The Second Scenario Analysis on Climate-Related Risks

(Banking Sector)

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Financial Services Agency

Bank of Japan

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<u>**Executive Summary**</u>

- The Financial Services Agency (FSA) and the Bank of Japan (BOJ), in collaboration with three major banks, conducted the second scenario analysis on climate-related risks (hereafter referred to as "the second scenario analysis"), following the first scenario analysis exercise utilizing common scenarios (hereafter referred to as "the first scenario analysis").

- As with the first scenario analysis, the second scenario analysis assessed the impact on loans (credit risk), which potentially has a large impact on banks' financial conditions. To consider the possibility that climate-related risks could materialize quickly due to policy changes, technological and resource constraints, and subsequent behavioral changes in corporations and households, the second scenario analysis focused on transition risk analysis over a shorter time horizon (7 years) compared to the first scenario analysis. The FSA and the BOJ also included a tailored stress scenario by modifying an NGFS scenario.

- Similar to the first scenario analysis, the aim of the second scenario analysis was not to quantitatively assess the impact of climate-related risks, but to identify areas for future improvement. Since the first scenario analysis, the FSA, the BOJ, and the participating banks have made progress in aligning the assumptions underlying the analysis and have extended their analytical framework. As a result, the participating banks submitted scenario analysis results, which were conducted under coordinated conditions with respect to the impacts on business performance and financial conditions of the sectors that are considered to be relatively susceptible to transition risks. The second scenario analysis has, therefore, provided insights for analyzing the transmission channels and impacts of transition risks.

- The analysis revealed that, even under scenarios with relatively severe stress, the estimated annual average credit losses remained low compared to the profitability of the participating banks. However, it should be noted that the results do not provide a definitive assessment of the impacts of climate-related risks, as there is still room for improvement in the methodologies of scenario analysis and data availability.

- Major issues and challenges involve assessing how the gaps between the transition strategies of individual borrowers and the macro-level assumptions in scenarios can affect scenario analysis. Additionally, identifying key parameters (e.g., pass-through rate of carbon prices) and conducting sensitivity analyses for impact assessment are also crucial.

- Financial institutions are expected to further enhance their risk management and utilize scenario analysis in their business strategies. To achieve this goal, ongoing efforts are expected in identifying the transmission channels of climate-related risks, enhancing the analysis of clients, and assessing the impacts on the overall credit portfolios of financial institutions, which could result from changes in clients' financial conditions and potential shifts in their business structures.
- The FSA and the BOJ will continue to engage in discussions with financial institutions on methods and practical applications of scenario analysis, including how to address the issues identified in the first and second scenario analyses.

I. Background and Purpose

It is important for financial institutions to adopt a forward-looking perspective on the opportunities and risks that changes in the business environment due to climate change may present to their clients and their operations. By supporting their clients' efforts to address climate change, financial institutions can help their clients establish business foundations that are resilient to such change. This also enables financial institutions to ensure sustainable business foundations.

Scenario analysis[1] is considered effective for forward-looking analysis and assessment of financial institutions from both opportunity and risk perspectives. The FSA and the BOJ, in collaboration with large financial institutions, conducted a pilot exercise of scenario analysis using common scenarios and published a report on the findings and issues in August 2022.[2]

In the first scenario analysis, the results showed that the three major banks[3] had the capability to conduct their risk analysis not only under the scenarios used in their sustainability disclosures (e.g., International Energy Agency (IEA) scenarios) but also under the common scenarios of the exercise (Network for Greening the Financial System (NGFS) scenarios). Furthermore, valuable insights for future improvements were gained from the first scenario analysis, such as understanding data constraints and assessing the validity of analytical assumptions and methods.

However, the first scenario analysis also revealed challenges in applying scenario analysis to assess risks and opportunities. Firstly, the NGFS scenarios, which are the common scenarios used in the exercise, lacked the future outlook data necessary to assess the impact of changes in clients' business environments, technologies, and business structures. As a result, the participating banks had to supplement the NGFS scenarios with external data and establish variables based on additional assumptions to conduct their scenario analysis. Consequently, this resulted in a wide variation in analyses among the participating banks, making it challenging to conduct horizontal reviews of scenario analysis results to identify issues with analytical methodologies.

[1] Scenario analysis uses simulations to assess the timing and scale of impacts on financial institutions' earnings and financial soundness via plausible transmission mechanisms under certain scenarios about the future rise in temperature and policy responses by governments.
[2] "Pilot Scenario Analysis Exercise on Climate-Related Risks Based on Common Scenarios" (August 2022, Financial Services Agency and Bank of Japan).
[3] Mizuho Financial Group, Sumitomo Mitsui Financial Group, and Mitsubishi UFJ Financial Group

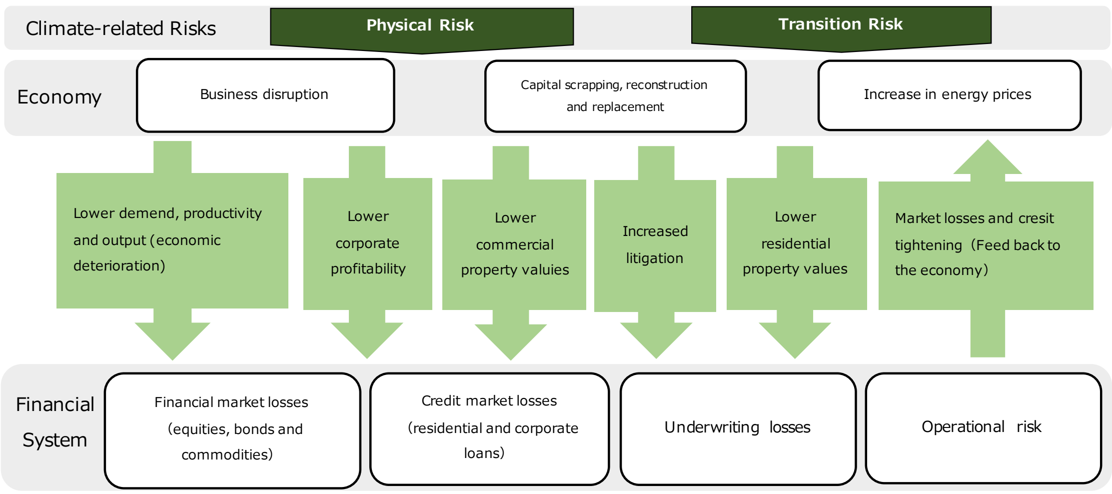
To enhance scenario analysis, financial institutions will need to refine their assessments of their clients and understand the potential impact on them resulting from structural changes across entire relevant industries. They should also consider the effects of business transitions facilitated by the support provided by financial institutions to their clients.

The FSA and the BOJ, in collaboration with the three major banks, conducted the second scenario analysis on climate-related risks. In reference to global developments in scenario analysis (Box 1), the second scenario analysis concentrated on transition risk under short-term scenarios, acknowledging the possibility that climate-related risks could materialize in a shorter period than previously assumed. For short-term analysis, data shortages and uncertainties were expected to be less significant compared to long-term analysis, making it easier to identify issues through horizontal reviews.

