Analysis of climate-related financial risks

(Summary)

This paper uses granular data, such as details of transaction-level corporate loans, collected from 49 regional banks that participated in the experiment[11] for a common data platform. It then focuses on the industries, products, and geographic conditions of client companies and clarifies the characteristics of climate-related risks (transition risks and physical risks) faced by regional banks, as well as the regional differences in these characteristics. Data and methodologies related to climate change are still developing, and the FSA will continue to enhance its data infrastructure and analysis for use in dialogues with financial institutions.

I. Background

With growing global interest in climate change, many financial supervisors are making efforts to understand its impacts on the financial system (climate-related financial risks). In 2022, the Japan Financial Services Agency (FSA) published a discussion paper entitled "Supervisory Guidance on Climate-related Risk Management and Client Engagement."[12] In this paper, the FSA emphasizes how important it is for banks to assess climate-related financial risks and engage with their clients to support the clients' response to climate change. The FSA also expresses its intention to engage with banks to discuss banks' challenges in addressing climate-related financial risks.

The impacts of climate change on banks may vary depending on their size and business model. For example, the sectoral composition of loan portfolios of regional banks may differ significantly from that of major banks. Therefore, in order for the FSA to engage effectively in dialogue with banks, it is important to deepen its understanding of banks' climate-related risk profiles.

From this perspective, the FSA conducted the following three trial analyses to better understand the characteristics of climate-related financial risks (both transition risks and physical risks) at regional banks for the use of future dialogues (Fig. 1).

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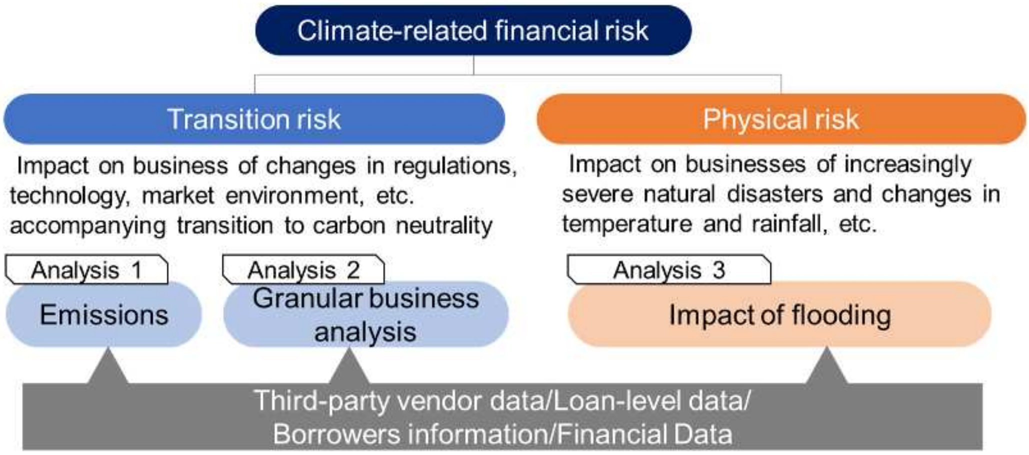
[11] Progress in Data Integration and Next Steps
https://www.fsa.go.jp/en/news/2023/20230721/progressindataintegration.pdf

[12] https://www.fsa.go.jp/en/news/2022/20220715/03.pdf

Figure 1 Structure of the analysis



1. Analysis on financed emissions of regional banks using the CO2 gas inventory[13]
2. Analysis on exposure to engine-related companies that may be affected by the shift to Electric Vehicles (EVs)
3. Visualization of flood risks on banks using borrower address information and hazard map data

These analyses were conducted as part of the experiment to develop a common data platform. The analyses used loan-level granular data collected from 49 regional banks that participated in the study. As data and analytical methods for climate-related financial risks are still evolving, caution is warranted in interpreting the results. Moreover, the study also aims to deepen the understanding of the benefits and limitations related to granular data. The FSA intends to continue its efforts to address data issues identified in the analyses and to improve the overall analysis.

II. Analysis 1: Characteristics of financed emissions of regional banks

To assess climate-related financial risks on banks' business, it is considered useful, as a first step, for banks to monitor not only greenhouse gas (GHG) emissions from their own business operations, but also financed emissions (FEs) of companies they invest in or lend to. Many banks have already initiated steps to estimate their FEs. In this context, it will be also important for the FSA to estimate and understand the characteristics of banks' FEs to make dialogue with them more effective.

Therefore, this analysis attempted to clarify the characteristics of FEs of regional banks and their variations across regions.

[13] Data summarizing the amount of greenhouse gases emitted or absorbed by a country in one year. Compiled by the National Institute for Environmental Studies based on the IPCC guidelines. https://www.nies.go.jp/gio/en/aboutghg/

1. Calculation method

As indicated in the guidance[14] issued by the Ministry of the Environment, the FEs of banks are calculated by summing up the emission of each company multiplied by the corresponding attribution factor[15] across their clients in the loan portfolio (see below).

$$FEs = \sum_{i} Attribution\ \ factor_i \times Emissions_i$$

$$Attribution\ \ factor_i = \frac{Outstanding\ \ amount_i}{Total\ \ equity\ \ +\ \ debt_i}$$

$$(\text{with}\ \ i = borrower)$$

The calculation of FEs can be done either through a bottom-up analysis by adding up emissions of individual companies or through a top-down analysis by allocating Japan-wide total emissions to each company using an industry-specific emission factor (e.g., carbon intensity). This analysis adopted a top-down analysis to better capture the characteristics of FEs throughout regional banks' entire portfolios. The methodologies used to estimate FEs are described as follows.

