FSR – A

Financial System Report Annex

Designing Scenarios in Macro Stress Testing at the Bank of Japan

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 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 irregular basis. This paper offers detailed explanation on scenario development for macro stress testing, a tool for assessing the stability of the financial system.

Abstract

Macro stress testing is a tool for analyzing the effects of adverse shocks to economies and financial markets on the stability of the financial system by employing the model that incorporates the feedback loop between financial and macroeconomic sectors. In the test, stress scenario development processes (i.e., how to design a scenario that threatens financial system) are critical for assessing the stability of the financial system.

The Bank of Japan presents the results of the macro stress testing in the *Financial System Report*. While in previous issues different stress scenarios were employed for each issue, from the October 2015 issue, the tail event scenario and the tailored event scenario are employed. The tail event scenario is characterized by severely adverse financial and economic conditions equivalent to the Lehman shock each time and assesses the stability of the financial system through fixed-point observations. Even in the same scenario, the effect of the stress on the financial system would differ depending on the risk profile and capital strength of the financial institutions as well as financial and economic conditions. On the other hand, the tailored event scenario is flexibly designed to investigate the vulnerability of the financial system under different circumstances for every test and to assess transmission mechanisms of salient risks from a new point of view by extending the model and source data as appropriate.

This document explains the framework of scenario design as well as the narratives and rationale behind the developing of scenarios and provides in detail the scenario employed in the October 2015 issue of the *Financial System Report*.

To help financial institutions develop their own stress testing, the main variables in each scenario are available for downloading from the Bank of Japan's web site.

1. Purpose of the paper

The Bank of Japan publishes the *Financial System Report* semiannually to assess the stability of the financial system with large emphasis on a macroprudential perspective. Macro stress testing plays an important role in the *Reports* as it assesses the stability of the financial system by capturing salient risks that would materialize in financial institutions and simulating profitability and capital of financial institutions under selected stress scenarios.[1]

The Bank of Japan's macro stress testing employs the Financial Macro-econometric Model (FMM), a medium-sized model that has two significant features.[2] First, the model incorporates the financial sector and the macroeconomic sector, and takes account of the feedback loop between the sectors. Second, the model analyzes not only aggregated variables of the financial sector, but also variables of individual financial institutions, such as capital adequacy ratios and profit. The two features of the model enable an analysis of the feedback loop such that substantial stress on the macro economy lowers the profits and capital adequacy ratios of individual financial institutions, which in turn adversely affects the macro economy through a decrease in loans and a rise in loan interest rates (Chart 1-1).
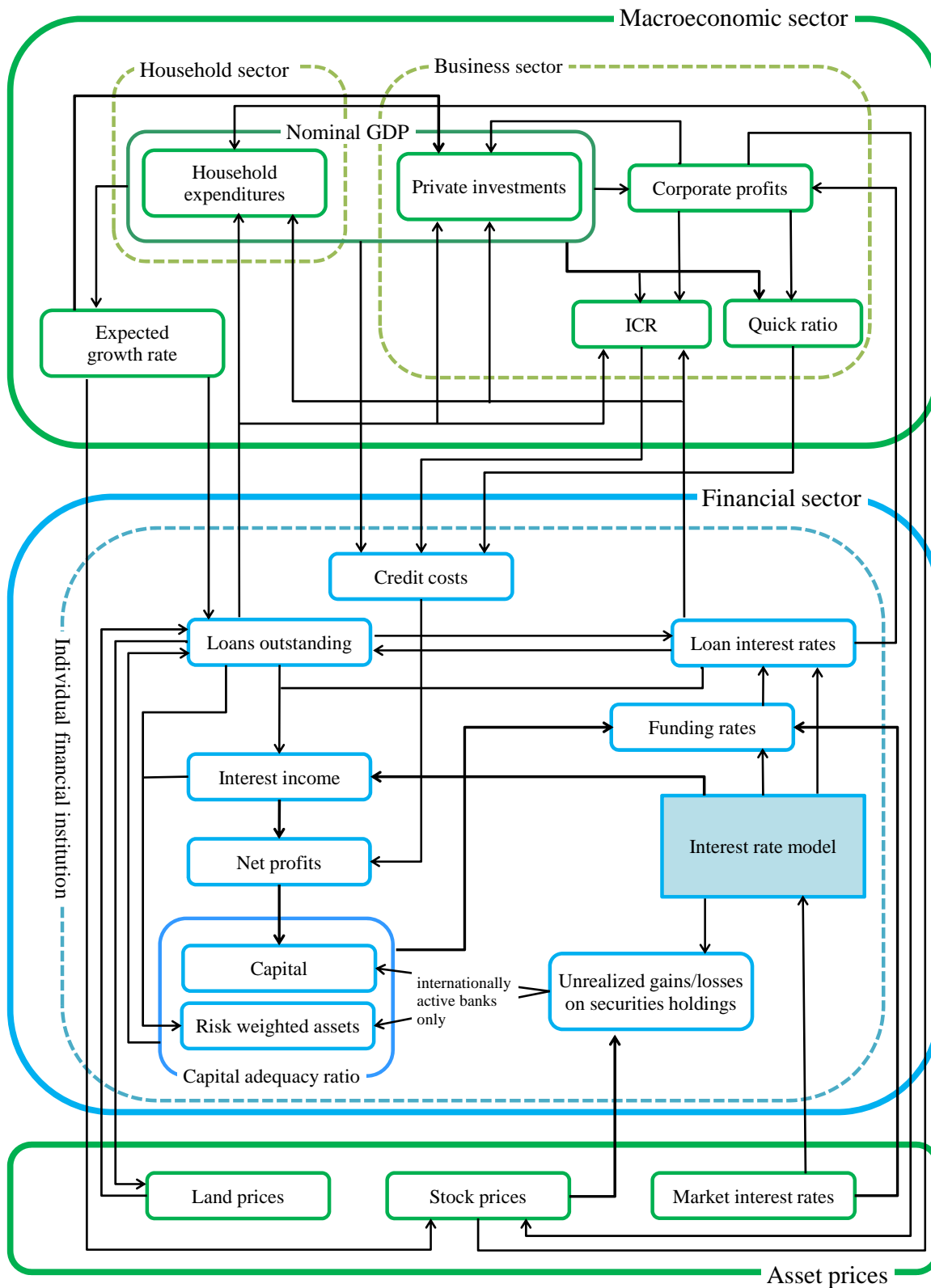
To assess stability of the financial system through macro stress testing, stress scenario development processes (i.e., how to design a scenario that threatens the financial system) are critical. This document explains the framework of scenario design as well as the narratives and rationale behind the development of scenarios and provides in detail the scenario employed in the October 2015 issue of the *Financial System Report*.

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[1] The Bank of Japan has announced the results of macro stress testing in its *Financial System Report* since March 2007.

[2] For details on the FMM, see Tomiyuki Kitamura, Satoko Kojima, Koji Nakamura, Kojiro Takahashi, and Ikuo Takei, "Macro Stress Testing at the Bank of Japan," BOJ Reports & Research Papers, October 2014.

Chart 1-1: Framework of Financial Macro-econometric Model

Macroeconomic sector

Household sector

Business sector

Nominal GDP

Household expenditures

Private investments

Corporate profits

Expected growth rate

ICR

Quick ratio

Financial sector

Individual financial institution

Credit costs

Loans outstanding

Loan interest rates

Funding rates

Interest income

Interest rate model

Net profits

Capital

Unrealized gains/losses on securities holdings

internationally active banks only

Risk weighted assets

Capital adequacy ratio

Land prices

Stock prices

Market interest rates

Asset prices

2. The approach to scenario design for macro stress testing

For the macro stress testing, a baseline scenario is developed to serve as a benchmark in assessing the simulation results under the stress scenarios explained later. In previous *Reports*, a tailored event scenario was developed corresponding to economic and financial developments, the risk profiles of financial institutions, and awareness of risk related to the financial system (Chart 2-1). While this approach flexibly analyzes problems with the financial system each time, it does not allow for fixed-point observations that assess how the financial system's resilience to risks changes over time in response to changes in the economic environment or a financial institution's balance sheets. Accordingly, from the *Financial System Report* of October 2015, in addition to the existing "tailored event scenario," the "tail event scenario," which assumes an approximately equal severe economic and financial environment for each test, is also introduced for fixed-point observation.