Box 1: Global Developments in Scenario Analysis

As established by the Basel Committee on Banking Supervision and the NGFS in their work on climate-related risks, these risks—both transition and physical—act as drivers of existing financial risks (such as credit and market risks) rather than introducing a new category of financial risk (BCBS, 2021; NGFS, 2019). Therefore, scenario analysis of climate-related risks can be described as the estimation of existing financial risks driven by transition and physical risks under selected scenarios, which are illustrated in Chart 1-1.

Chart 1-1: Transmission Channels of Climate-Related Risks to the Financial Conditions of Financial Institutions (Image Diagram)



Source: The FSA and the BOJ with reference to NGFS (2019)

Compared to conventional stress testing, scenario analysis for climate-related risks requires a significantly longer time horizon. Against this background, as uncertainty and data gaps have constrained analysis, the development of frameworks for scenario analysis has been progressing internationally, including the NGFS climate scenarios, to alleviate these constraints. However, reports on issues in the implementation of scenario analysis published by international organizations (NGFS, 2021; FSB・NGFS, 2022; BCBS, 2024) emphasize the ongoing need to improve these scenarios, as data gaps and uncertainties remain unresolved by the climate scenarios published thus far.

In addition, these reports mentioned that some respondents highlighted the need to re-examine scenarios from a risk analysis perspective. The NGFS and other climate scenarios were developed to analyze and consider the impacts of climate-related risks on socio-economic systems, using insights from climate science. However, the transmission channels from climate-related risks to existing financial risks remain unclear, and the impacts may materialize in the short term as well as in the medium-to-long term, as considered in existing climate scenarios.

In light of the challenges identified in these initial exercises, the scenario analyses published in recent years have generally been conducted over a shorter time horizon, where data gaps and uncertainties are relatively less significant. This approach considers additional transmission channels of climate-related risks with the aim of assessing future developments (EBA･EIOPA･ESMA･ECB, 2024; HKMA, 2025).

II. Framework and Results of the Second Scenario Analysis

1. Analytical Framework and Scenario Design

(1) Scenario analysis framework

In light of the situation described in "I. Background and Purpose," the framework for the second scenario analysis is defined as follows (see Chart 1).

(Climate-Related Risk)

The focus was on transition risks within the climate-related risks that contribute to financial risks. Through their first scenario analysis on physical risks, the FSA and the BOJ confirmed that there is extensive data available on the potential impacts of frequently occurring natural disasters in Japan. This data is detailed on a geographical basis (e.g., flood and typhoon) and pertains to physical risks associated with domestic loans. On the other hand, to effectively utilize physical risk data for risk management in financial institutions, it is deemed necessary to further enhance the data regarding the locations of client companies' business sites and assets, enabling them to be matched with hazard maps.

In light of the above challenges, the participating banks have been working to expand the scope of regions and types of disasters analyzed since the first scenario analysis. However, the progress made so far in data availability and methodologies has not been sufficient to significantly improve the framework compared to the first scenario analysis. Therefore, the second scenario analysis prioritized transition risk analysis, which is expected to yield more insights.

(Analysis Period)

The analysis period covers Fiscal Year (FY) 2024 to 2030 and is based on a static loan portfolio of the participating banks as of March 31, 2024. This timeframe was chosen because the Paris Agreement signatories, including Japan, have set their greenhouse gas (GHG) emission reduction targets for 2030 as part of their Nationally Determined Contributions (NDCs).[4] Furthermore, the targets and plans for the period up to FY 2030, set by various sectors and client companies based on NDCs, are available to complement

[4] On February 18, 2025, the Government of Japan decided on new contributions with the aim of reducing emissions by 60% and 73% from the FY 2013 level in FY 2035 and FY 2040, respectively, and submitted the targets to the Secretariat of the United Nations Framework Convention on Climate Change. However, when the framework for the second scenario analysis was considered in 2024, only the 2030 NDC target was available for most of the participating countries, including Japan.

the NGFS scenarios, which are the common scenarios.

In other respects, the framework remains largely unchanged from that of the first scenario analysis.

(Financial Risks)

Credit business is the largest source of income for banks, and credit risk assets such as loans account for a large part of their balance sheets. Therefore, the analysis focused on the impact on credit risk (credit losses).[5]

(Assumptions on Exposure and Balance Sheet)

For credit risk analysis, the scope of assets includes, in principle, all domestic and overseas credit exposure. Although the composition of the assets may change during the analysis period in practice, the FSA and the BOJ employed a static balance sheet assumption (no change in loan portfolio composition and volume), given that methods for estimating changes in the credit portfolio are still being developed.

Chart 1: Scenario Analysis Framework

	Second Scenario Analysis	First Scenario Analysis
Climate-Related Risk	Transition risk	Transition risk Physical risk
Analysis Period (transition risk)	FY 2024-FY 2030 (7 years)	FY 2021-FY 2050 (30 years)
Financial Risk	Credit risk (credit losses)	
Exposure	Domestic & international credit (loans, etc.)	
Balance Sheet Assumptions	Static balance sheet (no change in size or composition)[6]	
Analytical Approach	Bottom-up	
Scenarios (Transition risk)	Current Policies[7] Net Zero 2050[7] Net Zero 2050 with Modifications	Current Policies[8] Net Zero 2050[8] Delayed Transition[8]

[5] The preliminary analysis of market risk ("Climate-Related Scenario Analysis―Next Step in the Banking Sector―" (May 2024, the FSA and the BOJ)) indicates that the impact on securities holdings (market risk) was relatively small compared to the impact on loans (credit risk) under the NGFS scenarios. As the International Swaps and Derivatives Association (ISDA) has been developing its own scenarios to examine the impact on market risk in the trading book (ISDA, 2023; ISDA, 2024; ISDA, 2025), additional scenarios will be required for a full-fledged analysis of market risk.

[6] As of March 31, 2024, for the second scenario analysis, and as of March 31, 2021, for the first scenario analysis.

[7] NGFS scenarios Phase IV, REMIND-MAgPIE, NiGEM

[8] NGFS scenarios Phase II, REMIND-MAgPIE, NiGEM

(Analytical Approach)

In stress testing and scenario analysis organized by central banks and supervisory authorities, the analytical approach can be broadly divided into a top-down approach, where the impact assessment is conducted by the authorities, and a bottom-up approach, where it is conducted by financial institutions. As with the first scenario analysis, a bottom-up approach was adopted for the second scenario analysis. This was because the analysis aimed to identify challenges in how financial institutions use scenario analysis.

(2) Design of Scenarios

In addition to the two scenarios from the NGFS Phase IV scenarios—the Current Policies scenario (Scenario 1) and the Net Zero 2050 scenario (Scenario 2)—the FSA and the BOJ have added a tailored stress scenario (Scenario 3) by modifying the Net Zero 2050 scenario. The participating banks were asked to conduct the analysis based on these three scenarios (Chart 2).

Chart 2: Scenarios Used in the Second Scenario Analysis

	Description
Scenario 1	**Current Policies Scenario (NGFS Scenarios Phase IV, REMIND-MAgPIE, NiGEM)** Only currently implemented policies will be preserved.
Scenario 2	**Net Zero 2050 Scenario (NGFS Scenarios Phase IV, REMIND-MAgPIE, NiGEM)** Strict emissions reduction policies and innovation limit temperature increases to 1.5°C, achieving net-zero CO2 emissions globally by 2050.
Scenario 3	**Net Zero 2050 Scenario with Modifications** Economic activity stagnates due to a delay in the adaptation of the corporate and household sectors to climate policies. Consequently, the corporate sector is unable to pass through the carbon price[9] to product prices smoothly, leading to a deterioration in profitability, mainly in high-emission sectors.

