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Financial System Report Annex

Macro Stress Testing in the *Financial System Report* （April 2017）

FINANCIAL SYSTEM AND BANK EXAMINATION DEPARTMENT
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Background

The Bank of Japan publishes the *Financial System Report* semiannually, with the objective of assessing the stability of Japan's financial system from a macroprudential perspective and facilitating communication with concerned parties on relevant tasks and challenges in order to ensure such stability. The *Report* provides a regular and comprehensive assessment of the financial system.

The *Financial System Report Annex Series* supplements the *Financial System Report* by providing more detailed analysis and additional investigations on a selected topic on an ad-hoc basis. This paper provides a detailed explanation of the scenarios developed for macro stress testing in the April 2017 issue of the *Report*.

Abstract

In the *Financial System Report*, two macro stress tests are implemented: (1) a "tail event scenario" that assumes a set of severe financial and economic conditions equivalent to the Lehman shock for each regular test, in order to assess the stability of the financial system through fixed-point observations; (2) a "tailored event scenario" that varies according to macroprudential concerns at the time of the test and seeks to examine the vulnerabilities of the financial system to these specific concerns. In the April 2017 issue of the *Report*, the tailored event scenario features the impact of shocks in the real estate sector on the financial system, given a recent increase in Japanese financial institutions' exposures related to real estate. This paper explains the specifics underlying the stress scenarios, and the background to the approach employed.

1. Introduction

Macro stress testing involves examining the resilience of the financial system dynamically by estimating the extent of capital loss under specific stress events. This section explains the specifics underlying the stress scenarios, and the background to the approach employed.

The two stress scenarios under consideration are the "tail event scenario" and the "tailored event scenario." The former is designed to assess the stability of the financial system through fixed-point observations, by applying an approximately equal degree of severe stress in every semiannual *Financial System Report*. In particular, the assumed economic and financial conditions are comparable to those observed at home and abroad during the Lehman shock. Since the simulation assumes economic conditions comparable to those observed during the Lehman shock, the better the recent economic conditions are -- that is, the stronger the signs of economic overheating are -- the greater the degree of the stress to be applied. In other words, the degree of the stress is calibrated countercyclically in examining the resilience of the financial system against the stress and financial institutions' capital adequacy. In addition, as financial institutions' risk profiles and financial bases change from time to time, the impact of the stress on the financial system could vary even if placed under financial and economic stress of a comparable level of severity. The "tailored event scenario" is designed to be a multi-dimensional analysis of the vulnerabilities inherent in the financial system, with its focus changing from time to time. Under this scenario, the severity of the stress may not necessarily be as high as that observed under the tail event scenario. Nevertheless, the tailored event scenario is developed to assess a mechanism through which a shock is transmitted, by utilizing additional data or by extending the model as necessary. In the April 2017 issue of the *Report*, we examine the impact of shocks in the real estate sector, specifically a decline in real estate-related markets and a widening of the credit spreads for real estate firms, on the financial system, taking the rapid increase in financial institutions' exposures related to real estate into account.

Scenarios presented in this stress testing exercise are hypothetical, developed for the purpose of effectively conducting the above-mentioned examination and analysis. It should be noted that the scenarios presented are not an indication of the likelihood of outcomes for the economy, asset prices, or other factors, nor should they be interpreted as the Bank of Japan's outlook.
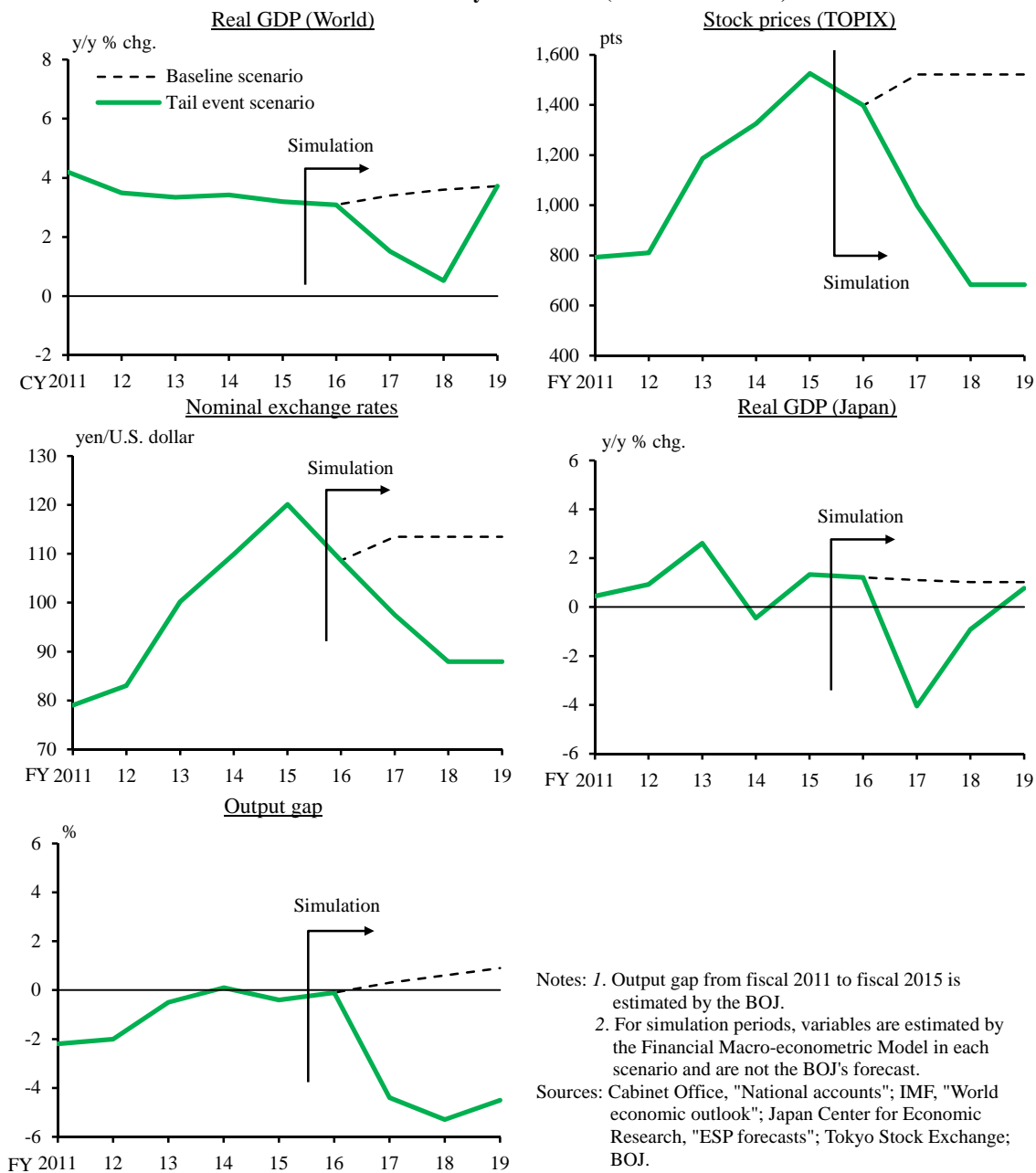
The following section will first discuss the baseline scenario, which will be used as a benchmark to assess the results of the stress test simulations, and then elaborate on the
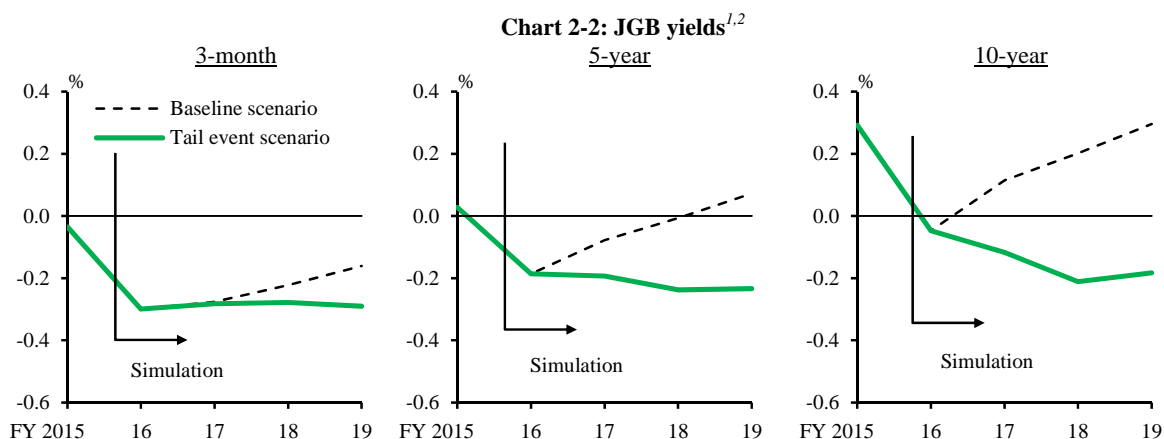
stress scenarios including their backgrounds.