First, "carbon intensity by industry" was calculated by dividing "CO2 emission by industry" by total sales of companies in the industry. We then multiplied the "carbon intensity by industry" by the sales volume of each borrower company in the industry to estimate the CO2 emissions of each borrower company. The CO2 emissions of each borrower company thus estimated were further allocated to the bank in accordance with the attribution factor,[16] and the CO2 emissions allocated by the borrower companies for each bank were aggregated to estimate the FEs.[17] (Fig. 2)

"Carbon intensity by industry" is calculated using CO2 emissions after the distribution of electricity and heat by industry in the greenhouse gas inventory, from the perspective of understanding both scope 1 (direct emissions from the reporting company's factories, offices, vehicles, etc.[18]) and scope

[14] https://www.env.go.jp/content/000125696.pdf (available only in Japanese)

[15] Where financial information can be obtained from multiple regional banks through the aggregation of the names of borrowers, the financial information of the regional bank with the largest outstanding balance of loans to the borrower is used. Negative figures for equity are replaced with zero.

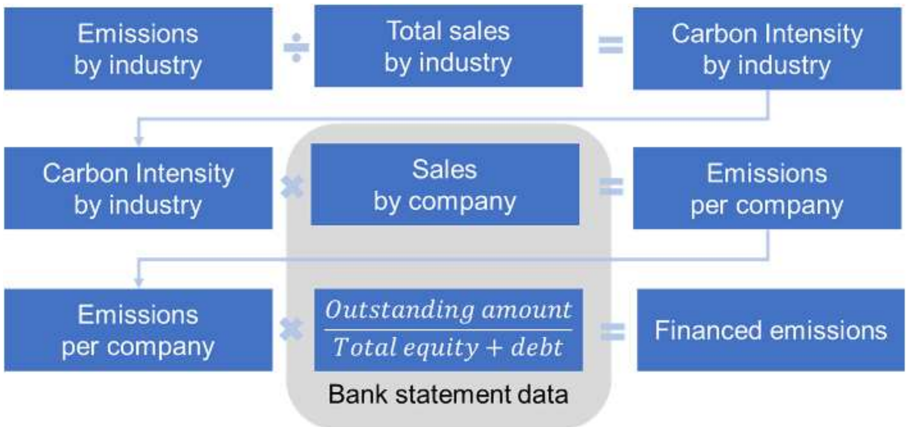
[16] Where the attribution factor was greater than 1, the attribution factor was set at 1.

[17] If the financial information of one firm is available at multiple banks, the information from the bank with the largest loan outstanding was used in the analysis. Zero floor is applied to capital and a ceiling of one is applied to an attribution factor. If there was no information on the sales volume or total funding amount of the borrower, FEs were estimated by multiplying the loan amount by the "FEs per loan by industry," which was calculated by dividing the total FEs in industry by the total loan amount in the respective industry.

[18] https://www.env.go.jp/earth/ondanka/supply_chain/gvc/en/supply_chain.html

2 (indirect energy-derived emissions from electric power and other energy consumed by the reporting company[18]) for each industry. As a result, the double counting of direct CO2 emissions from the electricity and gas industry (Scope 1) and indirect CO2 emissions from the use of electricity, gas, etc. by other industries (Scope 2) can be avoided because CO2 emissions related to electricity, gas, etc. are allocated to each industry that uses them. On the other hand, it should be noted that the FEs of the electricity and gas industry will be smaller than the FEs calculated based on the actual CO2 emissions because the allocated CO2 emissions of the industry will be smaller than the actual CO2 emissions of the industry.

Figure 2 FEs calculation process



2. Result of analysis

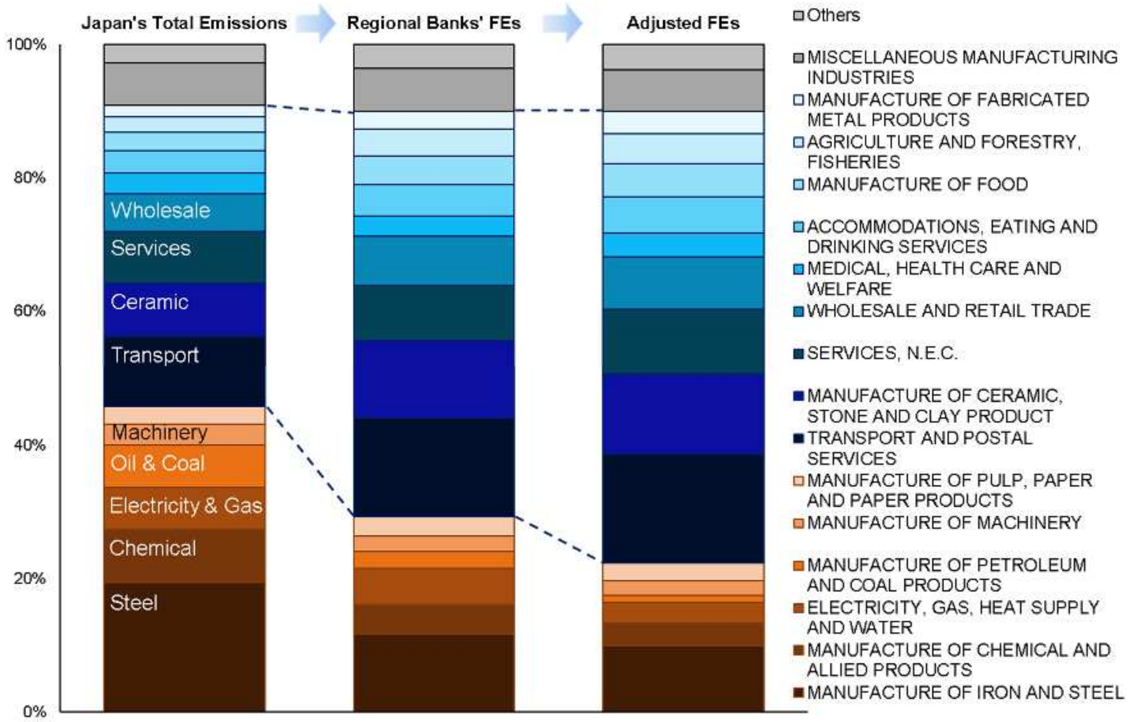
The left side of Figure 3 shows the composition of GHG inventory[19] by industry, and the center shows the composition of FEs by industry[20] for all regional banks that participated in the demonstration test (regional banks' FEs). In addition, whether or not a regional bank is the main bank of a corporate borrower is also an important factor in the form of support provided. Therefore, the FEs of a regional bank limited to a corporate borrower that is its main bank[21] (adjusted FEs) are estimated and shown on the right side of Figure 3.