While macroeconomic variables by country and region are provided in the NGFS scenarios, industry-specific variables are limited, except for certain sectors with high GHG emissions. Therefore, similar to the first scenario analysis, the FSA and the BOJ provided additional data on GDP by industry, which is not included in the NGFS scenarios, to the participating banks. This was done to enhance the comparability of their analyses by using consistent

[9] Carbon prices generally refer to prices charged for carbon emissions. However, the carbon price in the NGFS scenarios is not a market price, such as prices for regular goods and services. Rather, it is a shadow price of carbon that represents the cost of measures to reduce GHG emissions and is a variable that represents the intensity of transition risks.

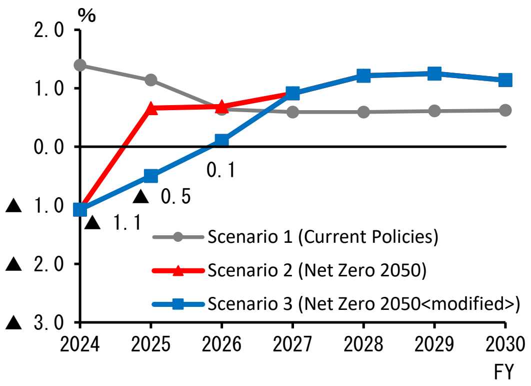
variables (Box 2). The remaining variables included in the NGFS scenario were generally used by participating banks without any changes.

For Scenario 3, to assess how significantly transition risks could increase due to delays by corporations and households in adapting to the transition, the following modifications were made to Scenario 2 as additional stresses: (1) stagnation of economic activity due to the delay in the adaptation of corporations and households to the transition, and (2) deterioration of profitability (reduction of gross margin), mainly in high-emission sectors, due to the delay in the smooth pass-through of the carbon price to their product prices.

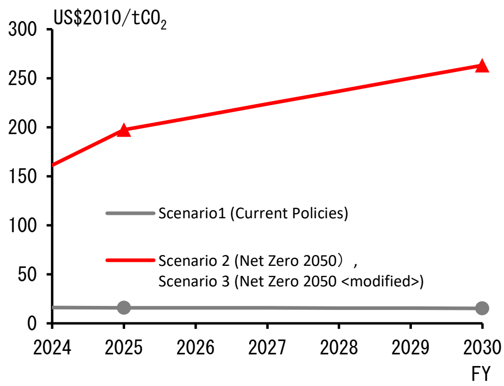
Specifically, Scenario 3 assumes a situation in which the recovery in GDP growth in FY 2025 and 2026 is delayed compared to Scenario 2 after a substantial rise in carbon prices in FY 2024 (Chart 3 (1)). Moreover, Scenario 3 assumes a situation in which it takes longer to pass through the carbon price to product prices than in Scenario 2, with the assumption that the pass-through rate will be 10-30% lower than the predefined rates for each participating bank by FY2027 (Chart 3 (3)).

Chart 3. Modifications in Scenario 3

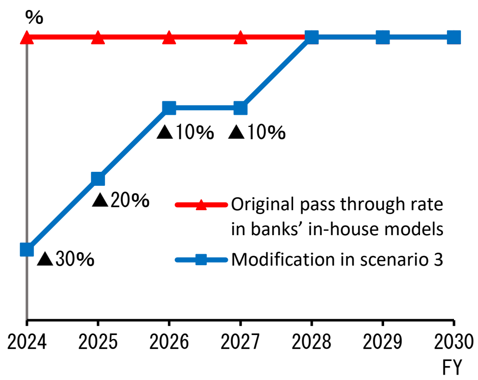
(1) GDP Growth Rate



(2) Carbon Prices



(3) Pass-Through Rate of Carbon Prices to Product Prices



Source: NGFS Scenarios Phase IV (REMIND-MAgPIE, NiGEM), the FSA, and the BOJ

Box 2: Additions and Modifications to Data and Scenarios in the Second Scenario Analysis

The FSA and the BOJ provided additional and modified data to the participating banks to ensure the comparability of risk estimates across banks, taking into account the experiences from the first scenario analysis. Moreover, the FSA and the BOJ provided macroeconomic variables for Scenario 3 (Net Zero 2050 scenario with modifications) to assess how much transition risks could intensify due to delayed adaptation by corporations and households.

Below is an outline of the method used to create these additional/modified data.

(GDP by Industry)

GHG emissions vary significantly across industries, with high-emission sectors being more susceptible to transition risks under scenarios where the transition towards carbon neutrality progresses. Therefore, the participating banks have enhanced their analytical capabilities by incorporating the characteristics of each industry. For example, they have developed sector-specific models, as will be described later. Meanwhile, the NGFS scenarios Phase IV, adopted as the common scenario in the second scenario analysis, has so far only provided a limited range of industry-specific variables, similar to those in Phase II used in the first scenario analysis.

Against this background, in the second scenario analysis, the FSA and the BOJ estimated the impact of carbon prices on GDP by industry using an industry-linkage-based general equilibrium model and provided the results to the participating banks, just like in the first scenario analysis (for details of the estimation, see Matsumura et al., 2024).

The model consists of 32 industries, where each industry produces goods utilizing intermediate inputs produced by other industries. The model captures spillover effects through inter-industry linkages. For example, if a carbon tax is imposed on the use of fossil fuels, which are a major source of carbon emissions, the model has a built-in mechanism whereby each industry substitutes intermediate inputs with other goods. As a result, the fossil fuel sector is experiencing a significant reduction in demand and a substantial decrease in the industry's value. Furthermore, the sector that is highly dependent on fossil fuels faces a significant increase in production costs, leading to higher selling prices and a decrease in production volume. The parameters of the model are determined using input-output tables.

This model also estimated GDP by industry at each point in time, consistent with the carbon prices and GDP provided by the NGFS scenarios, which were assumed to be given. According to the model, industries that face a reduction in demand and those with high GHG emissions at the production stage are likely to experience a relatively significant decrease in GDP. As a result, in Scenario 2 (Net Zero 2050 scenario) and Scenario 3 (Net Zero 2050 scenario with modifications), the decline in growth rates for high-emission sectors was larger than in Scenario 1 (Current Policies scenario).

(Adjustments in Electricity Prices)

In the first scenario analysis, some participating banks raised an issue on quantifying the impact of transition risks on the electrical power sector due to a large temporary rise in electricity prices anticipated around 2030 in the NGFS scenarios Phase II.[10]

In fact, the electricity prices set in the NGFS scenarios Phase IV were quite close to the cost of power generation, calculated under the assumption that capital investments are fully depreciated in the fiscal year they are incurred. This does not necessarily reflect the practices in Japan, where electricity prices are set based on the depreciation costs of facilities over their useful lives.