2. Baseline scenario

The baseline scenario, based on forecasts by the International Monetary Fund (IMF) and market participants, assumes that "the growth rate of overseas economies increases moderately, as the steady growth in advanced economies spreads to emerging and developing economies, resulting in a continued moderate recovery for Japan's economy" (Charts 2-1 and 2-2).

Chart 2-1: Summary of variables (tail event scenario)[1,2]

Notes: 1. Output gap from fiscal 2011 to fiscal 2015 is estimated by the BOJ.
2. For simulation periods, variables are estimated by the Financial Macro-econometric Model in each scenario and are not the BOJ's forecast.
Sources: Cabinet Office, "National accounts"; IMF, "World economic outlook"; Japan Center for Economic Research, "ESP forecasts"; Tokyo Stock Exchange; BOJ.

Chart 2-2: JGB yields[1,2]

Notes: *1*. Estimated by the BOJ.
     2. Figures for 3-month indicate the rate of treasury discount bills.
Sources: Bloomberg; Ministry of Finance, "Interest rate."

Specifically, under the baseline scenario, the growth rate of overseas economies (real GDP) rises moderately from 3.1 percent in 2016 to 3.7 percent by 2019.[1] The growth rate of the domestic economy (real GDP) remains above the potential growth rate, at approximately 1 percent, until fiscal 2019.[2] Based on these growth assumptions, the output gap enters positive territory in fiscal 2017 and widens to 0.9 percent in fiscal 2019.[3]

In terms of financial markets, in and beyond the second quarter of 2017, stock prices (TOPIX) and the nominal exchange rates remain unchanged at the values recorded in January 2017.[4] Furthermore, JGB yields, and swap rates, which serve as benchmarks for bank lending rates, evolve more or less in line with the yield curve (as at late January 2017).

3. Tail event scenario

The tail event scenario is designed such that "Japan's output gap deteriorates to around minus 7 to minus 8 percent, as experienced at the trough of the Lehman shock." Other financial and economic variables are calibrated so that they are generally similar in magnitude to changes during that time (Charts 2-1 and 2-2).[5]

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[1] Based on IMF forecasts available as at January 2017.

[2] Based on ESP forecasts published in January 2017.

[3] For the estimation of the output gap, the potential growth rate is assumed to remain constant at its average of around 0.7 percent from fiscal 2000 onward.

[4] Specifically, it is assumed that the TOPIX remains at 1,522 points and the nominal exchange rate is 114 yen/U.S. dollar.

[5] The set of financial and economic conditions assumed in the tail event scenario and the channels through which the shock propagates are the same as those described in the previous issues of the
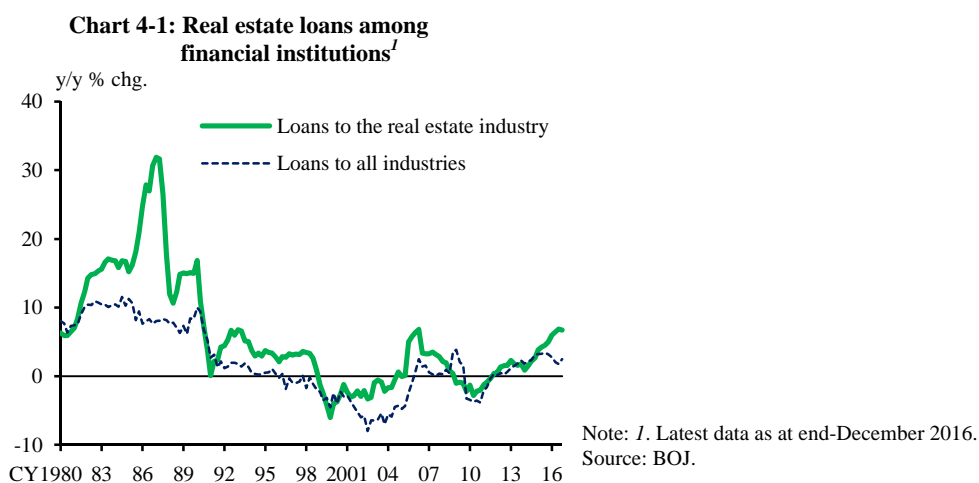
Specifically, the growth rate of overseas economies falls sharply from 3.1 percent in 2016 to 1.5 percent in 2017 and to 0.5 percent in 2018. The real growth rate of Japan's economy falls sharply to minus 4.1 percent in fiscal 2017 and remains in negative territory, at minus 0.9 percent in fiscal 2018. As a result, Japan's output gap deteriorates significantly to minus 4.4 percent in fiscal 2017, then to minus 5.2 percent in fiscal 2018, and remains substantially negative at minus 4.5 percent in fiscal 2019.[6]

As for financial markets, stock prices (TOPIX) fall by 55 percent to 683 points by the first quarter of 2018, and remain unchanged thereafter. 10-year JGB yields decline from minus 0.05 percent in fiscal 2016 to minus 0.21 percent in fiscal 2018. The nominal exchange rate is 98 yen/U.S. dollar in fiscal 2017 and 88 yen/U.S. dollar in fiscal 2018 and remains unchanged thereafter.

