Negative interest rate: what they mean to financial risk management and more

Chap.1 The era of negative interest rates

On January 29th, the world's third largest economy, Japan, surprised markets with the negative interest rate policy. The JGB 10-year yield first fell below zero on February 9th. Though it might be unthinkable, by then, more than 500 million of people and a quarter of the world GPD have moved to interest rate in negative territory (Figure 1, right).

With the continuing deterioration of the global economy, European Union, Switzerland, Sweden, Denmark and Japan have by far exercised negative interest rate policies. As could be found in the graph below (Figure 1, left), the trend of low interest rates has been prevailing in these major countries / region roughly since the financial crisis in 2008.

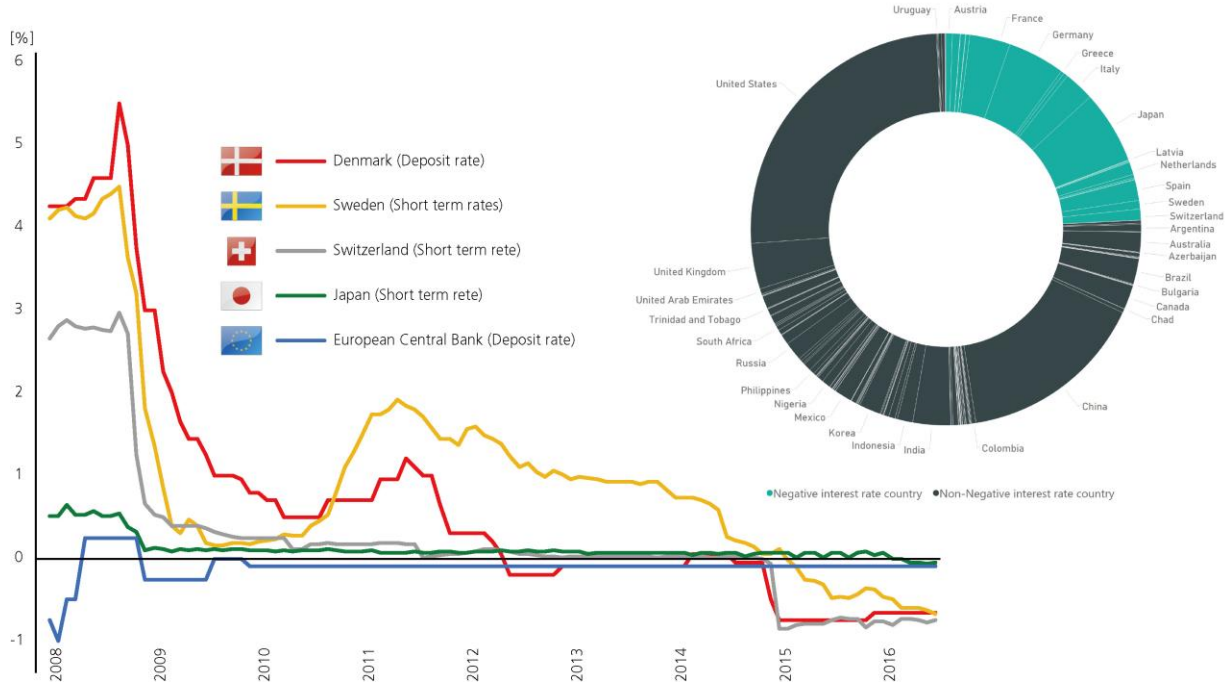

Figure 1: Era of negative interest rates:
Interest rate time series of major countries/region during 2006-2016 (Left)
Proportion of global GDP governed by a central bank with negative interest rates (Right)

In response to collapsing commodity prices and reliance on China's slowing economy, central banks across South East Asia are cutting interest rates to put downward pressure on their currencies. Inevitably, we cannot exclude the possibility that the interest rate falls below zero in this region. Managing the risk associated has posed a challenge on a lot of financial institutions.

Chap.2 Stress testing with negative interest rate

The negative interest environment results in adjustments in financial institutions and risk management systems. The following discussion will be focused on challenges in two aspects: stress testing (Chapter 2) and simulation methodologies (Chapter 3).