In the GHG inventory, CO2 emissions from industries generally referred to as high-emission industries, such as iron and steel, the chemical industry, electricity and gas, and oil and coal, account

[19] Based on final data for FY2021.
[20] Excluding financial/insurance business and public service.
[21] In this analysis, the bank with the largest loan outstanding as of the end of March 2022 to a firm is assumed to be the main bank of the firm.

for around 40% of Japan's total CO2 emissions. In the regional banks' FEs, however, the high-emission industries account for around 24% of Japan's total CO2 emissions. Furthermore, in the modified FEs, their share is around 17%.[22]

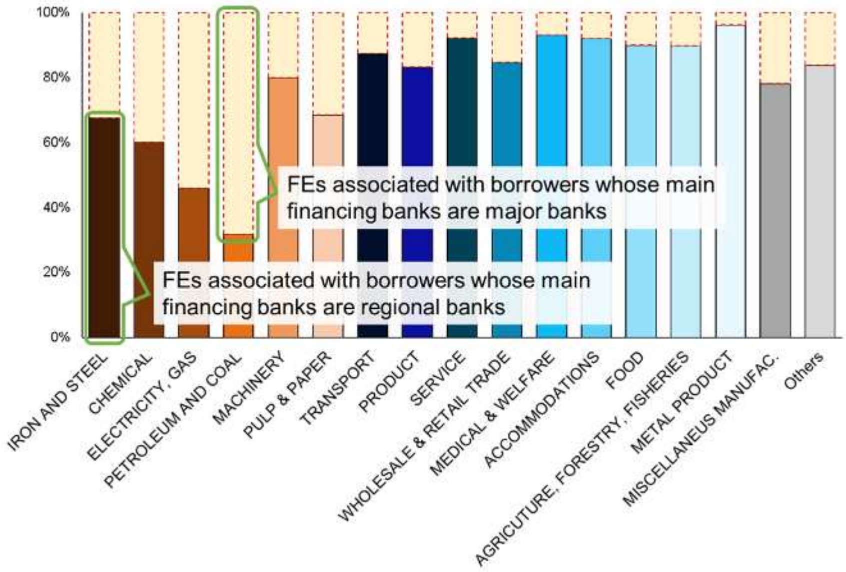
Figure 3 Comparison of Industry Composition of Regional Bank FEs



On the other hand, the share of the transportation, ceramic, stone and clay product manufacturing, and service industries turned out to be the highest for adjusted FEs, followed by regional banks' FEs, then Japan's total emissions. Although there were differences in the degree among banks, a similar trend was observed for individual banks. This may reflect the fact that there are relatively large enterprises in high emitting industries, such as iron & steel, chemical, electricity & gas, and oil & coal, and that in many cases, major banks such as mega-banks are the main banks for such enterprises. Looking at regional banks' FEs by who main banks are (major banks or regional banks), the proportion of the case where regional banks are main banks is low in high emitting industries, and it can be confirmed that a considerable portion of them belongs to major banks (Fig. 4).

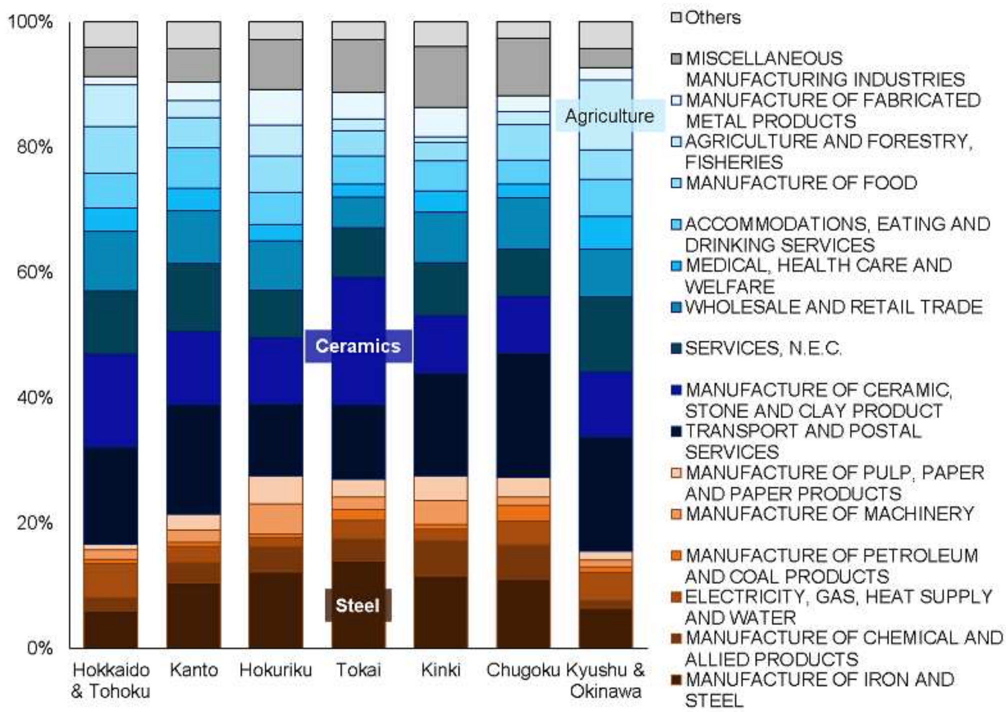
[22] When CO2 emissions from the GHG inventory before electricity and heat distribution are used for the electricity and gas industry, CO2 emissions from the high emission industries account for approximately 60% of the national total, 47% for the regional bank FEs, and 34% for the modified FEs.

