence pairs to be closer than dissimilar pairs in the embedding space.

Step (2) Dimensionality reduction using UMAP ($\mathbb{R}^{384} \to \mathbb{R}^2$) Before clustering the statements, we applied a dimensionality reduction step to mitigate the 'curse of dimensionality'. In clustering analysis, the curse of dimensionality describes several challenges encountered in high-dimensional spaces. These include the loss of meaningfulness in distance measures, increased data sparsity, and a rise in computational complexity. Together, these factors impede the effectiveness of clustering algorithms in identifying dense regions and forming meaningful clusters (Steinbach et al., 2004). Therefore, before the clustering step, we projected the 384-dimensional feature vectors (representing the output from the Sentence-Bert model) onto a two-dimensional space using Uniform Manifold Approximation and Projection (UMAP) (McInnes et al., 2018), which is a dimensionality reduction technique that better preserves the global structure of the data compared to other commonly used methods such as t-distributed Stochastic Neighbor Embedding (TSNE) (van der Maaten and Hinton, 2008). The choice of projecting statements onto a two-dimensional space is primarily motivated by the desire to enhance the interpretability of our results. This approach allows us to visually explore the data, understand patterns, relationships, and clusters that exist within it while acknowledging a potential trade-off in terms of losing some high-dimensional detail.

Step (3) Clustering based on HDBSCAN and GMM ($\mathbb{R}^2 \to \mathbb{N}$) Once the statements were represented by two-dimensional vectors, a clustering step was followed for each category independently. We chose category-specific clustering algorithms based on the observed patterns of the two-dimensional data within each category, different clustering algorithms make different assumptions about the data, and each has its pros and cons. More specifically, we selected two clustering algorithms described as follows.

- **GMM (Gaussian Mixture Model)** is a probabilistic model that assumes all the data points are generated from a mixture of a finite number of Gaussian distributions. This is a reasonable choice for datasets where the clusters appear to be distributed in an elliptical manner. In addition, GMM is capable of handling overlapping clusters. By default, GMM requires the user to specify the number of clusters beforehand. This can be a hurdle if the user does not have any prior knowledge about the number of clusters. On the other hand, this hyperparameter enables the user to control the granularity of the clusters.
- **HDBSCAN (Hierarchical Density Based Clustering)** is a density-based algorithm, meaning that it forms clustering by linking data points into dense regions if they are close to each other. It is especially useful when data has uneven cluster sizes or complex structures. As opposed to GMM, HDBSCAN does not require the user to specify the number of clusters, and it can identify points that do not belong to any cluster as noise. However, if data points are all connected with a rather uniformly distributed density, HDBSCAN will regard this collection of data points as one cluster. If one is still interested in the partition of such a dataset, other types of clustering algorithms should be considered.

[4] The all-MiniLM-L6-v2 model introduced by Reimers and Gurevych (2019).

We adopted HDBSCAN for both the risk and general categories due to the varying density in the data distribution, which gave us 3 and 10 clusters respectively. For the category product & services where we observed that the data is connected with a rather consistent density, we adopted GMM since it can effectively partition the data into clusters based on the likelihood of each data point belonging to a particular Gaussian distribution and does not rely on density differences to the same extent as HDBSCAN. This gave us 14 clusters for the product & services category. As a result, there are 27 clusters in total summing over the three categories.

2.2.2. Topic analysis strategy

After partitioning the set of statements into 27 clusters, we manually identified the main topic for each cluster based on keywords found in each cluster. Specifically, within each cluster, the frequency of each word was calculated. To compare word frequencies across clusters with different sizes, frequencies were normalized by dividing it by the total number of statements in that cluster. Keywords are words with the highest normalized frequency within each cluster and represent the most significant or most discussed topics in that group of statements. In the course of this analysis, English stop words were omitted from the selection of keywords of interest. Additionally, a manual review was conducted to eliminate any nonsensical terms and to exclude specific entities, such as bank names. Furthermore, expert analysis was used to validate topics based on a subset of statements within the clusters.

Following this, we produced heat maps to visually depict the data. In these heat maps, each row corresponds to a selected keyword, while each column denotes a different year, allowing for the visualization of the topic's evolution over time. The color intensity in each heat map cell reflects the normalized frequency of the word within that cluster. Warmer colors represent higher frequencies, and cooler colors signify lower frequencies.

3. Results

In this section, we qualitatively analyze the results from applying the NLP model to the 35 EU banks' sustainability reports. We start with providing an overview of the trends within the three categories, and introduce key identified clusters. We then examine each category and its key clusters in more detail to assess how they reflect banks' responses to the four societal expectations outlined in the introduction: (1) decarbonize their products and services (including end their financing of fossil fuel industries), (2) appropriately account for climate risk and the impacts their financing has on society, (3) decarbonize their own operations, and (4) improve their transparency to regulatory bodies and to the public in their disclosures.

3.1. The overall picture

The classification of banks' climate-related statements into the three distinct categories, general statements, risk-related statements, and statements concerning products and services, offers important insights into the banks' chosen focal points for public communication regarding climate change in their sustainability reports. It also sheds light on the evolution of their narrative over time.

Fig. 1 displays a scatter plot that merges all statements from 2015 to 2021, color-coded by category. This visualization reveals that the majority of statements fall under the general category, with risk-related statements being significantly less frequent. Notably, Fig. 1 also highlights the semantic relationships within the three categories. It shows that certain risk statements are semantically similar to those in the general category, while a distinct cluster of risk statements aligns more closely with discussions on banks' products and services.

Fig. 2 shows the number of statements within each category over the years 2015 to 2021. As can be seen, there is an increasing trend within all categories: the number of statements within the general category has increased about four times, discussions about products and services have increased almost seven times, and statements about risk more than 13 times. Normalizing the counts with the total number of climate-related statements shows that while a vast majority of the discussions about climate change in 2015 were of a more general character, they accounted for about 50% of the statements in 2021. At the same time, the percentage of statements related to risk has risen from around 5% to 15%. (see Fig. 3). It can also be noted that there is a positive correlation between the categories (see Figs. A.11, A.12, and A.13 in Appendix).

In relation to societal expectations, the overall increase in statements throughout the years is aligned with societal expectations that banks increasingly recognize their role in the climate transition. That being said, we recognize that this is a quantitative evaluation and says nothing substantively at this point about what banks are saying and if their discussion aligns with specific expectations. We note in particular that the small number of statements related to risk (especially compared to products and services and general categories) does not seem to align with the expectation to evaluate and disclose climate-related risks.

Further, Fig. 4 depicts normalized counts of statements by cluster and year showing that, while there has indeed been an increase in climate-related discussion (see Table A.2 in Appendix for statistical analysis and p-values), there is a large variation between clusters (note that the graph only shows the selection of clusters that will be discussed further below). Furthermore, as shown in Fig. 5 there is also a large between-bank variation, which is more pronounced for some of the clusters.

In the following subsections, we will conduct a more detailed, qualitative analysis of the three categories using selected clusters within each category to further evaluate their alignment with noted expectations. As we move into the more detailed analysis, we will refer to Figs. 1–5 when relevant.

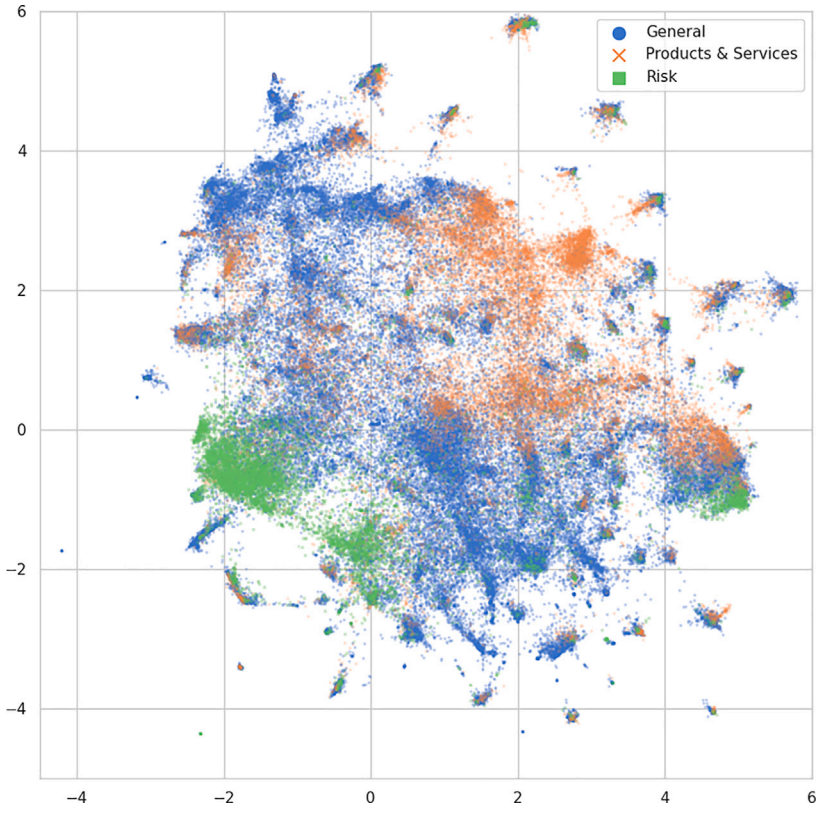

Fig. 1. Bank statements from 2015 to 2021. Each dot represents one statement. The x- and y-axes represent abstract numerical features derived from the dataset, capturing different latent patterns that help visualize clustering structures. These features do not have direct interpretability but serve to illustrate the spatial relationships between clusters.

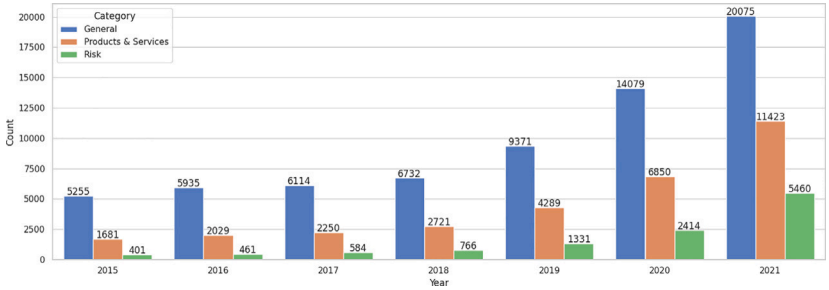

Fig. 2. The number of statements from each category by year.

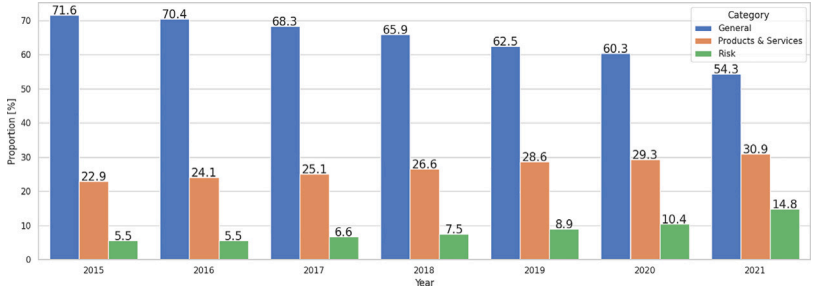

Fig. 3. The normalized count of statements from each category by year. The count is relative to the total number of climate-related statements.

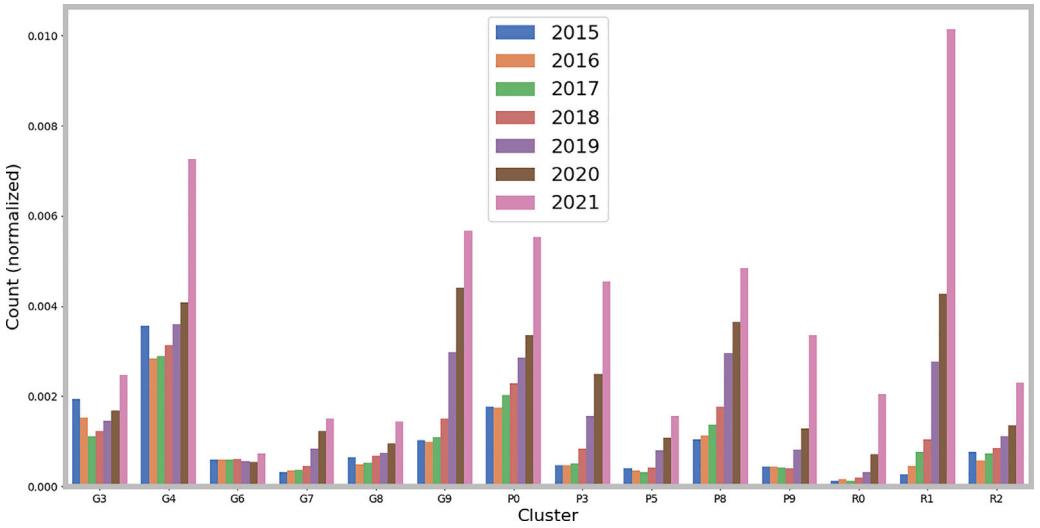

Fig. 4. Normalized cluster size over years. The size is relative to the total number of climate-related statements within a cluster.