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Understanding the fact that negative interests are unavoidable, regulators have been imposing negative interest in stress testing scenarios. On February 2nd, right after the announcement of negative interest rate policy by Bank of Japan, Federal Reserve Bank added severely adverse scenario, under which the short-term U.S. Treasury security would have negative yields[1]. In Bank of Japan's publication of "Financial System Report (2016/4): Macro Stress Testing Scenarios"[2], the scenarios for Japanese Government Bond (JGB) yields of different terms are described as in Figure 2. Notably, negative interest rates are supervised to be applied to baseline scenario of both 3-month and 5-year JGB yields.

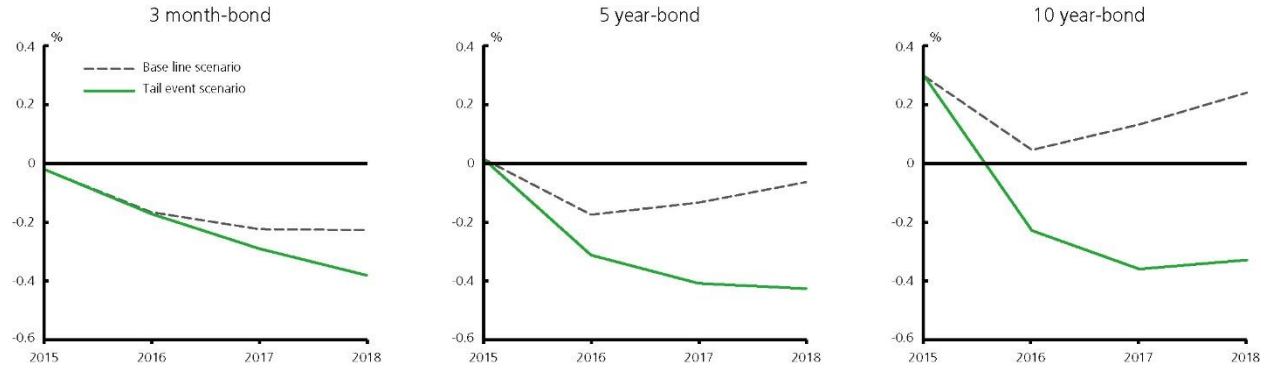

Figure 2: JGB yield scenario

To support forward-looking stress test, NtInsight® allows all the applied yield curves to be negative values at arbitrary grid points. On the other hand, although not seen in the market, foreseeing the possibility that there is possibility that coupon and lending rates falls below zero, Numerical Technologies allowed the system to accept negative values for them in the recent update.

