Macro stress testing at the Bank of Japan

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Objectives

- The Bank of Japan (BoJ) aims to achieve two primary objectives by conducting the macro stress test:
  1. Identifying potential risks Japan's financial institutions face and evaluating the resilience of the Japan's financial system against those risk factors.
  2. Facilitating communication with relevant domestic and foreign parties in order to secure the stability of the financial system.

Scope and publication

- The framework incorporates activities of 371 banks.
  - 10 major banks (including G-SIBs), 105 regional banks, and 256 *shinkin* banks (regional cooperative financial institutions).

- The aggregate-level results of the macro stress test are reported in Financial System Report (FSR) semiannually.

- The scenario design and changes made to our model, *etc.* are reported in FSR annex series.

- Paths of main variables in the scenarios are published on the BOJ website
  - Relevant macroeconomic series such as domestic GDP, international GDP, stock prices, nominal interest rates, and exchange rates

Main features of our models

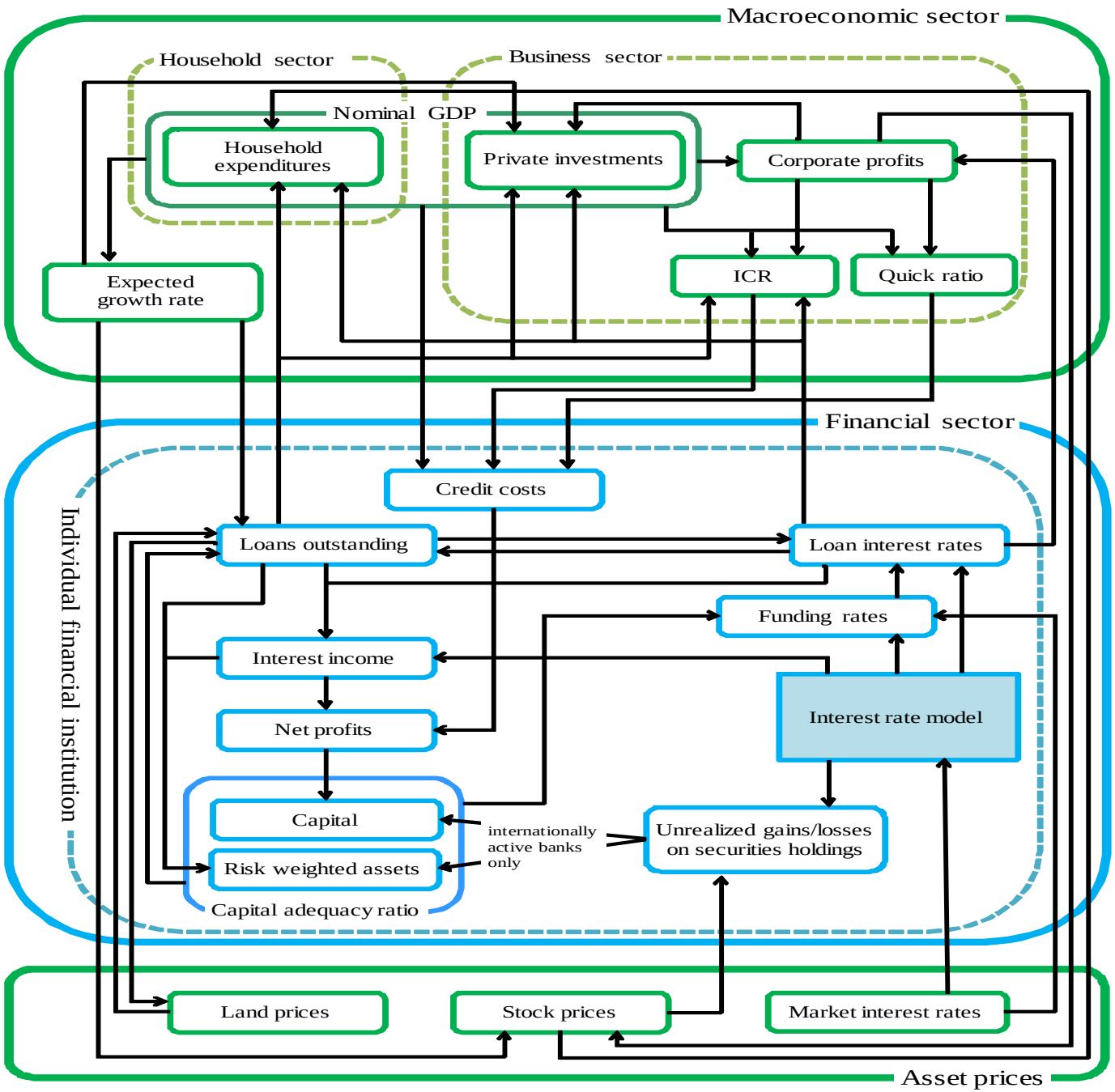
- Our stress testing is of top-down type.
- Two models for stress testing: FMM and interest rate model
- Financial Macro Econometric model (FMM): the main model
  - Incorporates **feedback loops between macroeconomy and financial sector**
- Interest rate model: the satellite model
  - Calculate the effects of changes in market interest rates:
    - effects on lending and funding rate
    - effects on unrealized gain/loss of bonds
- The details of the models are published: See Kitamura *et al*, “Macro Stress Testing at the Bank of Japan”, 2014 (http://www.boj.or.jp/en/research/brp/ron_2014/ron141008a.htm/)