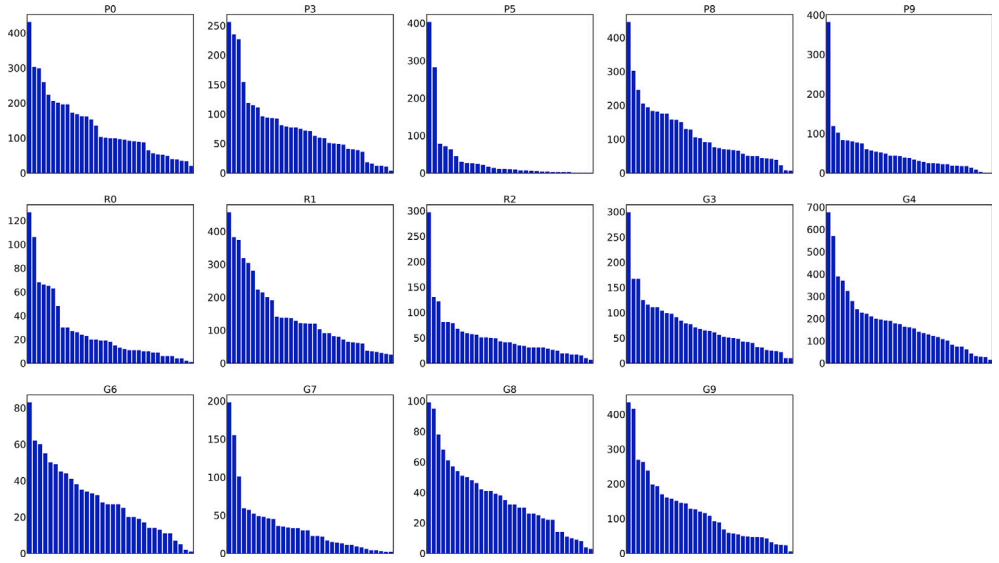

Fig. 5. Total statements within each cluster, sorted max to min by bank.

3.2. Financial products and services

3.2.1. Topic analysis of product and services

Our analysis in this section focuses on how banks are responding to expectations to decarbonize their products and services. We anticipate that banks can respond to these expectations by developing and/or promoting green products and services as well as reducing their financing and/or promoting a transition for fossil fuel-intensive industries. Based on the partitioning strategy described in the Data and Methodology section, ten individual clusters were identified (see Fig. 6). Out of the ten clusters, we focus on five clusters found to be most relevant to the analysis of banks' decarbonization of their products and services. We label each cluster according to their topic and, for clarity, we also refer to these clusters by a number. This numbering includes a prefix 'P' to indicate their association with the product and services category of statements, followed by the cluster number (P0, P3, P5, P8, and, P9). For ease of reference, the labels and the focused clusters are presented in Fig. A.14 in Appendix. A short description of each of the five clusters are presented next. Following these descriptions, we will discuss the societal expectation for banks to decarbonize their products and services in the context of our findings.

Renewable energy and energy efficiency (P0): In this cluster, banks' report on their products and services related to the energy transition, focusing on keywords related to home loans and investments in energy efficiency in buildings, as well as commercial and industrial renewable energy projects. See Fig. A.15 in Appendix for a heat map of the data-generated keywords and Table A.3 for example statements.

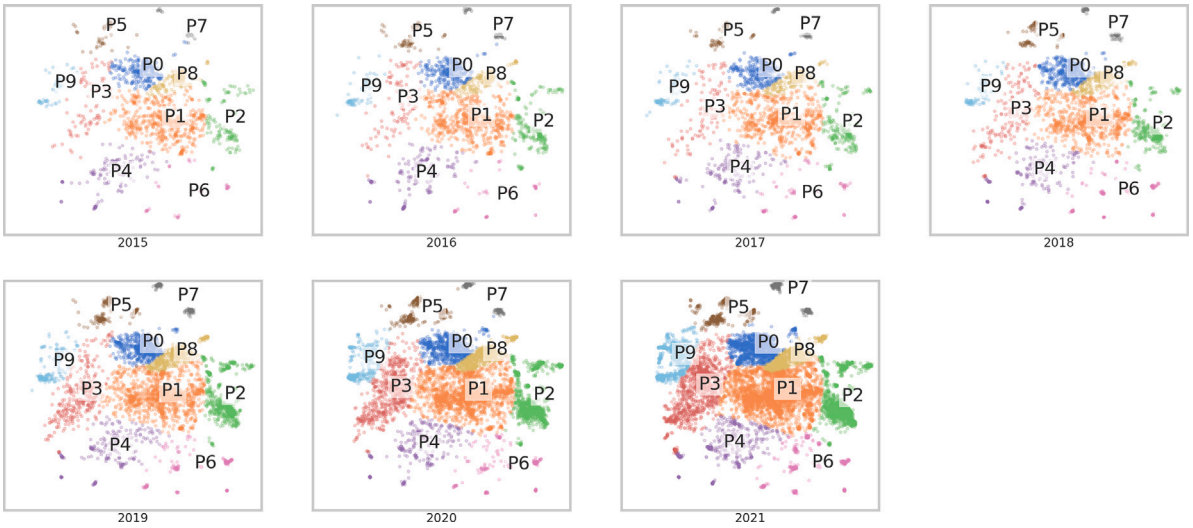

Fig. 6. Clustered bank statements related to products & services by year. Each dot represents one statement. Color indicates each cluster.

Climate aligned finance (P3): This cluster captures banks' targets and funding related to decarbonization and includes keywords like 'portfolio', 'Paris Agreement', 'Net-Zero', and 'investment' (see Fig. A.16 in Appendix for a heat map of the data-generated keywords and Table A.4 for example statements).

Clean mobility (P5): This cluster covers banks' products and services supporting the transition to zero-emission mobility, including keywords related to car loans and investments in green vehicles (see Fig. A.17 in Appendix for a heat map of the data-generated keywords and Table A.5 for example statements.)

Green bond (P8): This cluster focuses on green bonds and their development as financial product, including keywords like 'green bond' and 'sustainability-linked' bonds (see Fig. A.18 in Appendix for a heat map of the data-generated keywords and Table A.6 for example statements.)

Measuring negative impact (P9): This cluster discusses measurement of climate-related negative impacts, such as 'carbon footprint', 'financed emissions', and 'GHG emissions' (see Fig. A.19 in Appendix for a heat map of the data-generated keywords and Table A.7 for example statements.)

3.2.2. Expectation 1: Decarbonizing banks' products and services

As anticipated, banks overall talk more about their products and services in relation to climate change over time. From 2015 to 2021, 28% of climate statements in the reports are about products and services.

Of the five clusters described above, three are especially relevant to developing green products and services — the renewable energy and energy efficiency cluster (P0), the green bonds cluster (P8), and the clean mobility cluster (P5). These topics are likely seen as opportunities for banks rather than challenges to incorporate into their business, like measuring the negative impact of their financing (P9) and setting climate aligned finance targets (P3). Notably, the 'opportunity' clusters (P0, P5, and P8) have grown significantly over time (see Table A.2 and Fig. 4), indicating an alignment of banks with societal expectations.

These opportunity clusters encompass both consumer-facing products, like mortgages and car loans, and products targeting commercial clients, such as project investments and finance. Regarding clean mobility, there has been a surge in both regulatory developments, such as CO_2 performance standards (European Parliament, 2019b), and the global market for electric vehicles, where the proportion of newly sold electric cars reached 14% in 2022 as compared to less than 5% in 2020 (International Energy Agency, 2023). This is reflected in the positive trend in the discussions about clean mobility by banks as seen in Fig. 4 (and Table A.2 in Appendix) when looking at the clean mobility cluster (P5).

When reflecting on the renewable energy and energy efficiency cluster (P0) and the clean mobility cluster (P5), there seems to be a trend in focusing on consumer-facing products like home loans, energy efficiency, and car loans rather than project investments and finance. Interestingly, there is indeed a discussion about renewable energy, but the extent of this discussion is surprisingly limited.

Another important activity related to investment and finance is the development of green bonds. Green bonds are used to raise capital for projects and activities that have positive environmental or climate-related impacts. There has been regulatory focus specifically on green bonds, and as can be seen in Fig. 4 (and Table A.2 in Appendix) when looking at the green bond cluster (P8), there is a significant increase in discussion of green bonds from 2019–2021. This increase coincides with the introduction of proposed legislation in the EU for a green bond standard.[5] Banks that are increasingly highlighting green bonds in their reports may

[5] See EU website on European Green Bond Standard for more details. https://finance.ec.europa.eu/sustainable-finance/tools-and-standards/european-green-bond-standard_en.

be responding to the proposed legislative developments incentivizing green bonds. We anticipate but cannot confirm that this will continue as the legislation is adopted and implemented.

In relation to the clusters that potentially represent more of a challenge to banks, we do see a clear positive trend in banks talking about aligning their financing with overall climate goals and measuring the impact on climate of their financing (see the climate-aligned finance cluster (P3) and the measuring negative impact cluster (P9) in Fig. 4 and Table A.2 in Appendix). Referring back to expectations, governments expect that banks should appropriately measure and disclose negative impacts and price emissions into their financing considerations. We recognize that this explicit conversation about negative impacts and their pricing considerations may not take place as a part of their public reporting, yet we note that there is an increase in discussion on measuring the negative impact of their financing. Furthermore, the climate-aligned finance cluster (P3) shows keywords like "Paris Agreement" and "net-zero" along with words like "investment" and "portfolio" (see Fig. A.16 in Appendix), which could reflect banks' consideration of how to incorporate these reduction targets into their financing. Aligning with these goals is in line with societal expectations; yet, it is unclear from this cluster if and how these avenues of finance are distinct from other avenues of finance within the bank and to what extent climate is reflected in all financing considerations.

Ultimately, we see discussions in the banks' reports that respond to the expectation that banks should decarbonize their products and services.[6] We note that this response includes consumer-facing products as well as broader investment and financing discussions, both of which have a positive connotation and would serve well to be highlighted in the annual reports. We also note that these highlighted clusters seem to align with ongoing and developing regulatory incentives to drive more carbon-friendly products and services. While we cannot argue that these increased discussions are caused by relevant legislation, we do recognize a strong correlation between legislative developments and banks' discussions of their products and services.

3.3. Climate-related risks

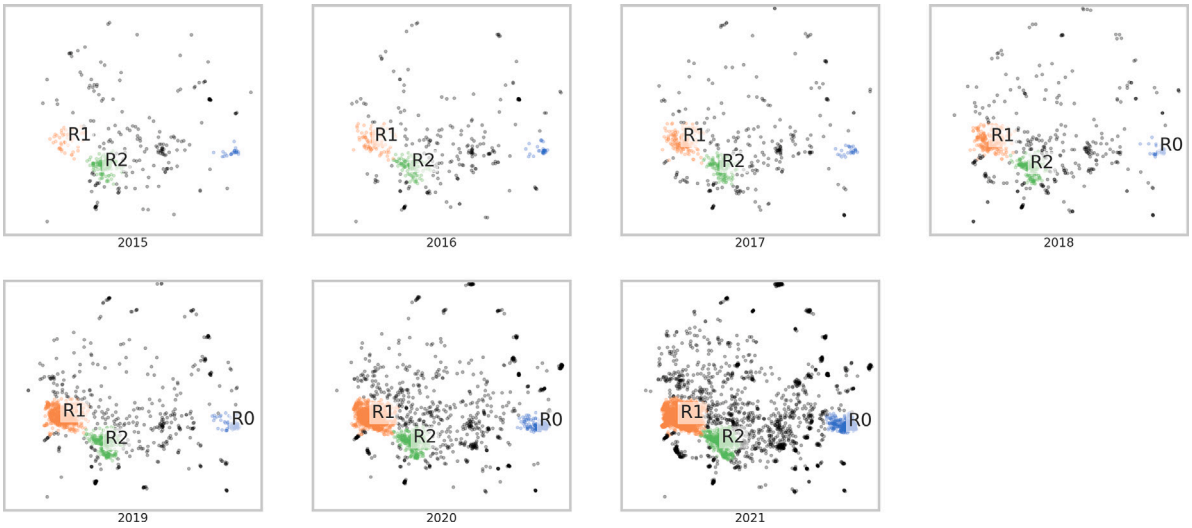

Fig. 7. Clustered bank statements related to risk by year. Each dot represents one statement.