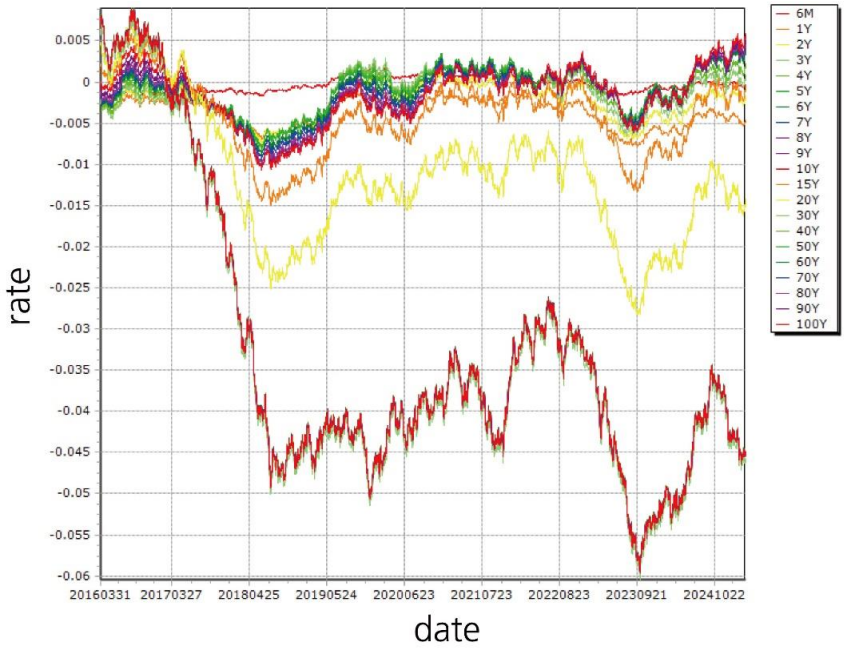

Figure 3: Stressed interest rate scenario (time series) generation by NtInsight®

[1] Dodd-Frank Act Stress Test 2016: Supervisory Stress Test Methodology and Results, https://www.federalreserve.gov/bankinforeg/stress-tests/2016-Supervisory-Scenarios.htm#subsection-173-01AC32CC

[2] https://www.boj.or.jp/research/brp/fsr/data/fsrb160422a.pdf

Chap.3 Simulation with negative interest rate in NtInsight®

Simulation with negative interest in NtInsight® includes two parts:

- Introduction of shift parameter for negative term structure
- Scenario generation of interest rate

Introduction of shift parameter for negative term structure

To model interest rate with a lognormal process, historical logarithmic return (i.e., viewing interest rates as individual risk factors) will be used for calculating relevant statistics in scenario generation; however, logarithmic return is not mathematically defined with negative values.

Shift parameter, h, is introduced to supply a lower limit for the interest rate value permitted by lognormal process. Historical interest rate is then modified to positive values (Figure 4).

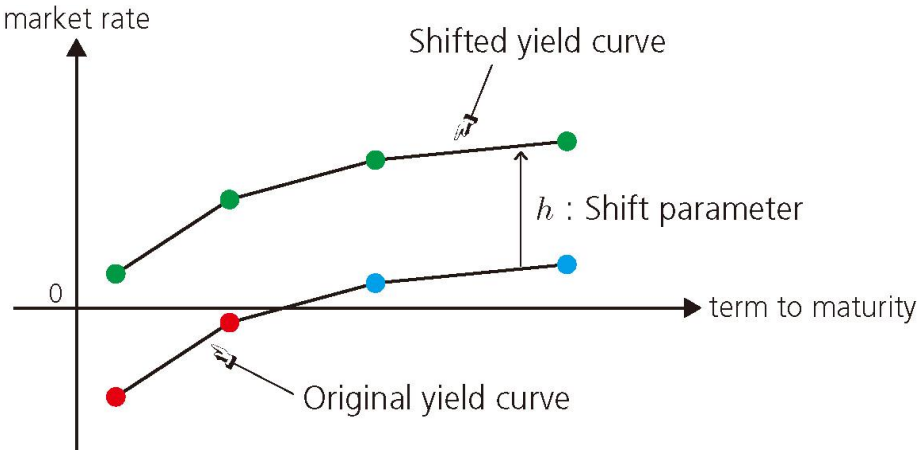

Figure 4: Parallel shift of parameter h in the original yield curve

The logarithmic return is calculated from this shifted interest rate, and the corresponding statistics of the new return will be used for scenario generation.

Scenario generation of interest rate

The intrinsic dynamics of interest rate (i.e., market rate R) is described by Equation (1), which is essentially a geometric Brownian motion with shifted parameter (A.K.A., Shifted Log-Normal model, SLN model).

$$\mathrm{d}R = (R + h)\sigma \mathrm{d}W \tag{1}$$

Figure 5 shows a diagrammatic sketch of scenario generation using Equation (1).