Chart 2-1: Past stress scenarios for macro stress testing

Published date	Stress scenarios for macro stress testing
October 2011	1. Economic downturn (an additional shock to the earthquake in 2011) 2. Protracted stagnation (U.S. and European balance-sheet adjustments, domestic electricity supply shortage) 3. Upward interest rate shift 4. Increasing correlation between domestic and overseas financial market (spillover of U.S. treasury market shocks to the JGB markets)
April 2012	1. Economic downturn (an additional shock to the earthquake in 2011) 2. Protracted stagnation (U.S. and European balance-sheet adjustments, further stagnation of low-growth regional economies) 3. Upward interest rate shift 4. Increasing correlation between domestic and overseas financial market (spillover of a drop in European stock prices and a rise in German government bond yields to the JGB markets)
October 2012	1. Economic downturn (stress equivalent to collapse of Lehman Brothers) 2. Upward shift of domestic interest rates
April 2013	1. Economic downturn (stress equivalent to collapse of Lehman Brothers) 2. Upward shift of domestic interest rates with economic improvement
October 2013	1. Economic downturn (stress equivalent to collapse of Lehman Brothers) 2. Upward shift of domestic interest rates with and without economic downturn
April 2014	1. Economic downturn (stress equivalent to collapse of Lehman Brothers) 2. Upward shift of domestic interest rates with economic improvement / upward shift of domestic interest rates with economic downturn
October 2014	1. Economic downturn (stress equivalent to collapse of Lehman Brothers) 2. Upward shift of domestic interest rates with economic improvement / upward shift of domestic interest rates with economic downturn
April 2015	1. Upward shift of interest rates (a rise of long-term interest rates at home and abroad, an appreciation of Japanese yen and a drop in stock prices)

Source: BOJ.

(1) Baseline scenario

The baseline scenario is designed to provide a benchmark for assessing the simulation results of the tail event scenario and the tailored event scenario. In developing the baseline scenario, private sector forecasts are used for the growth rate of the domestic economy, and the global economic forecast by the International Monetary Fund (IMF) is used for the growth rate of overseas economies. Other variables are set in line with the forecasts considering model predictions and the historical patterns of business cycles. In addition, other variables that are not derived from the model or the forecasts by the institutions are set based on simple assumptions (e.g., data follows past trends). It should be noted that the future economic and financial paths indicated by the baseline scenario does not represent the Bank of Japan's outlook.

(2) Tail event scenario

In each *Report*, the tail event scenario offers fixed-point observations that assess the stability of the financial system under severely adverse financial and economic conditions comparable to that at the time of the Lehman shock. Although the same scenario is employed in each *Report*, the degree of impact on the financial system may differ depending on the risk profile and financial strength of financial institutions, or the financial and economic conditions. The scenario is designed according to the following rules.

▽ Rules for designing the tail event scenario

Rule 1: The output gap reaches around minus 7 to minus 8 percent.[3]

Rule 2: The output gap worsens at least by 3 to 4 percentage points (i.e., the average in past economic recessions).

By ensuring that the output gap reaches the historical lowest level since 1980, Rule 1 makes it possible for the tail event scenario to reflect a certain level of severe economic downturn in each stress test (Chart 2-2). That is, regardless of the economic conditions at the time of stress testing, the tail event scenario is basically developed to reflect the most severe economic downturn equivalent to the Lehman shock, which enables an assessment of the stability of the financial system under such severe conditions. This

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[3] The output gap is estimated by the Research and Statistics Department, Bank of Japan. For the estimation procedures, see "The New Estimates of Output Gap and Potential Growth Rate," Bank of Japan Review Series, 2006-E-3.

offers a fixed-point observation that analyzes how the financial system's resilience to stress changes over time in response to changes in capital strength and exposures of financial institutions, and macroeconomic environment.

Chart 2-2: Approach for formulating the tail event scenario

Sources: BOJ, etc.
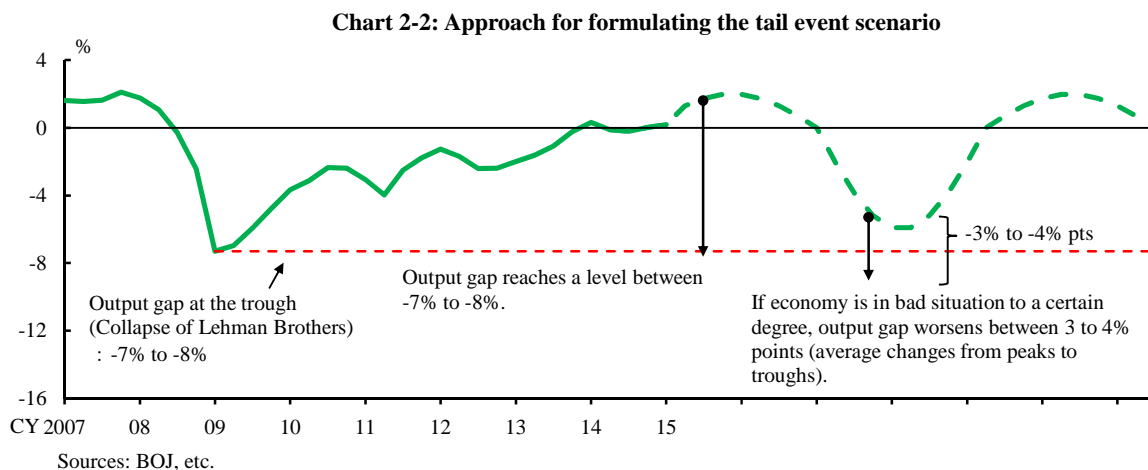
Rule 2 ensures sufficient severity when the economy is in recession. Under Rule 1, the severity of stress (i.e., changes in the output gap) increases in an expansion phase where the output gap is increasingly positive. Conversely, the stress decreases in a recession phase where the output gap is increasingly negative and the stress would not be sufficient for a tail event. For this reason, Rule 2 is introduced to ensure that the output gap worsens by at least 3 to 4 percentage points (Chart 2-3).

Chart 2-3: Output gap and business cycles[1]

%, % pts

Peak to trough	Duration	Output gap at trough	Changes in output gap
1977Q1 to 1977Q4	3 quarters	-1.4	-0.5
1980Q1 to 1983Q1	12 quarters	-0.9	-2.5
1985Q2 to 1986Q4	6 quarters	-0.9	-1.3
1991Q1 to 1993Q4	11 quarters	-1.7	-7.2
1997Q2 to 1999Q1	7 quarters	-2.7	-3.0
2000Q4 to 2002Q1	5 quarters	-3.5	-3.1
2008Q1 to 2009Q1	4 quarters	-7.3	-9.1
2012Q1 to 2012Q4	3 quarters	-2.4	-1.1
Average	6.2 quarters	—	-3.5

Note: *1*. Output gap is estimated by BOJ.
Sources: Cabinet Office; BOJ, etc.

(3) Tailored event scenario

The tailored event scenario is designed each time to investigate the vulnerability of the financial system under specific circumstances. The tailored event scenario is developed

flexibly to analyze important macroprudential topics taking account of financial and economic conditions and risk profiles of financial institutions. The tailored event scenario features various topics that the tail event scenario does not cover as the tail event scenario is basically developed to reflect the same financial and economic conditions at each time of stress testing. While the severity of stress is not necessarily as intense as that in the tail event scenario, the tailored event scenario is designed to assess the transmission mechanism of salient risks from a new point of view by extending the model and source data as appropriate.

(4) Notes on scenario development

Interpretation of stress scenarios: difference from economic forecasts

The stress scenarios in macro stress testing are designed to assess the stability of the financial system and the capital strength of individual financial institutions under stress, and are not necessarily events that are expected, or likely to materialize. That is, stress scenarios are developed to most effectively capture and analyze risks that threaten the stability of the financial system and the soundness of individual financial institutions given the financial system, risk profiles of individual financial institutions, and financial and economic conditions each time. Therefore, the stress scenarios are neither economic forecasts that indicate likely scenarios nor the Bank of Japan's outlook.

Key points in developing stress scenarios: consistency between variables

When developing a scenario, the relationship among economic variables needs to be consistent with economic theories as well as the financial and economic conditions of the scenario. In the Bank of Japan's macro stress testing, consistency is ensured by taking account of the financial and economic conditions of the scenario in addition to structure of the FMM.