3.3.1. Topic analysis of risk-related statements

The topic analysis of banks' discussions in relation to risk and climate change in the sustainability reports reveals three well-defined clusters (see Fig. 7). The three clusters focus on specific aspects of risk (described in more detail below): risks related to environmental, social and governance issues (ESG) (R0), risks related to climate (R1), and societal risks (R2) (see Fig. A.20 in Appendix for labeled clusters). As further illustrated in Fig. 7, two clusters, the climate cluster (R1) and the societal risk cluster (R2), are semantically closer, while the ESG cluster (R0) is more distinct. It has already been noted that there is an increasing trend among banks in discussing risks. We will next provide a brief description of each cluster, based on data-driven keyword generation and heat maps. Following this, we discuss in greater depth what our results suggest about the societal expectation for banks to increasingly account for climate change risks.

ESG risk (R0): This cluster represents banks' assessment of their exposure to ESG risks, referencing terms such as 'insurance', 'exposure', 'management', 'governance', and 'policies' (see Fig. A.21 in Appendix for a heat map of the data-generated keywords and Table A.8 for example statements).

[6] It should however be noted that there are significant differences between banks in terms of the number of statements within each cluster as can be seen in Fig. 5.

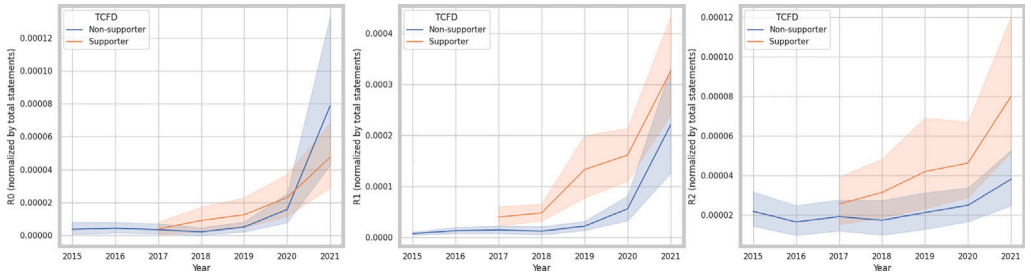

Fig. 8. Number of normalized statements for the three risk clusters: TCFD supporters vs non-supporters (95% confidence interval).

Climate risk (R1): Focusing on the risks posed by climate change to banks' operations, assets, lending, and financing, this cluster emphasizes keywords like 'climate change', 'scenario', 'transition', and 'global' (see Fig. A.22 in Appendix for a heat map of the data-generated keywords and Table A.9 for example statements).

Societal Risk (R2): This cluster discusses environmental and social risks related to banks' products and services, with keywords like 'environment', 'human rights', 'social', and 'reputational', highlighting their relevance to banks' risk assessments (see Fig. A.23 in Appendix for a heat map of the data-generated keywords and Table A.10 for example statements).

3.3.2. Expectation 2: Accounting for climate change risks

We now turn to the expectation that the banking industry should account for climate change risks. Considering the significance of risk and the expectations of governments and the public, it is noteworthy that risk as a category is the least discussed in annual sustainability reports, as seen in Fig. 3. Yet, there is a growing trend in the proportion of risk-related discussions over time. Additionally, Fig. 5, which shows total statements within each cluster sorted by bank, reveals considerable variation in discussion of risks among different banks. We can also note that a positive correlation exists between the frequency of banks' statements about risk and their discussions on products and services ($r = 0.695$, $p < 0.0001$, see Fig. A.11 in Appendix). Similarly, a significant correlation is observed between the extent of banks' risk discussions and their general discussions about climate change ($r = 0.645$, $p < 0.001$ see Fig. A.12 in Appendix).

We expected risks to be discussed primarily in relation to physical and transition risks, aligning for example with the supervisory expectations set out by the European Central Bank (European Central Bank, 2020). However, we note that the three clusters as described above do not differentiate between physical and transition risk. Instead, we find three well-defined clusters that engage with risk discussions from distinct perspectives. There is one cluster that specifically focuses on the risk of climate change to the banks' overall activities (R1). The other two clusters have a broader discussion of risks, namely ESG (R0) and societal risks (R2), where climate is acknowledged. The distinction between the ESG risk and climate risk clusters is that in the ESG risk cluster (R0) banks discuss incorporating climate risks into their overall processes and procedures, like top-level policies, instead of using climate-specific processes, such as scenario testing, to evaluate the relevant risks. For example, words like 'management' and 'policies' are keywords in the ESG cluster (see Fig. A.21 in Appendix). In the climate risk cluster, there is a notable increase in mentions of 'transition', suggesting an enhanced recognition of transition risk as a significant climate-related concern for banks (see Fig. A.22 in Appendix). Also prominent keywords like 'scenario' and 'impact' reflects how banks are incorporating the effect of climate change on banks' activities. Furthermore, there is an interesting distinction between the climate risk and societal risk clusters. The societal risk cluster seems to frame issues related to climate as a part of broader issues that can affect society which the bank likely sees as a non-financial or "reputational" risk to their business (see Fig. A.23 in Appendix). For example, key words like 'human rights' and 'social' are highlighted in this cluster.

As shown by these clusters, banks seem to discuss risk in terms of the differing perspectives that they use to evaluate these risks. These differing perspectives are important to understand as each perspective lends itself to different processes and procedures. For example, banks approaching risk from an ESG perspective may focus more on developing overall policies that align with ESG best practices, while banks that consider climate change as a societal risk might be looking more specifically at situations where their activities give rise to potential claims of harm. We recognize that individual banks do not necessarily align with one perspective, but are likely combining all three in various ways.

In relation to governance and internal processes as it relates to risk, TCFD is increasingly being referred to as a standard to report risk management. In our data, 66% of the banks state to support (or sign up to) TCFD as of 2021, and there is an increasing trend in support since 2017 when the first banks in our data signed up to TCFD (see Fig. A.24 in Appendix). A pertinent question arises: do banks that endorse TCFD, and presumably have implemented its recommendations, discuss risks more extensively in their sustainability reports? Although a majority of banks currently support the TCFD, there is notable variation in the years when different banks committed to these guidelines. Taking advantage of this, we can compare average (normalized) statements within the risk clusters; as expected TCFD supporters do seem to discuss both climate risk (R1) and impact to society (R2) to a larger extent, but there seems to be little difference in how much supporters and non-supporters talk about ESG risks (R0) (see Fig. 8). This is perhaps not surprising considering that ESG risk encompasses a spectrum of risks beyond the scope of TCFD.

To summarize, it is notable that the proportion of risk-related discussions within the total statements about climate change in banks' annual sustainability reports remains relatively low and at a general level. With the EU regulation pushing for enhanced risk disclosure, we anticipate a future increase in both the frequency and specificity of risk-related conversations in these reports.

3.4. General — Climate change governance and strategies

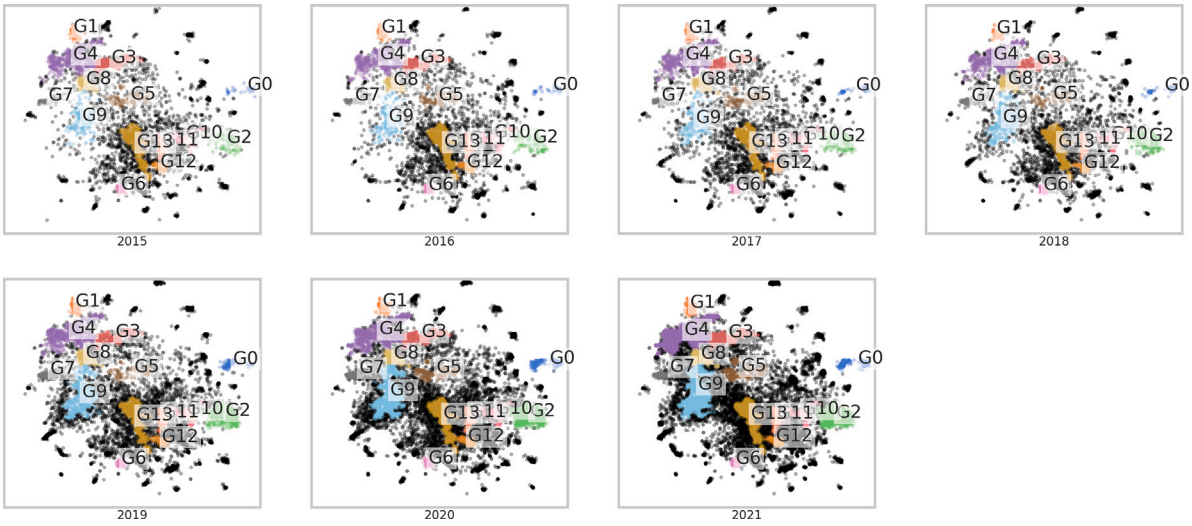

Fig. 9. Clustered bank statements in the general category by year. Each dot represents one statement.

3.4.1. Topic analysis of general statements

In this section, we will analyze three expectations placed on banks: decarbonizing their own operations, setting genuine climate commitments, and improving disclosure.

The results from the topic analysis for statements identified as general statements related to climate change are presented in Fig. 9. The broader category of general statements includes discussions of internal governance policies and strategies including statements related to decarbonization of banks' own operations and their suppliers, general statements related to the impact of climate change, and overall commitments and targets including signing up to various initiatives. Out of the 13 clusters identified in the cluster analysis, we identified 6 clusters that are most relevant to our analysis concerning banks' expectations to contribute to the climate transition (see Fig. A.25 in Appendix). Subsequently, we provide a brief description of each cluster.

Emissions from buildings (G3): This cluster focuses on emissions from buildings, including banks' own properties and the real estate and housing sector in general. Keywords include 'building', 'energy consumption', 'heating', 'renewable', and 'renovation' (see Fig. A.26 in Appendix for a heat map of the data-generated keywords and Table A.11 for example statements).

Measuring emissions (G4): This cluster discusses banks' measurement of emissions, often referencing the Scope Framework,[7] specifically Scope 3 emissions from business travel and vehicles and Scope 2 emissions from electricity and energy consumption. Financed emissions are discussed but are less prominent (see Fig. A.27 in Appendix for a heat map of the data-generated keywords and Table A.12 for example statements).

Suppliers (G6): In this cluster, banks discuss implementing sustainability measures with suppliers, highlighting keywords like 'code of conduct', 'procurement', 'purchasing', and 'standards', which indicate efforts to evaluate suppliers' sustainability (see Fig. A.28 in Appendix for a heat map of the data-generated keywords and Table A.13 for example statements).

Fossil fuel (G7): This cluster addresses energy sources and sectors contributing to climate change, with keywords such as 'coal', 'gas', 'fossil fuel', 'oil', and 'mining.' Keywords like 'financing' and 'policy' also feature prominently (see Fig. A.29 in Appendix for a heat map of the data-generated keywords and Table A.14 for example statements).

Climate targets (G8): This cluster focuses on banks' overall targets to reduce emissions with keywords like 'offset', 'operations', 'carbon', 'carbon footprint', 'reduction', and 'reduction target' (see Fig. A.30 in Appendix for a heat map of the data-generated keywords and Table A.15 for example statements).

Climate commitment and awareness (G9): This cluster relates to banks' awareness of and commitment to climate goals, often referencing voluntary initiatives and the Paris Agreement. Keywords include 'net-zero', 'targets', and 'goals' (see Fig. A.31 for a heat map of the data-generated keywords and Table A.16 for example statements).

