Quarterly Japanese Economic Model: Q-JEM

Naohisa HIRAKATA

Bank of Japan

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1-1. Overview of Q-JEM

- Old type Keynesian model
  - Not forward looking model. Not dynamic new Keynesian model.
  - Expectation in Q-JEM is not model consistent.
  - Demand driven propagation.

Background paper: Fukunaga et al. (2011)

Ichiro FUKUNAGA, Naoko HARA, SatokoKOJIMA, Yoichi UENO and Shunichi YONEYAMA (2011) "The Quarterly Japanese Economic Model (Q-JEM): 2011 Version," Bank of Japan Working Paper Series, No. 11-E-11.

➔ Current model is based on Fukunaga et al. (2011), although some parts have been revised.

1-2. Overview of Q-JEM: Modelling of Expectation

- Long-term expected inflation is determined by both target inflation rate and trend inflation rate. Trend inflation rate is calculated with actual inflation rate. Therefore, inflation expectation in Q-JEM is not model consistent expectation.

  - Inflation expectation is calculated following Trend Inflation Projection System (TIPS) by Takahashi (2016). Thus, inflation expectation block has been changed from Fukunaga et al. (2011).

    Background paper: Takahashi (2016)
    Koji TAKAHASHI (2016) "TIPS: The Trend Inflation Projection System and Estimation Results," Bank of Japan Working Paper Series, No. 16-E-18.

- Long-term expected inflation is used to calculate long-term interest rate, which is determined by Taylor rule-based expected future policy rates.

2. Forecasting and Policy Simulation by Q-JEM

- Q-JEM is used for quarterly forecast exercises and policy simulations.
  - We compare the Q-JEM's forecast with judgmental forecast and examine the difference between them given same exogenous variables.
  - Q-JEM is used for various simulation exercises, such as monetary policy (policy rate change), fiscal policy (tax rate change and government expenditure increase), exchange rate changes, oil price shock etc. On the other hand, Q-JEM is not suitable for simulating the effect of productivity change, because Q-JEM does not include a production function.
  - Kan et al. (2016) demonstrate the effect of Quantitative and Qualitative Monetary Easing (QQE).

Background paper: Kan et al. (2016)

Kazutoshi KAN, Yui KISHABA, and Tomohiro TSURUGA (2016), "Policy Effect since the Introduction of Quantitative and Qualitative Monetary Easing (QQE) – Assessment Based on the Bank of Japan's Large-scale Macroeconomic Model (Q-JEM) – ," Bank of Japan Working Paper Series, No. 16-E-15.

3-1. GDP, Output Gap and Natural Rate (1)

- GDP identity

$$Y_t = C_t + I_t + H_t + G_t + EX_t - IM_t$$

Y_t: real GDP
C_t: Consumption
I_t: Investment
H_t: Housing investment
G_t: Government expenditure
EX_t: Export
IM_t: Import

- Output Gap and Potential Output:

$$GAP_t = \frac{Y_t}{Y_t^*} 100 - 100$$

Potential output Y_t^* is calculated following Kawamoto et al. (2017).
Q-JEM does not have a production function. So, it's difficult to examine the effect of productivity changes.

Background paper: Kawamoto et al. (2017)

Takuji KAWAMOTO, Tatsuya OZAKI, Naoya KATO, Kohei MAEHASHI (2017), "Methodology for Estimating Output Gap and Potential Growth Rate: An Update," Research Papers, Bank of Japan.

3-1. GDP, Output Gap and Natural Rate (2)

● Natural Rate: r_t^*

Natural rate r_t^* is estimated following Clark and Kozicki (2005) so that we can get natural rate, which is consistent with output gap and potential output. Given the estimated natural rate r_t^*, the dynamics of natural rate is specified as follow:

$$r_t^* = \alpha + \beta dlnY_t^* + \gamma GAP_t$$

Clark and Kozicki (2005)

In estimation, observation equation and state equation are set as fellow:

(Observation equation)

$$GAP_t = \gamma_1 GAP_{t-1} + \gamma_2\left[\left(irl_t - \pi_{t,10Y} - r_t^*\right) - \left(irl_{t-1} - \pi_{t-1,10Y} - r_{t-1}^*\right)\right] + \varepsilon_t^y$$

(State equation)

$$r_t^* = r_{t-1}^* + \varepsilon_t^{r*}$$

irl_t: Long-term interest rate, $\pi_{t,10Y}$:10 year ahead inflation expectation

3-2. Phillips Curve and Inflation Expectation: TIPS

Phillips Curve: $\pi_t = \rho\pi_{t-1} + (1-\rho)\pi^e_{t,n} + \beta GAP_t$

Inflation expectation: $\pi^e_{t,n} = \rho\pi^e_{t-1,n} + (1-\rho)\bar{\pi}_t + \beta GAP^e_{t,n}$

Trend inflation: $\bar{\pi}_t = \delta_t\tau_t + (1-\delta_t)\pi^*_t$

Evolution of credibility: $\delta_t = \omega\delta_{t-1} + \kappa D_t$

Expectation of output gap: $GAP^e_{t,n} = \rho_1 GAP^e_{t,n-1} + \rho_2 GAP^e_{t,n-2}$

π^*_t: Target inflation rate

$\bar{\pi}_t$: Trend inflation

$\pi^e_{t,n}$: n-period ahead inflation expectation

$(1-\delta_t)$: Credibility of inflation target

$GAP^e_{t,n}$: n-period ahead output gap

τ_t: Permanent component of inflation

Background paper: Takahashi (2016)

Koji TAKAHASHI (2016) "TIPS: The Trend Inflation Projection System and Estimation Results," Bank of Japan Working Paper Series, No. 16-E-18.