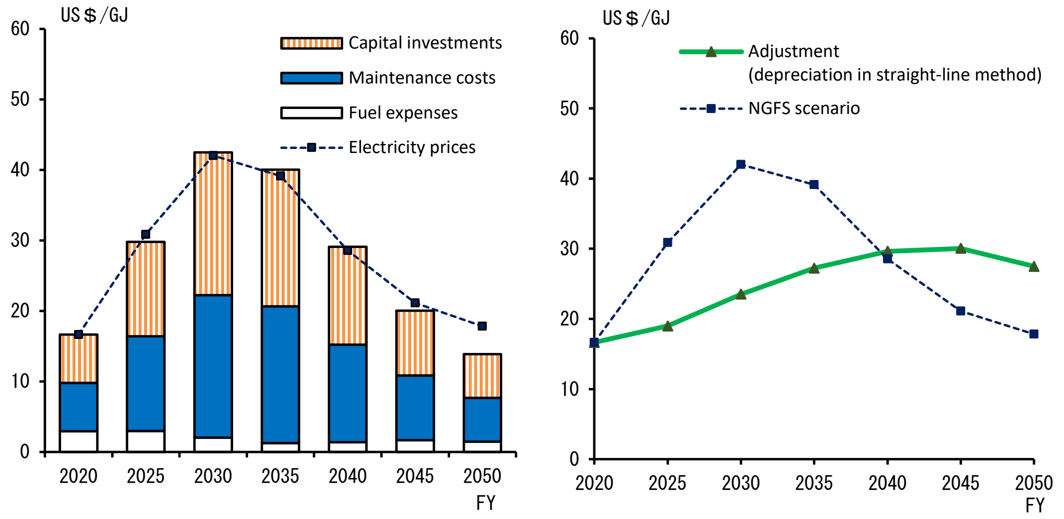
Therefore, the FSA and the BOJ provided adjusted electricity prices to the participating banks, proportionate to the depreciation costs (calculated using the straight-line method) based on the average useful lives of facilities in Japan (Chart 2-1). The adjusted electricity prices were expected to rise in Scenario 2 (Net Zero 2050 scenario) and Scenario 3 (Net Zero 2050 scenario with modifications), reflecting increased investment in renewable energy. However, the rise in the adjusted prices was smaller compared to those in the NGFS Phase IV scenarios. In particular, by 2030, it was less than half of the original Net Zero 2050 scenario. No adjustments were made for Scenario 1 (Current Policies) because it does not assume an increase in investment in renewable energy.

[10] "Discussion Paper – Study on Climate-related Scenarios Analysis: Characteristics of NGFS Scenarios and their Applications in Climate-related Financial Risk Analysis" conducted by the FSA (commissioned to the Central Research Institute of Electric Power Industry) also pointed out that, of the three integrated assessment models used to create NGFS scenarios, the scenario created by REMIND-MAgPIE is characterized by a temporary and large increase in electricity prices around 2030.

Chart 2-1. Electricity Prices Correction Under the NGFS Scenario (Net Zero 2050 Scenario)

(1) Electricity Prices and Power Generation Costs

(2) Adjusted Electricity Prices



Note: GJ (gigajoules) = 10^9

Source: Compiled based on NGFS Scenarios Phase IV, REMIND-MAgPIE, and NiGEM.

(Modifications in Macroeconomic Variables in Response to Increased Stress)

One of the challenges identified in the first scenario analysis was that existing climate scenarios, like the NGFS scenarios, do not necessarily account for the impact that the uncertainty of climate-related risks could have on the macroeconomic environment.

This view is widely recognized internationally. The discussion paper on scenario analysis published by the Basel Committee on Banking Supervision highlights the "severity of scenarios" as one of the challenges in conducting scenario analysis (BCBS, 2024).

For instance, integrated assessment models used in developing the NGFS scenarios simulate GDP with relatively smooth transitions in energy systems, such as a shift from fossil fuels to renewable energy, based on standard economic growth models. Consequently, the climate scenarios developed from these simulations do not assume significant macroeconomic stress.

However, given the high degree of uncertainty regarding the impacts of climate-related risks, it is useful to assess the impact when deviations from the assumptions of NGFS scenarios occur to some extent. Under Scenario 3 (Net Zero 2050 scenario with modifications) used in the second scenario analysis, GDP was simulated based on the assumption that the transition from fossil fuels to renewable energy does not proceed smoothly.[11] Furthermore, other macroeconomic variables, such as the inflation rate and the unemployment rate, were also adjusted to ensure consistency with the GDP, which had been modified using a time-series model.[12, 13]

[11] See Takeyama et al. (2023) for details on the economic growth model used in the integrated assessment model and details of how the GDP growth rate was corrected by adjusting the elasticity of substitution.

[12] Adjustments in electricity prices and macroeconomic variables described in this box are made for the variables subject to correction and the variables calculated using these variables, based on technical documentation on NGFS scenarios and relevant documentation on the integrated assessment models. Consistency among all variables throughout the entire scenario was maintained.

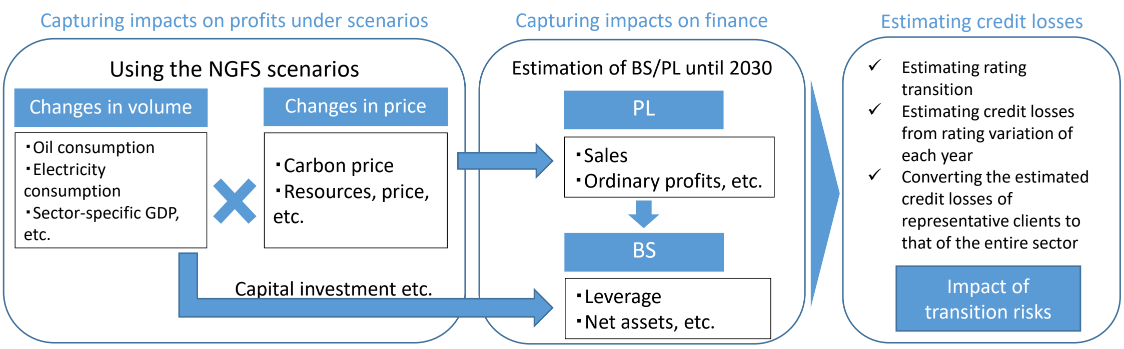
[13] The NGFS published "Short-Term Climate Scenarios" in May 2025, one objective of which was to provide scenarios that assumed more severe stress (NGFS, 2023; NGFS, 2025). The adjustments adopted in the second scenario analysis are consistent with the approach taken in the development of some of the scenarios in the NGFS' Short-Term Climate Scenarios.

2. Procedures and Methodologies for Transition Risk Analysis

As in the case of the first scenario analysis, the FSA and the BOJ employed a bottom-up approach in the second scenario analysis. Participating banks conducted the risk analysis using in-house models. They have identified the sectors that are potentially subject to large transition risks (i.e., key sectors) in their credit portfolio from the materiality assessment (i.e., the assessment of the magnitude of transition risks and the potential impact on their credit portfolios). Although the methodologies of transition risk analysis differ among the participating banks, they have adopted two types of analytical approaches for key sectors and other sectors in their transition risk analysis.

Regarding key sectors, the participating banks developed models tailored to each sector to address the unique risk factors present in these areas. These models allow them to simulate the financial performance and condition of representative clients chosen for each subsector based on variations in their business models, thus capturing the impact of transition risks on the entire sector. Subsequently, they aggregate and convert the estimated credit losses of these representative clients to estimate credit losses for the entire sector (Chart 4).