3.4.2. Expectation 3: Decarbonizing own operations

Among the clusters analyzed in the general category, we note that topics within several clusters relate to the expectation of reducing emissions from the bank's own operations. These clusters include building emissions (G3), measuring their scoped emissions (G4), measuring and evaluating their suppliers (G6), and banks' climate targets (G8). As with any other business, governments have set an expectation that banks should focus on reducing emissions from their operations as businesses have the most direct control

[7] https://ghgprotocol.org/sites/default/files/standards/ghg-protocol-revised.pdf

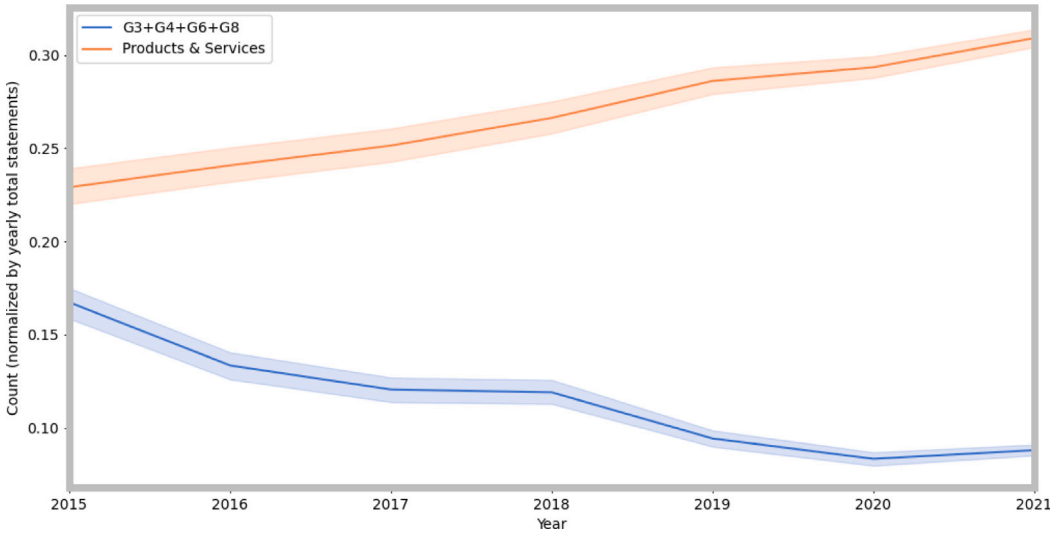

Fig. 10. Normalized counts: Clusters G3, G4, G6 and G8 compared to the products & services category (95% confidence interval).

over these emissions. That being said, this focus is notably easier for banks than, for example, more carbon-intensive industries. While we recognize that reducing emissions within banks' own operations is necessary for banks, we see such emission reduction activities as also more easily accomplished in comparison to decarbonizing their financing or addressing the potential climate impact of their financing. Fig. 10 shows that the share of statements within these clusters is decreasing over time. We argue that this correlates with banks initially focusing on implementing processes and procedures related to their direct emissions but then being able to relatively quickly decarbonize their own operations. They have since started to talk more about their indirect emissions from their financing (as shown by the increasing trend of statements in the products and services category in Fig. 10).

3.4.3. Expectation 4: Improved transparency and disclosure to regulatory bodies and to the public

Finally, an expectation that is clearly emphasized by governments, supervisory bodies, and the public is disclosure. Disclosing the impact of a bank's activities and commitments by reporting measured emissions, the extent of financing of the fossil fuel industry, and societal impacts are seen as critical for investors to make informed decisions, for regulators to be able to assess banks' climate transition and reduce greenwashing, and for the public to hold banks accountable in their role in the green transition. Our analysis primarily anticipated insights from clusters within the general statements category in addressing this expectation. However, we also see relevant discussions emerging from the other two categories, products and services, and risk. Therefore, clusters from these categories have been incorporated into our analysis as well.

We identify in particular four clusters of relevance that represent banks' disclosure of substantive impacts in relation to climate change — the measuring negative impacts cluster (P9), the climate risk cluster (R1), the measuring emissions cluster (G4), and the fossil fuel cluster (G7) (see example statements in A.18 in Appendix).

Aligning with the expectation of disclosure, we note that these four clusters increase significantly[8] over the years (see Fig. 4 and Table A.2 for statistics and p-values). Still, despite the positive trend, these clusters represent a small share of the total discussion of climate change in the annual sustainability reports and as already noted, the discussion of climate risk (R1) is scant. Banks talk relatively more about measuring emissions (G4) and negative impacts (P9). Yet, we observe that the discussion within the fossil fuel cluster (G7) is surprisingly thin especially when considering this is one of the main issues related to climate change. We see these clusters as very important to track in the coming years as they relate to significant issues that banks are disclosing to the public.

Next, we consider banks' discussion of commitments aligning with the global goals of climate change mitigation. Commitment to targets falls predominantly within the climate targets cluster (G8), which pertains directly to specific climate goals such as emission reduction targets. The climate targets cluster is interpreted as 'action-oriented', characterized by quantifiable statements against which banks' performance can be objectively assessed. In contrast, the climate commitment and awareness cluster (G9) comprises 'softer' declarations, where banks emphasize the importance of combating climate change, endorse various standards, and recognize the findings of climate science. Over time, both clusters have shown significant growth. However, the comparatively larger expansion of the climate commitment and awareness cluster (G9) suggests that while banks' awareness and readiness to commit have increased, the establishment of concrete climate targets is not keeping pace.

For example, based on our data, we note that the keyword "net-zero" (commonly used reflecting a commitment) was not used until 2018, and has increased in use significantly within the past 3 years (see Table A.17 for p-values and Fig. A.31 in Appendix).

[8] Except G4 which is borderline significant with a $p - value = 0.059$.

A commitment to achieving net-zero emissions by 2050 could however be perceived as neither robust nor consequential unless it is underpinned by explicit, interim targets and tangible commitments that necessitate demonstrable progress in the near term. Taking this under consideration, we look further into the climate targets cluster (G8) and the climate commitment and awareness cluster (G9) to understand whether banks mostly talk about net-zero only as a long-term commitment or if they seem to establish more near-term commitments that illustrate a path to their net-zero goal. After reviewing all statements in the two clusters that discuss net-zero targets and/or mention the years 2050, 2030, 2025, and 2020, we indeed find that the former hypothesis is the case. Banks more near-term climate targets relate mostly to banks' own operations, while the more long-term commitments related to net-zero are vague or recognize the global need to achieve net-zero targets by 2030 and 2050. Reducing financed emissions, clearly the most impactful aspect of how a bank could contribute to the climate transition, is hardly discussed at all in relation to a specific target.

4. Concluding remarks

In this study, we use NLP to analyze banks' discussion in their annual sustainability reporting in relation to prominent societal expectations to mitigate climate change. Through this analysis, we are able to extract meaningful signals regarding banks' responses to societal expectations, despite the challenging complexity and 'noise' inherent in this type of unstructured data.

From our analysis, we conclude that banks spend on average around 7% of their annual sustainability reporting on issues related to climate change. Out of the more than 1.5 million statements extracted, approximately 110,000 statements were about climate change. Yet, when qualitatively analyzing the statements that do relate to climate change, we find an interesting picture of how banks are increasingly responding to societal expectations, including (1) decarbonizing banks' products and services (including ending their financing of fossil fuel industries), (2) appropriately accounting for climate risk and the impacts their financing has on society, (3) decarbonizing their own operations, and (4) improving their transparency to regulatory bodies and to the public in their disclosures.

While there is a positive trend for banks to decarbonize consumer-facing products and services, such as home loans, energy efficiency, and car loans, and decarbonize their own operations, they at the same time report very little on risks in relation to their activities (even if the trend in reporting is positive). Based on their reporting, it seems as if banks are much further along in tackling emissions from their own operations, which we interpret as a quick win as financial operations are not the most carbon-intensive activity. Yet their financed emissions, particularly those linked to fossil fuels, have received comparatively less attention. Finally, we see a raised awareness of climate change and development of overall targets and commitments, yet we see less of a discussion regarding how these targets will be feasibly achieved.

In 2023, the Board of Governors of the Federal Reserve System in the United States published a paper conducting a stock-taking exercise of what larger banks are doing regarding climate change (Beltran et al., 2023). Even though our scope and methodological approach differ, we note that both this paper and our paper use the qualitative data found in banks' annual reporting for analysis and that a number of the main findings are similar. In particular, they also highlight banks' focus on direct emissions, and insufficient consideration of financed emissions, including fossil fuel financing.

We see a significant potential in using unstructured data obtained through banks' annual reporting to track and evaluate banks' responses to climate change. By systematically analyzing how banks communicate their climate-related activities, NLP can reveal patterns, omissions, and emphasis in reporting. This allows policymakers and advocacy groups to identify gaps between reported and expected behavior and detect under-reported but materially important topics. With this information, they can design or adjust incentives, disclosure requirements, or targeted interventions to promote more transparent and aligned climate action.

Finally, it should be noted that regulation could enhance the usefulness of this type of unstructured data by standardizing the disclosure content, thereby providing a more reliable basis for predicting bank behavior based on their discussions. We note three potentially significant developments in this regard in the EU, namely (1) the Sustainability Finance Disclosures Regulation which was adopted in 2019, (2) the Corporate Sustainability Reporting Directive which was adopted in 2022,[9] and (3) the European Single Access Point which was approved in 2023 and expected to be introduced in 2027. We recognize that our current data set is reflective of before these regulations come into effect, and it will be noteworthy to see how further standardization and easier access to reporting will allow NLP models to analyze this type of data and ultimately predict banks' actions concerning the climate transition in the coming years.

CRediT authorship contribution statement

Åsa Löfgren: Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Jasmine Elliott:** Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Yinan Yu:** Writing – original draft, Visualization, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Samuel Scheidegger:** Visualization, Software, Formal analysis, Data curation.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT and GPT 4 in order to check grammar. After using this tool/service, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

[9] Both the Sustainability Finance Disclosure Regulation and the Corporate Sustainability Reporting Directive are being reconsidered under the proposed Omnibus simplification package.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix

A.1. Tables

Table A.1
List of Banks and countries.

Bank	Country
ABN AMRO Group	Netherlands
BNP Paribas	France
Banca Monte dei Paschi di Siena	Italy
Banco BPM	Italy
Banco Bilbao Vizcaya Argentina (BBVA)	Spain
Banco Santander	Spain
Banco de Sabadell	Spain
Bank of Ireland	Ireland
Bayerische Landesbank	Germany
Belfius Banque	Belgium
CaixaBank	Spain
Commerzbank	Germany
Crédit Agricole	France
Crédit Mutuel Group	France
DZ Bank	Germany
Danske Bank	Denmark
Deutsche Bank AG	Germany
Erste Group Bank	Austria
Group BPCE	France
Handelsbanken	Sweden
ING Groep	Netherlands
Intesa Sanpaolo SpA	Italy
KBC Group	Belgium
La Banque Postale	France
Landesbank Baden Württemburg	Germany
Landesbank Hessen-Thüringen Girozentrale (Helaba)	Germany
Nordea Bank	Sweden
Nykredit	Denmark
OP Financial Group	Finland
Rabobank	Netherlands
Raiffeisen Bank International	Austria
Skandinaviska Enskilda Banken	Sweden
Société Générale	France
Swedbank	Sweden
UniCredit SpA	Italy

Table A.2
Cluster growth: This table shows the statistical analysis of the exponential growth from 2015 to 2021 for each cluster of interest. The growth is computed for the normalized cluster size (i.e. the proportion of each cluster with respect to all statements for each year). The column "Slope" in the table indicates the linear coefficient after taking the logarithm of the proportion. With statistical significance indicated by the p-value, if "Slope" is greater than 0, it indicates exponential growth; if "Slope" equals to 0, it indicates zero growth; otherwise, it indicates exponential decay.

	P0	P3	P5	P8	P9	R0	R1	R2	G3	G4	G6	G7	G8	G9
Slope	0.182	0.404	0.259	0.276	0.319	0.442	0.599	0.194	0.043	0.110	0.015	0.289	0.147	0.326
p-value	0.001	0.001	0.006	0.000	0.013	0.005	0.000	0.006	0.456	0.059	0.452	0.001	0.016	0.001
R^2	0.894	0.918	0.801	0.967	0.742	0.824	0.985	0.811	0.115	0.543	0.117	0.927	0.716	0.914

Table A.3
Example statements for cluster P0 (Renewable energy and energy efficiency).

Year 2016, Bankid: WTL	*"Another area of environmental involvement by the Bank is funding energy efficiency facilities in connection with specific operating lease products; this area ranges from public lighting to biomass-fired boilers and cogeneration plants."*
Year 2016, Bankid: YGL	*"In just 2016 alone, around EUR 630 million of new development loans were concluded in the field of energy efficiency and environmental protection."*
Year 2017, Bankid: AQU	*"The first of such initiatives have been targeted at homeowners and making it easier and more affordable for them to energy renovate their homes, thereby contributing to the green transition of the housing stock, which, according to the [Country] Council on Climate Change, is key if [Country] is to reach its climate goals."*

Table A.4
Example statements for cluster P3 (Climate aligned finance).

Year 2018, Bankid: VFQ	*"Aligning the main climate-related sectors with a 2 °C trajectory to achieve this ambition, the [BANK] is developing methodologies and tools measuring its lending portfolio's alignment with the objectives of the Paris Agreement."*
Year 2019, Bankid: SLK	*"The recommendations of the Task Force on Climate-Related Fin (TCFD) and the EU's action plan for financing sustainable growth are important steps in the development of an international regulation where the banks can play a clear role in financing the investments needed to achieve the goals in the Paris Agreement and SDGs."*
Year 2020, Bankid: DED	*"We have also announced that we will set a climate target for our corporate lending portfolio in alignment with the Paris Agreement on Climate Change, and [BANK] has joined the Net-Zero Asset Owner Alliance, thereby committing to decarbonize its total investment portfolio by 2050."*

Table A.5
Example statements for cluster P5 (Climate mobility).