For example, in a case in which the output gap worsens, the model implies several possibilities including a decrease in private consumption due to reduced income, a decrease in business fixed investment due to deterioration in corporate profits, and a decrease in exports due to the deterioration of the global economy. If a scenario is designed to examine the effects of a slowdown in overseas economies on the domestic economy, consistency between the scenario and the variables is maintained by substantially reducing exports instead of private consumption and business fixed investment.

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3. Scenarios developed in the *Financial System Report* (October 2015)

This chapter provides an explanation for the development process and background to each scenario developed in macro stress testing in the October 2015 issue of the *Financial System Report*. For the results of macro stress testing, see the October 2015 issue.

(1) Baseline scenario

As mentioned above, the baseline scenario is developed based on forecasts by the IMF and the private sector. Under this baseline scenario, overseas economies will see a recovery, in which recovery in advanced economies spreads to emerging and developing economies with sluggish growth. Under these circumstances, Japan's economy continues its moderate recovery while it decelerates in fiscal 2017 partly due to the effects of the consumption tax hike.

Details for the baseline scenario are as follows. The overseas real GDP growth rate rises moderately from 3.4 percent in 2014 to 3.8 percent toward 2017 (Chart 3-1).[4] Japan's real GDP growth rate rises from 1.2 percent in fiscal 2015 to 1.7 percent in fiscal 2016, exceeding Japan's potential growth rate. However, the growth rate falls to 0.1 percent in fiscal 2017, partly due to the effects of the consumption tax hike.[5] Under these circumstances, the output gap improves from 0.0 percent in fiscal 2014 to 1.6 percent in fiscal 2016, and then falls to 1.1 percent in fiscal 2017.[6] The stock price (TOPIX), 10-year JGB yields, and the yen's nominal exchange rate against the U.S. dollar remain unchanged from the end of March 2015.[7]
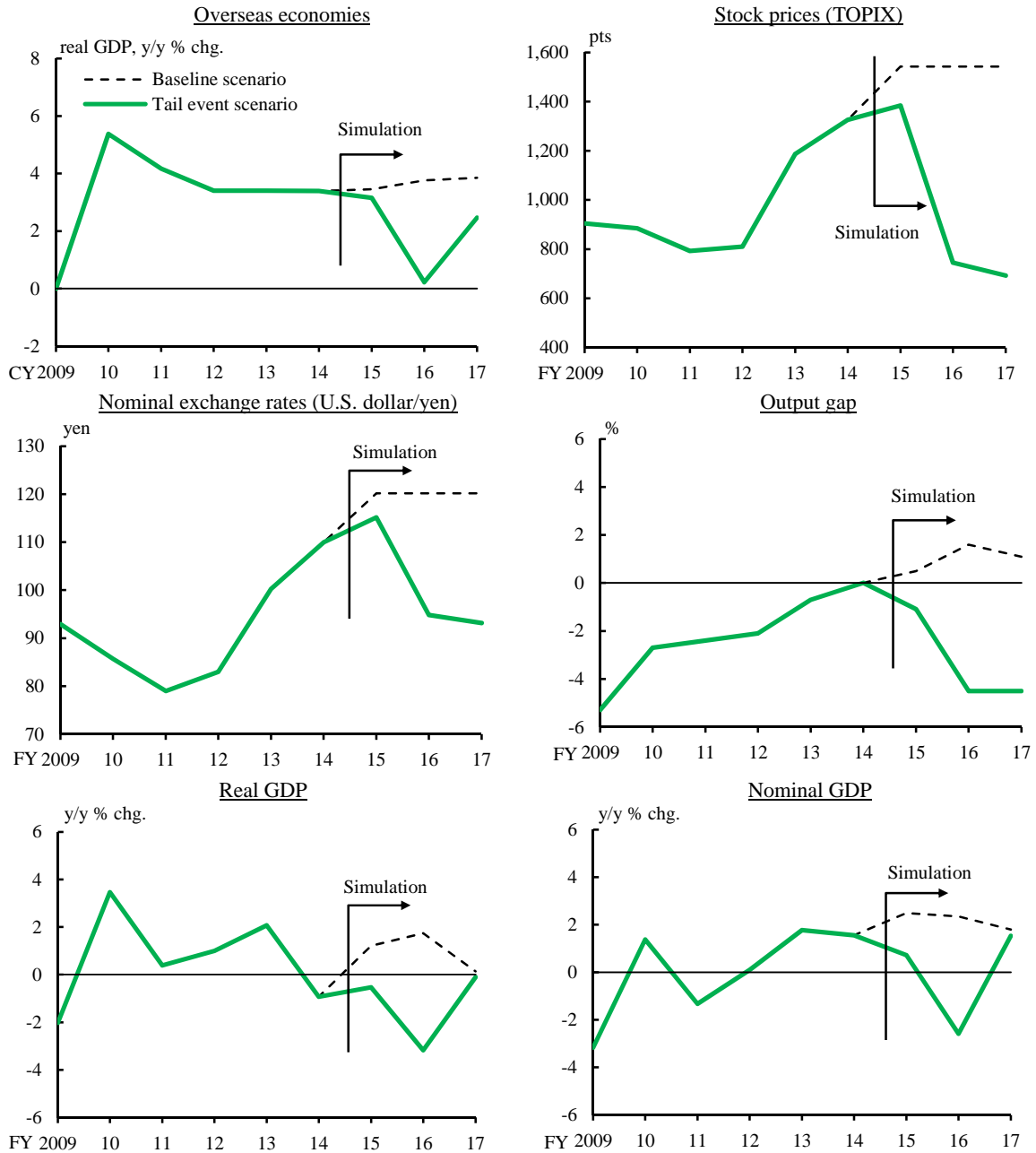
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[4] This is based on long-term forecasts made by the International Monetary Fund (IMF) as of April 2015.

[5] This is based on ESP forecasts made in August 2015.

[6] The potential growth rate during the simulation period is assumed to remain constant at its average for the period from fiscal 2000 onward.

[7] It is assumed that the TOPIX stands at 1,543 points, 10-year JGB yields at 0.405 percent, and the exchange rate (the yen's nominal rate against the U.S. dollar) at 120.21 yen.

Chart 3-1: Summary of variables (tail event scenario)[1]

Overseas economies

Stock prices (TOPIX)

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

Output gap

Real GDP

Nominal GDP

Note: *1*. Output gap from fiscal 2009 to fiscal 2014 is estimated by BOJ. For simulation periods, output gap is estimated by Financial Macro-econometric Model in each scenario and is not BOJ's forecast.

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

(2) Tail event scenario

As mentioned previously, the tail event scenario reflects developments at the time of the Lehman shock and the output gap is assumed to reach minus 7 to minus 8 percent under that scenario. Financial and economic conditions and transmission channels in the tail

event scenario are as follows.

The growth rate of overseas economies sharply falls mainly due to a global financial crisis whose magnitude is similar to the Lehman shock. As for financial markets, overseas stock prices fall due to deterioration of corporate earnings. In foreign exchange markets, the yen appreciates significantly, reflecting a flight-to-safety capital flow.

In the domestic economy, such a substantial decline in overseas economies and the appreciation of the yen sharply reduces Japanese exports.[8] This results in decreases in production, corporate profits, and employee income. With such developments in income, domestic demand (e.g., investment and consumption) decreases, and the growth rate of the domestic economy declines significantly. During this period, the deterioration of confidence and the expected growth rate that stems from the slowdown in domestic and overseas economies puts downward pressure on spending, which leads to a further decline in the growth rate.

As for domestic asset prices, the deterioration of Japanese companies' profitability lowers stock prices. Likewise, the deterioration of the domestic economy lowers real estate prices (land prices). Declines in asset prices adversely affect the domestic economy as consumption decreases due to a wealth effect and lending decreases due to a lower collateral value.

Finally, with regard to the impact on Japan's financial institutions, financial institutions' credit costs increase and their profits decrease as a result of the deterioration of the loan quality which reflects reduced profitability of domestic and foreign firms. Furthermore, as stock prices drop, unrealized losses on securities holdings lower the capital adequacy ratios of internationally active banks. Such a decline in the capital adequacy ratios raises funding costs including those of foreign currencies. Financial institutions' passive stances on lending supply, which stem from weaker capital strength and lower collateral value, also adversely affect the real economy.[9]

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[8] It is also possible that this exerts downward pressure on consumption by foreign visitors to Japan (so-called inbound consumption), which has increased markedly in recent years. Such developments are captured by a decrease in service exports (receipt of travel income).