4. Tailored event scenario

(1) Background to scenario design

The tailored event scenario in the April 2017 issue of the *Report* is designed to examine the impact of shocks in the real estate sector, specifically a decline in real estate-related markets and a widening of the credit spreads for real estate firms, on the financial system.[7]

Chart 4-1: Real estate loans among financial institutions[1]

Note: *1*. Latest data as at end-December 2016.
Source: BOJ.

Report. For details, see "Designing Scenarios in Macro Stress Testing at the Bank of Japan," *Financial System Report Annex Series*, October 2015.

[6] On a quarterly basis, the output gap deteriorates to approximately minus 7 percent in the first quarter of 2018.

[7] In the tailored event scenario, shocks are not applied to other sectors of the Japanese economy or overseas economies directly, in order to focus on the effects of shocks in the domestic real estate sector. However, a transmission mechanism through which a shock in the domestic real estate sector indirectly feeds back to the macroeconomy through the financial sector is incorporated.

The backdrop to the setting of such a scenario is the increase in Japanese financial institutions' exposures related to real estate. Real estate loans have been growing at an even faster pace, and continue to exceed the growth rate of loans to firms in all industries (Chart 4-1). Although the growth rate is still low compared to the bubble period during the 1980s, the amount outstanding of real estate loans as at end-December 2016 reached about 85 trillion yen, marking a new record high. By type of financial institution, major banks have been actively responding to demand for funds from J-REITs and large real estate developers, among other borrowers, with their loans continuing to grow by around 4 percent year on year recently (Chart 4-2). Among regional banks, real estate loans, particularly those to the housing rental business by individuals, and to small and medium-sized firms including asset management companies founded by individuals, have continued to grow at a high rate, recently at around 9 percent year on year. In addition, regional financial institutions have also increased equity investments in real estate funds at a fairly rapid clip in recent years (Chart 4-3).
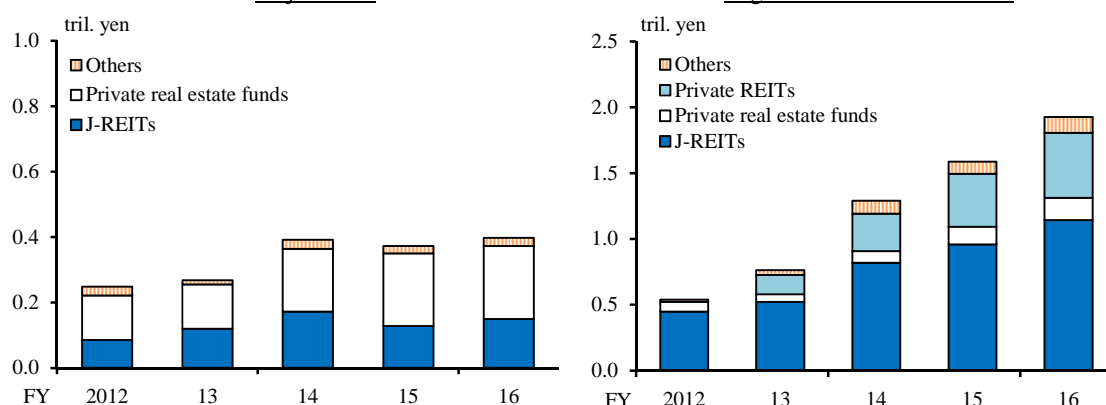
Chart 4-2: Breakdown of real estate loans[1]
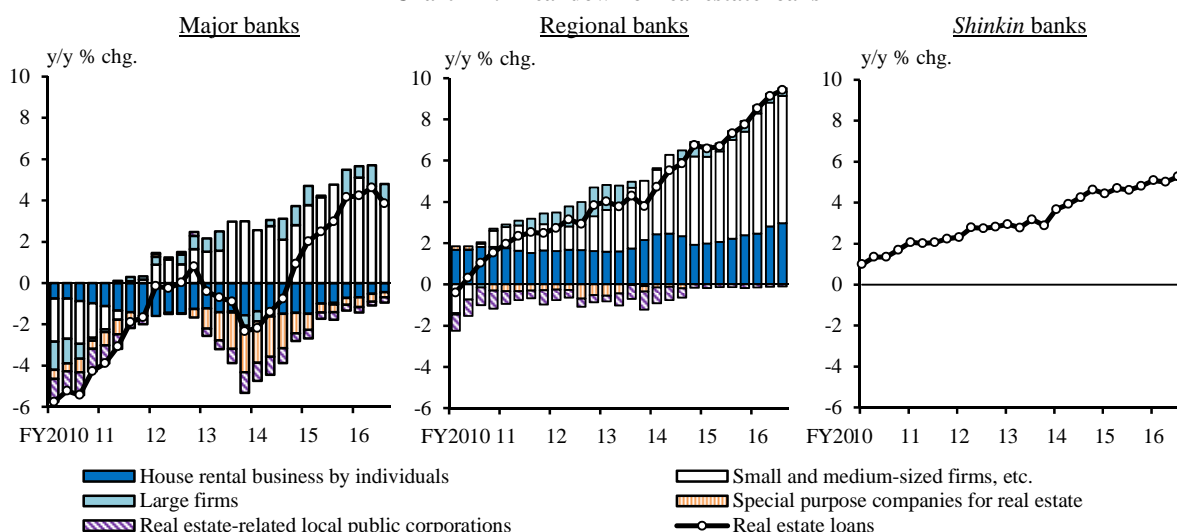
Note: *1*. Latest data as at end-December 2016.
Source: BOJ.

A decline in real estate-related markets and a widening of the credit spreads for real estate firms cause an increase in financial institutions' credit costs and a decline in their capital adequacy ratios through a deterioration in real estate firms' financial conditions, while expanding unrealized losses on financial institutions' investments in real estate funds through, for example, a drop in J-REIT prices. As observed in the April 2017 issue of the *Report,* the real estate market does not appear to show signs of overheating on the whole. However, taking into account the rapid increase in financial institutions' exposures related to real estate, it is necessary to examine their resilience against stresses

originating in the real estate sector.[8]

Chart 4-3: Equity investments in real estate funds by financial institutions[1,2]

Major banks | Regional financial institutions

Notes: *1*. Latest data for major banks as at the end of the first half of fiscal 2016, and for regional financial institutions as at end-December 2016.