Year 2017, Bankid: YHP	*"The investment financing in the amount of € 20 million provided for new transportation buses equipped with especially clean engines (EURO 6 emissions standard) and special soot particle filters also contributes to emission reduction."*
Year 2019, Bankid: CIX	*"In 2019, we launched green car leasing, which is yet another way for us to contribute to the shift to a low-carbon society."*
Year 2020, Bankid: FVL	*"We plan to launch many more green solutions related to the introduction of electric vehicles (EV) in our corporate clients' fleets, the green financing of EV fleets, the installation of charging points, etc. in our different countries in the coming months."*

Table A.6
Example statements for cluster P8 (Green bond).

Year 2017, Bankid: KWC	*"In 2017, we saw an increasing interest among our corporate customers for sustainable financing solutions manifested by the insurance of our first green bond — a EUR 500 million five-year bond."*
Year 2018, Bankid: RDV	*"The managers select the bonds, mainly investment grade, using the criteria defined by the Green Bond Principles in order to support the growth of environmental investments."*
Year 2019, Bankid: SLK	*"Investments in green bonds increased by over 80 per cent compared to the previous year, with just over SEK 21bn owned in the fourth quarter."*

Table A.7
Example statements for cluster P9 (Measuring negative impact).

Year 2017, Bankid: YHP	*"The withdrawal of many investors from the area of fossil energy, especially coal and carbon-dependent industries, is an indication that such assets of our customers or investees can be expected to fall in value over the medium term ("carbon bubble")."*
Year 2019, Bankid: WGQ	*"We've set out targets to 'green' our portfolio by reducing our financing to coal-power generation to close to zero by 2025."*
Year 2020, Bankid: RCQ	*"The weighted average carbon footprint, which decouples portfolio companies' turnover growth from CO2 emissions, decreased by 36% however, which is a positive trend."*

Table A.8
Example statements for cluster R0 (ESG Risk).

Year 2015, Bankid: XHX	*"Furthermore, to assist project managers to examine the extra-financial risks related to their project, an ESG checklist was drawn up in 2014."*
Year 2018, Bankid: AYL	*"From a point of view of the [Bank]'s business, ESG risks could materialize in aspects such as: potential exposure in financing/investment operations in sectors with high carbon emissions; possible mistakes in the assessment and coverage of operations or customers that are highly exposed to climate change risks; and potential exposure in social risk financing operations (e.g. violations of human rights), among others."*
Year 2021, Bankid: UOI	*"The aim is to assess the potential for medium-term deterioration in the rating of the borrower based on risks associated with ESG factors."*

Table A.9
Example statements for cluster R1 (Climate risk).

Year 2016, Bankid: DED	*"While companies are already feeling the physical impact of climate change, many companies also face even more acute non-physical risks, such as shifting market trends and public policies that accelerate the transition to a low-carbon economy."*
Year 2016, Bankid: SIX	*"One consequence of taking actions to reduce climate risks is the so-called carbon risk, or the risk of "stranded" assets, in the transition to net-zero greenhouse gas emissions."*
Year 2017, Bankid: WGQ	*"The perception of climate change as a risk by civil society, shareholders, governments and other stakeholders continues to increase, including in relation to the financial sector's operations and strategy, and international actions, such as the Paris agreement on CO2 emissions, may also result in financial institutions coming under increased pressure from such stakeholders regarding the management and disclosure of their climate risks and related lending and investment activities."*

Table A.10
Example statements for cluster R2 (Societal risk).

Year 2015, Bankid: AIF	*"As a subcategory of reputational risk in our risk taxonomy, sustainability risk is a transversal risk of increasing importance and is aligned with the bank's moderate risk profile and risk appetite."*
Year 2019, Bankid: LNK	*"Failure to respect human rights may adversely affect the working or living conditions of people in a producer's or supplier's country of origin, just as neglecting environmental matters may adversely affect the ecological footprint."*
Year 2020, Bankid: DED	*"We therefore screen our investments on an ongoing bases to identify sustainability risks and to address the negative impact on society that our investment decisions may have (referred to as principal adverse impacts)."*

Table A.11
Example statements for cluster G3 (Emissions from buildings).

Year 2017, Bankid: FVL	*"For instance, we have managed to reduce our energy consumption by over 20% in the past six years, and our head office in [CITY] now has a LEED (Leadership in Energy and Environmental Design) certificate."*
Year 2021, Bankid: DUE	*"We source our electrical supply almost exclusively from renewable energy providers, allowing our operations to address a significant source of GHG emissions across our estate."*
Year 2020, Bankid: XHX	*"This involves making occupants more aware of eco-friendly behavior, optimizing building equipment and ensuring all renovations incorporate energy performance by default and by design."*

Table A.12
Example statements for cluster G4 (Measuring emissions).

Year 2015, Bankid: KWC	*"Reducing our emissions from air travel remains a challenge for us and in 2015 we did not achieve the reduction we were aiming for."*
Year 2016, Bankid: RDV	*"With a view to continual improvement, reporting was extended to other indirect emissions referable to Scope3 and evaluation methods were improved in 2016."*
Year 2016, Bankid: CBA	*"In 2016, the [BANK] managed to cut energy consumption by 8.5%, CO_2 emissions by 6.8% and paper consumption by 23.9%."*

Table A.13
Example statements for cluster G6 (Suppliers).

Year 2015, Bankid: BGQ	*"Our sustainable procurement standard was revised in 2015, giving us more influence over our suppliers."*
Year 2015, Bankid: XHX	*"Depending on the purchasing categories, environmental and social concerns represent in general 10% of the global weighting of the rating criteria of the invitations to tender."*
Year 2017, Bankid: YHP	*"Suppliers are selected and classified according to selected criteria, with sustainability criteria being included in this process through aspects such as regionality."*

Table A.14
Example statements for cluster G7 (Fossil fuel).

Year 2019, Bankid: FVL	*"We are not going so far right now as to rule out investments in gas production."*
Year 2019, Bankid: UAT	*"Excluding companies involved in oil and gas does not mean we are opposed to their current activities per se, but what we are against is their lack of commitment to align future business operations to the Paris Agreement."*
Year 2021, Bankid: SLK	*"The bank no longer directly finances unconventional fossil fuel production or exploration of new oil and gas fields."*

Table A.15
Example statements for cluster G8 (Climate targets).

Year 2021, Bankid: AYL	*"A total of 20,239 tonnes of CO2 emissions were offset during the year thanks to the [BANK] involvement in a project recognised by Verified Carbon Standard (VCS)"*
Year 2016, Bankid: EFV	*"Our medium-term target is now to reduce our GHG emissions by 60 percent by 2020, and our long-term target is a reduction of 80 percent by 2030."*
Year 2020, Bankid: FVL	*"At the same time we will continue to reduce our actual direct footprint and are aiming for an 80% rather than 65% reduction in our GHG emissions (compared to base year 2015) – including commuter travel – by 2030."*

Table A.16
Example statements for cluster G9 (Climate commitment and awareness).

Year 2015, Bankid: YHP	*"The declared fight against climate change, based on the climate agreement in Paris in 2015, has given impetus to our ambitions in this area."*
Year 2019, Bankid: DED	*"We also participate in and support a number of different investor initiatives to encourage increased transparency and sustainability standards in companies and financial markets, such as CDP, Institutional Investors Group on Climate Change, Paris Pledge for Action, TCFD, Climate Action 100+, The Montreal Pledge, and the UN-supported Principles for Responsible Investment."*
Year 2019, Bankid: WGQ	*"Shifts in societal expectations on climate change and developments in climate science are driving new initiatives and policy updates within the bank to address this threat."*

Table A.17
Net-zero count and *p*-value as correlated with cluster G9.

Year	*p*-value	Count of Statements with "Net-Zero"	Total G9 Statements
2015	0.0	0	5255
2016	0.0	0	5935
2017	0.0	0	6114
2018	0.0	2	6732
2019	0.0	5	9371
2020	0.0	75	14 079
2021	0.0	291	20 075

Table A.18
Example statements in clusters P9, R1, G4, G7.

Measuring negative impacts (P9) Year: 2020, Bank ID: UOI	*For 2019, the emission-reducing impact of [COMPANY] financing transactions was determined to have exceeded 500,000 tonnes for the first time.*
Measuring negative impacts (P9) Year: 2021, Bank ID: UAT	*Also, as more energy labels become available for more properties, we expect that the calculations for a larger proportion of our real estate portfolio will be based on specific energy performance data and emissions factors, rather than relying on estimates which will impact the total reported emissions of the portfolio.*
Climate Risk (R1) Year: 2020, Bank ID: SLK	*In the transition to a climate neutral society, political actions such as the introduction of carbon taxes, or technological progress such as new production processes, will affect us and our customers, giving rise to transition risks.*
Climate Risk (R1) Year: 2018, Bank ID: KWC	*The materiality analysis we conducted in 2018 shows that our greatest impact and contribution to sustainable development is our indirect impact.*
Measuring emissions (G4) Year: 2018, Bank ID: UAT	*Since 2013, the Bank's yearly CO2 emissions have decreased by more than 7,700 tonnes.*
Measuring emissions (G4) Year: 2020, Bank ID: YHP	*In Scope 3, emissions have fallen by 62 per cent since 2011, while Scope 1 has seen a reduction of 60 per cent.*
Fossil fuel (G7) Year: 2018, Bank ID: MXP	*The Group has strengthened its sectoral policy on coal so that it no longer finances the extraction of coal, whether via mining projects or via specialized coal mining companies without a diversification strategy, as well as coal-based power plant projects.*
Fossil fuel (G7) Year: 2018, Bank ID: FVL	*We have translated these ambitions into clear targets:We exclude the financing and insurance of environmentally harmful energy-related activities, such as unconventional oil and gas, oil and coal-fired power generation, and coal-related activities.*

Table A.19
First Annotation Guidelines.

Generally accept	Generally reject
Climate change	Gibberish
Green	Languages not in English
Non-financial risks (if related to environment/climate change)	Sustainability not related to the environment (i.e. sustainable profits)
Green bond	Circular economy
Carbon	recycling not related to banks own operations
Global warming	Nature conservation efforts
Paris Agreement	Prompts from disclosure standards (i.e. GRI or TCFD)
Scope 1, 2, or 3 emissions	Section headings or titles
Sustainable finance	Statements that are part of a table of contents
ESG (environmental, social, governance)	Table figures
Fossil fuels (if related to environment)	
Energy industry (if related to environment)	
Sustainable development goals (if related to environment)	
Energy efficiency (in operations of bank or related to lending)	
Operational recycling efforts by bank	
Reference to disclosures (if related to environment/climate change)	
Non-financial risks (if related to sustainability (related to environment)	
Equator Principles	
Task Force on Climate Disclosures (TCFD)	
RE100	
UN Global Compact	
UN Environmental Programme (UNEP)	
UNEP Finance Initiative	
Principles for Responsible Banking (PRB)	
Principles for Responsible Investing (PRI)	
Carbon Disclosure Project (CDP)	
2 Degrees Investing Initiative	
EU Green New Deal	
EU Taxonomy	
EU 2019/2088	
EU 2019/2089	
EU 202/852	

A.2. Figures

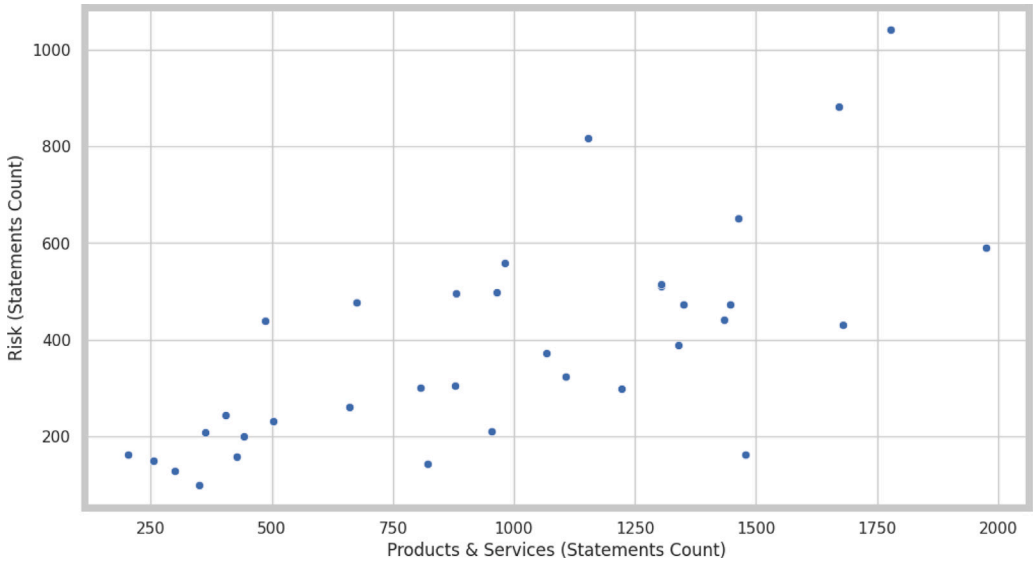

Fig. A.11. Statement counts: products & services vs risk (Pearson correlation r = 0.69, p < 0.0001).