[9] In addition, it is necessary to consider the impact of changes in the foreign currency funding environment on financial institutions with large exposures to overseas assets. Market funding accounts for a large proportion of Japanese financial institutions' foreign currency-denominated funding. Banks, in general, have sufficient liquidity reserves to cover liquidity needs for a certain period of stressful funding market environment. On this point, if a risk-averse behavior is transmitted to international financial markets or performances of European and American financial institutions that are the main sources of foreign currency for Japanese banks deteriorate amid overseas financial and economic stresses, it is possible that the cost of foreign currency-denominated funding in the

In a simulation with the FMM, taking account of the transmission channels above, the scenario is developed to reflect aforementioned shocks following the Lehman shock episode so that the output gap reaches minus 7 to minus 8 percent. That is, it incorporates negative shocks on the following: (1) the growth rate of overseas economies and exports, (2) asset prices (stock prices and foreign exchange rates) and the expected growth rate, and (3) distributed income (domestic corporate profits and employee income).

Details of the scenario are as follows (Chart 3-1).[10] The growth rate of overseas economies falls sharply from 3.2 percent in 2015 to 0.2 percent in 2016. The growth rate of Japan's economy is only at minus 0.5 percent -- 1.7 percentage points below the baseline scenario level -- in fiscal 2015, and falls substantially negative at minus 3.2 percent in fiscal 2016. The economy continues negative growth in fiscal 2017, standing at a growth rate of minus 0.1 percent. As a result, Japan's output gap deteriorates significantly to minus 1.1 percent in fiscal 2015 and minus 4.5 percent in fiscal 2016, and still remains at minus 4.5 percent in fiscal 2017.[11] In financial markets, stock prices (TOPIX) fall by 55 percent in the 1-year period following the end of September 2015, and afterward remain unchanged. 10-year JGB yields decline by about 0.1 percentage points during the 1-year period, and afterward remain unchanged. As for the nominal exchange rate, the yen appreciates against the U.S. dollar by 23 percent and reaches 93 yen in fiscal 2016, and afterwards remains unchanged.

(3) Tailored event scenario

Background of the tailored event scenario

The tailored event scenario in the *Financial System Report* (October 2015) is characterized by "a slowdown in the Asian economy," and focuses on the materialization of credit risks in overseas lending by Japanese banks and its effects on Japan's financial system. The background is as follows.

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market increases markedly, and this in turn may increase the difficulty of funding itself. Under such conditions, earnings and capital strength may be further worsened if domestic financial institutions are unable to pass the increased funding cost to lending interest rates or are forced to sell off foreign currency-denominated assets. However, the current model does not sufficiently take account of the transmission channel via foreign currency liquidity, and improvement in this area is an issue to be addressed in the future.

[10] Variables in this scenario are set to follow developments of variables at the Lehman shock.

[11] On a quarterly basis, the output gap falls to approximately minus 7.3 percent in the third quarter of 2016.

In recent years, Japanese financial institutions, notably major banks, have rapidly increased overseas lending, particularly to Asian countries, against the backdrop of a decline in the profitability of the domestic market (Chart 3-2). Furthermore, with regard to developments in domestic asset markets during this period, transactions by foreign investors have increased in the stock and real estate markets, and their influence is rising (Charts 3-3 and 3-4). Given such developments, Japanese financial institutions and Japan's financial system are becoming more sensitive to developments in overseas financial and economic conditions.

Chart 3-2: Overseas loans outstanding of three major banks by region
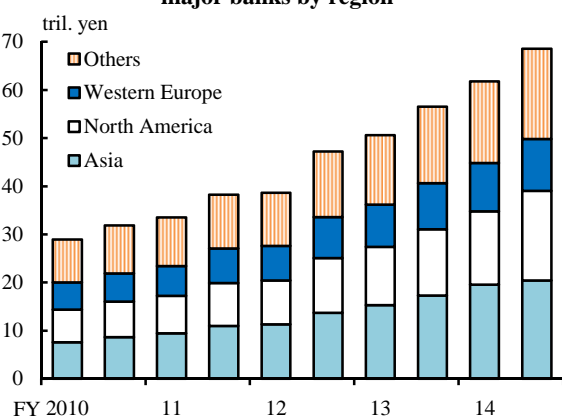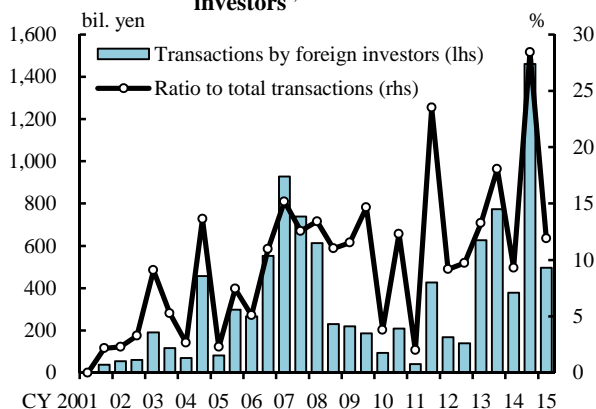

Sources: Published accounts of each bank.

Chart 3-3: Equity transactions by foreign investors[1]
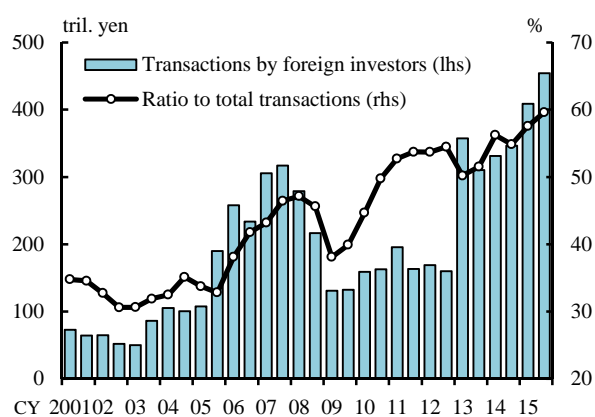
Note: 1. The data are semiannual and are counted from the week that includes the first date of January/July. The latest data are as of July-September 2015 converted into half year.
Source: Tokyo Stock Exchange.

Chart 3-4: Real estate transactions by foreign investors[1,2]

Notes: 1. The latest data are as of the first half of 2015.
2. Foreign investors are as defined by Japan Real Estate Institute.
Source: Japan Real Estate Institute.

As for the global economy, the forecasts of the growth rates, particularly those of emerging economies such as Asia, have been revised downward repeatedly. That is, the economic slowdown has become evident in emerging economies (Chart 3-5).

Chart 3-5: Revisions of projections for world economy by IMF

World | Advanced economies | Emerging market and developing economies
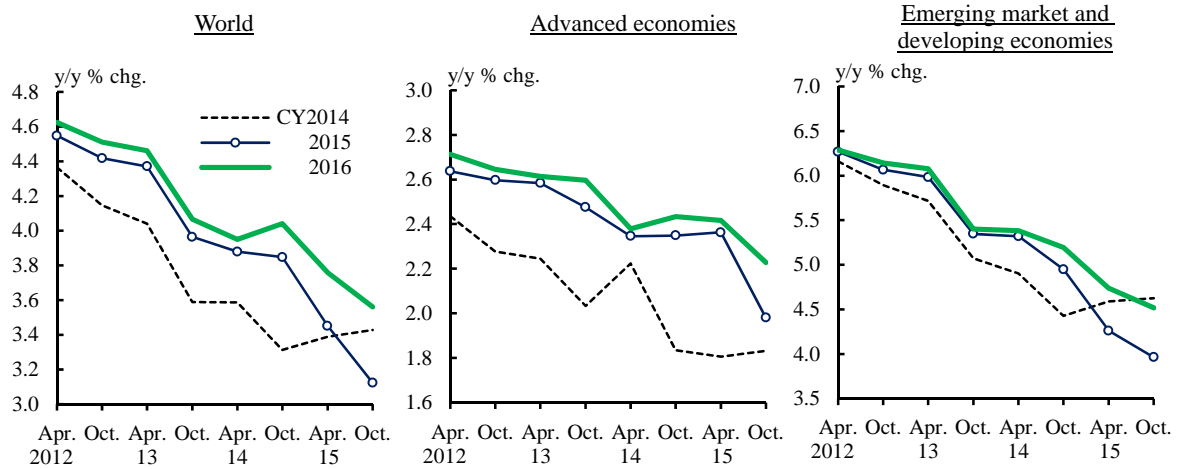
Source: IMF, "World economic outlook."