Figure 4 Non-main bank portion of regional bank FEs (industry)



Next, the analysis on the characteristics of the adjusted FEs by region found that there is a considerable variation in the industry composition of the adjusted FEs by region. For example, the share of high emitting industries varies widely from 13% to 23% depending on regions. This variation is even more pronounced at the individual bank levels. The banks in the Tokai region have a relatively high share of the ceramic, stone and clay product manufacturing industries as well as the iron and steel industry in their adjusted FEs, while the banks in the Kyushu and Okinawa regions have a relatively large share of the agriculture, forestry and fisheries industries (Fig. 5).

Figure 5 Industry Distribution of Adjusted FEs by Region



These results suggest that it is important for regional banks to consider strategies for engaging in FEs reduction based on the characteristics of their regional and individual portfolios, instead of uniformly prioritizing high emitting industries. At the same time, it would also be important for the FSA to take into account the characteristics of the region and each bank's portfolio in its dialogue with banks.

3. Future Issues

These initiatives have identified the characteristics of the FEs of regional banks and the industry distribution of FEs by region. On the other hand, it should be noted that the present analysis is a mechanical estimation using the average carbon intensity of each industry. As the next step, in addition to improving the accuracy of the analysis by utilizing bottom-up information, such as CO2 emissions disclosed by borrowing companies, it may be advisable to consider a forward-looking analysis that takes into account the transition policies of each financial institution and borrowing companies.

III. Analysis 2: Risks of business changes due to climate change

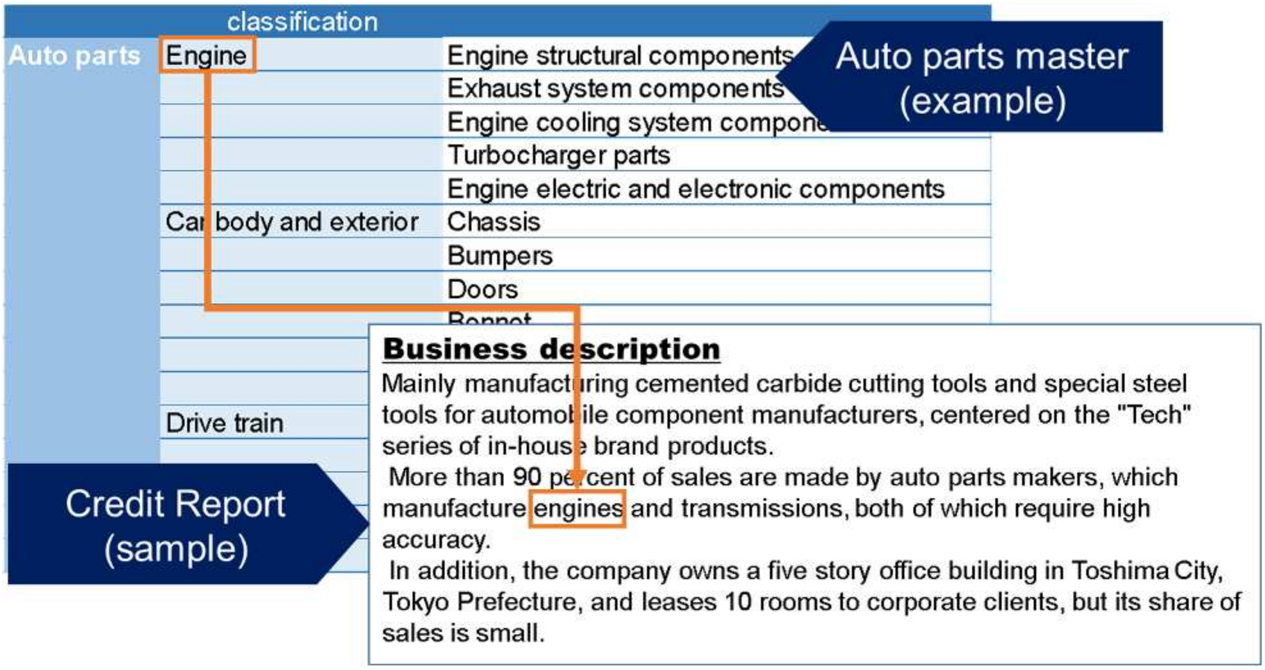
It has been pointed out that there is a possibility that the specifications of products manufactured by companies will change significantly due to companies' responses to climate change and changes in consumer preferences reflecting the increased awareness of climate change. Typical examples of such changes in product specifications include the next-generation of automobiles and the shift to EVs. In the future, as the shift to EVs progresses, companies that manufacture conventional engine parts may be exposed to significant changes in demand. Financial institutions are expected to support such companies’ responses to changes accompanying climate change through engagement.

On the other hand, the CO2 emissions of the transportation machinery and equipment manufacturing industry, which is considered to include many of the companies that manufacture engine parts, account for only 1-2% of the total GHG inventory. Therefore, the risks of changes in demand for engine parts cannot be appropriately identified from the perspective of FEs analyzed in the previous section. In order to identify such risks, it is important to focus on manufactured parts and identify the companies that will be affected. Therefore, this section used business information of companies to identify and clarify the characteristics of engine part manufacturing companies that are potentially affected by the shift to EVs.

