NOMURA

Japan Bond Indices Handbook

CROSS-ASSET

The Nomura Bond Performance Index, or NOMURA-BPI, has been widely used by institutional investors in Japan and other countries as a benchmark for measuring bond performance and is now a leading bond market index in Japan. Nomura Securities has developed the NOMURA-BPI/Ladder as a benchmark index with stable duration, which charts the performance of laddered JGBs. Furthermore, indices of inflation-linked JGBs (JGBi) and 15yr floating-rate JGBs (CMT) have risk-return profiles that are different from fixed-coupon bonds.

In this document, we introduce each index, including the basic facts related to bonds, corresponding to the Plan-Do-See approach used for pension investment management, breaking this down into three viewpoints – Plan: Know the Index; Do: Invest the Index; and See: Review Index Investing.

In the first section, "Plan", we provide an overview of the domestic bond market and introduce characteristic features of each index with an emphasis on duration and yields that are of critical importance to bond investment.

In the next section, "Do", we introduce the composition of each index, the characteristics of turnover rates and risk indicators, which are important for index investing.

In the final section, "See", we provide the results of the decomposition of the returns of each index as a reference for reviewing fund performance, which is indispensable to risk management.

We hope this document helps your index investing in fixed income.

Global Markets Research

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1. Introduction

Nomura Securities' Quantitative Research Center publishes the NOMURA-BPI, NOMURA-BPI/Ladder, NOMURA J-TIPS Index and NOMURA CMT Index. Nomura Securities' Index Operations Dept. (IOD) is the Administrator of these indices. Each index is meant to be used as:

- A tool for determining investment policies (asset allocation strategies);
- A tool for determining a "manager structure";
- An investment management benchmark;
- A tool for portfolio risk management;
- An investment performance indicator; and
- A tool for risk management for each issue.

When making use of various indices as policy benchmarks or managers' benchmarks, it is essential for both asset owners and fund managers to have an understanding of the nature of these indices.

This is because it is important for the asset owner to manage his or her assets in accordance with his or her investment objectives in determining asset allocation to understand the risk/return characteristics of investment assets and/or the benchmarks. By contrast, the fund manager is also required to invest funds in accordance with the benchmarks set for the fund.

Hence, the composition of the index, the sector and degree of risk to which it is exposed, and understanding the characteristics of the constituents of the index portfolio, are all essential information.

In this document, we introduce each index, including the basic facts related to bonds, corresponding to the Plan-Do-See approach used for pension investment management, breaking this down into three viewpoints – Plan: Know the Index; Do: Invest the Index; and See: Review Index Investing.

In the first section, "Plan", we provide an overview of the domestic bond market and introduce characteristic features of each index with an emphasis on duration and yield that are of critical importance to bond investment.

In the next section, "Do", we introduce the composition of each index, the characteristics of turnover rates and risk indicators, which are important for index investing.

In the final section, "See", we provide the results of the decomposition of the returns of each index as a reference for reviewing fund performance, which is indispensable to risk management.

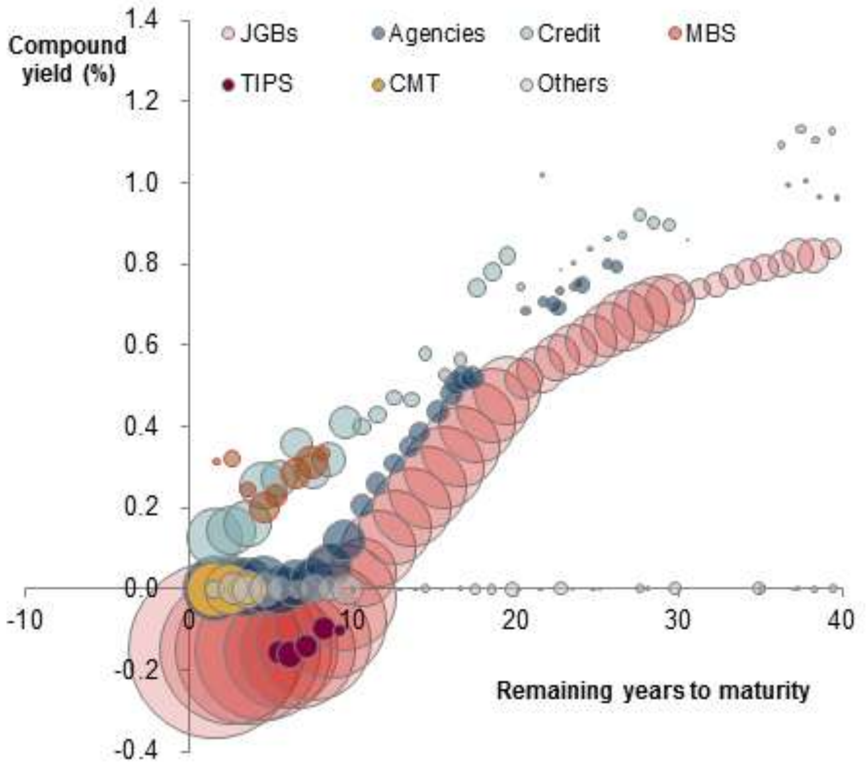
Please note that, while the rules for calculating each index have been previously published as a handbook, starting with the publication of NOMURA-BPI's rule book "NOMURA- BPI Index Rulebook" in February 2018, we have published a series of rule books on indices including the NOMURA-BPI/Ladder and the NOMURA J-TIPS Index. Please refer to these rule books and to our web page (http://qr.nomura.co.jp/en/index.html) for the rules for each index. Furthermore, the data and the analytical contents for the various indices are also summarized in this document, which is designed to provide explanatory material.

2. Plan: Know the Index

2.1 The Domestic Bond Market and Index (Overview of the Domestic Bond Market)

First, we briefly detail the composition of the domestic bond market. Fig. 1 shows the relationship between the remaining years to maturity (more than 1 year remaining), yields and the outstanding amounts (face value) of the securities in the domestic bond market. The size of each bubble represents the total outstanding amount by one year intervals with the remaining years to maturity.

Fig. 1:Domestic bond market bubble map (28 December 2018)



Source: Nomura

Note:

1.Each item is summed up as follows:

"JGBs": NOMURA-BPI JGB

"Agencies": NOMURA-BPI Municipals, Government Guaranteed bonds and Bank Debentures

"Credit": NOMURA-BPI/Extended Corporate bonds and Samurai bonds and ABS

"MBS": NOMURA-BPI MBS

"TIPS": NOMURA J-TIPS Index

"CMT": NOMURA CMT Index

"Others": Publicly offered domestic bonds other than above[1] with remaining years to maturity more than 1 year.

2.The yields for "CTM" and "Others" are treated as 0.

3.The remaining years to maturity are calculated taking into consideration early redemption, which is weighted average life.

Fig. 1 shows the following characteristics of the domestic publicly offered bond market as at the end of December 2018:

Outstanding amount

- The longer the years to maturity, the less the amount tends to be if the remaining years to maturity are more than 10 years.
- There are very few credit bonds with remaining years to maturity in excess of 20 years.

1 It meets floating bonds, corporates bonds with rated lower than BB and so on.

- The outstanding amount of "Others" is small, and the proportion of floating-rate bonds and corporate bonds with ratings of BB or lower is extremely small.

Yields

- The yield curves for government bonds, government-guaranteed bonds, local government bonds and bank debentures are nearly flat with the remaining years to maturity less than seven years.
- Yields on "credit" tend to rise as the number of years remaining to maturity increase.