    2. For regional financial institutions, private real estate funds in fiscal 2012 include private REITs.

Source: BOJ.

(2) Assumptions of shocks in the real estate sector

This subsection will explain specifically how shocks are applied to the real estate sector. First, we elaborate on a decline in real estate-related markets (real estate and real estate funds). Second, we explain in detail the widening of the credit spreads for real estate firms.

A decline in real estate-related markets

Taking differences among the types of real estate business into account, real estate loans are classified into the following two categories: (1) loans to firms engaging in real estate transactions and (2) loans to firms engaging in real estate rental and management, including housing rental businesses (Chart 4-4). A shock is applied in the form of a decline in real estate-related markets that have the greatest impact on firms' financial conditions -- a decline in commercial real estate prices in the case of the former category and a decline in office rents in the case of the latter. We divide the domestic market into four areas -- the Tokyo area, the Osaka area, the Nagoya area, and others -- and different shocks are applied to commercial real estate prices and office rents in each area, reflecting heterogeneity among the areas.[9]

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[8] A decline in real estate prices could also raise credit costs of financial institutions by lowering collateral values, thereby pushing up the loss given default (LGD) of exposure to non-real estate industries. However, this scenario does not incorporate such channel because loans backed by real estate collaterals account for only about 15 percent of the overall loans and the proportion of the loans that are expected to incur the credit costs is even smaller.

[9] The regional classification of financial institutions is based on the locations of their head offices.

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The shocks applied to commercial real estate prices and office rents in each area have been calibrated so that the ratio of the rate of decline in the simulation to the rate of increase from 2012 to 2016 matches the ratio of the rate of decline to the rate of increase after and before the Lehman shock (Chart 4-5). Overall, as the recent increase has not been as large as before the Lehman shock, the calibrated rates of decline are smaller than those observed after that event. By area, the calibrated rates of decline in the Tokyo area are larger since the recent increase in commercial real estate prices and office rents in the area has been larger than other areas. The calibrated rates of decline in the Nagoya area and others are relatively smaller.

Chart 4-4: Ratio of real estate loans to total loans[1]

	Major banks	Regional banks	*Shinkin* banks
Ratio to total loans (%)	8.0	14.1	22.0
Firms engaging in real estate transactions	4.1	4.2	5.6
Firms engaging in real estate rental and management	3.9	9.9	16.4

Note: *1*. Estimated by the BOJ. Data as at end-March 2016.

Chart 4-5: Assumptions of real estate prices[1]

Commercial real estate prices

Office rents
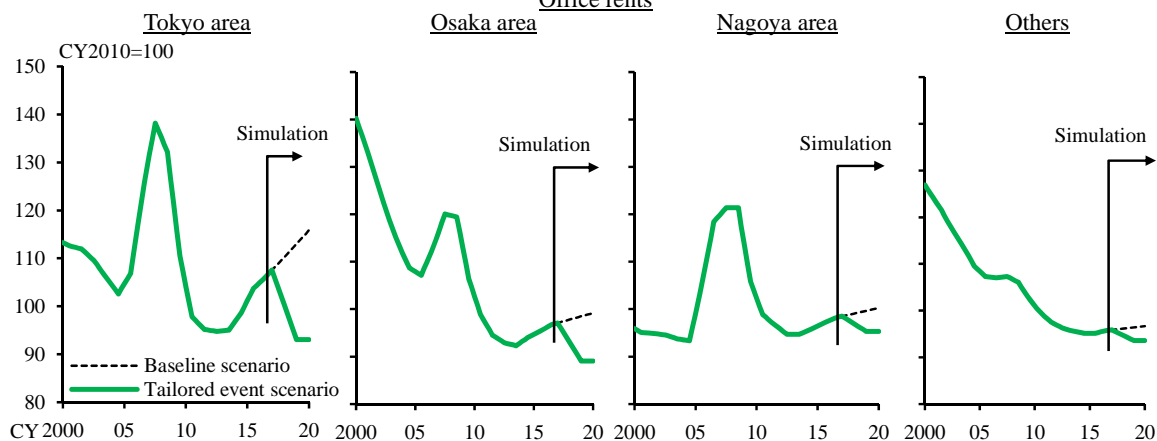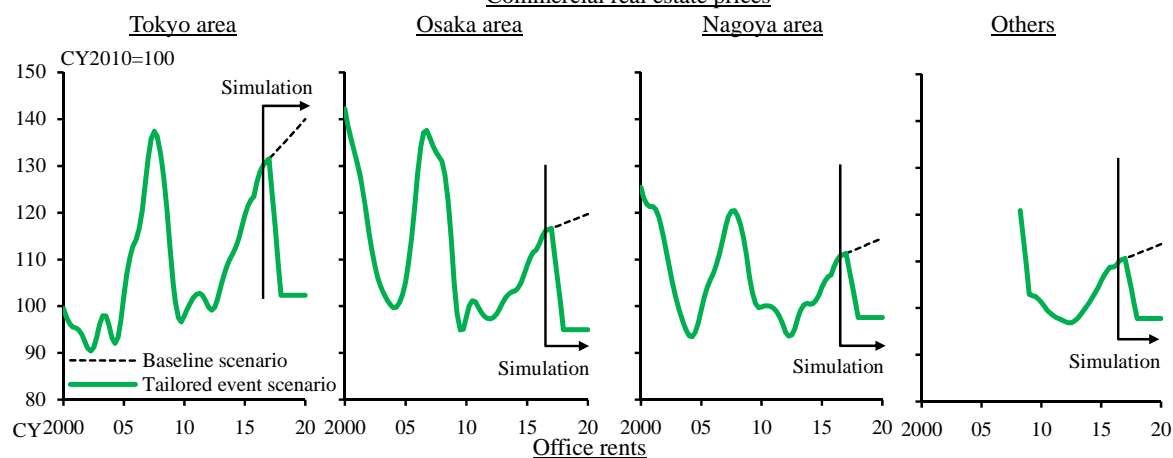
Note: *1*. Estimated by the BOJ.

Sources: Aichi Association of Real Estate Appraisers; Japan Real Estate Institute; Ministry of Land, Infrastructure, Transport and Tourism; Osaka Association of Real Estate Appraisers; Tokyo Association of Real Estate Appraisers.