Chart 4: Estimation Methods for Credit Losses in Key Sectors



Source: Prepared by the FSA and the BOJ concerning descriptions in each participating bank's sustainability disclosure

Regarding other sectors, the participating banks may not develop sector-specific models to capture the characteristics of individual sectors and clients. Instead, they might conduct analyses using macroeconomic variables, for instance, by customizing existing stress testing models for this scenario analysis.

3. Progress in Analysis and Estimated Credit Losses of Participating Banks

(1) Analysis of Participating Banks

The framework for transition risk analysis among the participating banks shows little change from the first scenario analysis. However, amongst each participating bank's ongoing efforts to improve its framework, each bank's risk analytical capability has been further enhanced since the first scenario analysis.

Firstly, the coverage of sectors that can be analyzed by sector-specific models has expanded. In the first scenario analysis, all participating banks commonly cover two key sectors: oil & gas, and electrical power. In the second scenario analysis, they cover an additional two sectors—steel and automotive (OEM)—bringing the total to four sectors. The participating banks can analyze these four sectors, which account for approximately 60% of Japan's GHG emissions and approximately 20% of the participating banks' credit portfolios, using sector-specific models.[14,15]

Furthermore, all the participating banks completed documents on the structure of climate scenario analysis models, including sector-specific models for key sectors, which were still being drafted by some banks during the first scenario analysis. These documents were shared with the FSA and the BOJ before the launch of the second scenario analysis. This indicates progress in establishing a basic framework for discussions on the risk analysis framework.

As shown in Chart 1-1 in Box 1, the impacts of climate-related risks on corporate earnings and financial conditions vary widely across the four key sectors. Transmission channels of transition risks are generally categorized into four groups: (1) decreased sales due to reduced demand for fossil fuels, (2) reduced gross profits because of the carbon pricing burden, (3) impairment losses resulting from decreased profitability of existing production

[14] In addition to the four sectors above, the participating banks that have developed sector-specific models for maritime transportation and aviation have submitted the results of analyses based on the sector-specific models for these sectors.

[15] Based on "The GHG Emissions Data of JAPAN," published by the National Institute for Environmental Studies, and "CO_2 Emissions in the Transportation Sector" published by the Ministry of Land, Infrastructure, Transport and Tourism. The figures are the total for the energy transformation, the iron and steel in the industry sector, and road transportation (automobiles) in the transport sector in terms of CO_2 emissions by sector (before allocation of power and heat). The GHG emissions of automobiles are mainly generated while driving. They are included in the emissions (Scope 3 emissions) of other companies associated with the automotive companies, not in the direct emissions (Scope 1 and 2 emissions) of the automotive companies.

facilities linked to (1) and (2) above, and (4) increased interest-bearing liabilities as a result of capital expenditures for the deployment of new technologies aimed at reducing GHG emissions.

In the simulations conducted up to 2050 by the participating banks in the first scenario analysis, it was assumed that significant reductions in GHG emissions would be achieved in most sectors before the end of the simulation. All four sectors took into account the four transmission channels mentioned above.

In contrast, by the end of FY 2030, it is anticipated that among the four key sectors, the steel sector will primarily reduce emissions by enhancing the efficiency of existing technologies, whereas the electrical power sector is expected to achieve substantial emissions reductions through significant investment in new technologies (Box 3). In the second scenario analysis, by selecting short-term scenarios up to FY 2030, the four key sectors experience varied changes in their business environments. This reflects the differences in the timing of development and introduction of GHG emission reduction technologies among the sectors (Box 3).

From the perspective of conducting scenario analysis for risk management and client engagement, it is important for banks to develop the ability to conduct climate scenario analysis tailored to the specific conditions of companies and their respective sectors. In this context, short-term scenario analysis can be valuable.

Box 3: Major Changes in the Business Environment Faced by Key Sectors

Chart 3-1: Changes in Business Environment, Earnings, and Financial Risks

	Technologies and Regulations Expected to be Implemented	Performance and Financial Risks
Oil and Gas	Conversion to hydrogen and ammonia (from 2030s) Synthetic fuels (from 2030s)	Sales decrease (consumption decrease) Reduction in gross margin (carbon price burden)
Electrical Power	Renewable energy (put to practical use) Conversion to hydrogen and ammonia in thermal power generation (from late 2020s) CCUS (from 2030s)[16]	Reduction in gross margin (carbon price burden) Increase in interest-bearing debt (capital investment burden)
Steel	CCUS (from late 2020s) Hydrogen reduction steelmaking (phased in from 2030) Introduction of high-performance electric arc furnaces (from 2030s)	Reduction in gross margin (carbon price burden) Increase in interest-bearing debt (capital investment burden)
Automotive (OEM)	Conversion to EVs (put to practical use) Regulations on the manufacture and sale of internal combustion vehicles (2030s <variation by region>) Conversion to synthetic fuel (from 2040s)	Sales decrease (decrease in sales of internal combustion locomotives) Increase in interest-bearing debt (capital investment burden)

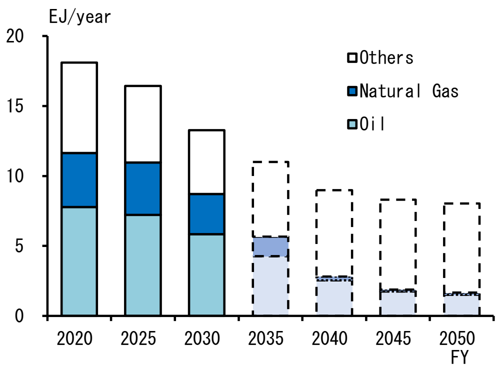
Note: Underlined parts indicate technologies and regulations that are expected to be introduced during the period covered by the second scenario analysis (2024 to 2030) and their impacts.

Source: Roadmap for promoting transition finance in the economic and industrial fields (Minister of Economy, Trade and Industry (METI)

[16] Carbon Dioxide Capture and Storage (CCS), in which carbon dioxide (CO_2) contained in exhaust gas from thermal power plants and factories is captured and buried underground, and Carbon Dioxide Capture and Utilization (CCU), in which carbon dioxide is reused as a resource, are collectively referred to as CCUS.

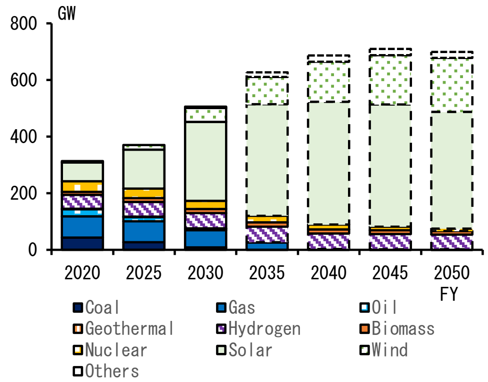
Chart 3-2: Business Environment Expected to be Faced by 2030