Overview of FMM

Macroeconomic Sector

Financial Sector

Asset Prices



Key FMM equations to capture the feedback loops

- Interest coverage ratio of business sector (ICR)

  $ICR = f_{ICR}(NGDP, other\ variables)$

- Credit costs of bank b (CC_b)

  $CC_b = f_{PD}(ICR, NGDP, other\ variables)$

- Capital adequacy ratio of bank b (CAR_b)

  $\Delta CAR_b = f_{CAR}(CC_b, other\ variables)$

- Loans outstanding of bank b (L_b)

  $L_b = f_{CAR}(CAR_b, other\ variables)$

- Nominal GDP ($NGDP$)

  $\Delta NGDP = f_{NGDP}(\Delta \sum_b L_b, other\ variables)$

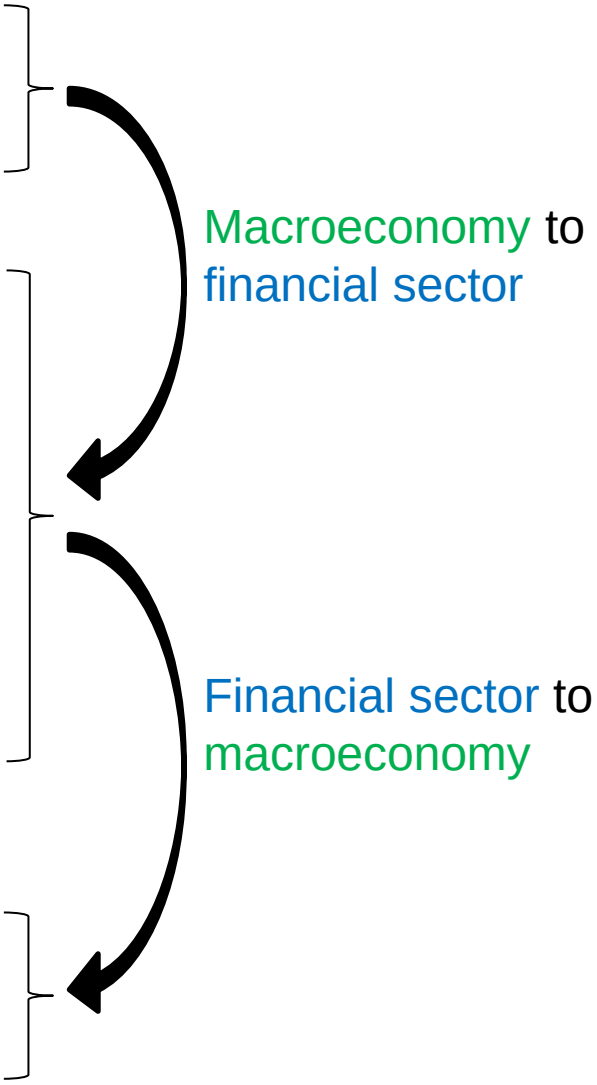
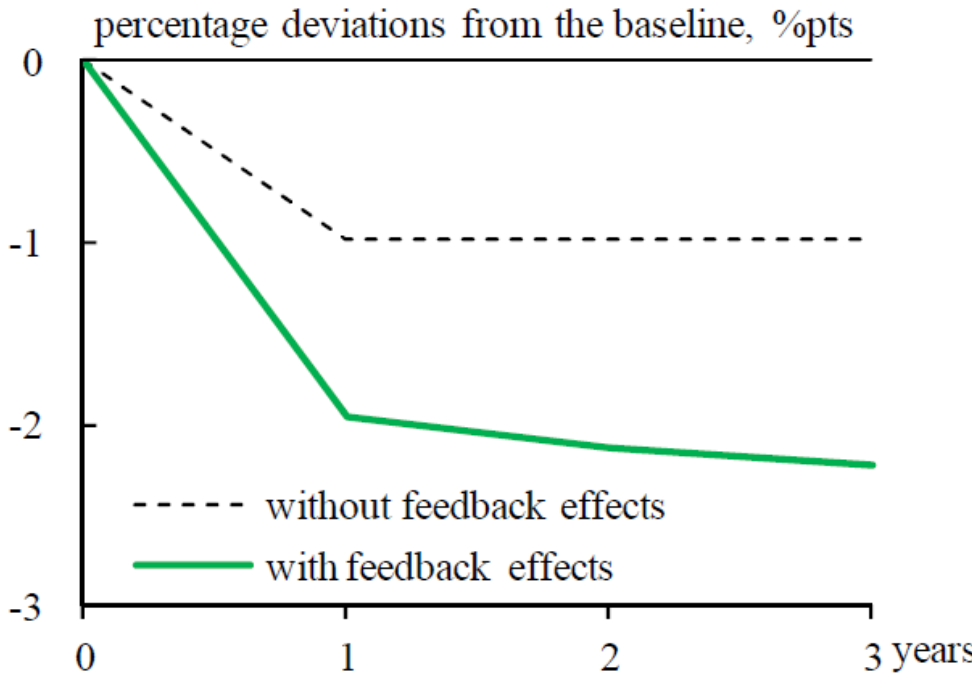
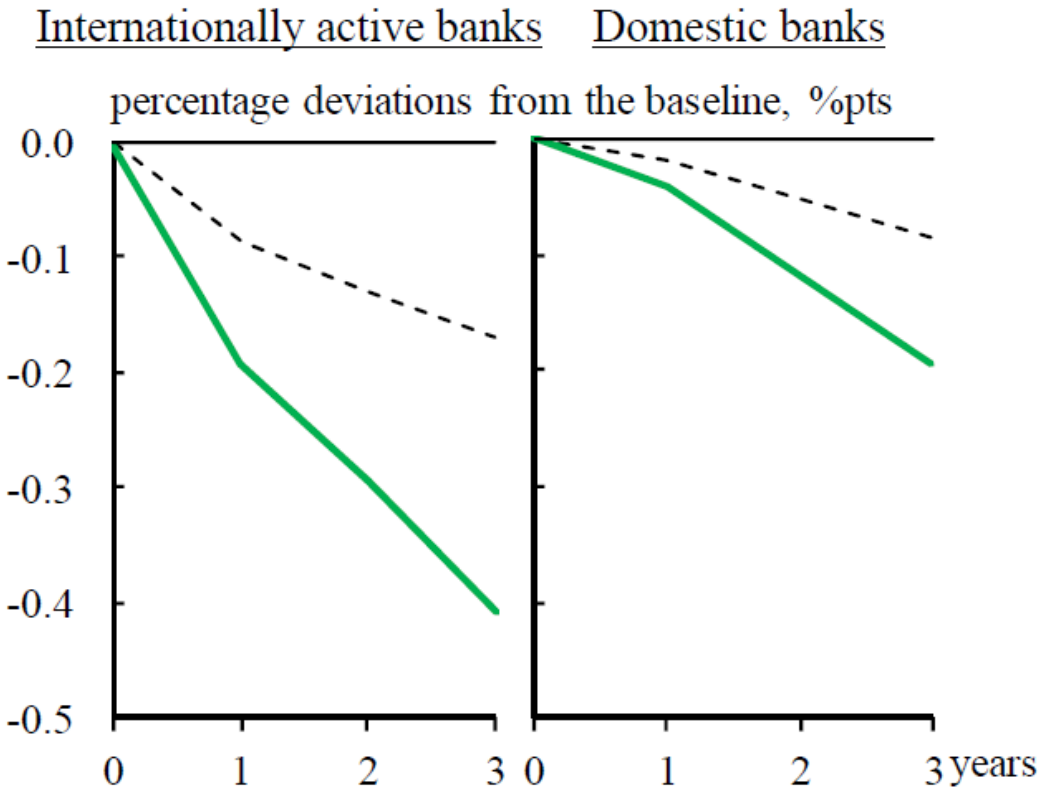