3-3. Policy Rule and Expected Policy Rate

- **Taylor rule**

$$rn_t = \rho\, rn_{t-1} + (1-\rho)[rn_t^* + 0.5GAP_t + 1.5(\pi_t - \bar{\pi}_t)]$$

$$rn_t^* - \bar{\pi}_t = \alpha + \beta dlnY_t^*$$

rn_t: Policy rate (call rate)

rn_t^*: Equilibrium Policy rate

- **Expected Policy rate**

$$rn_{t,n}^e = \max\{\rho\, rn_{t,n-1}^e + (1-\rho)[rn_t^* + 0.5GAP_{t,n}^e + 1.5(\pi_{t,n}^e - \bar{\pi}_t)], 0\}$$

$rn_{t,n}^e$: n-period ahead expectation of the policy interest rate in period *t*.

➔ By using $rn_{t,n}^e$s, long-term and medium-term interest rates are calculated.

3-4. Consumption

Consumption is specified as follow:

$$C_t = f_C\left(YD_t, irl_t - \pi^e_{t,10Y}, dlnY^*_t, FA_t\right)$$

YD_t: Disposal Income irl_t: Long-term interest rate

$dlnY^*_t$: Potential growth rate FA_t: Financial asset

$\pi^e_{t,10Y}$: 10 year-ahead Inflation expectation

- Consumption follows error correction mechanism. The equation of Long-run equilibrium is a function of long-run real interest rate, potential growth, and the amount to financial asset.

3-5. Firms' Investment

$$\frac{I_t}{Y_t} = f_I\left(lr_t - \pi^e_{t,4Y} - r^*_t, sp_t, EX_t\right)$$

Investment follows error correction mechanism.

- Long-run equilibrium of Investment is determined by interest rate gap $\left(lr_t - \pi^e_{t,4Y} - r^*_t\right)$.
- Short-run dynamics equation includes stock price sp_t and export EX_t.

lr_t: Bank lending rate

$\pi^e_{t,4Y}$: 4 year-ahead Inflation expectation

r^*_t: Natural interest rate

EX_t: Real export

sp_t: Stock price

3-6. Bank Lending Rate Spread

Bank lending rate spread, $lr_t - MR_t$, depends on firms financial position, which is determined by firms' profit (a proxy for credit worthiness).

$$lr_t - MR_t = f_{BL}(FP_t)$$

$$FP_t = f_I(profit_t, lr_t, sp_t)$$

$$profit_t = f_I(lr_t, EX_t)$$

lr_t: Bank lending rate
MR_t: Medium-term market rate
sp_t: Stock price
EX_t: Real export
FP_t: Financial position (Lending attitude of financial institutions D.I.)
$profit_t$: Firms' profit

Medium term market rate (MR_t) is calculated with expected policy rate $rn^e_{t,n}$.

3-7. Housing Investment

$$\frac{H_t}{Y_t} = f_H\left(PopAge_t, \left(lr_t - \pi^e_{t,4Y} - r^*_t\right), SH_t\right)$$

SH_t: Housing stock

$PopAge_t$: Demographic factor

(ratio of the population aged 50 years or over)

lr_t: Bank lending rate

r^*_t: Natural rate

$\pi^e_{t,4Y}$: 4 year-ahead inflation expectation.

$lr_t - \pi^e_{t,4Y} - r^*_t$: Interest rate gap in terms of bank lending rate.

3-8. Export and Import

- **Real Export**

  Export is specified as a function of foreign GDP ($FGDP_t$) and real effective exchange rate (FXR_t):

$$EX_t = f_{EX}(FGDP_t, FXR_t)$$

- **Real Import**

$$IM_t = f_{IM}(IAD_t, FXR_t)$$

$$log\, IAD_t = \omega_C\, log\, C_t + \omega_G\, log\, G_t + \omega_I\, log\, I_t + \omega_{EX}\, log\, EX_t,$$

ω_k : Import content of a demand component.

IAD_t: Import intensity-Adjusted Demand.

- ω_k is calculated following Bussière et al. (2013).

$$\omega_k = \frac{\mathbf{uA^m}\left(\mathbf{I}-\mathbf{A^d}\right)^{-1}\mathbf{F_k^d}+\mathbf{uF_k^m}}{\mathbf{uF_k^d}+\mathbf{uF_k^m}}, k \in \{C, G, I, EX\}$$

$\left(\mathbf{I}-\mathbf{A^d}\right)^{-1}$: Leontief Inverse.