2.2 Bond Returns

It is difficult to make direct comparisons with the prices of specific bonds. This is because different coupon levels may lead to different price levels if issuance periods are different even if they have the same issuer and the same number of years remaining to maturity. It is therefore more common, in the case of ordinary fixed-rate bonds, to evaluate such bonds in terms of yield rather than price. The yield falls (rises) when the price of the bond rises (falls), and so yield is a very important concept in considering bond returns.

Modified duration (hereinafter referred to as duration) is the price sensitivity to a change in yield, and is also a very important concept when considering bond returns. For regular fixed-rate bonds, the return can be almost entirely explained by duration and compound yield.[2]

Furthermore, the yield on government bonds tends to rise as the number of years remaining to maturity increases (with the prolongation of duration). Therefore, for JGBs (Japanese Government Bonds) the level of the yield is expected to be roughly equal by matching the duration. In other words, JGBs that have roughly equivalent duration can be expected to have almost the same price volatility, and so substitution between issues is relatively easy.

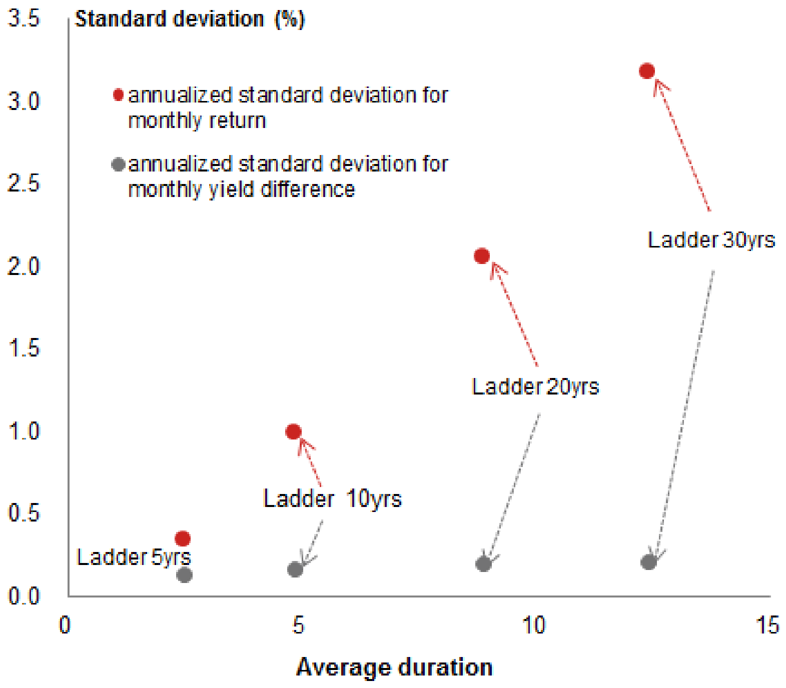
By contrast, bonds other than government bonds such as corporate bonds, the level of the yield differs for each issuer even with the same duration level. This is because the T spread, which is a yield added to the government bond yield, reflects factors such as the issuer's default risk and liquidity risk. Therefore, the T spread shows different types of movement from that of interest rates, the yields of government bonds, and so the asset owner/manager often monitors bond risks by breaking yields further down into interest rate and the T spread. The following shows the impact of duration and T spreads on the returns of each index.

Effect of duration on returns

If other conditions are same, duration is longer for long-term bonds, and so price sensitivity to yield fluctuations also increases. We show the difference in the standard deviation of return (the so-called risk) owing to the difference in duration by using NOMURA-BPI/Ladder. Fig. 2 shows the average duration and standard deviation of monthly returns of the NOMURA-BPI/Ladder. Although the standard deviation for monthly yield differences is also provided, those of the NOMURA-BPI/Ladder do not differ much, but the level of the standard deviation of the monthly return is greatly different. As duration gets longer, fluctuations in the return are larger by comparison with fluctuations in yield differences.

[2] It is difficult to explain the return completely by duration alone, which is a coefficient of the linear approximation to yield change, as the price changes nonlinearly in response to a yield change. By considering convexity, it is possible to explain the return more precisely, but the influence is small compared with duration.

Fig. 2: Average duration and standard deviation of monthly returns



Source: Nomura
Note:

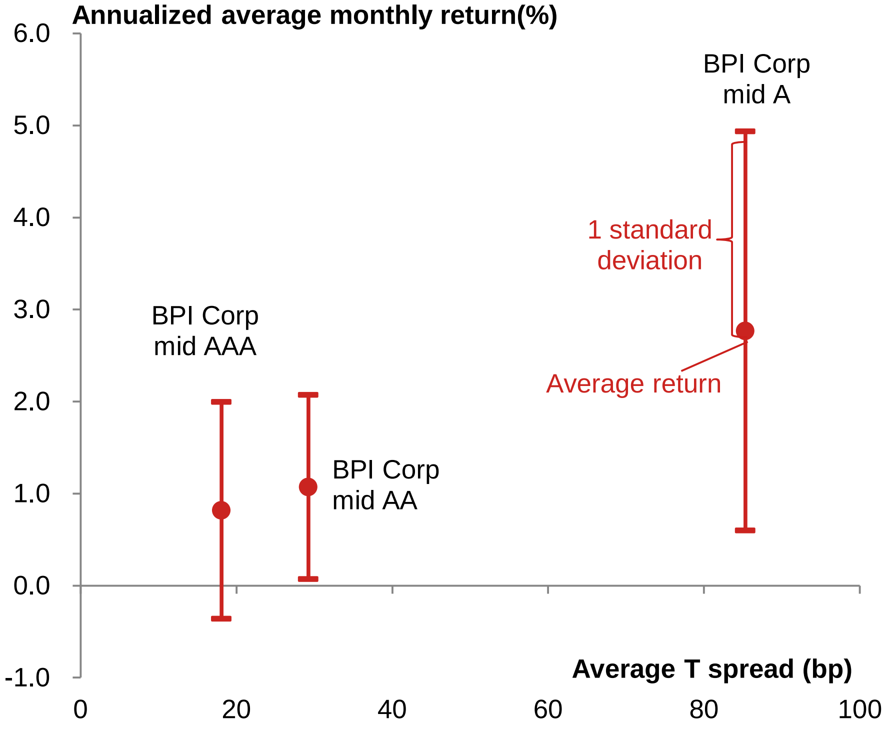
1 Based on monthly returns in Feb 2009-Dec 2018. Standard deviation data are annualized.

2 The standard deviation for monthly yield differences is calculated using yield differences between the end of previous month and the end of the month in the period from end-Feb-2009 to end-Dec-2018 and annualized, which are multiplied by the square root of 12.

Effect of T Spreads on Returns

Fig. 3 shows the relationship between average T spreads and returns on indices with the same duration level but different T spread levels. We have focused on the average return level (red circle) and have also provided the level of 1 standard deviation. As the average T spread is higher, the average return tends to rise. However, as the T spread increases, the standard deviation also tends to rise. In this calculation period, the standard deviation was larger for the sub-index with a AAA rating than for the sub-index with a AA rating. This is mainly due to the performance of some electric power companies, which were included in the sub-index with a AAA rating at the time, which experienced very large fluctuations at the time of the Great East Japan Earthquake of March 2011.