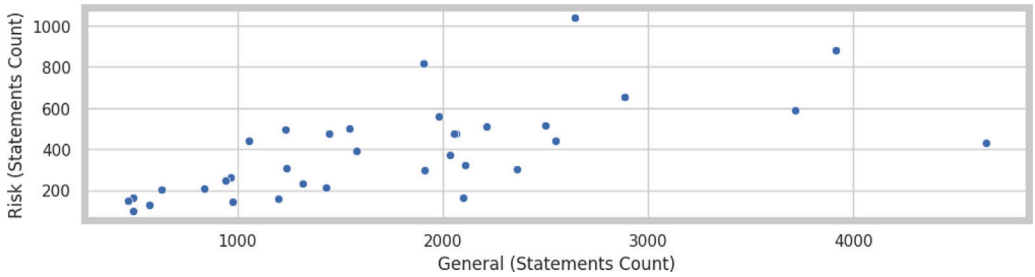

Fig. A.12. Statement counts: general vs risk (Pearson correlation r = 0.65, p < 0.001).

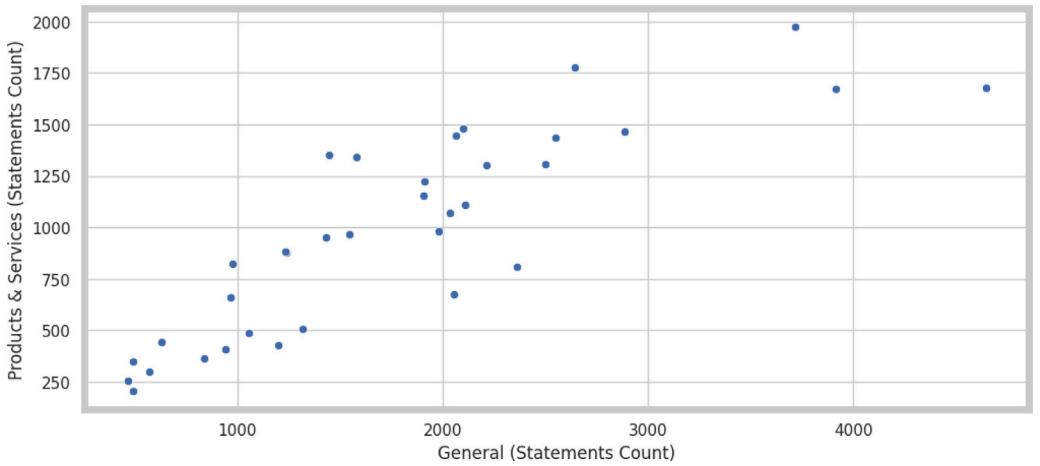

Fig. A.13. Statement counts: general vs products & services (Pearson correlation r = 0.85, p < 0.0001).

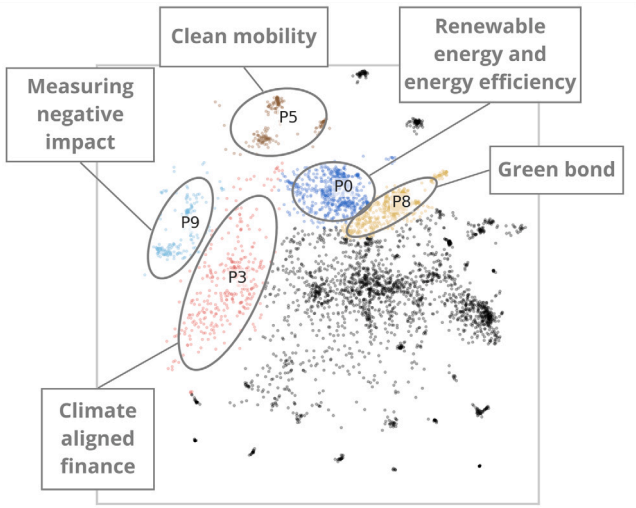

Fig. A.14. Labels of clusters P0, P3, P5, P8, and P9 — year 2019.

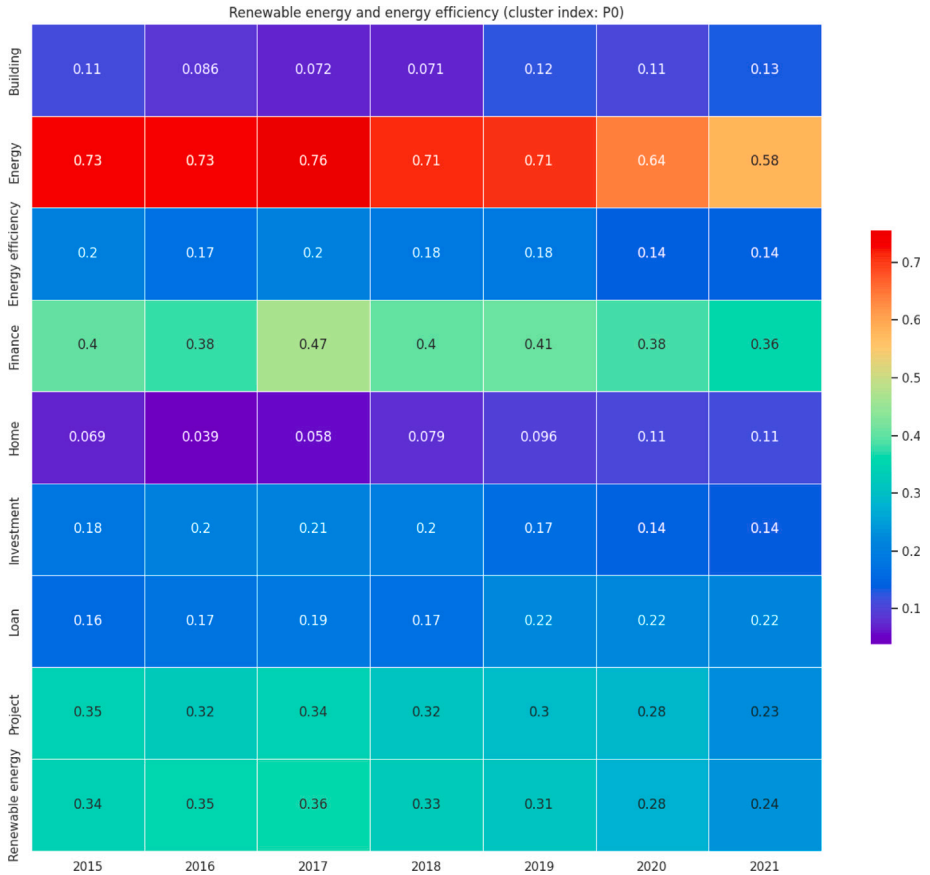

Fig. A.15. Heat map of data-generated keywords, cluster P0 — Renewable energy and energy efficiency.

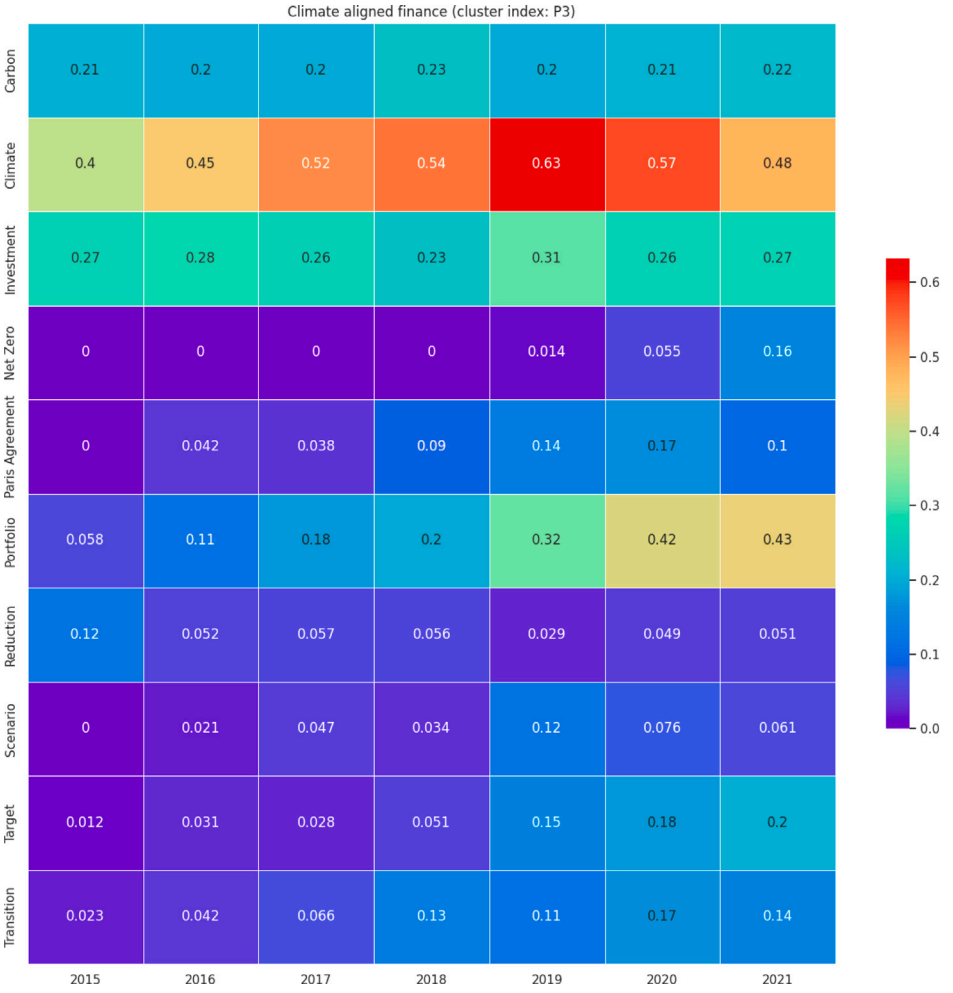

Fig. A.16. Heat map of data-generated keywords, cluster P3 — Climate aligned finance.

Fig. A.17. Heat map of data-generated keywords, cluster P5 — Clean mobility.

Fig. A.18. Heat map of data-generated keywords, cluster P8 — Green bond.

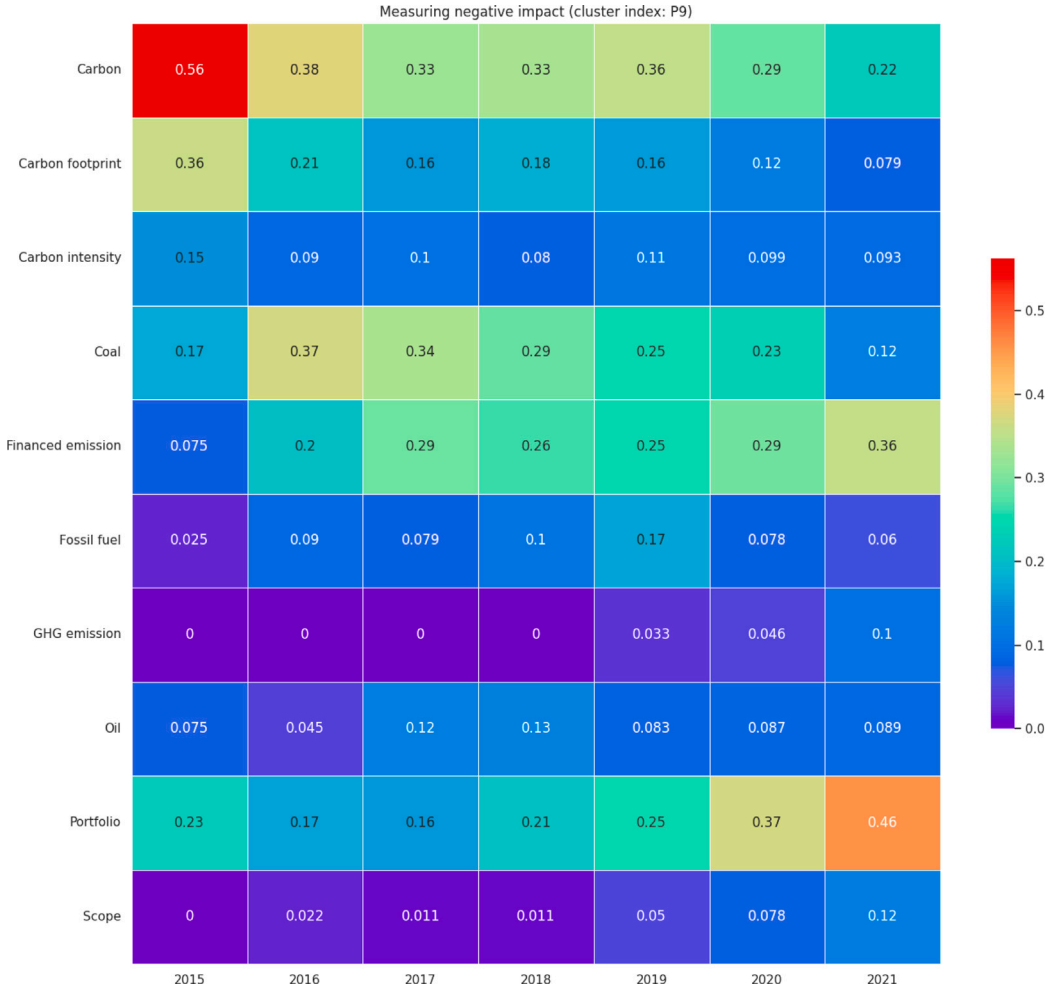

Fig. A.19. Heat map of data-generated keywords, cluster P9 — Measuring negative impact.