$\mathbf{A^d}$: domestic input coefficient matrix

$\mathbf{A^m}$: import input coefficient matrix

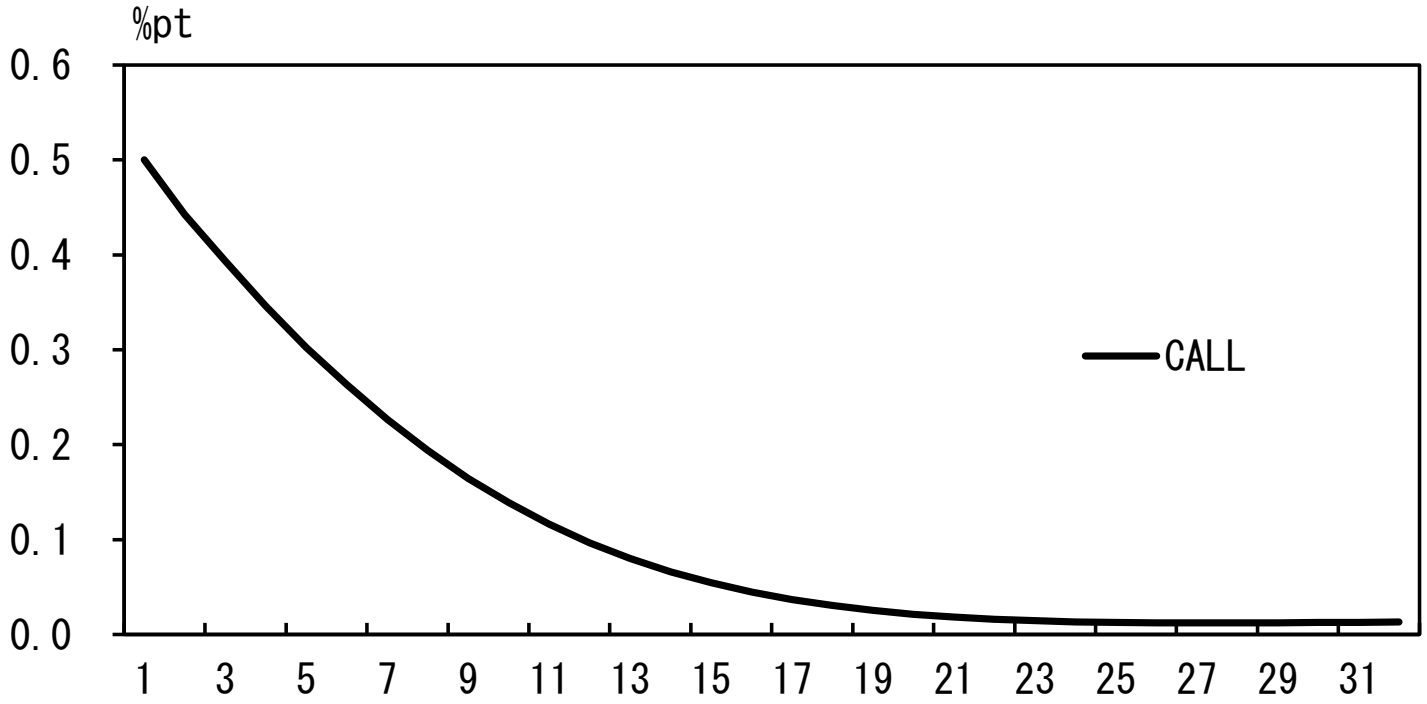
$\mathbf{F_k^d}$: final demand of domestically produced goods and services

$\mathbf{F_k^m}$: direct imports of goods and services by final expenditure component

$\mathbf{u}$: unit vector

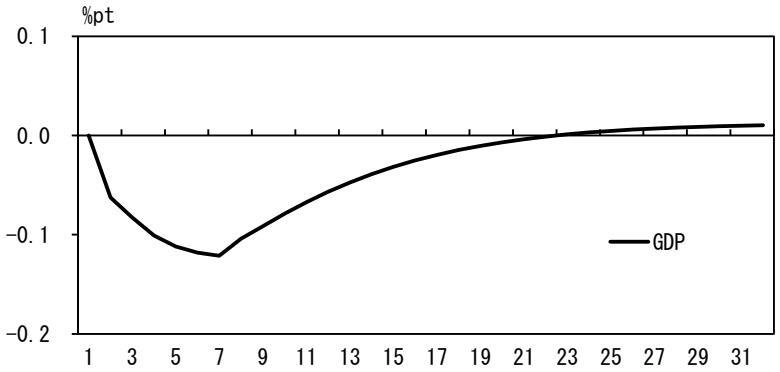
4. Impulse Response

● Shock: 50bps increase in the policy rate

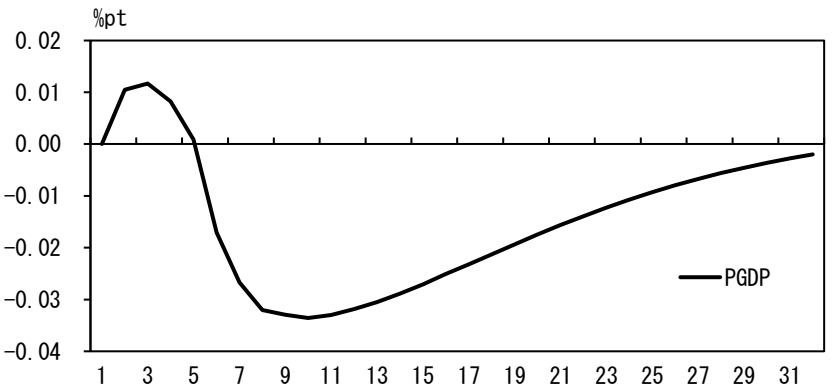


● Impulse Response to 50bps increase in the policy rate

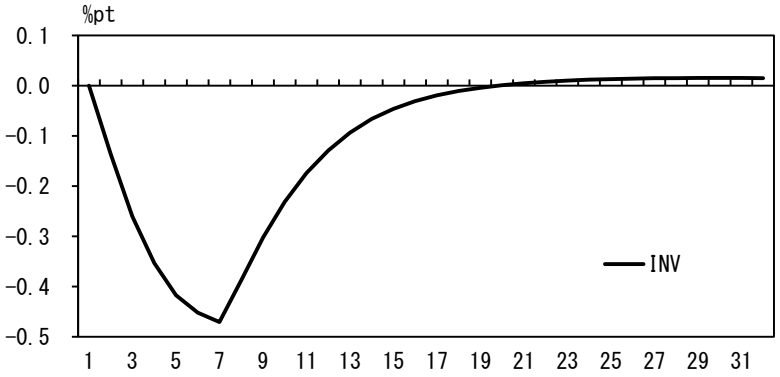
Real GDP
(level, deviation from baseline)