1. Analytical methods

According to the Japan Standard Industry Classification (JSIC), companies can be classified only into a broad category, such as "transportation machinery and equipment manufacturing" and cannot be classified by manufactured parts. Therefore, with the cooperation of TEIKOKU DATABANK, Ltd. (TDB), companies classified as transportation equipment manufacturers under the JSIC were selected, and companies that included the word "engine(s)" in the qualitative information of the TDB’s credit report of each company were flagged. Then, the characteristics of the extracted companies were analyzed (Fig. 6). It should be noted that this analysis mechanically flags whether or not the word "engine(s)" is included, and it is not possible to confirm whether or not the companies selected actually manufacture engine-related parts and to what extent engine-related parts account for the sales of those companies.

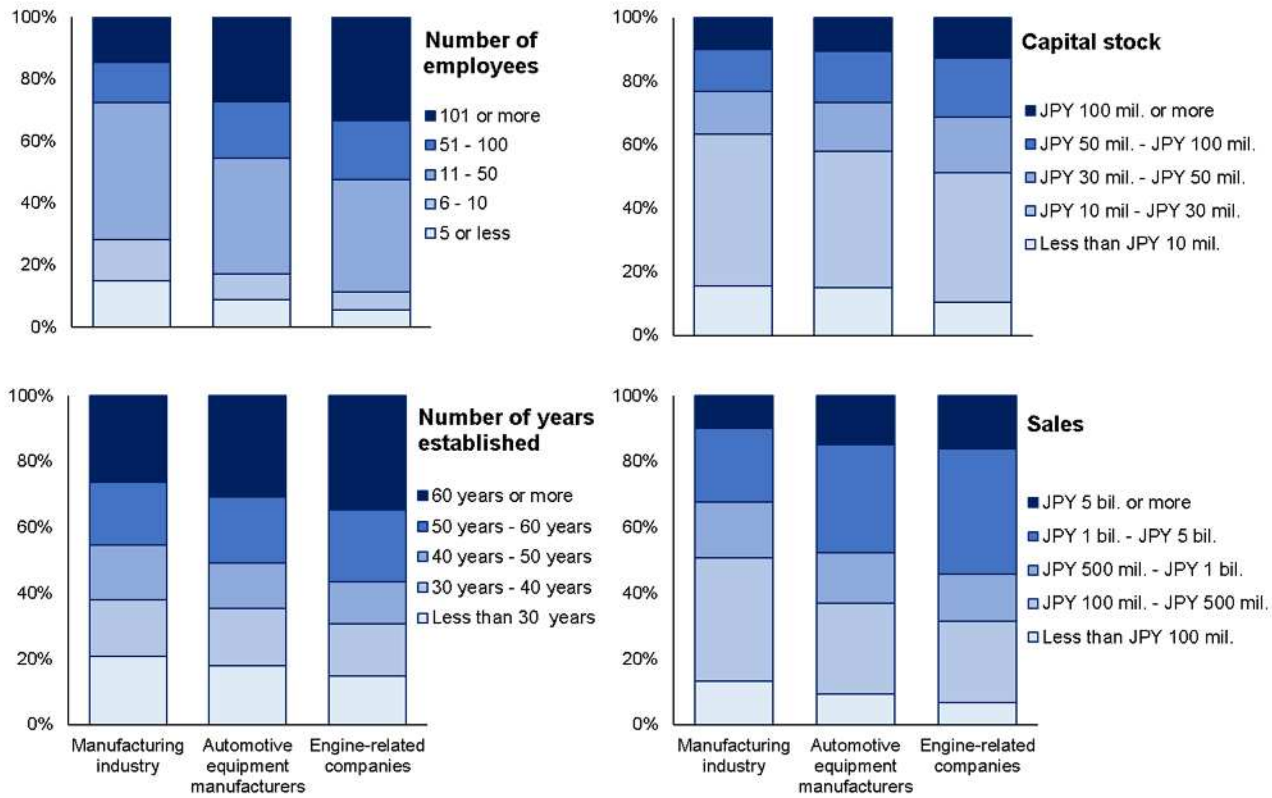
Figure 6 Method for identifying engine-related companies (example)



2. Result of analysis

Figure 7 shows the distribution of the number of employees, years established, the amount of capital stock and net sales of the manufacturing industry as a whole, the automotive-related transportation equipment manufacturing industry (automotive equipment manufacturers), and the companies flagged as engine-related companies (engine-related companies). In order to exclude, to the extent possible, enterprises engaged in diversified businesses including manufacturing of engine-related parts from the enterprises flagged as engine-related, the analysis focused only on SMEs.[23] From this analysis, it has become clear that the number of employees, number of years established, capital stock, and net sales of engine-related companies are larger than those of the manufacturing industry as a whole and the automotive equipment manufacturers, which may reflect the fact that engines have been a key component in the history of the auto industry.

Figure 7 Characteristics of automotive component manufacturers



[23] SMEs are defined as a company with capital of 300 million yen or less (100 million yen in wholesaling, 50 million yen in retail and food services), or regular employees of 300 or less (100 in wholesale service, 50 in retail and food services).

Next, when aggregating the share of loans to engine-related companies in corporate loans outstanding by region where the head offices of regional banks are located, it is found that the proportion of loans to such companies is relatively high in the Tokai and Chugoku regions (Fig. 8). This is considered to reflect the proximity of major production bases of automakers to some extent. Mapping the locations of the headquarters of engine-related companies revealed that they were concentrated in the Tokyo metropolitan area, the Tokai region, Osaka, Okayama, and Hiroshima prefectures, where automakers have major production bases. Furthermore, the share of loans outstanding[24] to automotive equipment manufacturers and that for engine-related companies by bank generally have a positive correlation, which indicates that regional banks with a high share of both tend to extend loans to major automakers[25] (Fig. 9).