Fig. 3: Average spread and average return

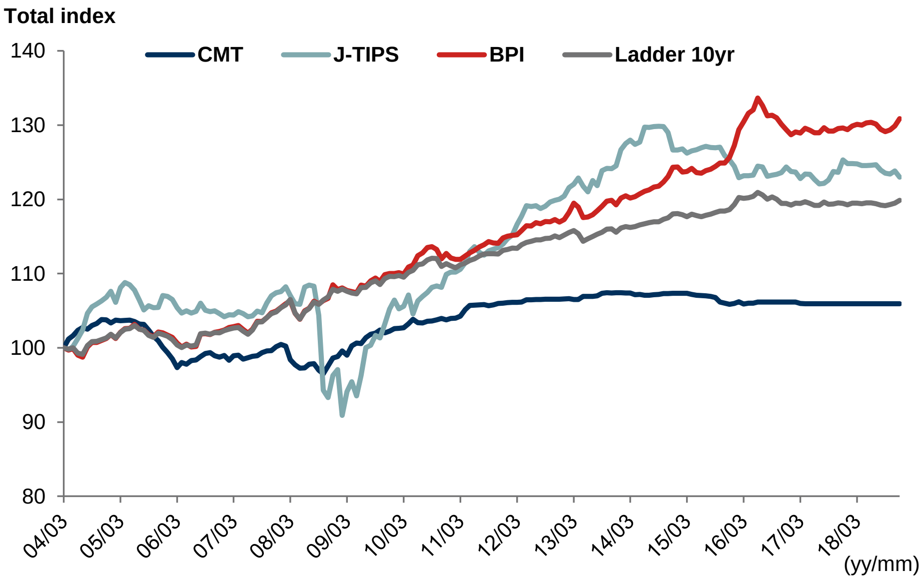


Source: Nomura
Note: Based on monthly returns in Jan 2009-Dec 2018. Average return data are annualized.
"mid"- term means 3 years or more and less than 7 years.

2.3 Historical Performance of the Total Index

In Fig. 4, we show the historical performance of the cumulative investment return index (= total index) for each index. These indices are rebased such that the value as of end-March 2004 is 100.

Fig. 4: Movements in the total index for each index



Source: Nomura
Note: Shows monthly index values in Mar 2004-Dec2018. Each index is rebased so that end-Mar 2004 = 100.

Fig. 5 shows duration of the NOMURA-BPI had increased from around 5 years since the beginning of 2004. This level of duration is same as the NOMURA-BPI/Ladder, which is shown in Fig. 9. Furthermore, there has been no big credit event. Hence, the performance of NOMURA-BPI and NOMURA-BPI/Ladder 10yr has moved in a similar direction, but diverged along with duration lengthening of NOMURA-BPI. In addition, the

the NOMURA J-TIPS Index’s weaker performance has been caused by a fall in the expected inflation rate with a widening gap between supply and demand during the financial crisis in 2008.

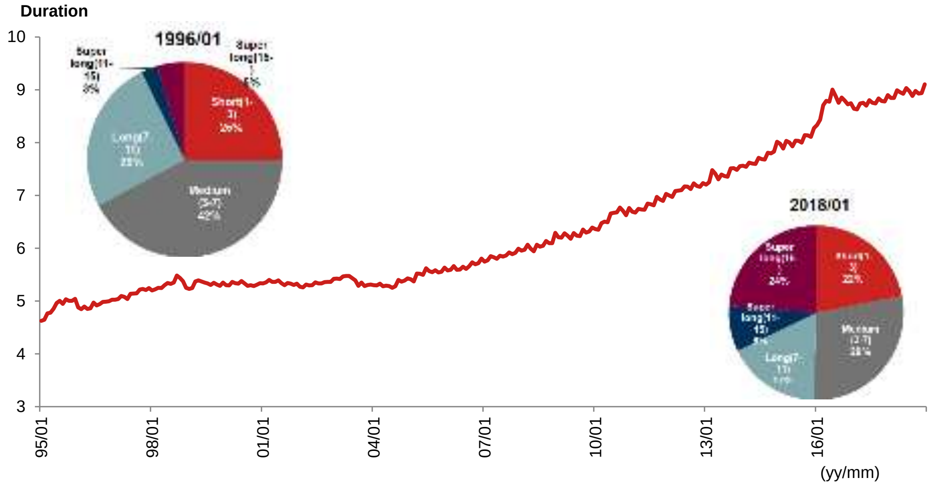
2.4 NOMURA-BPI, NOMURA-BPI/extended

In section 2.2 we explained that the return on plain fixed-income bonds can be explained almost entirely by duration and yield. In other words, these two points are essential for knowing the characteristics of the index. In this chapter, we introduce the characteristics of each index focusing on duration and yield, specifically the weight for the remaining years to maturity and the sectors. In addition, we also introduce the outstanding amounts to gauge market liquidity.

Duration

First, we show changes in the NOMURA-BPI's duration levels in Fig. 5.

Fig. 5: Changes in NOMURA-BPI duration and comparison of weight by remaining years to maturity



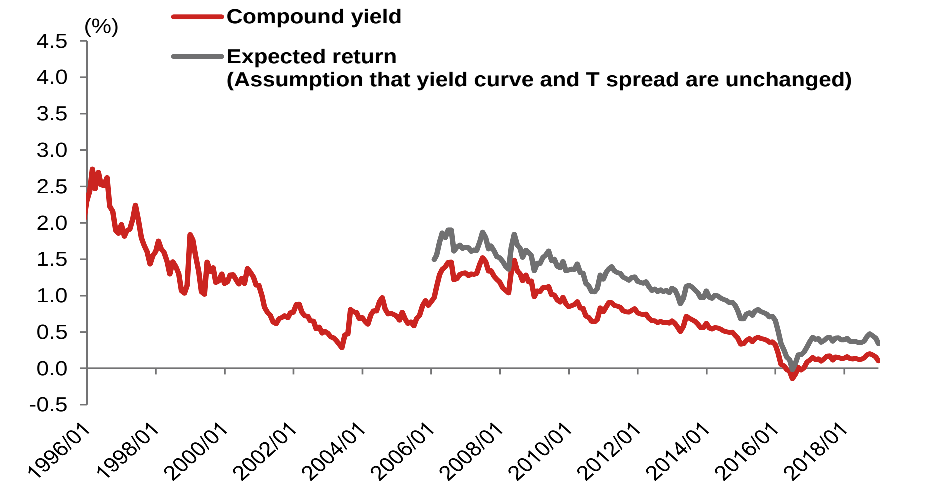
Source: Nomura
Note: Shows the end of month duration level in Jan 1995-Dec 2018.

Fig. 5’s pie chart shows, duration is prolonged with the increase in the weighting of super long-term bonds.

Compound yield

We show the NOMURA-BPI's compound yield (Fig. 6) and T spread levels (Fig. 7), and its components at each point in time.

Fig. 6: NOMURA-BPI compound yield and expected return



Source: Nomura
Note:
1 Shows the end of month compound yield in Jan 1996-Dec 2018.
2 Shows the end of month expected return in Jan 2006-Dec 2018.