Illustration of the feedback effects

Nominal GDP



Capital Adequacy Ratio



Credit losses of loans

- Credit losses are calculated based on the transitions of loans between banks' internal rating categories.
  - Different categories have different loan-loss provisioning rates.
  - Worse categories have higher rates.
  - Moving from better to worse category entails credit losses.

- The transition probabilities are linked with corporate financial strength (B/S, P/L) and macroeconomic conditions.

Example of the estimation of transition probabilities

D.1-8. Transition probability from m to n ($m \neq n$)

$$\ln\left(\frac{PT_{i,t}^{mn}}{1-PT_{i,t}^{mn}}\right) = \overline{\alpha^{mn}} + \alpha_i^{mn} + \beta^{mn} \cdot \text{nominal GDP growth rate}_t + \gamma^{mn} \cdot \text{ICR}_t + \delta^{mn} \cdot \text{quick ratio}_t + \eta^{mn} \cdot \text{DE ratio}_t$$

$PT_{i,t}^{mn}$ is transition probability of bank i from category m to n.

$\overline{\alpha^{mn}}$ is the mean value of bank i's fixed effect ($\overline{\alpha^{mn}} + \alpha_i^{mn}$).

m		n = 1	2	3	4	5
1	β		—	—	-3.96*	-9.25***
	γ		-0.07*** L: -0.06***	—	-0.14***	-0.16***
	δ		-2.68***	-8.06*** L: -9.05***	-7.88***	-20.12***
	η		—	—	—	—
2	β	—		—	—	—
	γ	0.08***		—	-0.03***	-0.18***
	δ	—		-6.40*** L: -4.43**	—	-10.27***
	η	—		—	—	—
3	β	—	—		—	—
	γ	MA2: 0.10**	—		O: -0.20**	O: -0.19* R, MA2: -0.18***
	δ	—	MA4: 2.28*		—	—
	η	—	—		—	—
4	β		—	—		—
	γ		—	MA2: 0.10**		-0.07***
	δ		3.27***	—		-9.19***
	η		—	—		—

Notes: 1. Category 1: normal; category 2: need attention excluding special attention; category 3: special attention; category 4: in danger of bankruptcy; category 5: de facto of bankrupt or bankrupt.