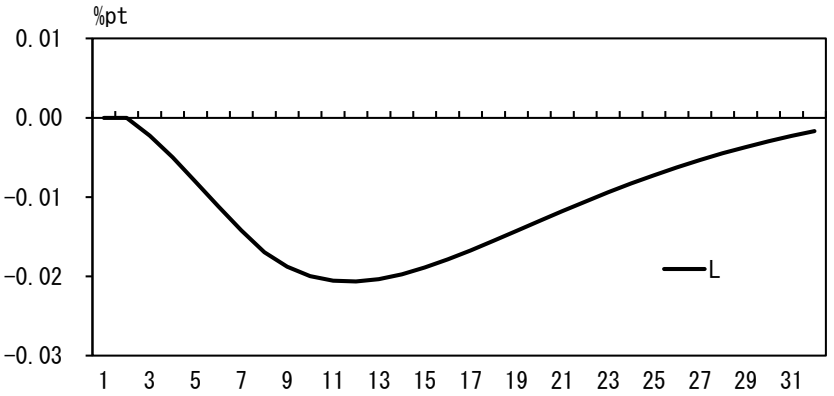
GDP Deflator
(four-quarter change, deviation from baseline)



Investment
(level, deviation from baseline)

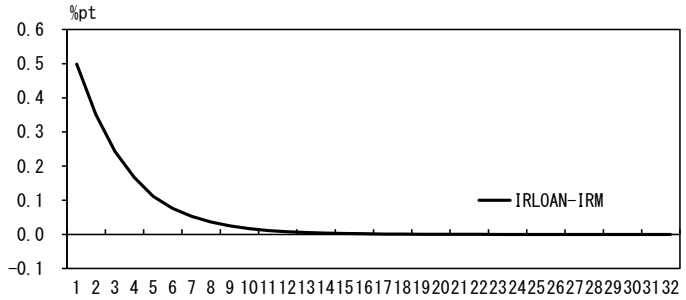


Labor
(level, deviation from baseline)

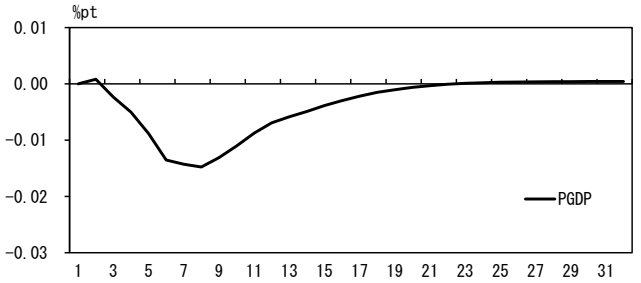


● Impulse Response to Financial shock (widening credit spread by 50bps)

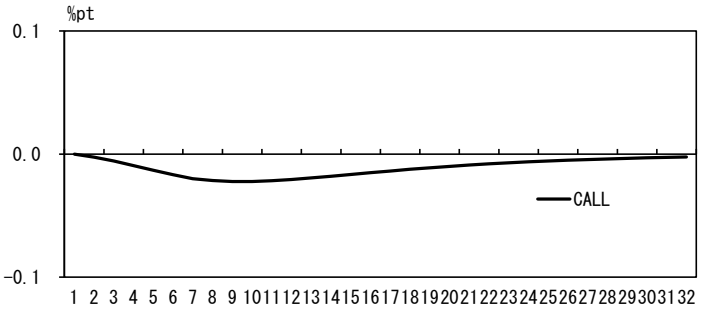
Credit Spread (level, deviation from baseline)



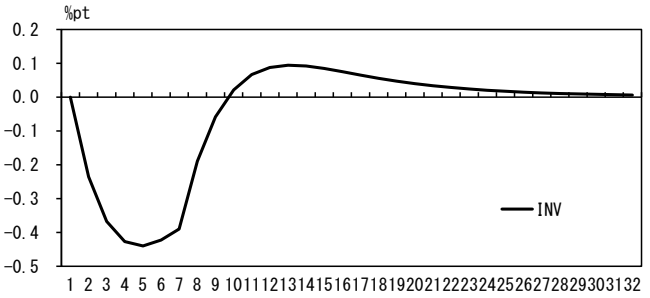
GDP Deflator (four-quarter change, deviation from baseline)