Price developments of real estate funds are calibrated in the same way, based on developments in J-REIT prices observed before and after the Lehman shock (Chart 4-6). Prices for nonmarketable assets, such as private REITs, also decline similarly, assuming that their fair values also decline under stress in real estate markets.
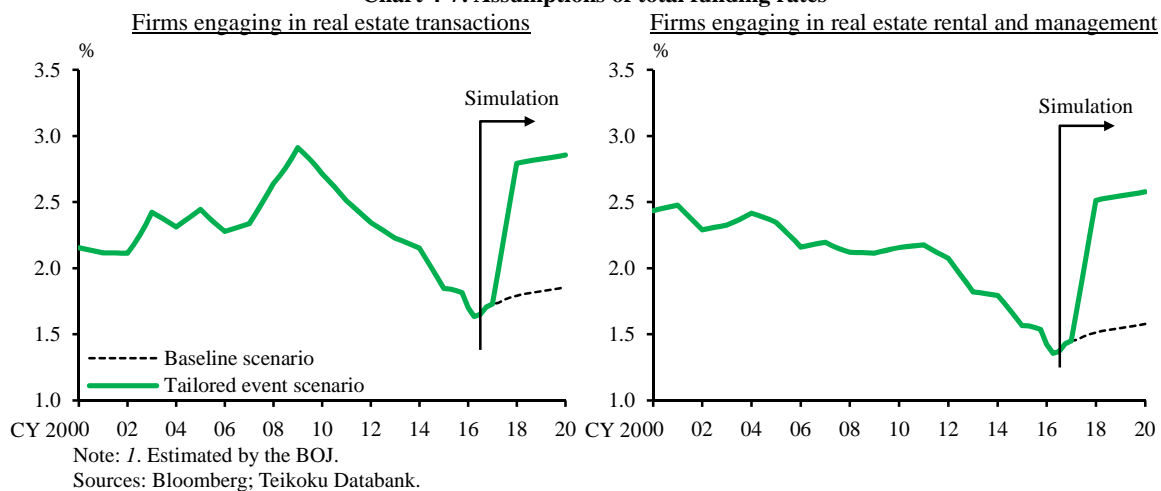
Chart 4-6: Assumptions of Tokyo Stock Exchange REIT Index[1]

end-March 2003=1,000

Note: *1*. Estimated by the BOJ.
Source: Bloomberg.
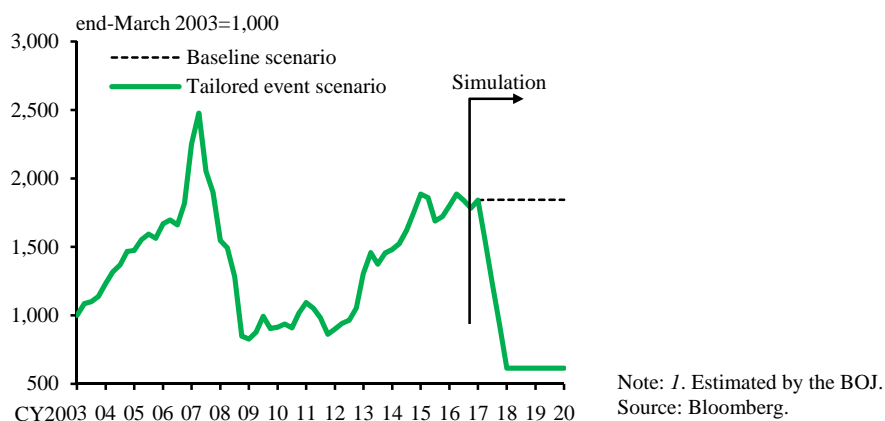
An increase in real estate firms' total funding rates

A decline in real estate-related markets leads to a deterioration in real estate firms' financial conditions, resulting in the widening of their credit spreads and a rise in funding rates, which in turn leads to a further deterioration in their financial conditions. In this scenario, with the widening of the credit spreads, the total funding rate rises by 100 basis points to a level comparable to that observed after the Lehman shock (Chart 4-7). As the focus of this scenario is to analyze the impact of shocks in the real estate sector, we keep other market interest rates, such as JGB yields, unchanged from the baseline scenario.

Chart 4-7: Assumptions of total funding rates[1]

Firms engaging in real estate transactions

Firms engaging in real estate rental and management

Note: *1*. Estimated by the BOJ.
Sources: Bloomberg; Teikoku Databank.

Financial institutions are expected not to raise loan interest rates, for real estate firms with which they have developed long-term relationships through lending activities, to an

extent corresponding to the widening of the credit spreads in the corporate bond market, even if the firms' creditworthiness deteriorates due to declines in real estate-related markets. Therefore, we assume that the rise in financial institutions' loan interest rates is smaller than the rise in the total funding rates of real estate firms.[10]

(3) The impact on financial institutions

A decline in real estate-related markets and an increase in the interest costs of real estate firms affect financial institutions through a rise in the credit costs of loans and unrealized losses caused by a decline in prices of real estate funds. Below, the method of estimating the impact is explained.
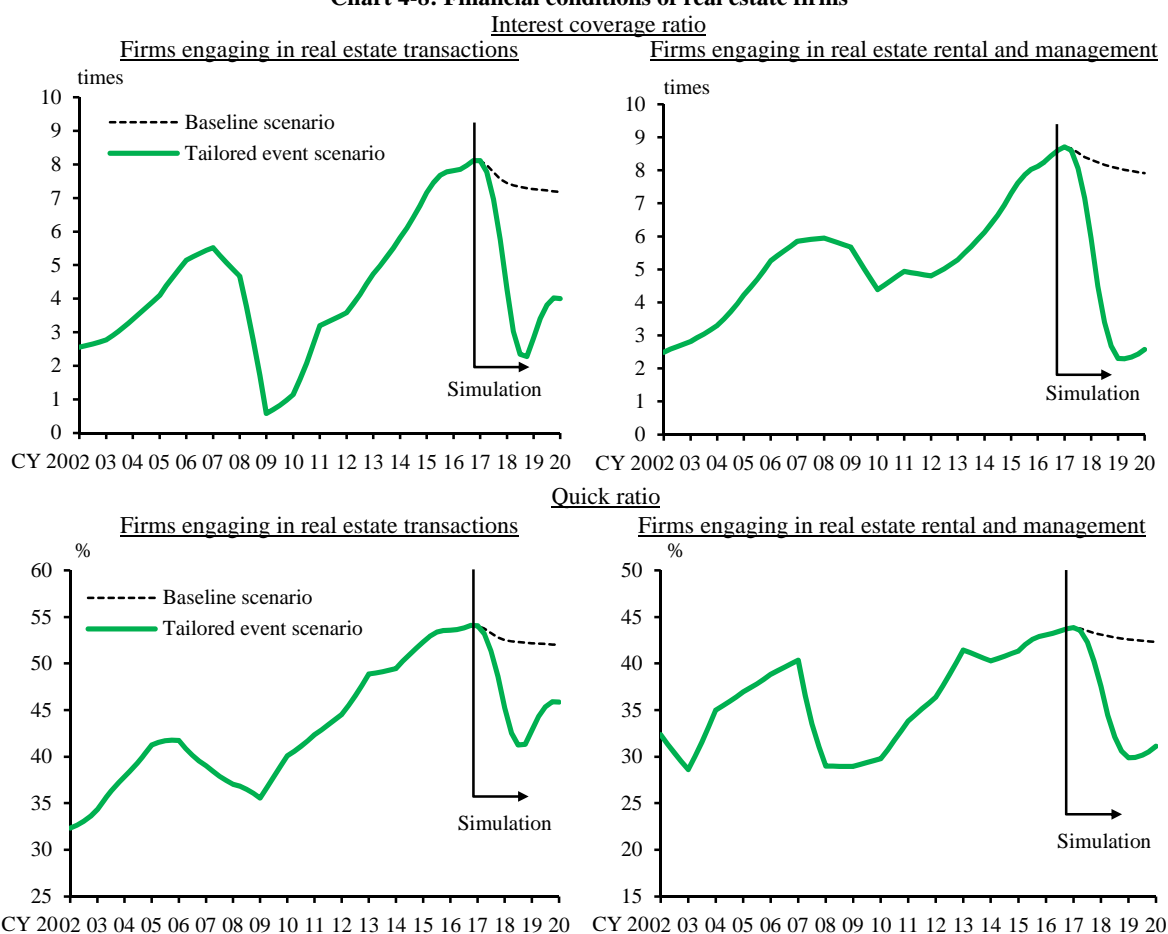
The impact on the credit costs of real estate loans is estimated in two steps. In the first step, real estate firms' financial conditions deteriorate due to shocks in the real estate sector. In the second step, the deterioration in real estate firms' financial conditions increases financial institutions' credit costs by raising the probabilities of downgrade in borrower classification.