(1) Oil and Gas



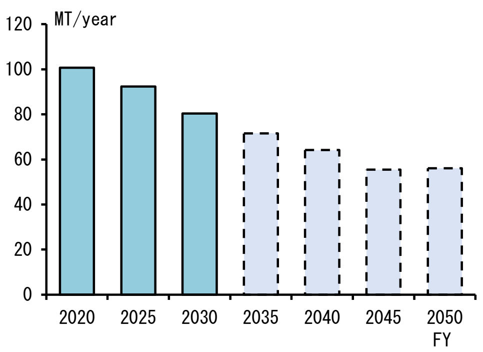
Note 1: Primary energy consumption

(2) Electrical Power



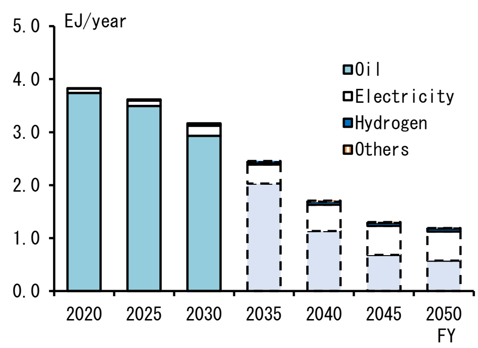
Note 2: Generation Capacity by Power Source

(3) Steel (production volume)



Note 3: Production volume

(4) Automotive (OEM)



Note 4: Energy consumption in transportation sector

Note 5: EJ (exa-joules) = 10 to the 18th power, GW (gigawatts) = 10 to the 9th power, MT (megatons) = 10 to the 6th power

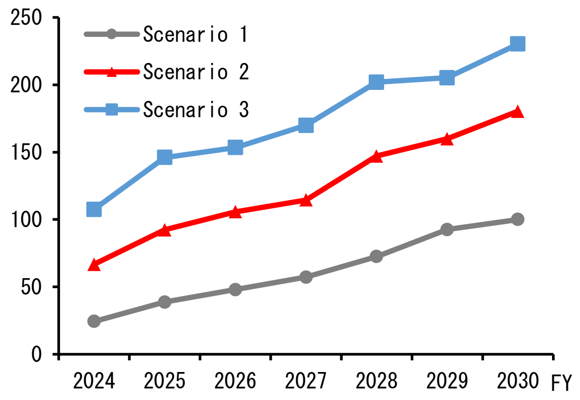
Source: NGFS Scenarios Phase IV, Net Zero 2050 scenario by REMIND-MAgPIE, NiGEM, all of which apply to Japan

(2) Estimated Credit Losses of Participating Banks

The estimated credit losses indicate that the impact of transition risks under the three scenarios is significantly lower than the average annual net income of the participating banks. This suggests that the impacts of climate-related risks on the business operations of these banks may not be substantial.

In Scenario 2, which assumes the promotion of GHG emission reduction measures to achieve net-zero GHG emissions by 2050, cumulative credit losses through 2030 are estimated to be 1.8 times those under Scenario 1. In Scenario 3, where the implementation of GHG emission reduction measures and the response of the corporate and household sectors are not considered to be as smooth as under Scenario 2, the cumulative credit losses are estimated to be 2.3 times those under Scenario 1 (Chart 5).

Chart 5: Cumulative Credit Losses (Total of Participating Banks)



Note: Cumulative credit loss in Scenario 1 through FY 2030 is indexed at 100.

The relatively marginal impact of transition risks is due to expectations that changes in the business environment will be minimal during the analysis period, even in key sectors likely to be significantly affected by these risks, as shown in Charts 3-1 and 3-2 of Box 3.

In addition, under Scenario 3, which assumes the same level of GHG emission reduction measures as Scenario 2 but with a delay in firms' and households' responses to the transition and in the pass-through of the carbon price to product prices, credit losses are expected to increase by about 30% compared to those in Scenario 2. These results indicate that it is necessary to assess the impact of transmission channels that are not included in existing climate scenarios, such as the NGFS scenarios, when quantitatively evaluating the impacts of climate-related risks.

4. Major Issues and Challenges

To share knowledge and insights about scenario analysis with financial institutions, the FSA and the BOJ assessed the characteristics of the participating banks' risk modeling through horizontal reviews, compared the analyses submitted by the banks, and held dialogues with the banks on the challenges and potential improvements for the use of scenario analysis in the future.

As part of the efforts to establish a framework for scenario analysis, the major issues and challenges that financial institutions face when using scenario analysis for risk management and client engagement are summarized as follows.

(Validity and Consistency of Scenarios)

(1) Discrepancies Between the Transition Strategies of Individual Borrowers and Scenarios and Their Impact on Analysis Results.

Participating banks noted that their scenario analyses may not accurately reflect the transition strategies of individual borrowers. This is because the banks primarily rely on sector-level variables derived from climate scenarios built on consistent, long-term modeling, rather than on the published transition strategies and plans of individual borrowers. This is not only due to discrepancies between scenarios and individual borrowers' actual and planned results, but also because the information disclosed by individual borrowers is not comparable, even within the short time frame of the second scenario analysis.[17]

Such discrepancies between climate scenarios and individual borrowers' transition strategies may impact the outcomes of scenario analysis. For example, certain key sectors might need to make large-scale capital investments to reduce their GHG emissions. If a deviation occurs due to the borrower's emission reduction delay compared to the scenarios, eliminating this deviation promptly could imply that individual borrowers are expected to make a larger capital investment than initially assumed in the scenarios. On the other hand, if it is assumed that individual borrowers take an excessively long time to correct the deviation, banks may underestimate the burden of capital investment compared to the

[17] The existence of a discrepancy between the paths set in the climate scenarios and the planned values of individual borrowers does not necessarily mean that their transition strategies are inconsistent with the temperature targets of the corresponding scenarios.
Several organizations, including the Science Based Targets initiative (SBTi), have published guidelines to verify the alignment of corporate transition plans and GHG emission reduction targets with the goals established by the Paris Agreement. The guidelines clearly state that there may be multiple methods for setting plans and targets that align with the goals of the Paris Agreement.

scenario, which could lead to an underestimation of the impact.

In general, there is no single method to bridge the gap between scenario metrics and the actual or planned metrics of individual borrowers. Consequently, the magnitude of the gaps at each point in time and the period required to fill them will depend on the approach taken, and the results of the analysis will differ accordingly. It was observed that when certain variables included in the scenarios were used in the analyses, the estimated capital investment was significantly lower than what was assumed in the scenarios. Since it might be useful to consider individual borrowers' plans based on the purpose of the scenario analysis, it is important to evaluate how the differences between the transition strategies of individual borrowers and the macro-level assumptions in the scenarios can impact the analysis.

In addition to risk analysis, it is also important to examine the impact on their clients' business structure transformation prompted by the funding through engagements with clients, such as transition finance, in analyses focusing on opportunities for climate change measures. Box 4 and Box 5 present a literature review, discussions with banks, and a model illustration of scenario analysis related to transition finance.

(Granularity and Uncertainty of Analysis)

(2) The Pass-Through Rate of Carbon Prices to Product Prices

In the second scenario analysis, the pass-through rate of the carbon prices to product prices was left at the initial level in the individual participating banks' in-house models in Scenario 2, while in Scenario 3, it was assumed that the pass-through rate would be lower than that in Scenario 2 for the first four years.

Participating banks pointed out that no reliable references on the plausible pass-through rate are available. However, it should be noted that although there were challenges in specifying the plausible level, the banks recognized that the pass-through rate was a key parameter in transition risk analysis and that there was room to assess the impact of this parameter on the burden of carbon prices using sensitivity analysis.

It is also important to understand that the analysis may vary depending on the level of the pass-through rate that is set at the discretion of the financial institution. Given that the results of scenario analysis of climate-related risks may vary due to various uncertainties, it may be useful for financial institutions to identify key parameters, such as the pass-through rate, in their models and analyze the impact of changes in these parameters.