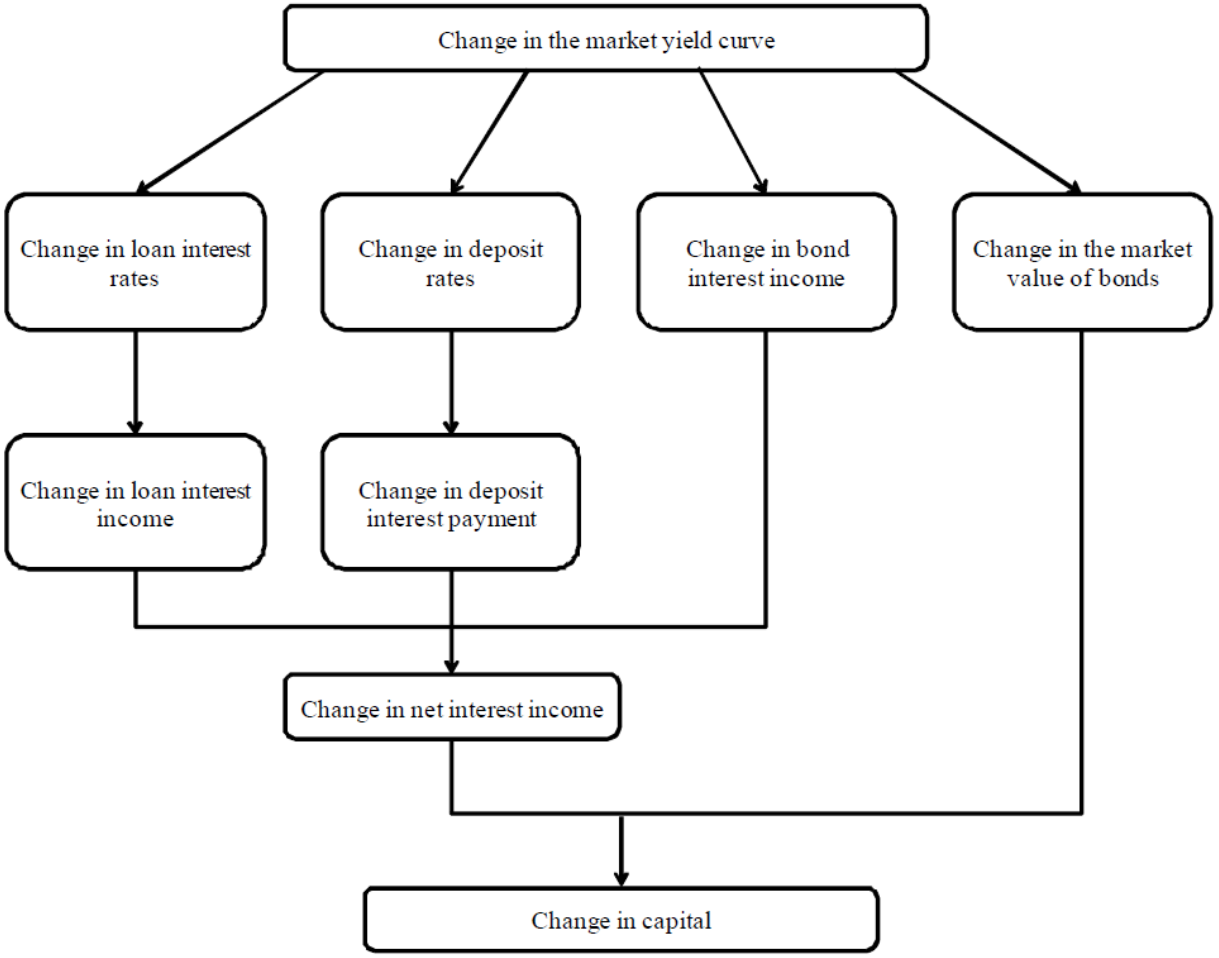
2. The sample period is from the first half of fiscal 2005 to the first half of fiscal 2013.

3. L represents a one period lag and MAn is the moving average of n period lags. O is the parameter for major banks and R is the parameter for regional banks.

4. In the shaded area, no statistically significant parameter is estimated and the transition probability is treated as an exogenous variable.

Overview of the interest rate model

- The model analyzes the effects of changes in the market yield curve on
  1. net interest income (via loan interest rates, deposit rates, bond interest income), and
  2. market value of bonds.