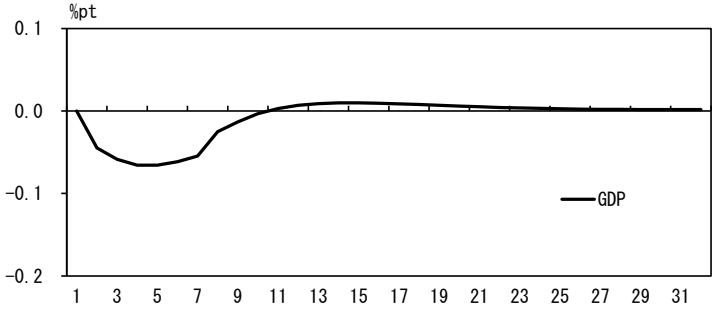
Policy Rate (level, deviation from baseline)



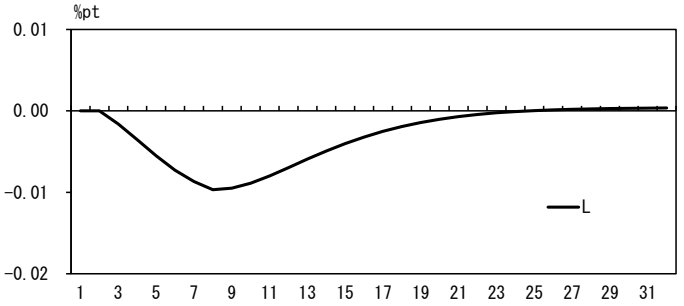
Investment (level, deviation from baseline)



Real GDP (level, deviation from baseline)



Labor (level, deviation from baseline)



5-1. Assessment of QQE

- Counterfactual simulation, a kind of scenario analysis, enables us to assess risks and evaluate policy effects in a convenient manner.
  - Example: Bank of Japan conducted "Comprehensive Assessment of Quantitative and Qualitative Easing (QQE)" in September 2016.

History of monetary policy of Bank of Japan

Period	Policy Making
January 2013	Price stability target of 2%
April 2013	QQE1. Large-scale asset purchases.
October 2014	QQE2. Accelerate asset purchases.
January 2016	QQE with a Negative Interest Rate
September 2016	QQE with Yield Curve Control

Background paper: Kan et al. (2016)
Kazutoshi KAN, Yui KISHABA, and Tomohiro TSURUGA (2016), "Policy Effect since the Introduction of Quantitative and Qualitative Monetary Easing (QQE) – Assessment Based on the Bank of Japan's Large-scale Macroeconomic Model (Q-JME) – ," Bank of Japan Working Paper Series, No. 16-E-15.

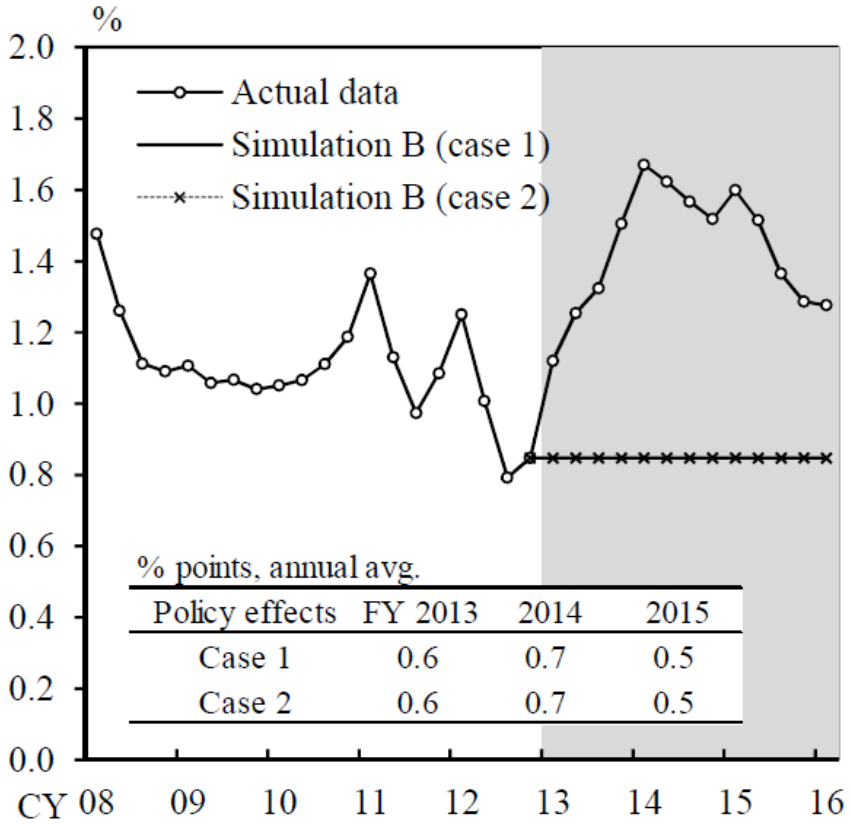
5-2. Assessment of QQE

	Simulation A	Simulation B
Case 1	"Policy shocks" are defined as the declines in nominal long-term interest rate and the rise in medium- to long-term inflation expectations since one quarter prior to the introduction of QQE in April 2013.	"Policy shocks" are defined as the declines in nominal long-term interest rates and rises in medium- to long-term inflation expectation since one quarter prior to the introduction of "the price stability target" of 2 percent in January 2013.
Case 2	"Policy shocks" are defined as the declines in nominal long-term interest rates, rises in medium to long-term inflation expectations, depreciation of the yen, and surges in stock prices since one quarter prior to the introduction of QQE in April 2013.	"Policy effects" are defined as the declines in nominal long-term interest rates, rises in medium to long-term inflation expectations, depreciation of the yen, and surges in stock prices since one quarter prior to the introduction of "the price stability target" of 2 percent in January 2013.