Given such behavior of Japanese financial institutions and developments in the economic environment, it is crucial to assess the profitability of financial institutions and the stability of the financial system under a scenario that Japan's economy decelerates and asset prices fall due to a slowdown in the global economy, particularly in the Asian economy.

Patterns of the occurrence of credit costs differ from region to region. Thus, in examining credit costs in overseas loans, it is assumed that the size of slowdown differs from region to region, and that in particular the slowdown in the Asian economy is sharper than that of other regions.

Overview of the tailored event scenario

The financial and economic conditions and the transmission channels reflected in the tailored event scenario are as follows.

At the onset of the scenario, the growth rate of the Asian economy decelerates significantly. This significantly lowers the growth rate of its trading partners via trade linkages, and exerts an adverse effect on commodity-exporting countries through a fall in resource prices.[12] As a result, the growth rate of the global economy is significantly lowered. Such significant slowdown in overseas economies lowers the growth rate of Japan's economy by reducing its exports. In addition, overseas investors increase their risk aversion, withdrawing funds that have been flowing to Japan's stock and real estate markets, which in turn causes a fall in stock prices and real estate prices to flow out.

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[12] The decline in commodity prices has a positive effect on the domestic economy through improvements in terms of trade, but the model does not take this into account.

This reduces domestic demand such as investment and consumption through the wealth effect. The reduced domestic demand adversely affects Japan's economy.
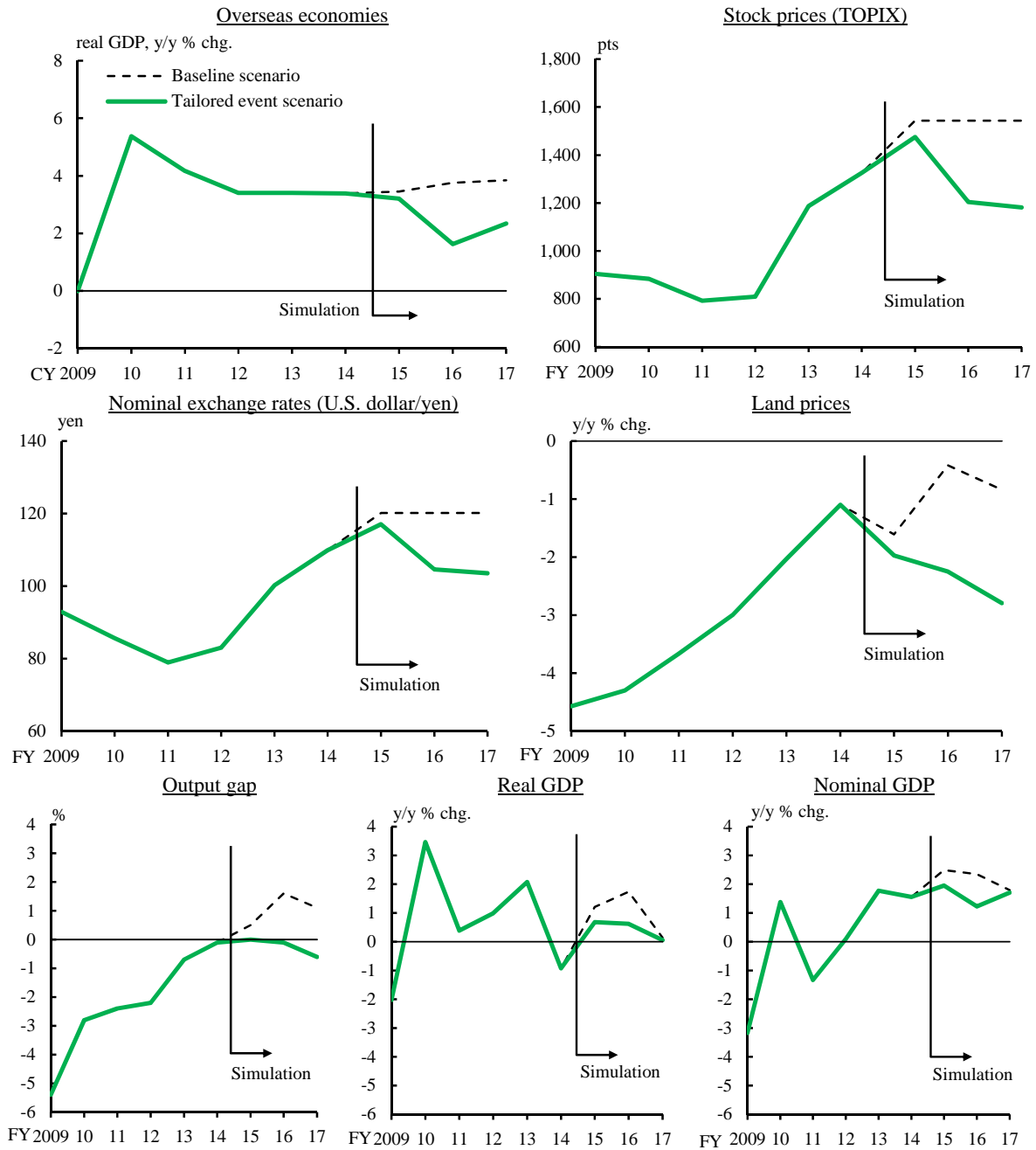
With respect to the effect on financial institutions, foreign companies are greatly affected by a significant slowdown in overseas economies and their probabilities of default substantially increase, which result in considerable credit costs in overseas lending. In particular, financial institutions with large exposure to overseas lending are deeply affected in terms of profitability and capital strength. Credit costs also occur in domestic lending due to deterioration in the performance of domestic companies caused by a slowdown in the domestic economy. In addition, the occurrence of unrealized losses on securities holdings resulting from a fall in stock prices lowers the capital adequacy ratios of internationally active banks. Financial institutions' passive stance on lending supply due to weaker capital strength and the decline in collateral value caused by a fall in real estate prices also adversely affects the domestic economy.

In the simulations, a vector auto regression (VAR) model is used to estimate the slowdown in overseas economies if the growth rate of the Asian economy declines to a level almost equivalent to that during the Asian currency crisis. An additional shock to exports is applied to reflect a sharper slowdown in the Asian economy, a key destination for Japanese exports. Further, in accordance with the assumption that overseas investors withdraw investments to Japan, shocks to stock prices and real estate prices (land prices) are applied, that is, the size of the shocks is larger than that would stem solely from the slowdown in the domestic economy. In contrast to the tail event scenario, no other shocks (e.g., shocks to income or expected growth) are directly applied to the domestic economy in the tailored event scenario, because the tailored event scenario focuses on the slowdown in overseas economies and its impact on credit costs for overseas loans.

The details of the scenario are as follows (Chart 3-6). The growth rate of the Asian economy declines significantly, from 6.8 percent in 2014 to 6.2 percent in 2015 and to 3.0 percent in 2016. The growth rate in 2016 is approximately equivalent to that of the Asian economy during the Asian currency crisis. Such significant slowdown in the Asian economy spills over into other countries via international trade linkages and lowers commodity prices. Such transmissions lower the growth rate of overseas economies to 3.2 percent in 2015 and to 1.6 percent in 2016. As a result, a decrease in exports puts downward pressure on Japan's economy, with the growth rate of real GDP declining to 0.7 percent in fiscal 2015, 0.6 percent in fiscal 2016, and further to 0.1 percent in fiscal 2017. The slowdown of the global economy affects overseas

Chart 3-6: Summary of variables (tailored event scenario)[1]

Overseas economies

Stock prices (TOPIX)

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

Land prices

Output gap

Real GDP

Nominal GDP

Note: *1*. Output gap from fiscal 2009 to fiscal 2014 is estimated by BOJ. For simulation periods, output gap is estimated by
Financial Macro-econometric Model in each scenario and is not BOJ's forecast.

Sources: Bloomberg; Cabinet Office, "National Accounts"; IMF, "World economic outlook"; Japan Center for Economic
Research, "ESP forecasts"; Japan Real Estate Institute, "Urban land price index"; BOJ.

investors' behaviors and the capital that has flowed into Japan's stock and real estate
markets flows out. Reflecting such an outflow of the capital, stock prices fall by 23
percent over a 1-year period following the end of September 2015, while the
year-on-year rate of change in land prices in fiscal 2017 declines to minus 2.8 percent,

approximately 2.0 percentage points below the baseline.[13] As for the yen's nominal exchange rate, the yen appreciates against the U.S. dollar, reaching 104 yen over the 1-year period following the end of September 2015, and then remains unchanged thereafter.