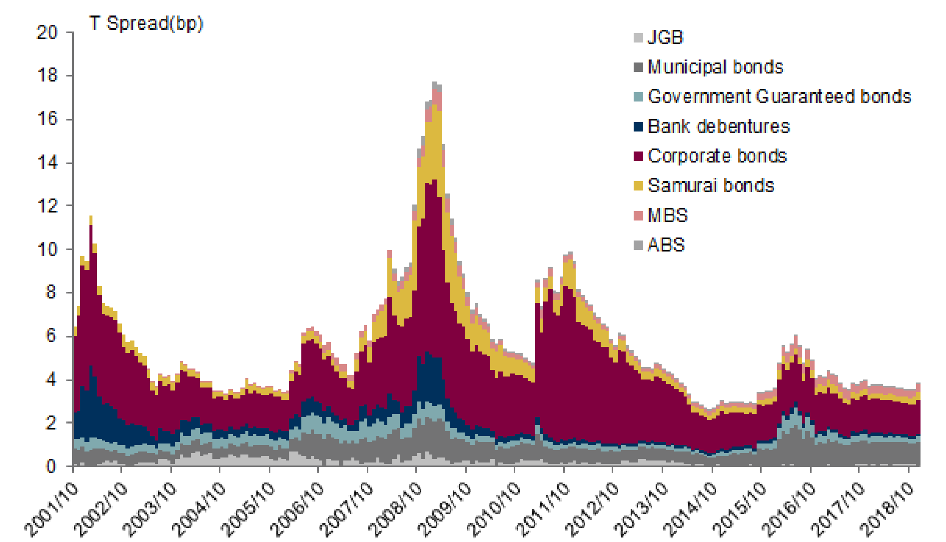
Because the Bank of Japan (BOJ) introduced a negative interest rate policy in February 2016, the compound yield on the NOMURA-BPI also became negative at the time, but at end-December 2018, it became positive. As the expected returns in Fig. 6 show (assuming the yield curve and the T spread are the same as in the current situation), even if the compound yield of the NOMURA-BPI becomes negative, because of the positive yield curve there is a return by roll-down effect, and so the expected return is not necessarily negative, and has been higher than the compound yield.

T spread

As of September 2018, the impact of credit spreads on the NOMURA-BPI was not particularly large, with JGBs having an 80% weighting in the index, but at the time of the Lehman brothers shock in 2008 and the Great East Japan Earthquake of 2011, volatility in the T spread had a great influence on NOMURA-BPI's performance. To better understand the risk characteristics of the NOMURA-BPI therefore, it is also necessary to look at the level of the T spread.

Fig. 7 shows a breakdown of the contribution to the T spread movements of the NOMURA-BPI by sector.

Fig. 7: Contributions to NOMURA-BPI T spread by sector

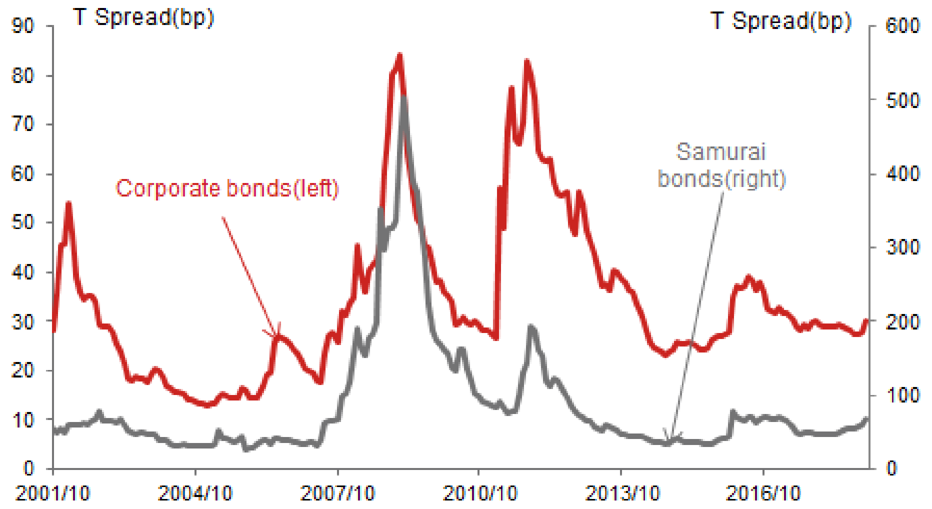


Source: Nomura
Note: Shows the end of month T spreads in Oct 2001-Dec 2018.

In the NOMURA-BPI the biggest contributor to the T spread is the corporate bond sector. Furthermore, in risk management, fluctuations in the T spread are important when the T spread is widening, and at such times there is a rising contribution from samurai bonds.

Samurai bonds are the highest T spread sector in the NOMURA-BPI. This is because these bonds are exposed not only to credit risks and liquidity risks that exist in the corporate bond sector, but also to risks relating to the country to which the issuer belongs. For this reason, these bonds are susceptible to credit crunches and concerns about the stability of the financial system, as was evident in 2008 when the T spread widened significantly. Fig. 8 shows historical data for the T spreads of corporate bonds and samurai bonds.

Fig. 8: Changes in the T spread for corporate bonds and samurai bonds



Source: Nomura
Note: Shows the end of month T spread in Oct 2001-Dec 2018.

Both indices showed a significant widening of the T spread at the time of the 2008 Lehman brothers shock.

There was a steep widening in the corporate bond sector in 2002. It is because the sequence of defaults at retail companies and many financial institutions caused increased wariness among investors. Besides, the corporate bond sector experienced the great widening owing primarily to the Great East Japan Earthquake of March 2011.

There was no big widening in the samurai bond sector in 2002 and 2011, while the T spread of the corporate bond sector was wide. By contrast, the T spread of the samurai bond sector was widening because of the European debt crisis in early 2010 in contrast with the stable T spread of the corporate bond sector.

2.5 NOMURA-BPI/Ladder

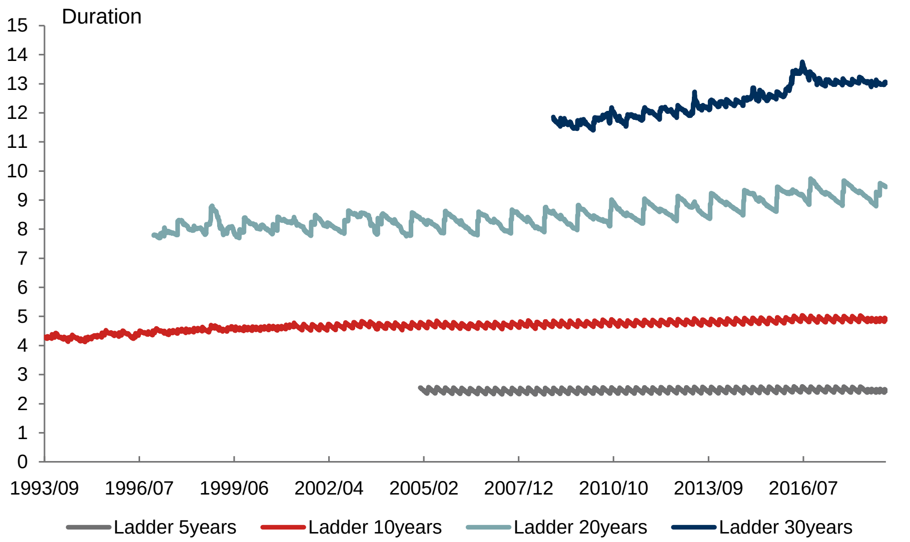
Duration

We have already mentioned that in choosing a bond index the level of duration is a key factor that directly influences the level of return, nevertheless there is a problem called moving targets that affect not just the NOMURA-BPI, but also market indices in general. The moving target problem refers to the fact that levels of duration and credit risk fluctuate greatly according to the composition of the outstanding amounts in terms of remaining years to maturity of the market and the weighting of JGBs. Using indices with unclear duration levels in the future as benchmarks will result in uncertain future risk levels for benchmarks.

The NOMURA-BPI/Ladder was developed as a means of solving this moving target problem. The NOMURA-BPI/Ladder is an index for the laddered portfolio of JGBs with no credit risk. There are four types of indices for 5, 10, 20, and 30 years. Duration is maintained at a stable level because an equal amount of the par value (JPY10bn) is evenly distributed according to remaining years to maturity. Furthermore, by combining these four indices, a customised benchmark in terms of duration can also be provided.

Fig. 9 shows the changes in the duration.