5-3. Assessment of QQE

- Inflation expectation and interest rate as “Policy Shock”

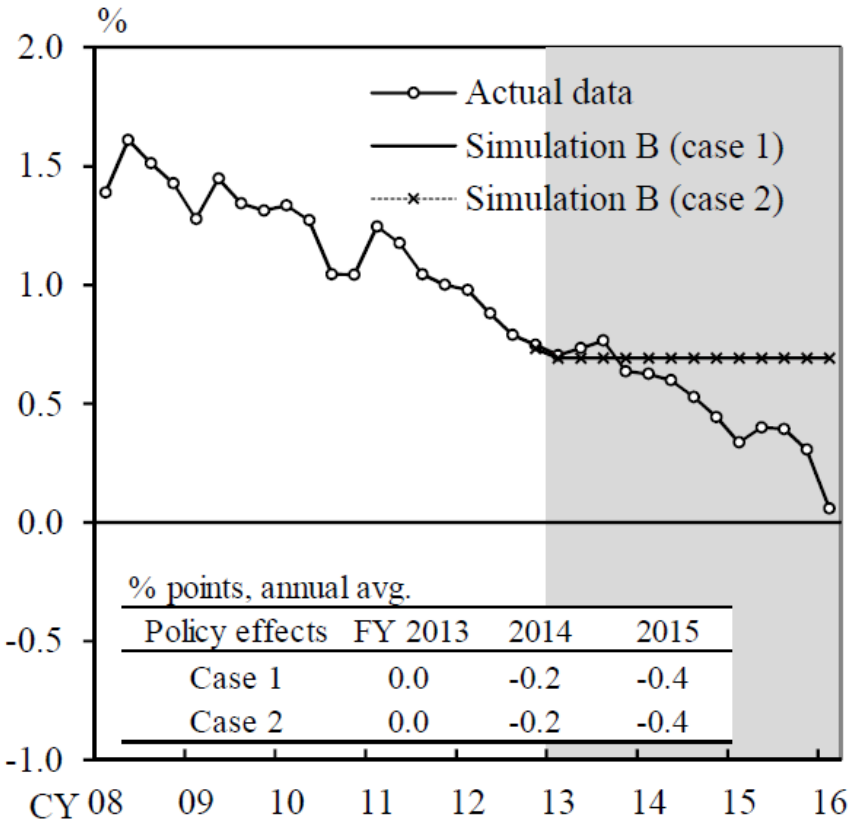
(1) Medium- to Long-Term Inflation Expectations



% points, annual avg.

Policy effects	FY 2013	2014	2015
Case 1	0.6	0.7	0.5
Case 2	0.6	0.7	0.5

(2) Nominal Long-Term Interest Rate (10 year JGBs)



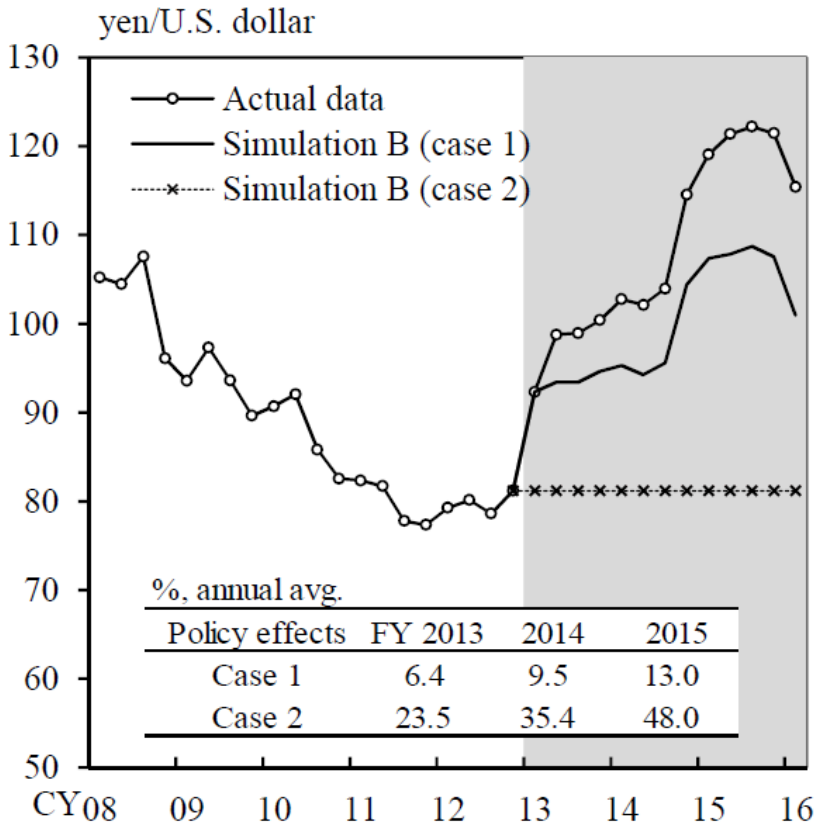
% points, annual avg.