In the first step, a regression analysis is conducted to estimate the impact of a decline in real estate-related markets and a rise in real estate firms' total funding rates on firms' financial variables. Specifically, dependent variables -- interest coverage ratio (ICR) and quick ratio for real estate firms -- are regressed on total funding rates, as well as on year-on-year rates of change in commercial real estate prices in the case of firms engaging in real estate transactions or on office rents in the case of firms engaging in real estate rental and management (Chart 4-8).[11] The estimation results indicate that all parameters are statistically significant and have the expected signs (Chart 4-9). Using the parameters obtained, the extent of the deterioration in the financial conditions (i.e., ICR and quick ratio) of firms engaging in real estate transactions and firms engaging in real estate rental and management is calculated by applying the area-by-area price decline in real estate-related markets (commercial real estate prices and office rents) and the rise in total funding rates mentioned earlier.

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[10] After the Lehman shock, the rise in firms' borrowing rates from banks was only approximately 30 percent of the rise in firms' total funding rates. Likewise, the rise in firms' borrowing rates from *shinkin* banks was approximately 70 percent of the rise in small and medium-sized firms' total funding rates. Given those, we assume that banks and *shinkin* banks raise their loan interest rates by 30 basis points and by 70 basis points, respectively, when the total funding rate rises by 100 basis points.

[11] As region-level data for real estate firms' financial variables are not available, nationwide data are employed for dependent variables. Nationwide data for commercial real estate prices and office rents are employed for independent variables. In the simulation, the deterioration in real estate firms' financial conditions on a regional level is calculated by using estimated nationwide parameters and regional-level shocks in commercial real estate prices and office rents.

Chart 4-8: Financial conditions of real estate firms[1,2]

Interest coverage ratio

Firms engaging in real estate transactions | Firms engaging in real estate rental and management

Quick ratio

Firms engaging in real estate transactions | Firms engaging in real estate rental and management

Notes: 1. Estimated by the BOJ.
    2. Data for simulation periods are based on the commercial real estate prices and the office rents in the Tokyo area.
Sources: Japan Real Estate Institute; Ministry of Land, Infrastructure, Transport and Tourism; Teikoku Databank.

Chart 4-9: Estimation results[1,2,3]

Firms engaging in real estate transactions

		Dependent variables	
		ICR	Quick ratio
Independent variables	Commercial real estate prices (y/y % chg.)	0.14 ***	0.34 ***
	Total funding rates	-2.89 **	-10.74 ***
	Adj-R²	0.83	0.80

Firms engaging in real estate rental and management

		Dependent variables	
		ICR	Quick ratio
Independent variables	Office rents (y/y % chg.)	0.10 ***	0.36 *
	Total funding rates	-4.82 ***	-9.29 **
	Adj-R²	0.74	0.31

Notes: 1. Estimated by the BOJ.
    2. Estimation period is from the October-December quarter of 2001 through the January-March quarter of 2015.
       Independent variables are 4-quarter moving averages.
    3. ***, **, and * indicate statistical significance at 1 percent, 5 percent, and 10 percent levels, respectively.
Sources: Japan Real Estate Institute; Ministry of Land, Infrastructure, Transport and Tourism; Teikoku Databank.

In the second step, we estimate the degree to which the deterioration in real estate firms' financial conditions increases the probabilities of downgrade in borrower classification, and thereby calculate the credit costs of financial institutions. [12] Although the

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[12] The impact of the deterioration in real estate firms' financial conditions on the probabilities of downgrade is estimated based on an all-industry level relationship between the transition probabilities and ICR/quick ratio, which is used in the Financial Macro-econometric Model.

deterioration in real estate firms' creditworthiness leads to a rise in financial institutions' loan interest rates, the net impact on financial institutions' profits is negative as the increase in the credit costs overwhelms this channel.