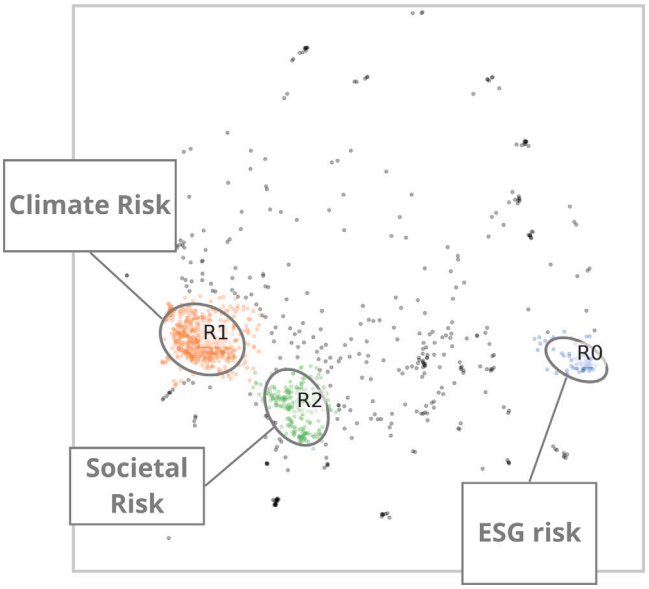

Fig. A.20. Labels of clusters R0, R1 and R2 — year 2019.

Fig. A.21. Heat map of data-generated keywords, cluster R0 — ESG Risk.

Fig. A.22. Heat map of data-generated keywords, cluster R1 — Climate Risk.

Fig. A.23. Heat map of data-generated keywords, cluster R2 — Impact on Society.

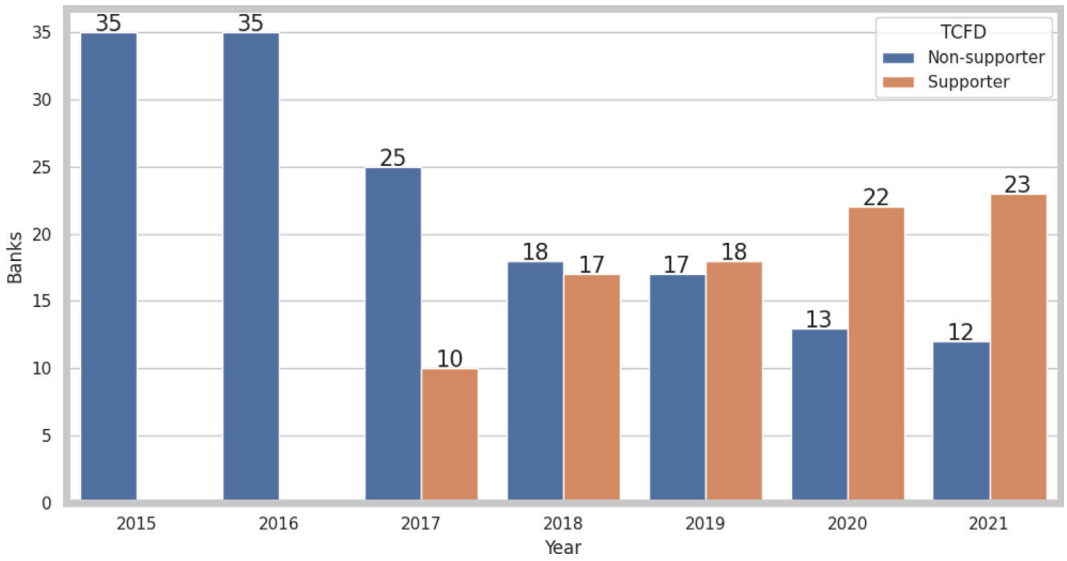

Fig. A.24. TCFD supporters within sample bank group over the years.

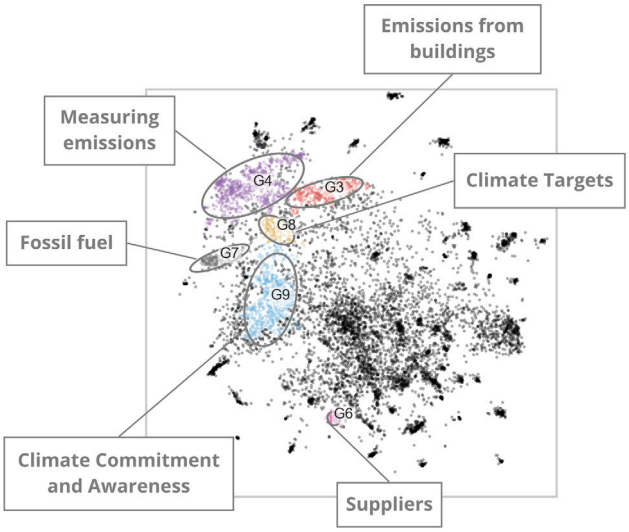

Fig. A.25. Labels of clusters G3, G4, G6, G7, G8, and G9 — year 2019.

Fig. A.26. Heat map of data-generated keywords, cluster G3 — Emissions from Buildings.

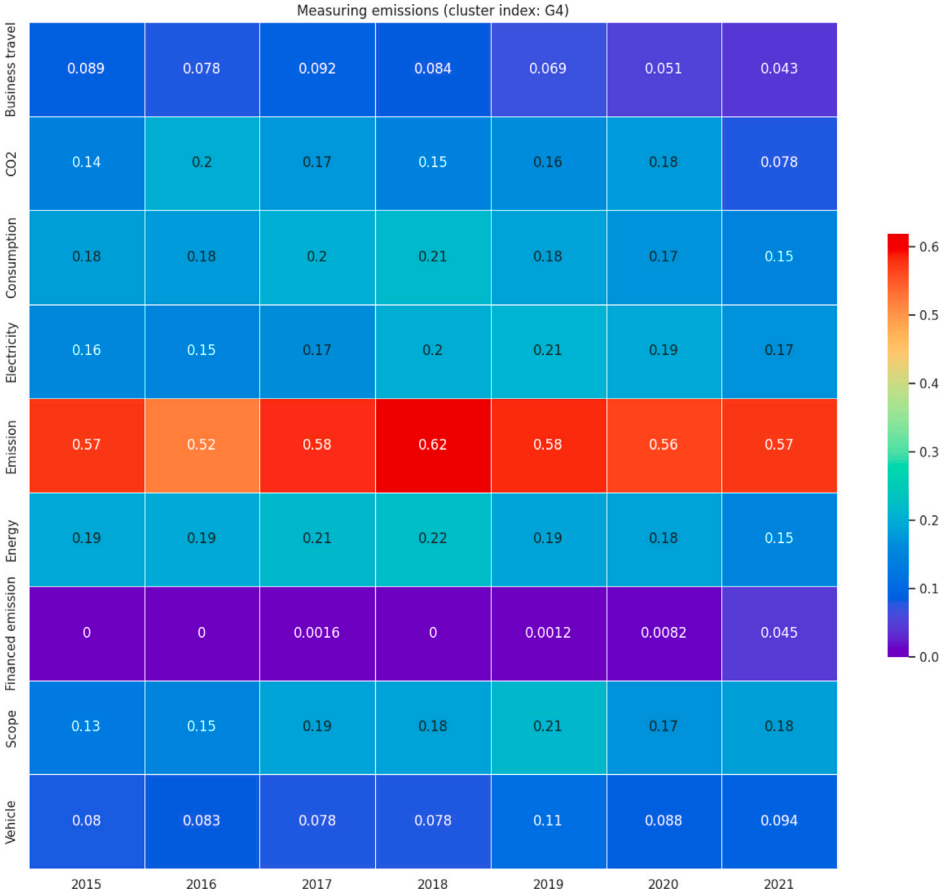

Fig. A.27. Heat map of data-generated keywords, cluster G4 — Measuring Emissions.

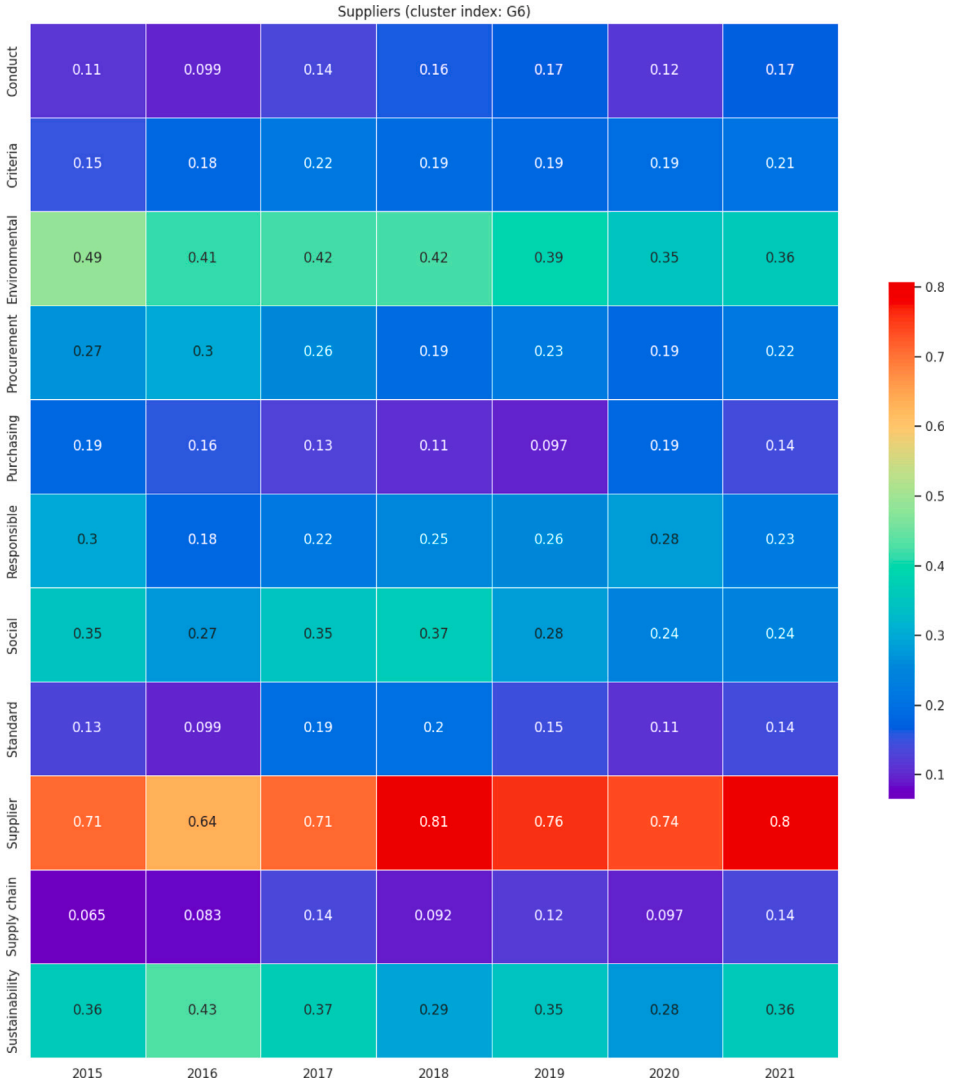

Fig. A.28. Heat map of data-generated keywords, cluster G6 — Suppliers.