Figure 8 Share of loans to engine-related companies in total corporate loans share of lending (by region)

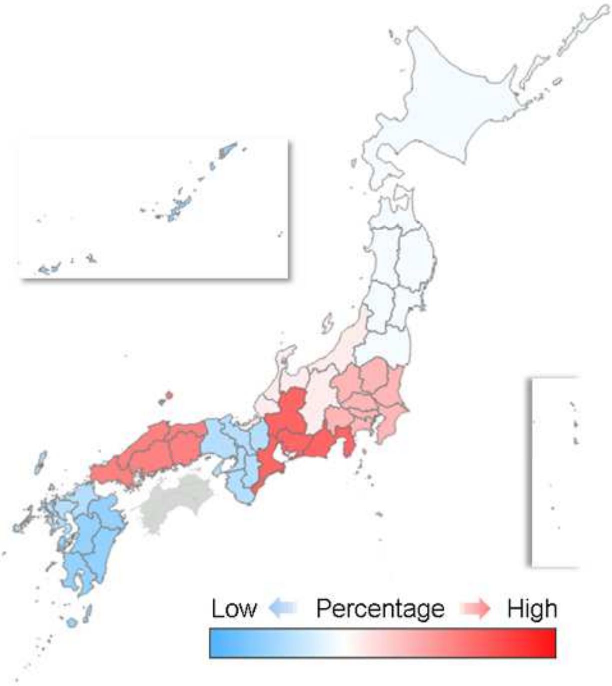
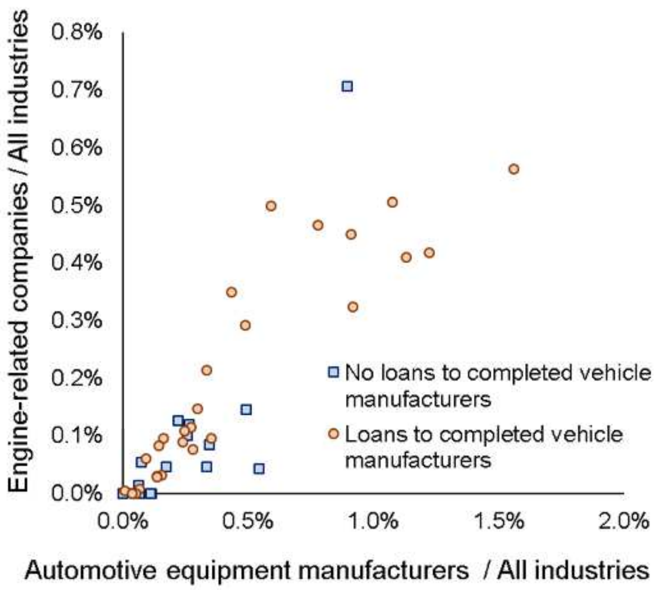


Figure 9 Convergence between engine-related companies and the manufacture of transportation equipment and the industry ratio of total assets by bank



[24] Aggregated figures for outstanding loans that can be linked to TDB data (as of the end of March 2022).
[25] Suzuki, Subaru, Daihatsu Motor, Toyota Motor Corporation, Nissan Motor Co., Ltd., Honda Motor Co., Ltd., Mazda Motor Corporation, Mitsubishi Motors Corporation

3. Future Issues

This analysis selected companies that included the keyword "engine(s)" in their business summaries and identified the characteristics of those companies. It is useful to examine the appropriateness of the sampling results through exchanges of opinions with financial institutions and to improve the sampling method. In addition, these engine-related companies often belong to the supply chain of a specific automaker. In this case, it will be important for multiple financial institutions that provide financing to companies in the supply chain to work together to promote climate change measures throughout the supply chain. An area for further exploration is to visualize the financing relationships between financial institutions and companies in the supply chain to promote collaboration among financial institutions related to the supply chain,.

IV. Analysis of physical risks using hazard maps

As global warming progresses, it has been pointed out that natural disasters are increasing in frequency and severity. If a borrower suffers damage due to a natural disaster, its sales and financial condition may deteriorate due to the suspension or stagnation of the business of the borrower, which may lead to the deterioration of credit risk for financial institutions (physical risk). This analysis used granular data, such as loan details of the regional banks that participated in the experiment, together with flood hazard maps, to understand the characteristics of the physical risks of flooding faced by regional banks, and attempted to visualize them on maps.

1. Analytical methods

First, banks' loan data was linked to the address of borrowers' head office to through Corporate Numbers (Japanese legal entity identifier) obtained from the National Tax Agency's Corporate Number publication site.[26] This was then mapped onto the flood hazard map[27] of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) to determine which inundation category (representing the risk of a flood) on the flood hazard map can be assigned to each borrower based on the location

[26] National Tax Agency Corporate Number Publication Site https://www.houjin-bangou.nta.go.jp/download/ (available only in Japanese)
[27] Ministry of Land, Infrastructure, Transport and Tourism https://nlftp.mlit.go.jp/ksj/gml/datalist/KsjTmplt-A31-v3_0.html (available only in Japanese)

of its head office. Next, the number of business suspension/business stagnation days[28] for each borrower (in the event of a flood) was estimated based on the borrower's inundation category using information from the Flood Control Economic Manual[29] of the MLIT. Then, the "flood risk level" of loans was defined as the number of business suspension/business stagnation days at each company times the amount of loans provided to the company. The flood risk levels were aggregated for each bank to analyze their characteristics (Fig. 10).