Analysis of overseas credit cost

The simulation in the tail event scenario is not designed to analyze loan portfolios separately by country or region. In the tailored event scenario, the model and data are extended to analyze loan portfolios separately by country or region, as it is characterized by a slowdown in overseas economies, especially in Asia.

More concretely, the effects of the rise in probabilities of default for overseas companies amid a slowdown in overseas economies on a borrower classification transition matrix is calculated with regard to the three major banks with large exposures to overseas loans.[14] Details of the procedure are as follows.

(1) Moody's rating classifications are mapped into the borrower classification of Japanese financial institutions. In accordance with this mapping, Moody's rating transition matrix by region (North America, Europe, Asia, and Other) is converted into the borrower classification transition matrix for overseas lending by region.[15]

(2) The difference between the borrower classification transition matrix under stress (M_h) for each region and that of long term average ($\overline{M}_h$) is calculated to measure the adverse effect on the borrower classification transition matrix under stresses (Chart 3-7 and 3-8).[16] In addition, the decrease in the growth rate of real GDP under stress from the long-term average growth rate (ΔGDP_h) is calculated for each region. With this information, the change in the borrower classification transition matrix in response to a 1 percentage point change in the real GDP growth rate $\Delta M_h \left(= \left(M_h - \overline{M}_h \right) / \Delta GDP_h \right)$ is obtained.

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[13] The rate of decline in stock prices and the pace of year-on-year decline from the baseline level for land prices are set taking into account the growth rate of domestic and overseas economies.

[14] Mizuho Bank, The Bank of Tokyo-Mitsubishi UFJ, and Sumitomo Mitsui Banking Corporation.

[15] For the other regions, the transition matrix for the world is used.

[16] The crises referred to are the Asian Currency Crisis (data for 1997 and 1998) for Asia and the Lehman shock (data of 2009) for the other three regions. Furthermore, averaged over transition matrices are measured with the data from 1990 to 2003 for Asia and with data from 1970 to 2009 for the other regions. The data show that the probability of default in Asia during the Asian currency crisis is higher than that of the U.S. and Europe during the Lehman shock.

Chart 3-7: Borrower classification transition probabilities by region[1]
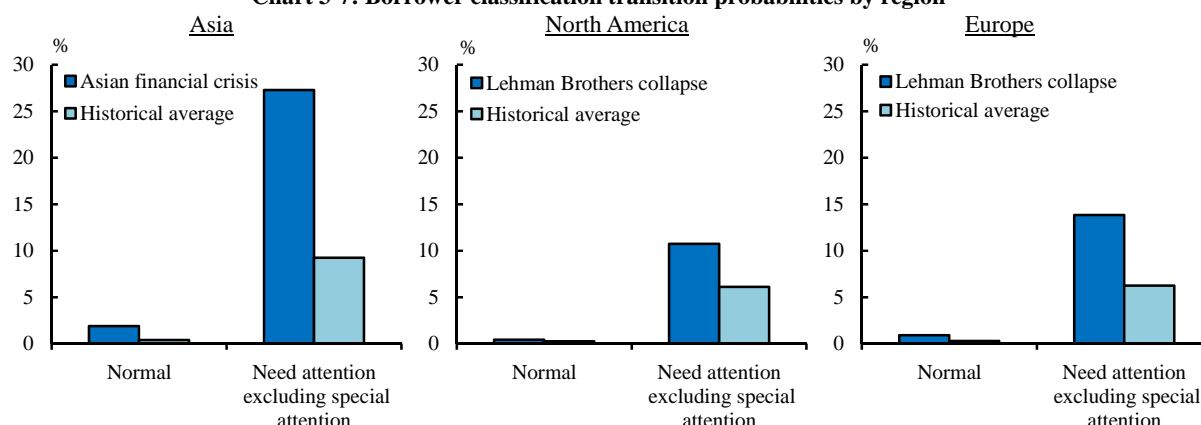
Note: *1*. The vertical axes show the transition probabilities to "special attention" or lower borrower classifications. The horizontal axes show the borrower classifications before transition.

Sources: Moody's; BOJ.

Chart 3-8: Transition probabilities for Asia[1]

(M_h) 1997 - 1998 (Asian financial crisis)

%

from \ to	Normal	Need attention excluding special attention	Special attention	In danger of bankruptcy	De facto bankrupt or bankrupt
Normal	95.93	2.18	0.00	1.81	0.09
Need attention excluding special attention	0.00	72.73	0.00	4.55	22.73
Special attention	0.00	0.00	0.00	0.00	0.00
In danger of bankruptcy	0.00	0.00	0.00	50.00	50.00

($\bar{M}_h$) Historical average (1990 - 2003)

%

from \ to	Normal	Need attention excluding special attention	Special attention	In danger of bankruptcy	De facto bankrupt or bankrupt
Normal	99.24	0.37	0.00	0.29	0.10
Need attention excluding special attention	10.83	79.92	0.00	3.35	5.91
Special attention	0.00	0.00	0.00	0.00	0.00
In danger of bankruptcy	0.59	4.58	0.00	82.10	12.73

(M_h - $\bar{M}_h$) Shocks to transition probabilities between categories under stress period

% pts

from \ to	Normal	Need attention excluding special attention	Special attention	In danger of bankruptcy	De facto bankrupt or bankrupt
Normal	-3.31	1.81	0.00	1.52	-0.02
Need attention excluding special attention	-10.83	-7.19	0.00	1.20	16.82
Special attention	0.00	0.00	0.00	0.00	0.00
In danger of bankruptcy	-0.59	-4.58	0.00	-32.10	37.27

Note: *1*.Moody's rating classifications do not correspond strictly to borrower classifications by banks. Therefore, shocks to transition probabilities are calculated with some assumptions (e.g., Moody's rating equivalent to "special attention" is counted as "in danger of bankruptcy").

Sources: Moody's; BOJ.

(3) A growth rate of real GDP in each region given a slowdown in the Asian economy is estimated by VAR (the left-hand column of Chart 3-9) and the size of a decrease in the growth rate of real GDP (ΔGDP_s) during the simulation period is obtained. Next, by multiplying ΔGDP_s and ΔM_h, the deterioration in the borrower classification transition matrix $\text{M}_s (= \Delta\text{GDP}_s * \Delta\text{M}_h)$ during the simulation period is obtained (the right-hand column of Chart 3-9).[17]