Some details: Estimating loan interest rate pass-through (1)

$$\Delta i_{L,k,t} = \mu_k + \sum_{j=1}^{2} \kappa_j \Delta i_{L,k,t-j} + \sum_{j=0}^{\Lambda} \underbrace{\left(\beta_j + \sum_m \beta_{mj}^* X_{m,k,t-1}\right)}_{\text{short-run impact}} \Delta i_{M,t-j} + \underbrace{\left(\alpha + \sum_m \alpha_m^* X_{m,k,t-1}\right)}_{\text{adjustment towards long-run relationship}} \left(i_{L,k,t-1} - i_{M,t-1}\right) + \sum_m \lambda_m X_{m,k,t-1} + \phi \bar{Z}_{k,t} + \varepsilon_{k,t}$$

where

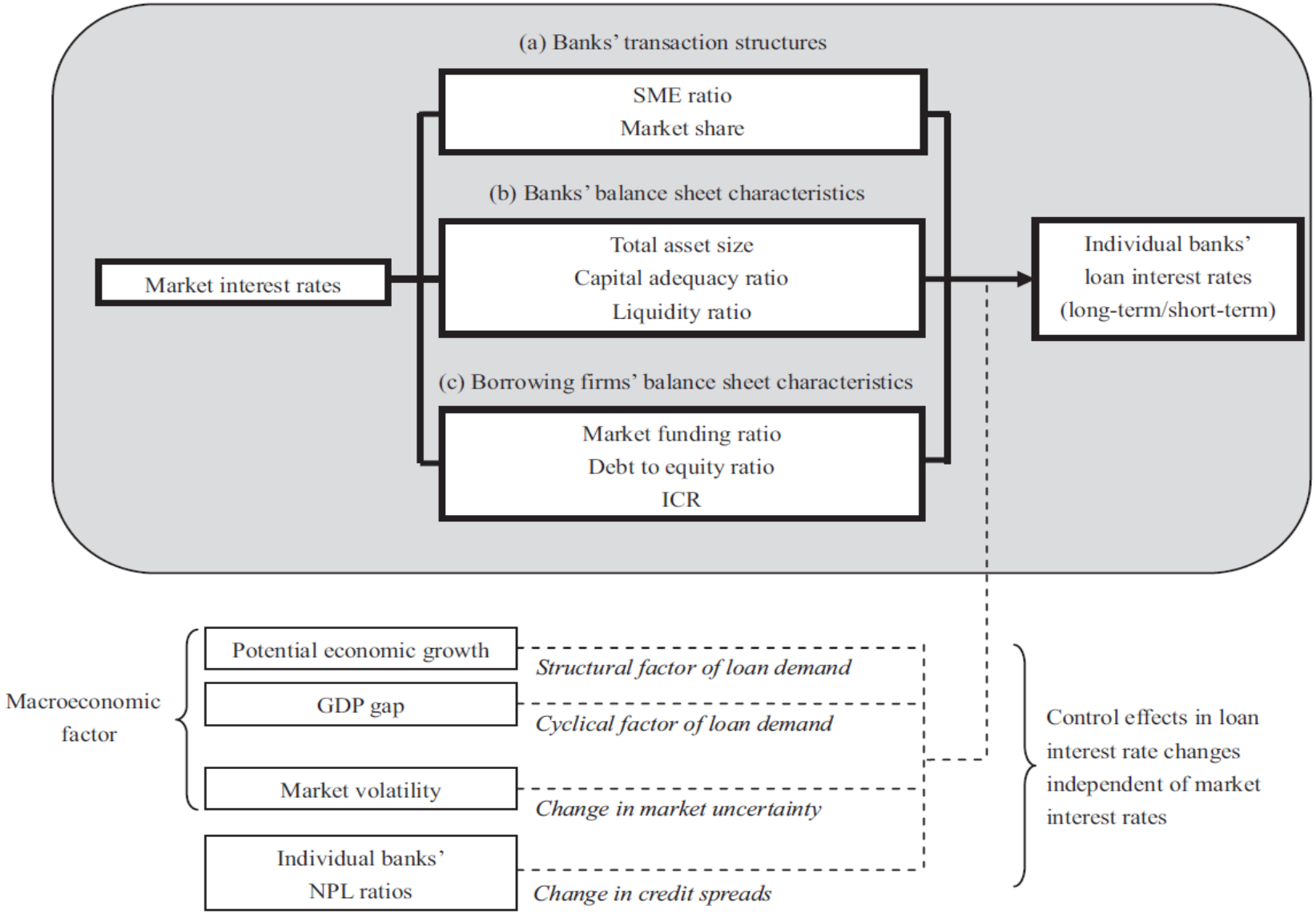
$i_{L,k,t}$: loan interest rate of bank k at period t