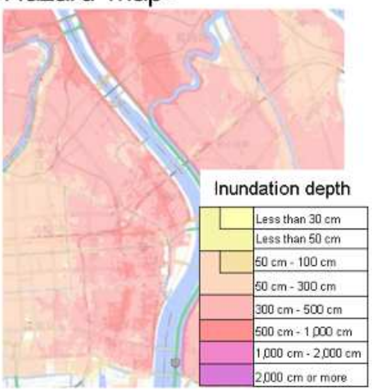
Figure 10 Methods for calculating degree of risk[30]

<Borrowers information>

Company name	Address	Loan balance
AA Company	…, Tokyo	¥ x,xxx,xxx,xxx

× Number of business suspension/ stagnation days = Flood risk level

<Hazard map>



Inundation depth (cm)	Number of business suspension days	Number of business days	Number of suspended/ stagnant days
Less than 50	6.4	18.8	15.8
50 – 100	13.5	25.0	37.8
100 – 200	20.0	35.6	
200 – 300	41.2	64.0	
300 – 500	56.1	83.2	97.7
500 – 1,000	-		156.8
1,000 – 2,000			282.6
2,000 or more			356.1

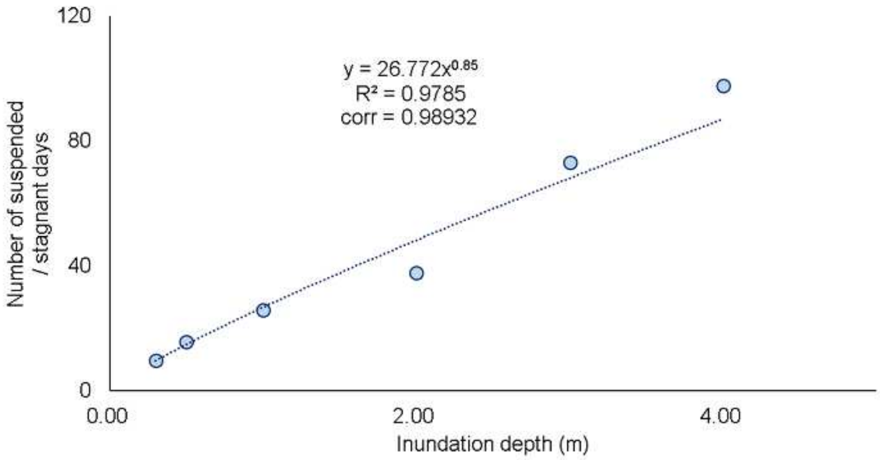
Compiled based on the Economic Survey Manual for Flood Control issued by the Ministry of Land, Infrastructure

[28] The number of business suspension days is the period when no sales are recorded, and the number of business stagnation days is the period when a decline in sales is recorded. The decline of sales in the business stagnation days is assumed to be 50% and, based on the foregone sales, "the number of business suspension / business stagnation days" is defined as "number of suspended days" + "number of suspended days x 1/2". (Practical Guide to Scenario Analysis of Climate Change Risks and Opportunities in Line with the TCFD Recommendations (for the Banking Sector) (Ministry of the Environment), https://www.env.go.jp/content/900518880.pdf (available only in Japanese))

[29] Flood Control Economic Manual
https://www.mlit.go.jp/river/basic_info/seisaku_hyouka/gaiyou/hyouka/r204/chisui.pdf (available only in Japanese)

[30] Flood Hazard Mapping Handbook
https://www.mlit.go.jp/river/basic_info/jigyo_keikaku/saigai/tisiki/hazardmap/suigai_hazardmap_tebiki_202112.pdf (available only in Japanese)

Figure 11 Methods for calculating the number of suspended/stagnant days



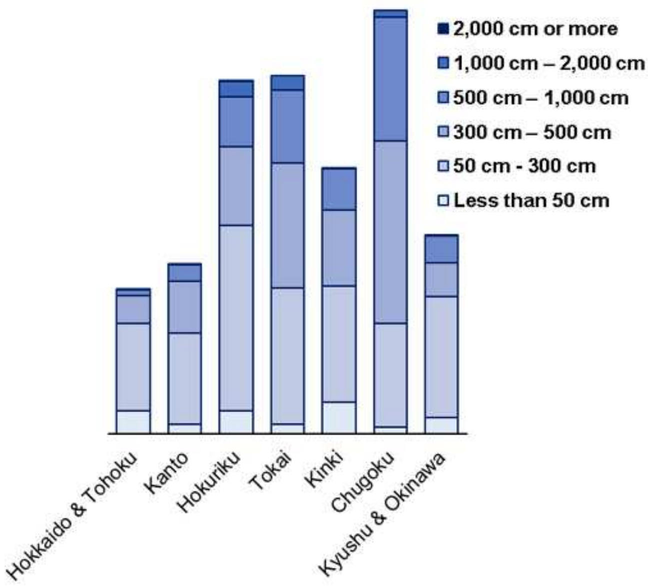
Since the MLIT's Flood Control Economic Manual does not provide the number of business suspension / business stagnation days corresponding to an inundation depth beyond 300 cm, a power trendline was used for the extrapolation. Also, an adjustment was made to align the classification of Flood Control Economic Manual (e.g. "50 to 99 cm," "100 to 199 cm," "200 to 299 cm") and that of the hazard map (e.g. "50 cm to 300 cm").