Fig. 9: Changes in duration for the NOMURA-BPI/Ladder



Source: Nomura
Note: Shows the daily duration in Sep 30 1993-Dec 28 2018 as for Ladder10years, in Jan 6 1997-Dec 28 2018 as for Ladder 20years, in Jan 4 2005-Dec 28 2018 as for Ladder 5years, in Jan 5 2009-Dec 28 2018 as for Ladder 30 years.

Fig. 9 shows that duration is generally stable. Note that the NOMURA-BPI/Ladder 20yr has fewer issues than other NOMURA-BPI/Ladder because the NOMURA-BPI/Ladder 20yr only includes the issues whose redemption timing is September. Hence, please pay attention to the tendency for duration extension as reconstitution is large.

In addition, the level of NOMURA-BPI/Ladder 30yr duration became longer in the former part of 2016. It was not caused by the reconstitution, but by the characteristic of fixed income bonds that the level of duration becomes longer as the yield falls. Usually this impact is not so big, but this feature was marked especially in the NOMURA-BPI/Ladder 30yr when interest rates fell steeply in the former part of 2016.

2.6 NOMURA J-TIPS Index

As the name implies, inflation-linked government bonds (JGBi) are bonds whose principal and interest payments, on a nominal basis, change in line with the consumer price level. The NOMURA J-TIPS Index is an index for JGBi (with or without principal guaranteed). Although the issuance of JGBi without principal guaranteed, which were first issued in 2004, was suspended temporarily in 2008, JGBi with principal guaranteed (deflation floor) were subsequently issued in October 2013 and, as of 2018, periodic issuance has continued. Along with this, the NOMURA J-TIPS Index was also broken down into two sectors – with or without-deflation floor in November 2013.

Yields

In Section 2.2 we described why there was a need to refer to the (nominal) yield in considering the nominal bond price. Similarly, yield is also an important concept for JGBi. However, in JGBi, both nominal yield and real yield need to be considered, and the NOMURA J-TIPS Index also defines these two types of yield. In this section, we introduce these two types of yield and also show actual changes.

The definitions of each symbol are as follows.

DP	:	Dirty price unadjusted for inflation
ADP	:	Dirty price adjusted for inflation
t_i	:	Number of years until CF_i Occurs
T	:	Number of years until redemption cash flow occurs
CF_i	:	Real cash flow for the ith period
$DF(t)$	:	Discount factor (nominal) for time t
$IR_{(today)}$	:	Index ratio, as of today

π : Break-even inflation rate

n Nominal compound yield

r Real compound yield

First, nominal yields are the actual payment amount. The nominal price of a JGBi with a deflation floor is expressed as follows using nominal future cash flow and nominal discount factors.

$$ADP = \sum_i IR_{(today)} CF_i (1+\pi)^{t_i} DF(t_i) + IR_{(today)} max\left\{100 \times (1+\pi)^T, \frac{100}{IR_{(today)}}\right\} DF(T) \quad (2.1)$$

Here, the dirty price adjusted for inflation excluding the effect of the indexation coefficient $IR_{(today)}$, which indicates the level of fluctuation for the CPI from the time of issuance (dividing both sides by $IR_{(today)}$), is transformed into an equation (2.2).

$$DP = \sum_i CF_i (1+\pi)^{t_i} DF(t_i) + max\left\{100 \times (1+\pi)^T, \frac{100}{IR_{(today)}}\right\} DF(T) \quad (2.2)$$

The equation (2.2) is based on the real price, that is the price unadjusted for inflation, at the time of investment, and future cash flows are considered on a nominal basis based on the time of investment. Specifically, we evaluate the nominal future cash flow $CF_i(1+\pi)^{t_i}$ with the nominal discount factor DF_i at each point in time. The break-even inflation rate π (hereinafter referred to as "BEI") added is considered to represent the average expected inflation rate from investment time to maturity.

Furthermore, when the equation (2.2) is expressed by the nominal compound yield n, it becomes the following equation (2.3).

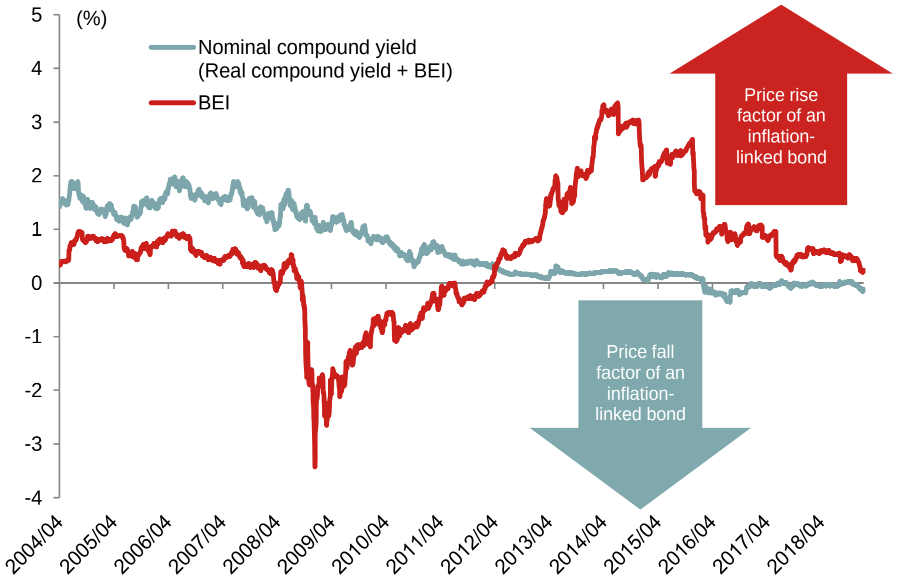
$$DP = \sum_i CF_i (1+\pi)^{t_i} \left(1+\frac{n}{2}\right)^{-2t_i} + max\left\{100 \times (1+\pi)^T, \frac{100}{IR_{(today)}}\right\} \left(1+\frac{n}{2}\right)^{-2T} \quad (2.3)$$

Considering future cash flows on a real basis, we can calculate the real compound yield r using the following equation (2.4).

$$DP = \sum \frac{CF_i}{\left(1+\frac{r}{2}\right)^{2t_i}} \quad (2.4)$$

Fig. 10 shows the transition of the nominal compound yield of the NOMURA J-TIPS Index and the BEI. The nominal compound yield here is the sum of the real compound yield and the BEI.

Fig. 10: Changes in the nominal compound yield and the BEI for NOMURA J-TIPS Index



Source: Nomura
Note: Shows daily nominal yield and BEI in Apr 1 2004-Dec 28 2018.

As Fig. 10 shows, the rise in the BEI may lead to a rise in the price of JGBi, and a decline in the nominal compound yield may lead to a price rise in JGBi.

Fig. 11 shows the change in real compound yields.