$i_{M,t}$: market interest rate at period t

$X_{m,k,t}$: (vector of) pass-through explanatory variables

Some details: Estimating loan interest rate pass-through (2)

Pass-through explanatory variables ($X_{m,k,t}$)



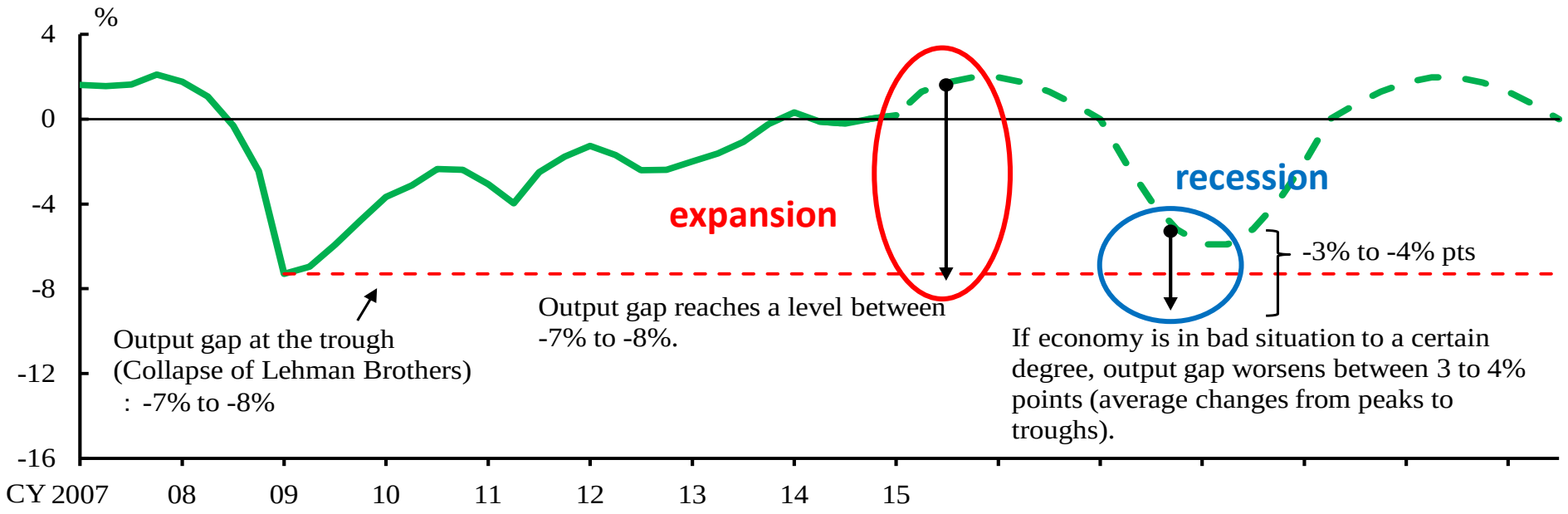
Scenario design: two stress scenarios

- Tail event scenario
  - Characterized by severely adverse financial and economic conditions equivalent to the Lehman shock each time,
  - Used to assess the stability of the financial system through fixed-point observations.

- Tailored event scenario
  - Flexibly designed to:
    - investigate the vulnerability of the financial system under different circumstances for every test, and
    - assess transmission mechanisms of salient risks from a new point of view by extending the model and source data as appropriate.

Cyclical nature of the Tail Event Scenario

Condition 1	**The output gap troughs around minus 7 to minus 8 percent.**
Condition 2	**The output gap worsens at least by 3 to 4 percentage points (i.e., the average in past economic recessions).**



Sources: BOJ, etc.