2. Results of analysis

Figure 12 shows SMEs'[31] flood risk levels per loan outstanding, aggregated by region according to the location of the headquarters of lender banks.[32] This shows that the risk per loan balance is relatively high for regional banks whose head offices are located in the Chugoku, Tokai, and Hokuriku regions. It was found that the flood risk levels of these regional banks' borrowers differ greatly by municipality,[33] and that risks are concentrated in specific areas (Fig. 13). Such areas are often geographically located on the side of the mid-section or lower reaches of rivers that are prone to flooding in times of disaster. However, it should be noted that the corporate borrowers' address information included in the regional banks' granular data collected in the experiment is basically limited to the head office location, and does not take into account the locations of plants and other important business bases owned by the corporate borrowers. In addition, the data does not reflect the existence or effectiveness of flood control measures taken by the corporate borrowers.

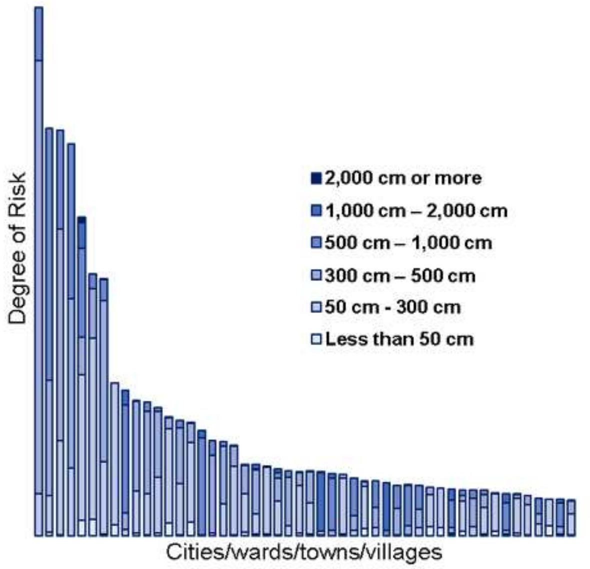
[31] Excluding financial/insurance business and public service.
[32] Note that this graph is aggregated by the regions where the head offices of the regional banks that participated in the experiment are located, and loans may be extended to other regions (e.g., cases where a regional bank whose head office is in the Chugoku region extends loans to a company in the Kanto region), so it does not indicate the degree of risk by region.
[33] Municipalities are aggregated separately for ordinance-designated cities, cities, special wards, wards, towns, and villages.(Reference: https://www.e-stat.go.jp/municipalities/number-of-municipalities (available only in Japanese))
The graph shows the top 50 most risky municipalities when the risks of regional banks with head offices in the Chugoku, Tokai, and Hokuriku regions are allocated to all 916 municipalities where the head offices of borrowing companies are located.

Figure 12 SMEs' flood risk levels per outstanding loan by region



(Flood risk levels per outstanding loan for each region where the head offices of regional banks are located (the legend in the graph indicates the inundation depth))

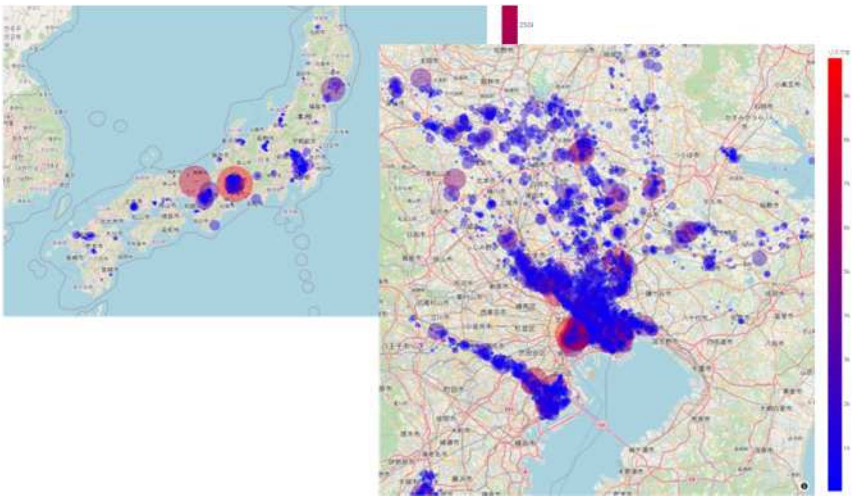
Figure 13 SMEs' Flood risk levels by municipality



(Flood risk levels by municipality for regional banks with head offices in the Chugoku, Tokai, and Hokuriku regions (the legend of the graph indicates flood depth))

A tool was created to show on a map of Japan both the location of a company and the degree of risk of each company by a color and the size of a circle, making it possible to visually identify which areas are affected most. For example, Figure 14 is a mapping of the flood risk levels of SMEs in the manufacturing sector in the Tokyo metropolitan area. This map shows that risks are concentrated along rivers such as the Arakawa River.

Figure 14 Mapping of flood risk levels



3. Future Issues

This analysis linked granular data collected from regional banks participating in the experiment with hazard maps to compare the degree of physical risk (water disaster risk) across regions. In addition, by mapping the flood risk levels of each corporate borrower on a map and turning it into a tool, it has become possible to visualize flood risk levels for specific regions and banks. These tools will be further improved and developed to understand the physical risks of financial institutions and the geographical characteristics of the areas in which they operate.

V. Conclusion

This paper conducted a pilot analysis on climate-related risks at regional banks from three aspects: FEs, business changes in product lines, and geographical conditions, using granular data, such as loan details, collected from the 49 regional banks that participated in the experiment. As a result, it became clear that the share of high-emission industries in the FEs of borrowers for which regional banks are the main banks is considerably lower than the share of high-emission industries among total CO_2 emissions in Japan. The analysis also revealed the geographical characteristics of engine-related companies and flood risks. In addition, it was reaffirmed that the use of a wide range of data beyond the financial sector is effective in order to better understand climate-related risks. Going forward, the FSA will continue to enhance its data infrastructure and analysis related to climate change, in order to facilitate dialogues with financial institutions regarding their understanding of climate-related risks and support for clients in responding to climate change.