Policy effects	FY 2013	2014	2015
Case 1	0.0	-0.2	-0.4
Case 2	0.0	-0.2	-0.4

5-4. Assessment of QQE

- Exchange rate and Stock prices as “Policy Shock”

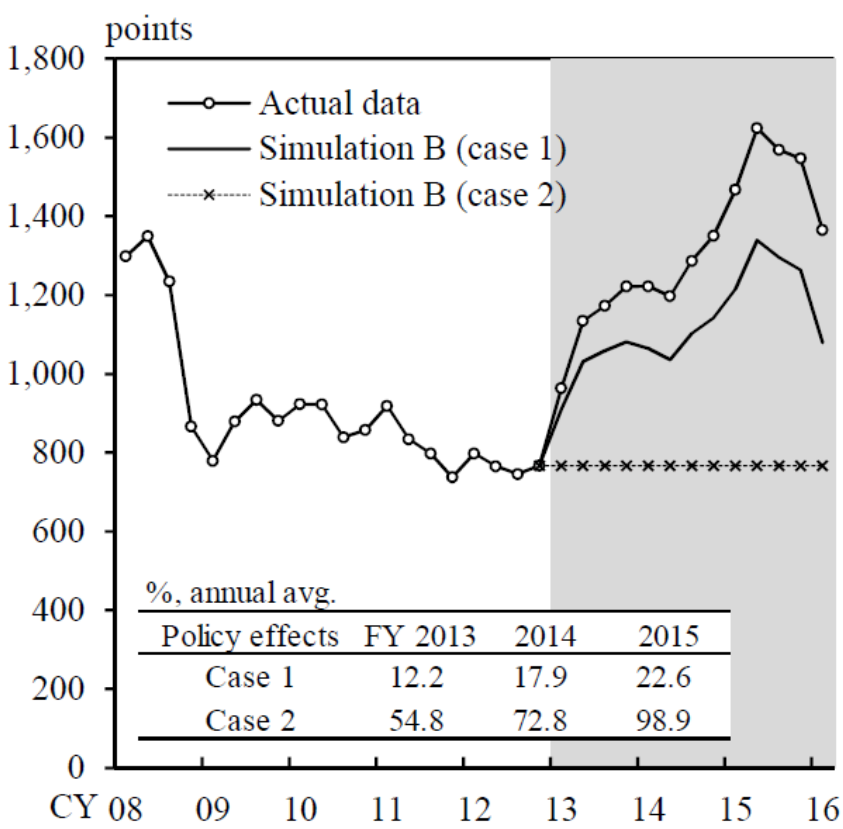
(3) Exchange Rate



%, annual avg.

Policy effects	FY 2013	2014	2015
Case 1	6.4	9.5	13.0
Case 2	23.5	35.4	48.0

(4) Stock Prices (TOPIX)