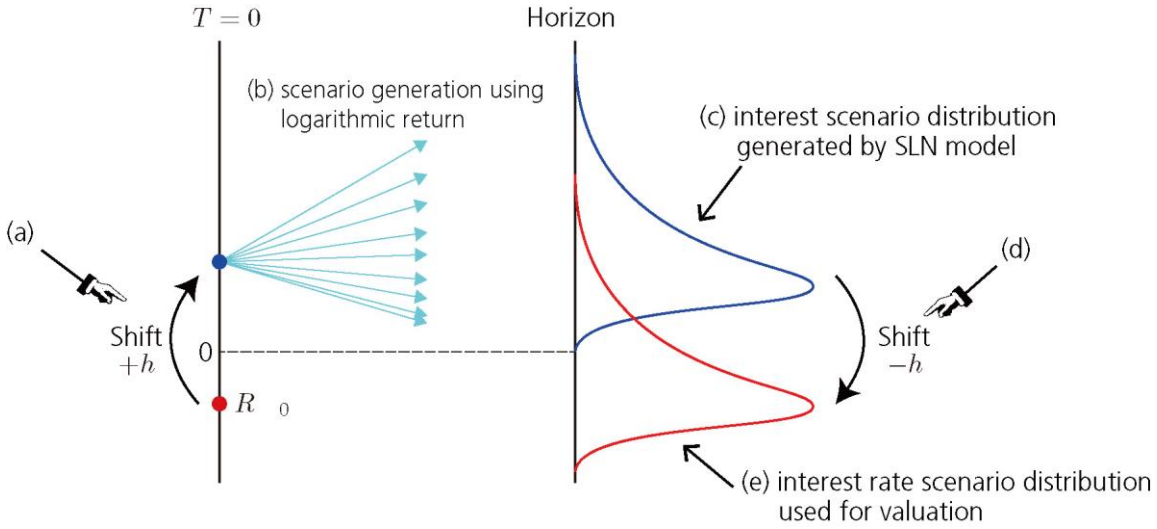

Figure 5: Scenario generation using SLN model

a) Shift the initial value of interest rate, R_0, by h so that the process is defined
b) Generate interest rate scenario using logarithmic return according to the process, Equation (1)
c) Obtain the distribution of interest rate scenarios generated by SLN model
d) Shift the obtained distribution by $-h$
e) Derive the interest rate scenarios used for valuation

Figure 6 below shows an example of interest rate scenarios generated by NtInsight® for ALM.

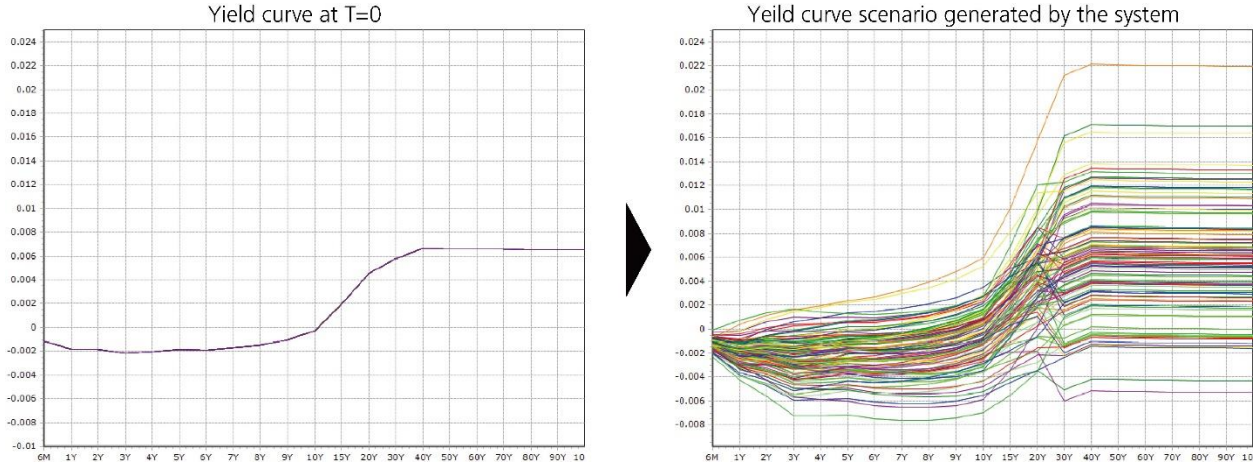

Figure 6: Yield curve scenario generation with negative interest rate using NtInsight® for ALM:
Yield curve at T = 0 (Left)
Yield curve scenario generated by the system (Right)

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