The unrealized losses on investments in real estate funds are calculated by multiplying the value of financial institutions' such investments by the rate of decline in the prices. In the case of domestic banks, this does not affect their capital adequacy ratios because unrealized gains/losses on securities are not taken into account in their regulatory capital. If the prices of real estate funds decline by 50 percent or more relative to their book value, it results in impairment, and domestic banks' capital adequacy ratios will be affected. However, the impairment is not considered in our simulation, as the book value of real estate funds is not available.
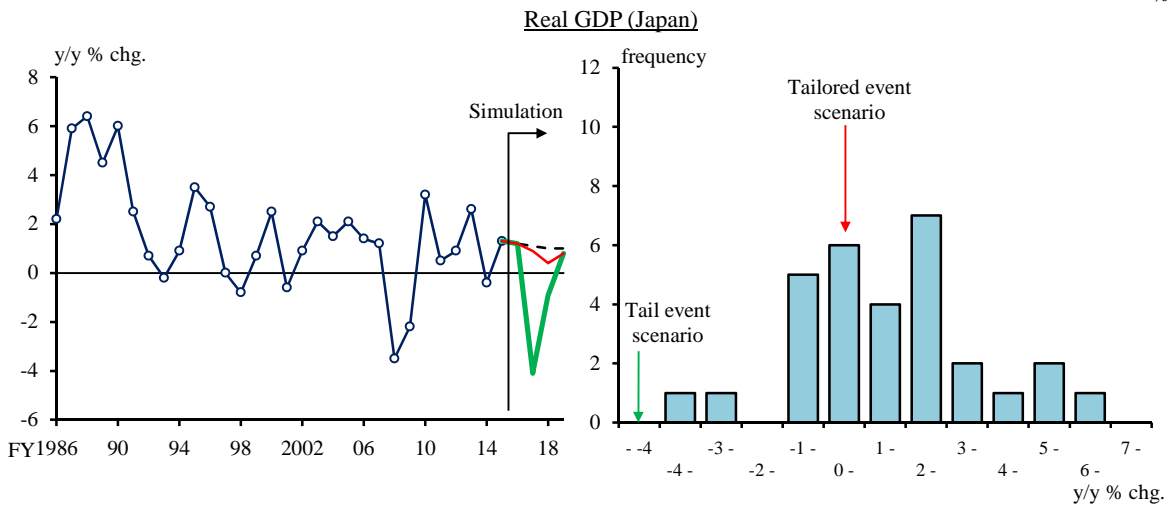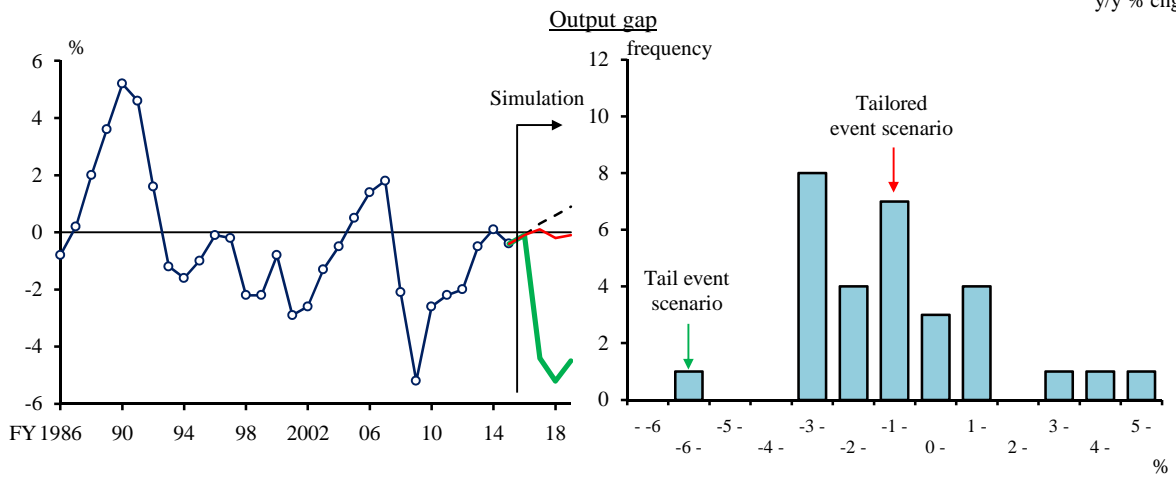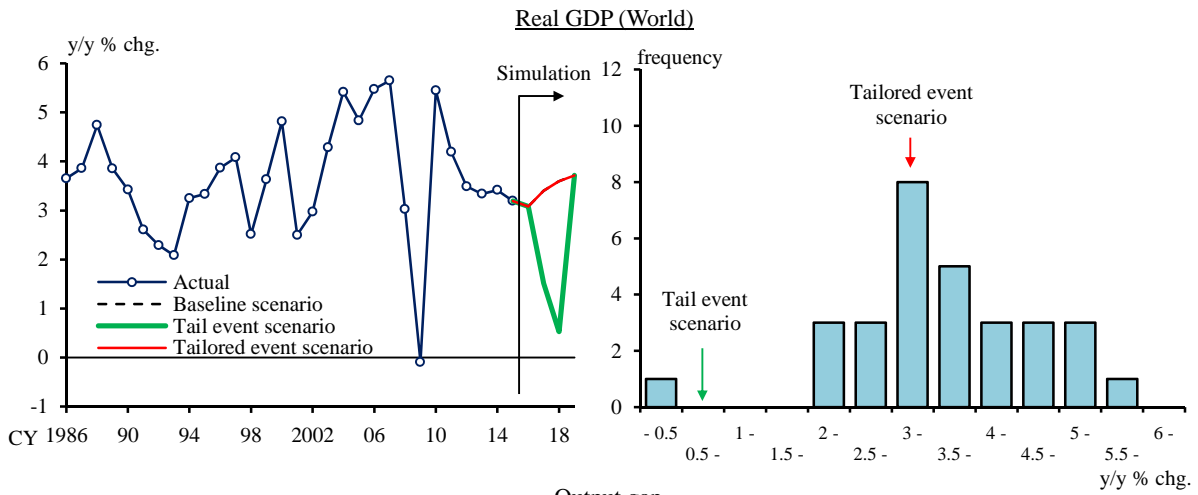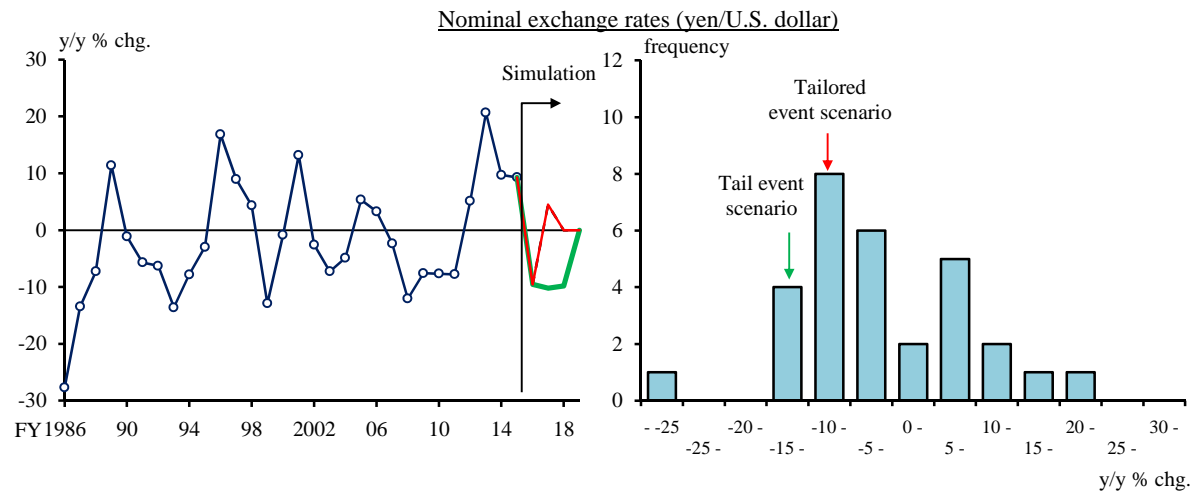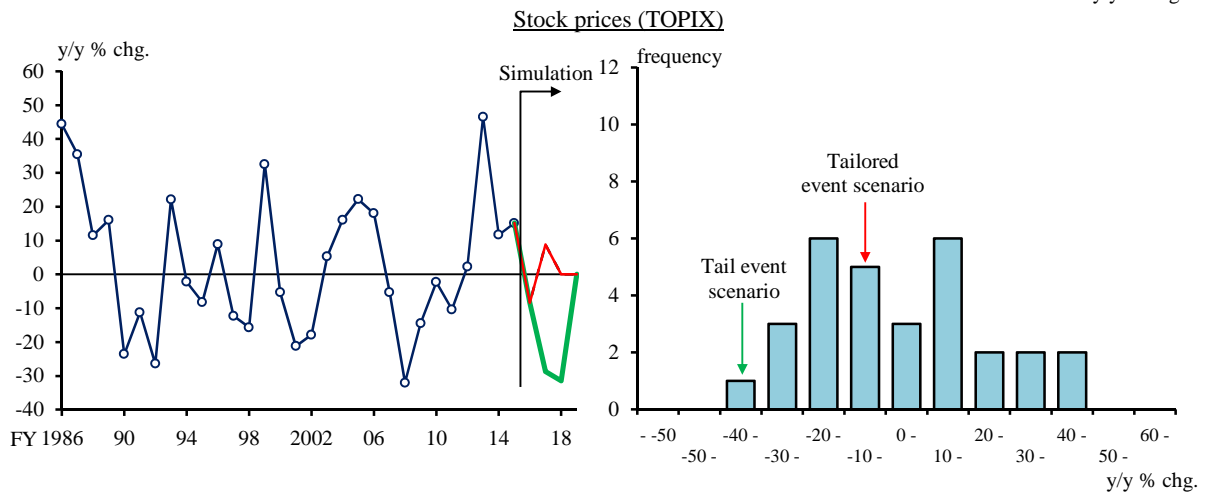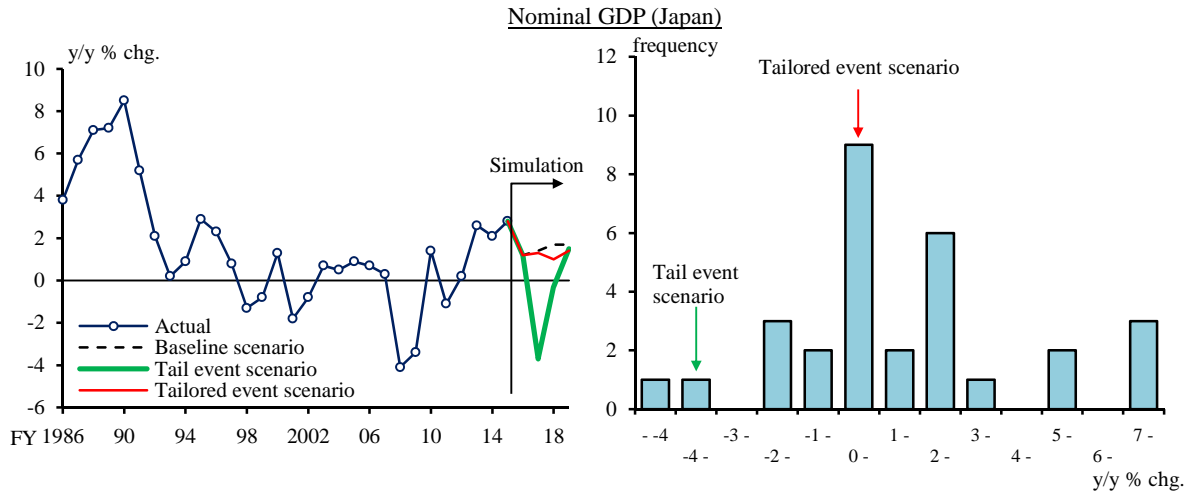