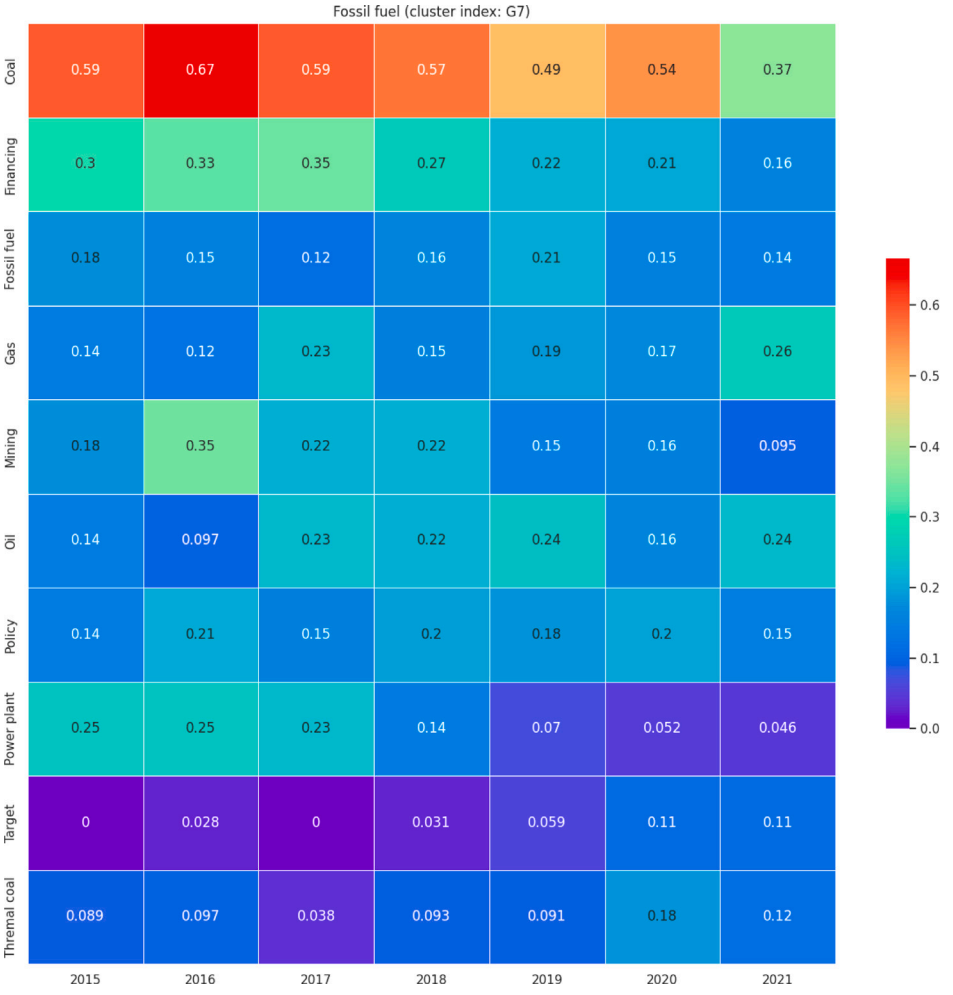

Fig. A.29. Heat map of data-generated keywords, cluster G7 — Fossil Fuel.

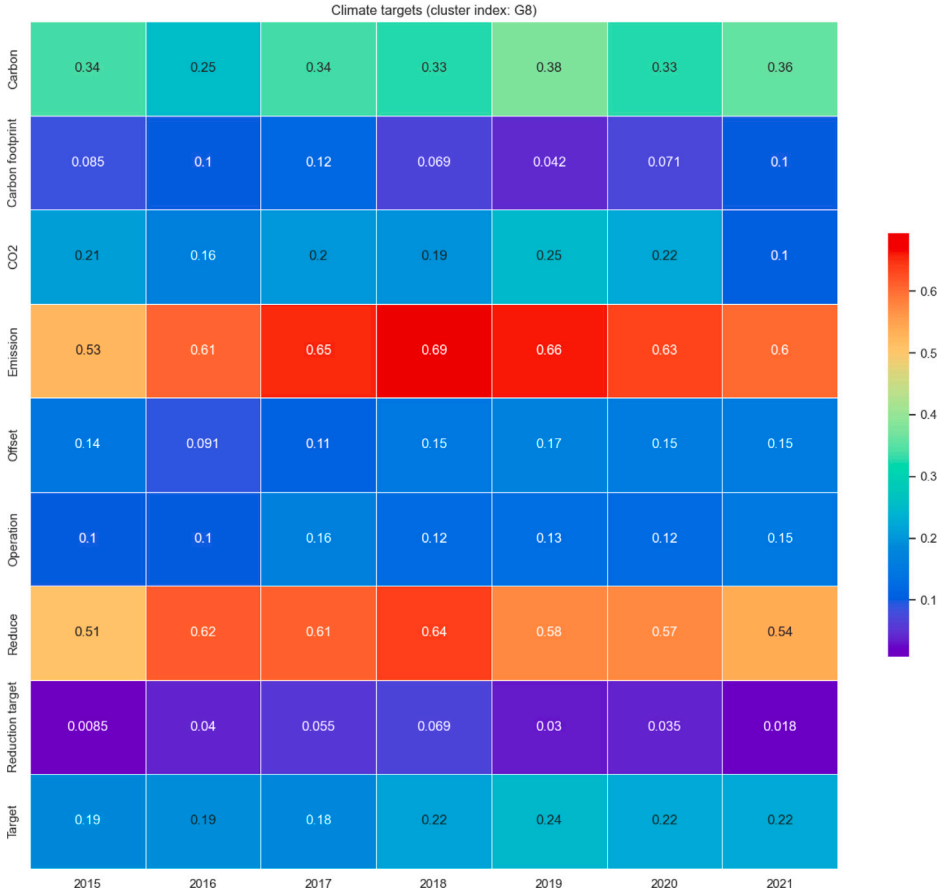

Fig. A.30. Heat map of data-generated keywords, cluster G8 — Targets Own Operations.

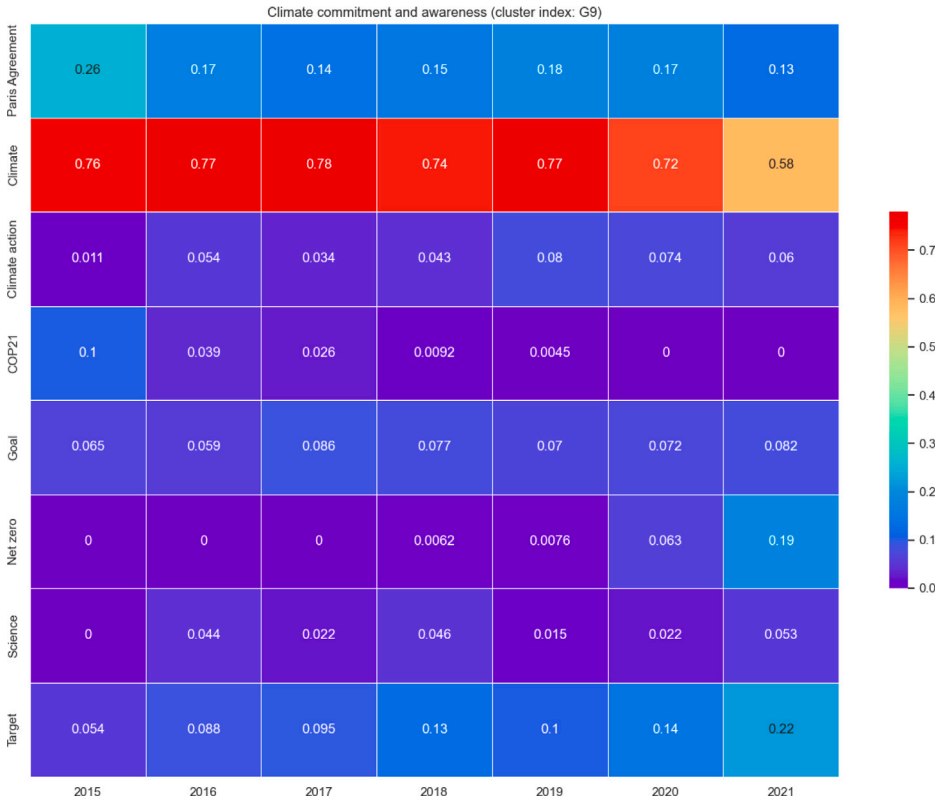

Fig. A.31. Heat map of data-generated keywords, cluster G9 — Overall Targets.

A.3. Annotation guide — for risks, product and services, and general categories

This project aims to understand how EU commercial banks are talking about climate change and environmental sustainability (both in their operations and in relation to their clients), particularly after the introduction and continued implementation of EU Sustainable finance regulation. We are using natural language processing AI to review the annual sustainability reports (2015–2020) of around 40 of the largest EU banks (by balance sheet total). The next step of this review is to manually review the AI's output of statements from the reports that it deems as related to climate change and environmental sustainability. This will happen in two stages:

A.3.1. First annotation: is this statement really about climate change or environmental sustainability?

You will be given a random statement from the database to annotate. The larger statement in the middle is the statement to be annotated. The smaller, gray statements are before and after the statement to be annotated in the database (to provide context if helpful for annotating). If the statement is NOT about climate change or environmental sustainability, click "A" on your keyboard or press "Remove" on your touchscreen device. If the statement is about climate change or environmental sustainability, click "S" on your keyboard or press "Accept" on your touchscreen device. See Table A.19 for guidance on what should and should not be considered climate-related.

A.3.2. Second annotation: how is this statement discussing climate change or environmental sustainability?

You will be given a random statement from the database to annotate. The larger statement in the middle is the statement to be annotated. The smaller, gray statements are before and after the statement to be annotated in the database (to provide context if helpful for annotating). For each annotation statement, choose the best option that summarizes what the statement is about (see below for further guidance related to the options) by clicking on the text.

- Risk
- Opportunity
- General

You also have the option to override the first "accept" annotation (if, for example, the statement is not actually about climate change) by clicking on the gray "remove" button. In terms of priority of annotation for this step, it is important to choose an

annotation based on what a statement is about or mostly about. It is important to consider what the main point of the statement is when considering group and sub-group.

- For example, if the sentence is about doing something with the bank's investment funds, it should be considered "Opportunity" (unless it is a collective standard setting initiative with other banks, then it would be an "Other").
- For sentences that just list a number of actions, it may be helpful to count the actions in relation to their group and decide from there.

This is the final annotation step — statements will be marked as "fully tagged" after completing this step.

A.3.3. How is this statement discussing climate change or environmental sustainability?

Risk — Is the bank talking about specific risks that climate change or the sustainable transition poses to their business or that they are trying to consider further in their risks processes?

- Key words to look for can include credit risk, operational risk, physical or transitional risk, insurance risk, risks in relation to pending legislation change.
- Note that discussion of updates to the actual risk framework or the process for assessing risk should be included in "Other".

Opportunity — Is the bank talking about products and services that they can provide to clients?

- Key words to look for can include bonds, funds, advisory, financing, loans, and investment.
- Note that discussions of collective standard-setting initiatives amongst numerous banks related to their funding should be considered "Other".

Other — Other statements in relation to climate change or sustainability that do not fit into Risk or Opportunity. This can include:

- Actions or discussions of initiatives in relation to their own operations (electric fleet cars, green electricity, training, etc.)
- ESG or sustainability committees, ESG frameworks, ESG or sustainability internal governance or internal policies that they have (including prohibitive financing policies to controversial sectors)
- Reference to incorporating ESG risks into bank's risk assessment process and methodology, bank's risk committee and due diligence process
- Collective initiatives they are taking part in (PRI, TCFD, UNEP FI)
- Definition statements that are related to the bank's actions or considerations ("SDG 13 is . . . ") (defining a certain index or award).
- Reference or discussion of data that they are using to track their climate or sustainability performance, primarily in their own operations (we are looking for the possibility comparability over time when it comes to indicators. The data point does not need to be in the statement; we are interested in seeing if and what they are tracking)
- Awards that they have gotten in relation to sustainability
- Goals or targets that they have/will implement (ex. general net zero commitments, reducing their CO2 emissions by a certain percentage)
- Regulations related to climate change or sustainability (ex. EU Green New Deal, EU Sustainability Taxonomy, Paris Agreement (if main aspect of the sentence, otherwise most likely an initiative or lending), national legislation, regulatory authority guidance
- "Fluffy" statements that do not show or refer to an action or a commitment by the bank

Data availability

Data will be made available on request.

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