Fig. 11: Change in the real compound yield for NOMURA J-TIPS Index

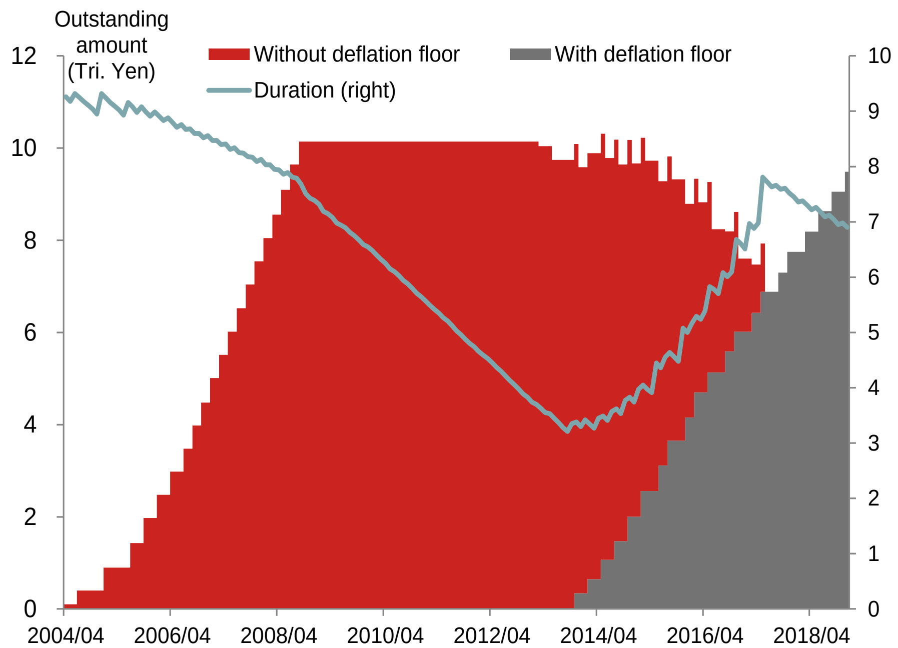
Source: Nomura
Note: Shows daily real yield in Apr 1 2004-Dec 28 2018

Fig. 11 shows that the real compound yield, that is the real price, has fluctuated significantly, along with changes in BEI.

Duration

The duration of the NOMURA J-TIPS Index is calculated as real price sensitivity to real compound yield changes. Fig. 12 shows changes in the outstanding amount, along with changes in duration.

Fig. 12: Changes in duration and the outstanding amount for NOMURA J-TIPS Index



Source: Nomura
Note: Shows the end of month outstanding amount and duration in Apr 2004-Dec 2018.

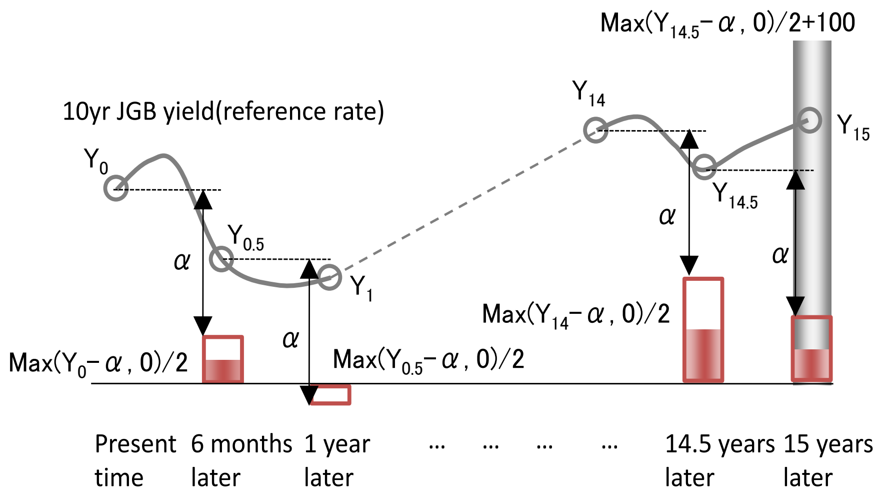
During the temporary suspension of JGBi issuance from 2007 to 2012, the constituents of the NOMURA J-TIPS Index were unchanged, so duration was shortened. Thereafter, owing to the exclusion of issues that had less than one year remaining to maturity and the inclusion of issues with deflation floors, duration has increased since June 2013.

Please also refer to Chapter 3 as for duration extension of index portfolio.

2.7 NOMURA CMT Index

The 15yr floating-rate JGB, CMT, which is included in the NOMURA CMT Index has the characteristics of one whose coupon rate is revised semi-annually according to market interest rates. Fig. 13 shows this concept. The coupon rate of the CMT is determined by subtracting the fixed value (usually expressed as α) from the reference rate (the compound yield of the average accepted bid of the 10yr JGB auction, which is held six months before the coupon payment month). The reference rate changes every six months. The spread α is determined by the CMT auction, and does not change until redemption. The coupon rate of the CMT has a zero floor, the effect of which cannot be overlooked particularly in the recent low yield environment.

Fig. 13: Reference rate of JGB floaters and cash flow (conceptual figure)

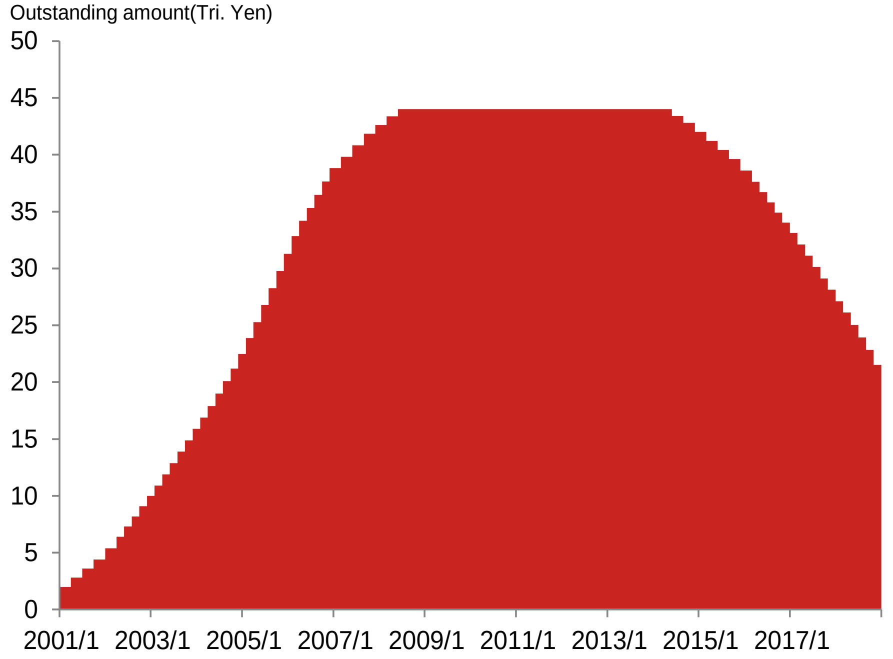


Source: Nomura
Note: Y_t stands for the reference rate at the time t and α stands for the spread between reference rate and coupon rate.

Outstanding amount

First, we show the trend in the outstanding amount of the NOMURA CMT Index.

Fig. 14: Change in the outstanding amount for NOMURA CMT Index



Source: Nomura
Note: Shows the end of month outstanding amount in Jan 2001-Dec 2018.

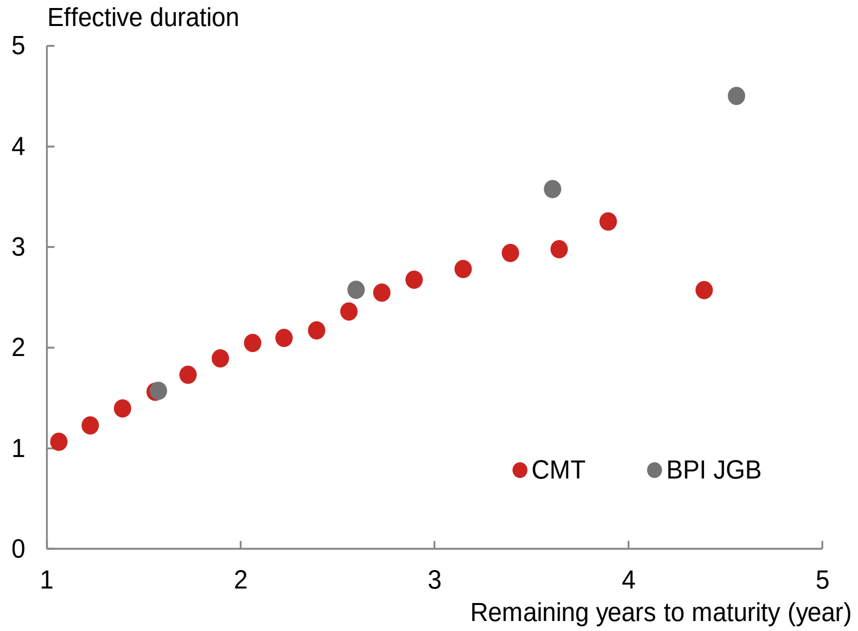
CMT issuance has been suspended since 2008, and the outstanding amount of the NOMURA CMT Index has been decreasing since 2014.