(4) A weighted average of the changes of the borrower classification transition matrices in each region based on their loans outstanding is used for that in overall overseas lending. By multiplying this matrix and the ratio of overseas lending in total lending to firms, the impact of the credit deterioration of the overseas firms on domestic and overseas borrower classification transition matrix is obtained. In performing simulations, the borrower classification transition matrix is changed in line with this impact (Chart 3-10).
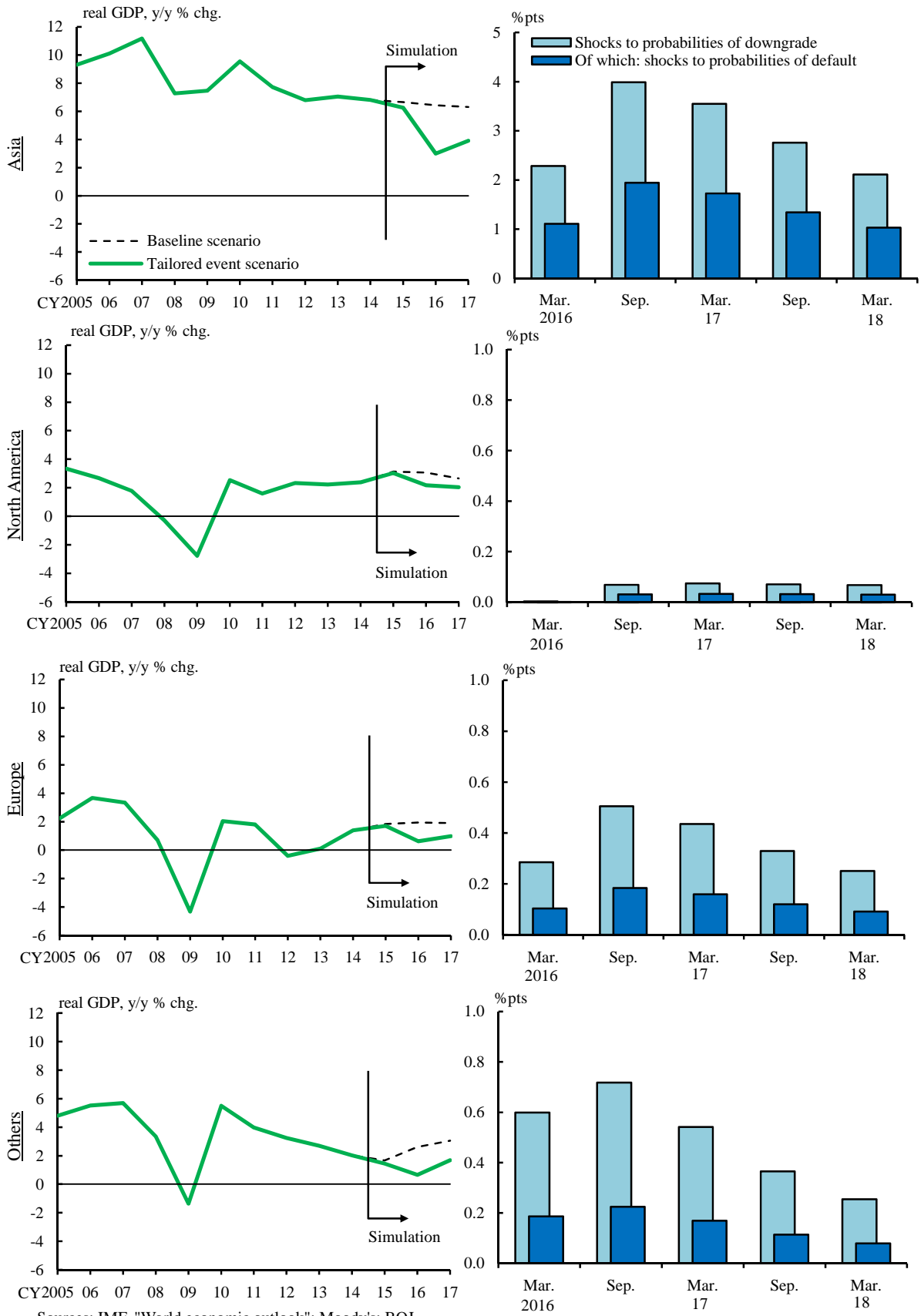
According to the above procedures, the average of the three major banks' borrower classification transition matrices shows that the probability of downgrading increases by around 0.6 percentage points and the probability of default increases by around 0.3 percentage points in the first half of fiscal 2016, compared to those of the baseline (Chart 3-10).[18]

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[17] The change in the borrower classification transition matrix in Asia is greater than that in other regions since its growth rate of real GDP falls more and its sensitivity of the borrower classification transition matrix to the growth rate of real GDP is higher.
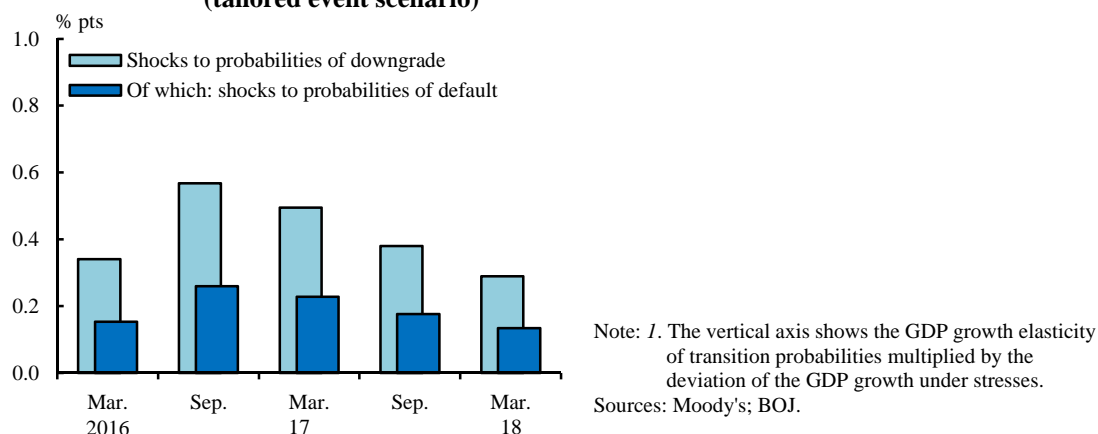
[18] Probability of default is defined as a probability that a borrower classified as normal or need attention falls to special attention or worse classifications.

Chart 3-9: Overseas economies and shocks to transition probabilities (tailored event scenario)

Asia

real GDP, y/y % chg.

- - - Baseline scenario
— Tailored event scenario

Simulation

%pts

■ Shocks to probabilities of downgrade
■ Of which: shocks to probabilities of default

Mar. 2016   Sep.   Mar. 17   Sep.   Mar. 18

North America

real GDP, y/y % chg.

Simulation

%pts

Mar. 2016   Sep.   Mar. 17   Sep.   Mar. 18

Europe

real GDP, y/y % chg.

Simulation

%pts

Mar. 2016   Sep.   Mar. 17   Sep.   Mar. 18

Others

real GDP, y/y % chg.

Simulation

%pts

Mar. 2016   Sep.   Mar. 17   Sep.   Mar. 18

Sources: IMF, "World economic outlook"; Moody's; BOJ.

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Chart 3-10: Shocks to transition probabilities
(tailored event scenario)[1]

Note: 1. The vertical axis shows the GDP growth elasticity of transition probabilities multiplied by the deviation of the GDP growth under stresses.
Sources: Moody's; BOJ.

4. Conclusion

With financial institutions' business models evolving and their risk profile increasing in complexity, it is necessary for financial institutions to increase the sophistication of their risk management, and a stress test works as a potent tool. Although financial institutions rapidly expand their overseas business and portfolio investments, they may not have sufficient data to conduct stress testing, due to the short period of time involved. In such a case, it is necessary for financial institutions to devise ways of designing scenarios and conducting stress tests effectively, such as by utilizing external data as demonstrated in this paper.

When an individual financial institution conducts stress testing, it generally does not consider the impact of its behavioral change on the macro economy and the financial system. However, under a stress which involves all financial institutions, when each financial institution adopts a lending behavior similar to other institutions, this could pose an adverse effect to the macro economy, which further deteriorates the profitability and financial strength of each financial institution and the financial system overall. In this regard, macro stress testing at the Bank of Japan incorporates the behaviors of individual financial institutions, which are aggregated to that of the overall financial sector, thereby making it possible to examine the interaction between the financial system and the macro economy. Accordingly, it will be helpful for financial institutions to compare the results of their own stress tests with those of the Bank of Japan.

The main variables in the scenarios explained in this paper are shown in Chart 4-1, and are available for downloading from the Bank of Japan's web site.[19] In order to enhance

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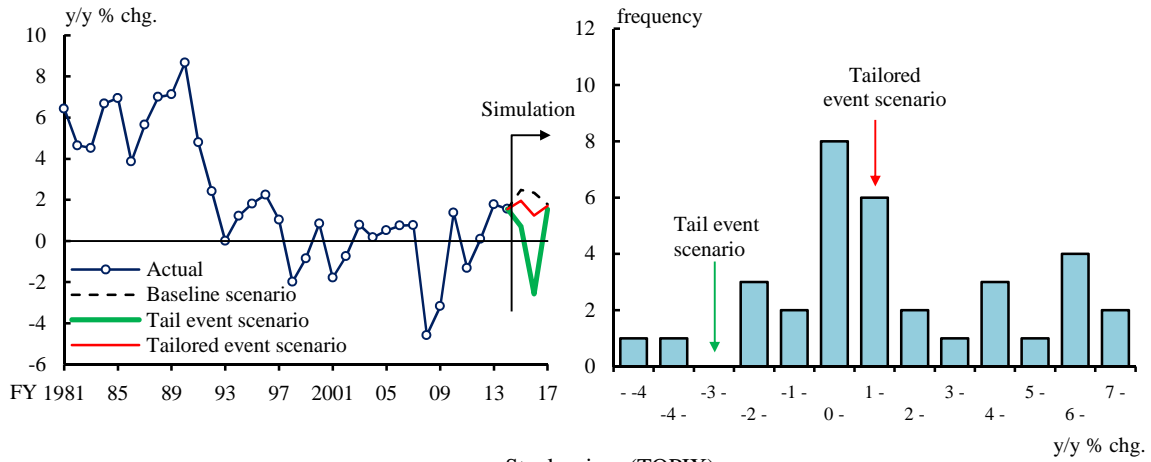[19] http://www.boj.or.jp/en/research/brp/fsr/data/fsrb151026b.zip