(3) Allowance for Impairment of Long-Lived Assets

In some sectors, demand for fossil fuel-related products and products based on existing high-emission production methods is expected to decline on a long-term basis. Under such circumstances, the profitability of fixed assets such as existing production facilities will decline, and the recovery of investment cannot be expected. Therefore, the possibility of impairment accounting (reduction of book value) will increase. In fact, participating banks have considered the impact of impairment accounting in their transition risk analysis.

In transition risk analysis, the participating banks project the future profits of individual borrowers in key sectors at a corporate level. On the other hand, impairment testing of fixed assets in financial accounting is generally conducted on a more granular basis by grouping relevant fixed assets. Despite this difference, since impairment is one of the transmission channels of transition risks, it may be useful to understand the magnitude of risks associated with impairment.

(Comprehensive Development of Framework for Scenario Analysis)

(4) Challenges in Using Short-Term Scenarios

The participating banks noted that the second scenario analysis expanded the variations in scenario analysis beyond the long-term scenario analysis that has been conducted so far and that it may be utilized for stress event simulation.

On the other hand, the participating banks pointed out that climate-related scenario analysis and conventional risk management, such as stress testing, differ in their assumed benchmarks. Recognizing and reconciling these differences is necessary to utilize short-term scenarios for risk management.

For example, the Current Policies scenario is often treated as the benchmark in transition risk analysis because it can be regarded as the scenario with the lowest transition risk. However, the scenario assumes lower economic growth than the potential growth rate, even in the 2020s, due to the impact of global warming in the NGFS Scenarios, Phase IV. On the other hand, the baseline scenario, a typical benchmark in conventional risk management, tends to assume economic expansion at a pace roughly equivalent to the current actual rate, reflecting the average outlook of market participants. Therefore, they noted that the baseline scenario in traditional risk management significantly differs from the Current Policies scenario, making it challenging to directly integrate climate-related scenario analysis into conventional risk management.

(5) Challenges in Data Collection

The participating banks pointed out that the disclosed information of individual borrowers used in scenario analysis is not necessarily comparable and that the granularity of the information disclosed is uneven. This makes it difficult to directly use the data for scenario analysis. Additionally, the participating banks noted that detailed information, such as emissions by scope, business domain, and region, would be desirable, and that relevant information[18] would be necessary to accurately derive the projection of individual borrowers' investment amount in decarbonization technologies.

[18] Investment plans, production plans, and estimated manufacturing costs—including expenses for fuel and electricity consumption—for each existing and decarbonization technology.

Box 4: Literature Review and Discussions with Participating Banks on Transition Finance

This box provides a literature review on whether the private sector's climate-related investment and financing can align with climate goals such as the Paris Agreement and actually contribute to decarbonization of the economy to envision the involvement of financial institutions in the transition of their clients, which is not covered in the second scenario analysis, particularly the functions and challenges related to transition finance.

Among investments and loans related to climate change measures, it has been pointed out that those based on frameworks that have long been developed (e.g., green finance) contribute to promoting environmental initiatives by the fundraising companies and that such a track record may serve as a signal for investors to choose companies that are addressing environmental issues. (See, for example, Flammer, 2021, for information on green finance.)

On the other hand, transition finance has a relatively short history, and therefore, data development is still ongoing globally. Furthermore, the purpose of transition finance is to support companies' long-term efforts to reduce GHG emissions in line with their long-term strategies (METI, 2025). Consequently, at present, there are not many studies on the effects of transition finance on companies, sectors, and the overall economy, and it will take time to gather more research.

Under these circumstances, monitoring the progress of companies for transition over a long period is considered important in providing transition finance. Some argue that financial institutions can help reduce GHG emissions from high-emission companies by supporting the development of long-term transition plans through client engagement while continuing to provide financing and investment (IPFS, 2024).[19]

Studies have reported numerous research findings on the impact of shareholder engagement in reducing GHG emissions, comparing it to divestment (the reduction or withdrawal of investments).

The divestment of high-emission companies is often categorized as "a strategy that restricts the production and GHG emissions activities of these companies by tightening their financing conditions and increasing their cost of capital." Empirical analyses of

[19] OECD (2022) and IOSCO (2024) point out that transition finance covers a wider range of initiatives than the conventional framework, the definition and taxonomy of transition finance are still ambiguous, and the level of understanding of transition finance is not sufficiently high. On the other hand, both organizations emphasize the importance of monitoring and follow-up by financial institutions.

such divestment provide mixed results. One study (Berk and van Binsbergen, 2025) found that the increase in cost of capital due to divestment is limited (several bps in terms of spread), while another study (Cheng et al., 2024) found that the increase in cost of capital is somewhat considerable (20 bps or more). Hartzmark and Shue (2023), who conducted an empirical analysis of the production activities of high-emission companies before and after changes in the financing environment, argued that there is a possibility of a paradoxical effect where companies might prioritize obtaining short-term cash flows and lean towards high-emission production activities when they face financing constraints due to divestment.

On the other hand, engagement in climate change measures can be viewed as actions that prompt corporate managers to implement such measures, with investors interested in mitigating the negative impacts of corporate activities on society and the environment (e.g., GHG emissions reductions) becoming stakeholders (Hart and Zingales, 2017).

In recent years, a growing body of research has pointed to the important roles of investor engagement in effectively reducing corporate GHG emissions. Broccardo et al. (2022) theoretically examined the case where a large number of investors invest in multiple companies that produce products with external diseconomies. They demonstrated that when certain conditions are met—such as when investors, even those slightly aware of the need to consider environmental issues, invest in a diversified portfolio of companies—projects that reduce environmental impacts (even at higher economic costs) can be implemented. This is because shareholders' proposals aimed at minimizing external diseconomies garner support. Kahn et al. (2023), using data on U.S. pension funds, empirically showed that companies for which green-oriented pension funds have increased shareholdings reduce their emissions.

The dialogues with the participating banks revealed that they not only provide financial support to their clients but also have a policy to deepen their engagement with their clients by supporting the development of climate change strategies. Specifically, the participating banks are focusing on their clients' progress in setting and announcing emission reduction targets, developing concrete action plans to achieve these reductions, and developing data and indicators to measure the progress of these efforts. In this regard, the participating banks are supporting their clients' initiatives. Such engagement methods, such as supporting developing the long-term emission reduction plans, have been shown in empirical research to positively correlate with actual reductions in company emissions (Pless, 2023). Further academic research is warranted as authorities and financial institutions understand the diverse forms of engagement.

Box 5: Illustrative Model of Scenario Analysis on Transition Finance

Given the limited research on transition finance, it is not easy to predict the impact of it on corporate GHG emissions in the future. One option would be to model the decision-making of companies and financial institutions based on economic theory and then simulate the impact on companies' and financial institutions' profits as well as changes in the volume of transition finance loans and GHG emissions under various assumptions. This box provides an overview of a pilot model for such a scenario analysis framework, along with the results of the analysis.