Duration

In the case of plain fixed-rate bonds, we said yields and duration would explain the return almost completely. However, for floating-rate bonds with variable coupon rates, yields cannot be defined in the first place, and it is also difficult to calculate duration, which is the price sensitivity to yield fluctuations. Therefore, to calculate the interest rate risk of floating-rate government bonds, concepts such as effective duration and key rate duration, which are price sensitive to changes in the spot rate instead of yields, are used. Effective duration is the price sensitivity to a parallel shift in the spot rate, and the key rate duration is the concept of decomposing effective duration, representing price sensitivity to a change in the spot rate in a specific term, not in all terms. The NOMURA CMT Index also defines the effective duration and the key rate duration.[3]

Fig. 15 gives the results of comparing the effective duration of each issue that makes up the NOMURA CMT Index with JGBs of the same remaining years to maturity.

Fig. 15: The effective duration of CMT and BPI JGB



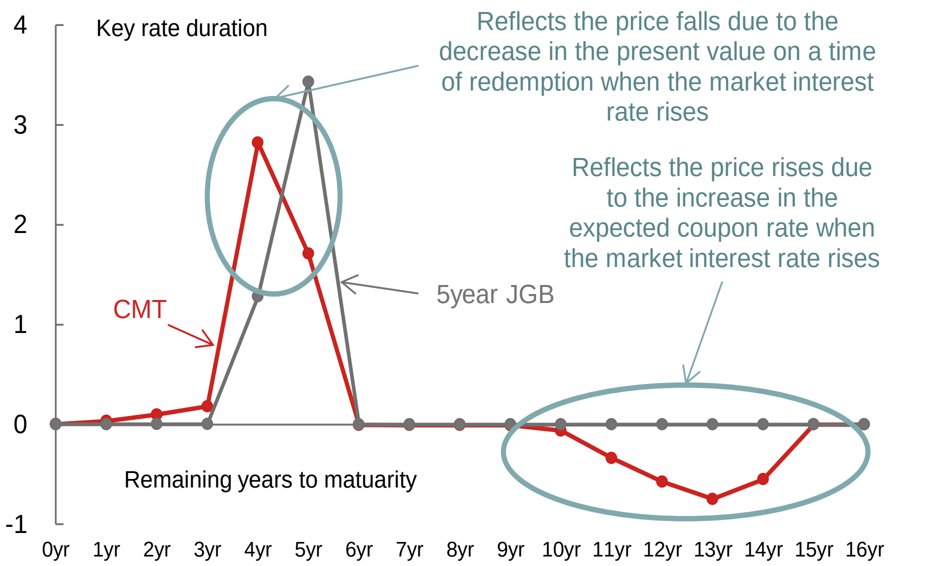
Source: Nomura
Note: As of 28 Dec 2018. BPI JGB is represented by the sub-indices regarding one year intervals with the remaining years to maturity

The effective duration of CMT is small when compared with JGBs of similar remaining years at maturities of two-and-a-half years or more. This does not mean the degree of price change with respect to the change in the interest rate is smaller than that of JGBs, but is because they have negative sensitivity (the price rises when interest rates rise) depending on terms.

Specifically, it can be shown by the shape of key rate duration, which is the price sensitivity to a change in the spot rate in each term. Fig. 16 shows key rate duration of the CMT (due for maturity in September 2023) and the 5yr JGB(due for maturity in May 2023) that has the approximately the same number of remaining years to maturity as the selected CMT.

[3] Effective duration can explain price change for plain fixed-rate bonds, and we also calculate the value of the effective duration on a daily basis for the NOMURA-BPI. However, in the case of a plain fixed-rate bond, as the most impactful cash flow occurs at the time of the maturity of the bond, there is no significant difference between the effective duration and the (modified) duration.

Fig. 16: Key rate duration of CMT and fixed rate bonds

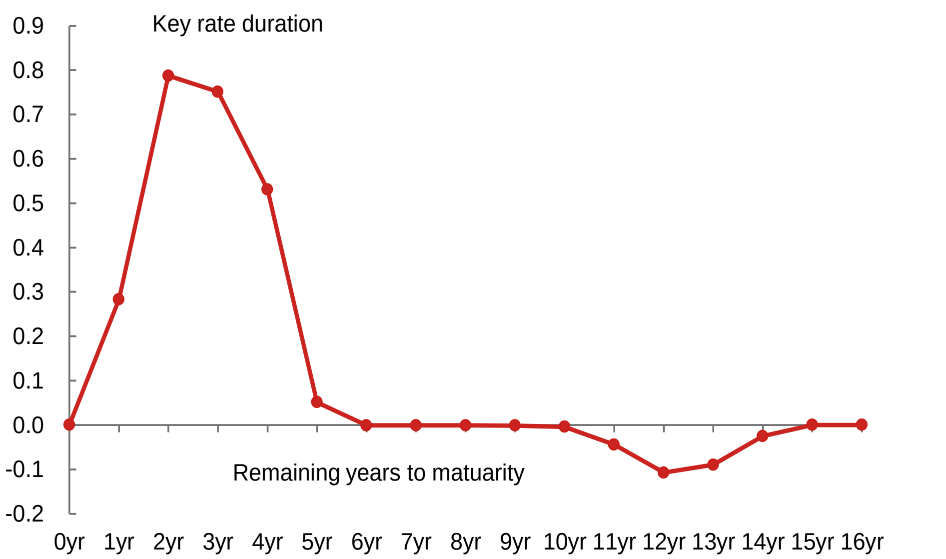


Source: Nomura
Note: As of 28 Dec 2018

In Fig. 16, the sensitivity of the CMT is negative when it is near the term of 13 years. Unlike plain fixed-rate bonds, for the CMT, the sensitivity on this term reflects price rises owing to the increase in the expected coupon rate when the market interest rate rises.

Key rate duration of the NOMURA CMT Index, which is an average of the key rate duration of each issue weighted by the total market value including accrued income, is shown in Fig. 17.

Fig. 17: Key rate duration of NOMURA CMT index



Source: Nomura
Note: As of 28 Dec 2018

Fig. 17 shows negative key rate duration focused on 12yr as of 28 December 2018.

The CMT, in contrast with ordinary fixed-rate government bonds, has issues whose price declines are restrained by higher coupon rates in an environment of rising market interest rates. However, Fig. 16 and Fig. 17 show whether the interest rate at the time of maturity changes or the interest rate at the time of evaluating the reference rate changes will have a different impact on the arbitrage price than the ordinary fixed-rate government bond.

3. Do: Invest the Index

When using index investing, it is also important to understand the constituents of the index from various viewpoints and know the characteristics of the individual issues which are included or excluded on reconstitution, not only to understand the overall picture such as the level of duration and yield. We will describe these issues in this chapter.