5. Conclusion

In recent years, financial institutions have been placing increasing emphasis on stress testing as a means of capturing and analyzing varied and complex risks as well as their effects on profitability and financial strength, as part of a risk management framework. To perform a constructive stress test on a financial institution, it is critical to develop an appropriate scenario that applies suitably severe stress corresponding to its risk profile. Other important elements of a constructive stress test include the appropriate specification and classification of borrower attributes, and the appropriate selection of financial and economic variables that influence credit costs for each borrower attribute. The stress scenarios in this round are also designed reflecting this viewpoint.

In addition to refining the models used in macro stress testing, the Bank of Japan will continue to enhance communication with financial institutions while making detailed disclosures of the scenarios and test results. The results of this round of macro stress testing can be found in Chapter V of the April 2017 issue of the *Report*. The major economic variables for each scenario can also be downloaded from the Bank of Japan's website (Chart 5-1).[13] Going forward, the Bank of Japan will set out to compare the results of individual financial institutions' stress tests with its own, during its on-site examinations and on other occasions, as part of its dialogue with financial institutions.

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[13] http://www.boj.or.jp/en/research/brp/fsr/data/fsrb170421b.xlsx

Chart 5-1: Characteristics of variables for each scenario[1,2,3]

Real GDP (World)

Output gap

Real GDP (Japan)

13

Nominal GDP (Japan)

Left chart: y/y % chg. axis from -6 to 10. FY 1986, 90, 94, 98, 2002, 06, 10, 14, 18. Simulation. Legend: Actual, Baseline scenario, Tail event scenario, Tailored event scenario.

Right chart: frequency axis 0 to 12. Tailored event scenario. Tail event scenario. y/y % chg. axis: -4, -3, -2, -1, 0, 1, 2, 3, 4, 5, 6, 7.

Stock prices (TOPIX)

Left chart: y/y % chg. axis from -40 to 60. FY 1986, 90, 94, 98, 2002, 06, 10, 14, 18. Simulation.

Right chart: frequency axis 0 to 12. Tailored event scenario. Tail event scenario. y/y % chg. axis: -50, -40, -30, -20, -10, 0, 10, 20, 30, 40, 50, 60.

Nominal exchange rates (yen/U.S. dollar)

Left chart: y/y % chg. axis from -30 to 30. FY 1986, 90, 94, 98, 2002, 06, 10, 14, 18. Simulation.

Right chart: frequency axis 0 to 12. Tailored event scenario. Tail event scenario. y/y % chg. axis: -25, -20, -15, -10, -5, 0, 5, 10, 15, 20, 25, 30.

Notes: *1*. Distribution of world real GDP is compiled with data from 1986 to 2015; distributions of other variables are compiled with data from fiscal 1986 to fiscal 2015.
2. Output gap from fiscal 1986 to fiscal 2015 is estimated by the BOJ.
3. For simulation periods, variables are estimated by the Financial Macro-econometric Model in each scenario and are not the BOJ's forecast.

Sources: Cabinet Office, "National accounts"; IMF, "World economic outlook"; Japan Center for Economic Research, "ESP forecasts"; Tokyo Stock Exchange; BOJ.