communication with financial institutions, the Bank of Japan continues to improve the models of macro stress testing, and discloses the scenarios and test results in detail.
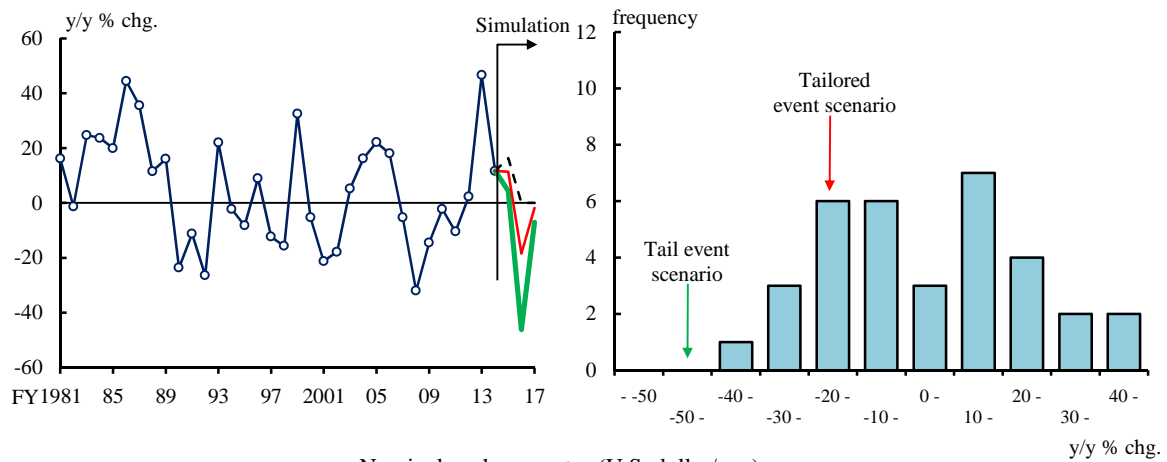
Chart 4-1: Characteristics of variables for each scenario[1,2]
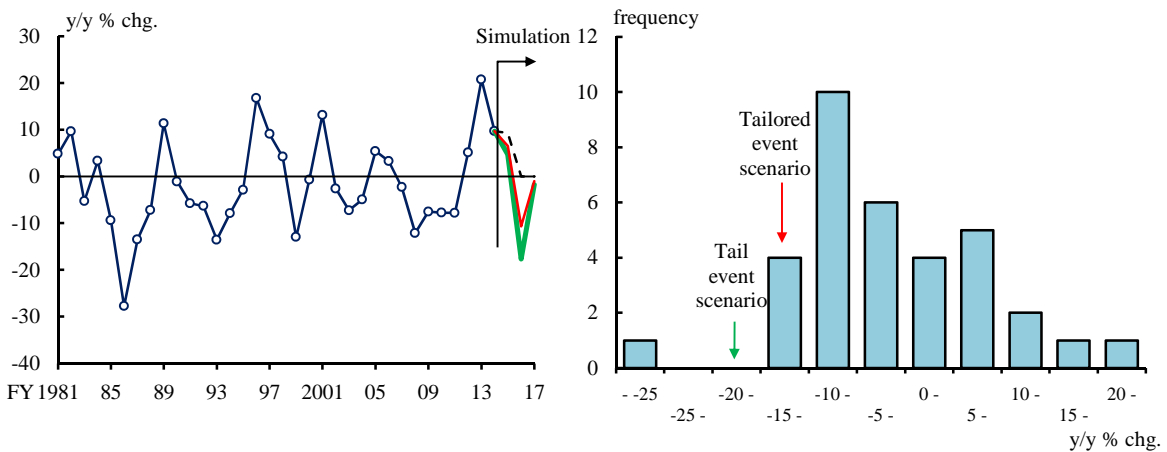
Overseas economies

Output gap

Real GDP
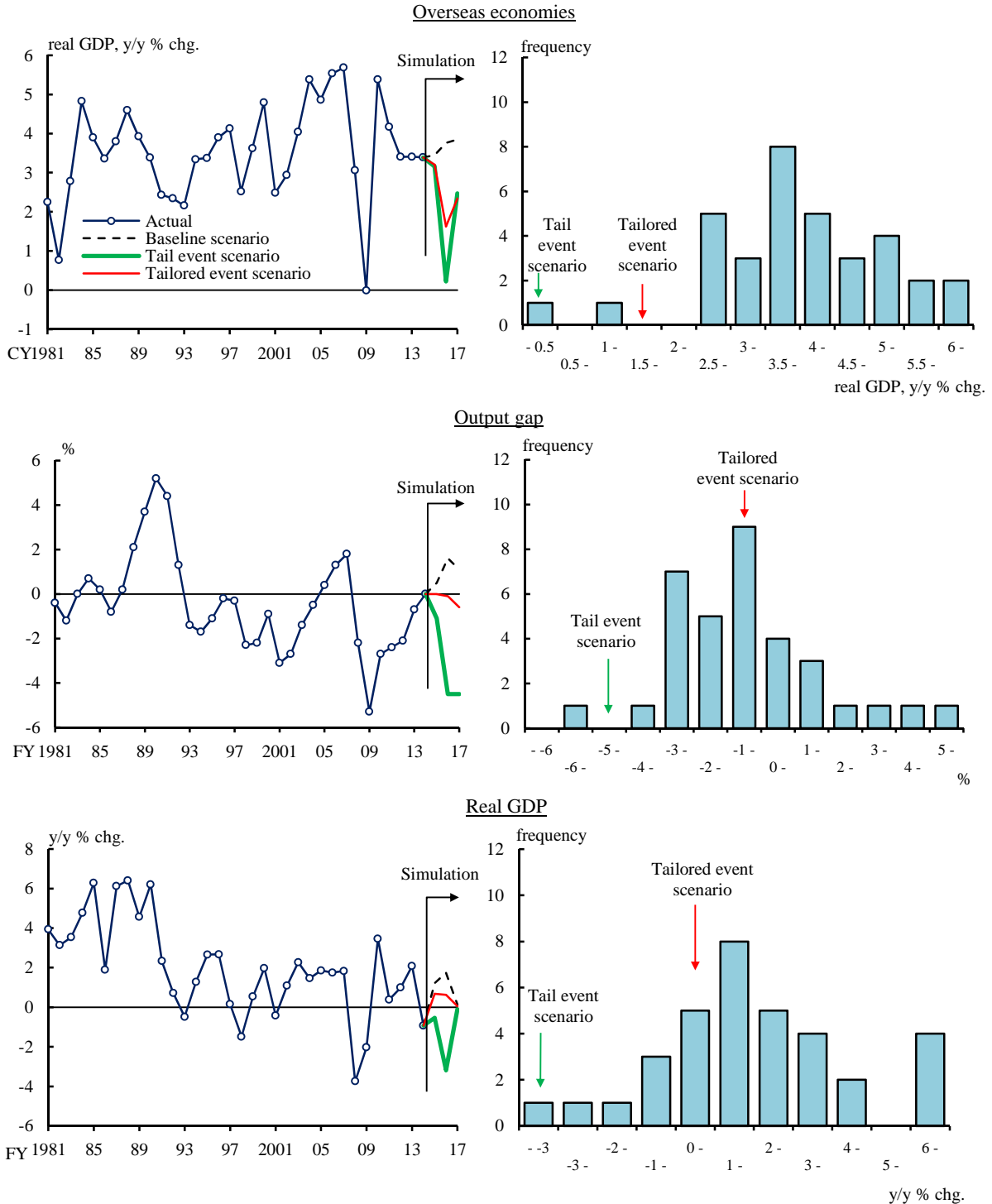
Nominal GDP

Stock prices (TOPIX)

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

Notes: *1*. Distribution of overseas economies is compiled using data from 1981 to 2014; distributions of other variables are compiled using data from fiscal 1981 to fiscal 2014.
      2. Output gap from fiscal 2009 to fiscal 2014 is estimated by BOJ. For simulation periods, output gap is estimated by Financial Macro-econometric Model in each scenario and is not BOJ's forecast.
Sources: Bloomberg; Cabinet Office, "National accounts"; IMF, "World economic outlook"; Japan Center for Economic Research, "ESP forecasts"; BOJ.