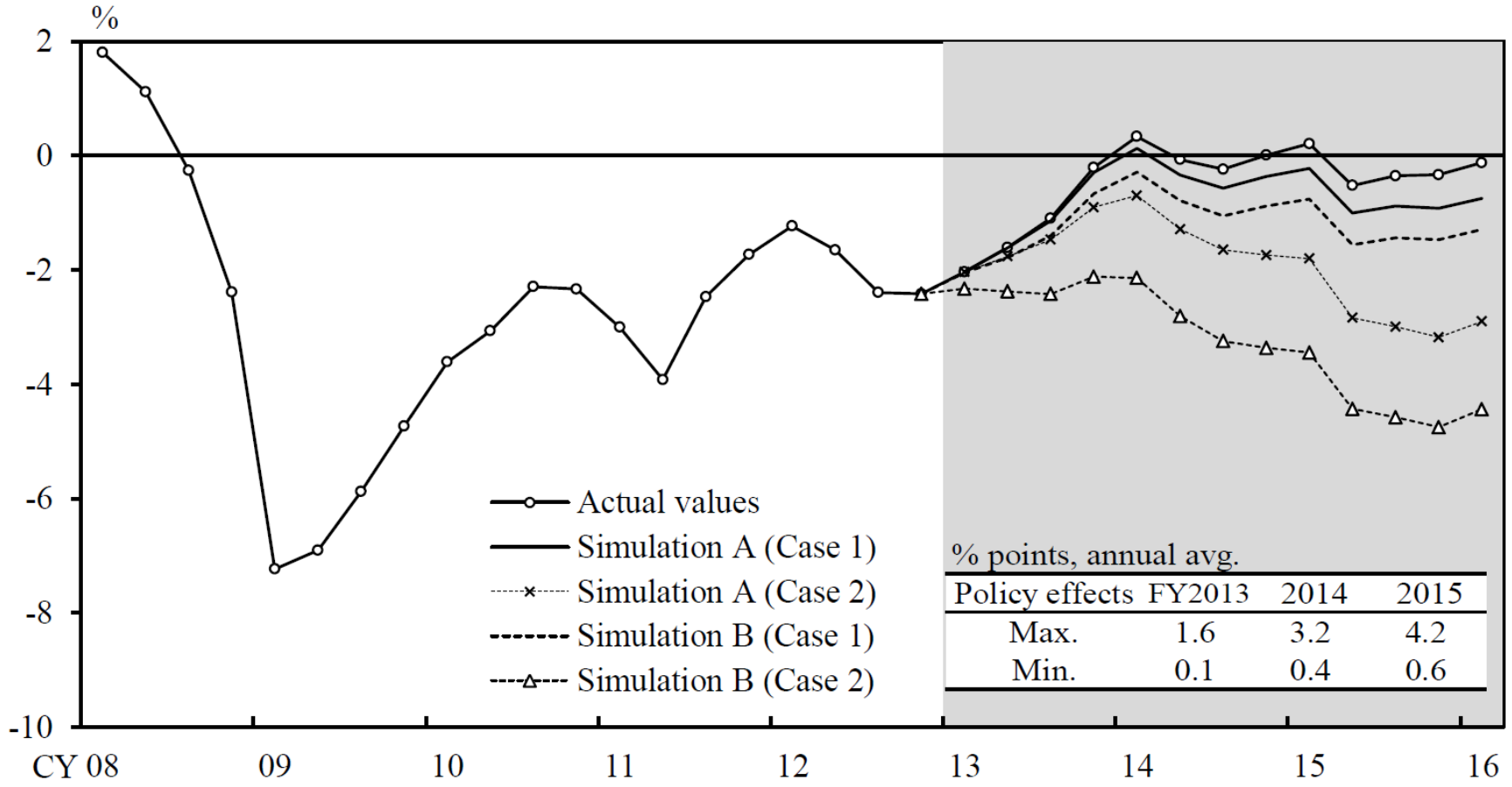


%, annual avg.

Policy effects	FY 2013	2014	2015
Case 1	12.2	17.9	22.6
Case 2	54.8	72.8	98.9

5-5. Assessment of QQE

- Counterfactual paths of Output Gap

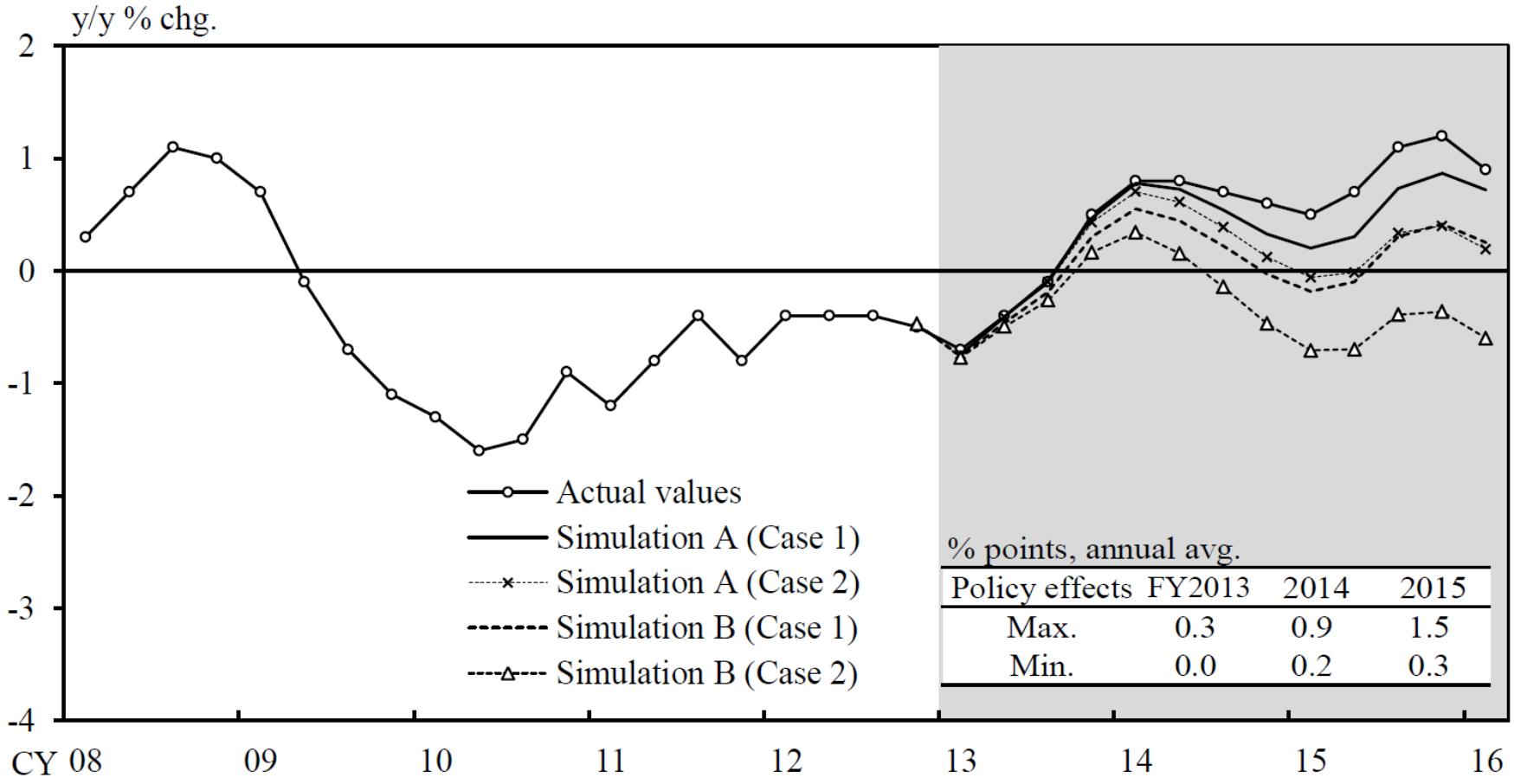


% points, annual avg.

Policy effects	FY2013	2014	2015
Max.	1.6	3.2	4.2
Min.	0.1	0.4	0.6

5-6. Assessment of QQE

- Counterfactual paths of CPI



% points, annual avg.

Policy effects	FY2013	2014	2015
Max.	0.3	0.9	1.5
Min.	0.0	0.2	0.3

References

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