The model illustrates the equilibrium of loan demand and supply in a loan market where banks (the supply side of funding) and companies (the demand side of funding) participate.[20] Companies use borrowed funds for production activities and investments to maximize the benefits for their shareholders. This model assumes that investors not only seek profit maximization as assumed in basic economic theory, but also consider social values such as environmental impacts caused by GHG emissions to some extent (see Broccardo et al., 2022, etc.). Notably:

- Modeling investors that take into account social value

  As previously mentioned, investors are presumed to have a preference for mitigating the environmental impacts associated with GHG emissions. This suggests that an increase in GHG emissions from production activities negatively impacts corporate value. Under this assumption, the investor engages corporate managers to execute investments aimed at reducing GHG emissions. The equilibrium amount of transition finance reflects the extent of engagement driven by investors' preferences.

- Modelling corporate decision-making, including investments to reduce GHG emissions

  Companies will invest in reducing GHG emissions in addition to their conventional production activities, taking into account investors' preferences and associated engagement related to GHG emissions. If investors prefer to reduce environmental impacts, companies will focus on investing in reducing GHG

[20] It draws on the oligopolistic lending market model of Freixas and Rochet (2023), section 3.3. Although the results are not shown below, the model also formulates the relationship between transition finance and GHG emissions reductions, so it can be integrated with GHG emissions simulations.

emissions.

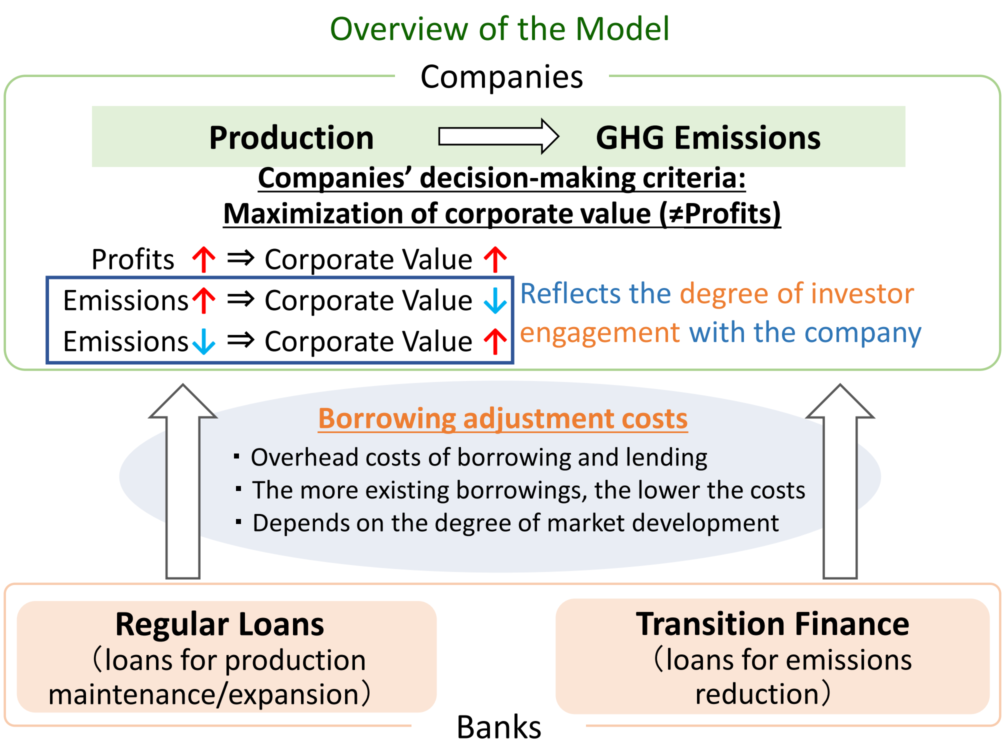
➢ Modelling bank decision-making

Banks will provide transition finance[21] for investments to reduce GHG emissions, as well as regular finance for conventional production activities, based on demand from companies. Banks may adjust the ratio of regular finance to transition finance or alter the size of transition finance based on how their financed emissions reduction targets affect their lending activities.

➢ Borrowing adjustment cost

Both regular finance and transition finance require various expenses (borrowing adjustment costs) for companies, such as collecting necessary information and considering investment and business plans. This may be affected not only by companies' cost structures and the profit structures of the companies they invest in, but also by the degree of economic and social development for financing and investment.

Chart 5-1: Model Concept on Transition Finance



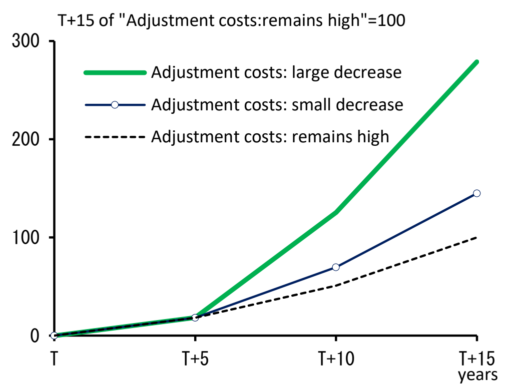
[21] It is not necessarily consistent with what financial institutions define as transition finance.

By utilizing such a model, where the demand for transition finance is generated endogenously, it is possible to simulate how changes in the external environment—such as advancements in emission reduction technology, improvements in financing and investment conditions, and shifts in corporate managers' behavior due to investor engagement—will affect the equilibrium amount of loans.

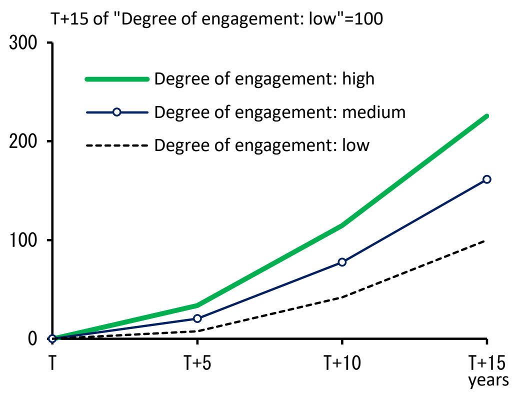
The charts below illustrate the impact of changes in model parameters on the volume of transition finance, with a focus on changes in borrowing adjustment costs for transition finance (left) and changes in the investor's engagement degree (right).[22, 23]

Chart 5-2: Impact on Transition Finance Lending Volume

Impact of Borrowing Adjustment Costs



Impact of Engagement



[22] Transition finance is a relatively new concept and involves new business operations for banks, so it tends to entail higher borrowing costs than regular borrowing. As described in Box 4, although frameworks for transition finance are being developed internationally, this model focuses on these aspects and assumes a situation in which borrowing adjustment costs decline as a result of an increase in the level of existing borrowing and improvement in the economic and social environment for financing and investment.

[23] These figures are the results of simulations based on certain assumptions and parameters and are not intended to be definitive future paths.

III. Way Forward

To utilize the scenario analysis in business strategy development and risk management, financial institutions need to further enhance their methodologies, including addressing the issues identified in the first and second scenario analyses, taking into account their risk profiles as well as international discussions and developments in practice.

The application of a scenario analysis in engagement with clients to support addressing climate change would require financial institutions to refine their analysis of clients. In the course of refinement, financial institutions may need to consider the impacts of structural changes in related industries on clients, as well as the effects of business transformation through discussion with clients.

The FSA and the BOJ will continue to engage in discussions with financial institutions regarding the methods and applications of scenario analysis. This will include discussions on how to address the issues identified in the first and second scenario analyses.