3.1 NOMURA-BPI

Composition of corporate bond sector, and samurai bond sector

When tracking the NOMURA-BPI, we generally use a stratified sampling method because of the constraints on face amounts relative to the AUM and liquidity. To use a stratified sampling method, it is needed to match the weightings, duration, compound yield and T spread levels of each category of the portfolio and the benchmark for management. And the category must be divided up such that the issues in each category have the almost the same risk/return characteristics. Fig. 18 shows the number of issuers for each sector of the NOMURA-BPI.

Fig. 18: NOMURA-BPI, Number of issuers by sector (28 December 2018)

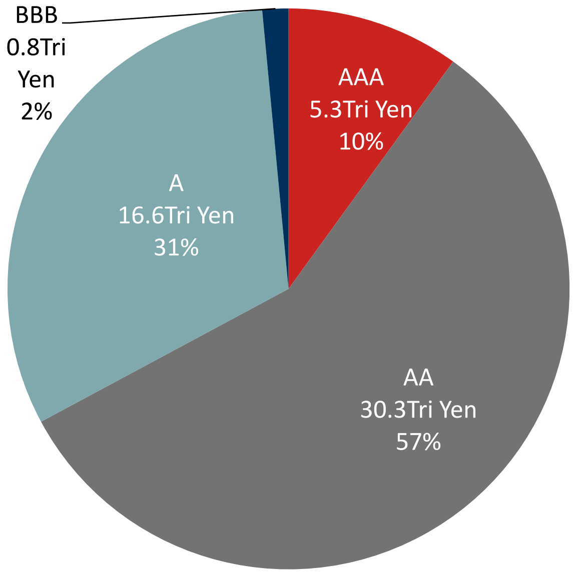
JGBs	Municipals	Government Guaranteed bonds	Bank debentures	Corporate bonds	Samurai bonds	MBS	ABS
1	62	15	1	334	43	1	46

Source: Nomura

Further, we show the composition, in slightly greater detail, of the corporate bond sector and the samurai bond sector, both of which include a variety of issues.

As mentioned in Chapter 2, the T spread level plays an important role in affecting bond returns. Additionally, the rating level is very important information as it will help with knowing the T spread. Fig. 19 and Fig. 20 show the value by rating category for NOMURA-BPI/Extended corporate bonds and samurai bonds, including BBB equivalents. For the definition of the highest rating, please refer to the "NOMURA-BPI Index Rulebook".

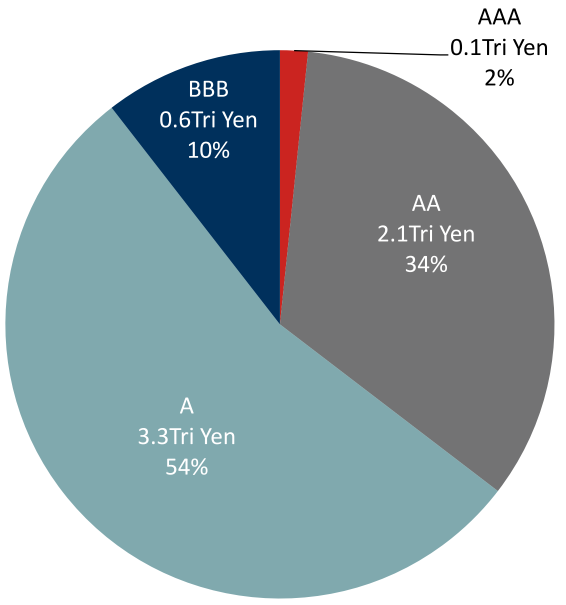
Fig. 19: Outstanding amount of NOMURA-BPI/extended corporate bonds classified by the highest rating



Source: Nomura
Note: As of 28 Dec 2018

The weight of AA and A sectors is large in the NOMURA-BPI/extended corporate bonds.

Fig. 20: Outstanding amount of NOMURA-BPI/extended samurai bonds classified by the highest ratings

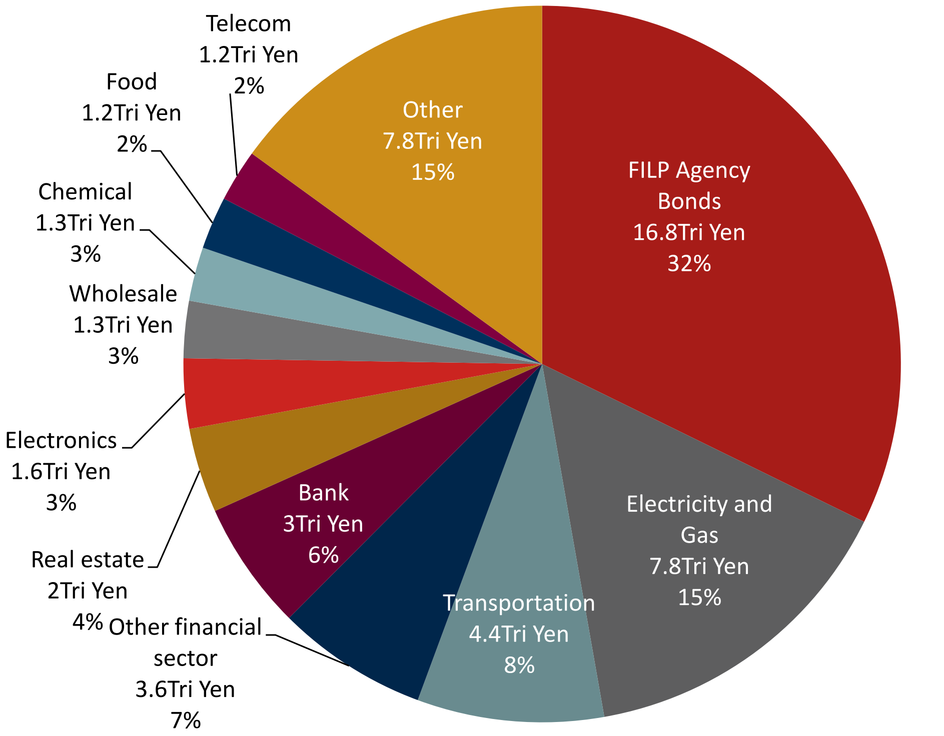


Source: Nomura
Note: As of 28 Dec 2018

In the NOMURA-BPI/extended samurai bonds, the weight of the AAA sector is smaller and the BBB sector is larger relative to the NOMURA-BPI/extended corporates.

Basically, the T spread reflects corporate creditworthiness and the average T spread of the index is often explained using the weighted average credit rating with the outstanding amount as shown above. By contrast, however, when unusual events occur such as the Great East Japan Earthquake, the T spread may change significantly for certain industries. For this reason, it is important to show the composition by industry. Fig. 21 shows the face value of the corporate bond sector by industry.

Fig. 21: Outstanding amount of NOMURA-BPI Corporate bonds classified by sector



Source: Nomura
Note: As of 28 Dec 2018

Fig. 21 shows that the weight of FILP agency bonds and others sector such as the electricity and gas sector are large and 85% of the pie chart is made up of the 11 highest industry categories.

Duration extension

In tracking portfolios, it is important to match interest rate sensitivity. In the NOMURA-BPI, issues with years remaining to maturity of less than one year are excluded on a monthly basis. When issues with short remaining years to maturity are excluded from the portfolio, the average duration of that portfolio extends. This extension is particularly marked at the end of months when large amounts of JGBs are excluded. To demonstrate this fact, past trends are shown separately for each factor of inclusion and exclusion. The methods for calculating the inclusion factor and exclusion factor are as follows.

$$\text{exclusion factor} = D_{keep}(eom) - D(eom)$$

$$\text{inclusion factor} = D_{pl}(eom) - D_{keep}(eom)$$

Note that

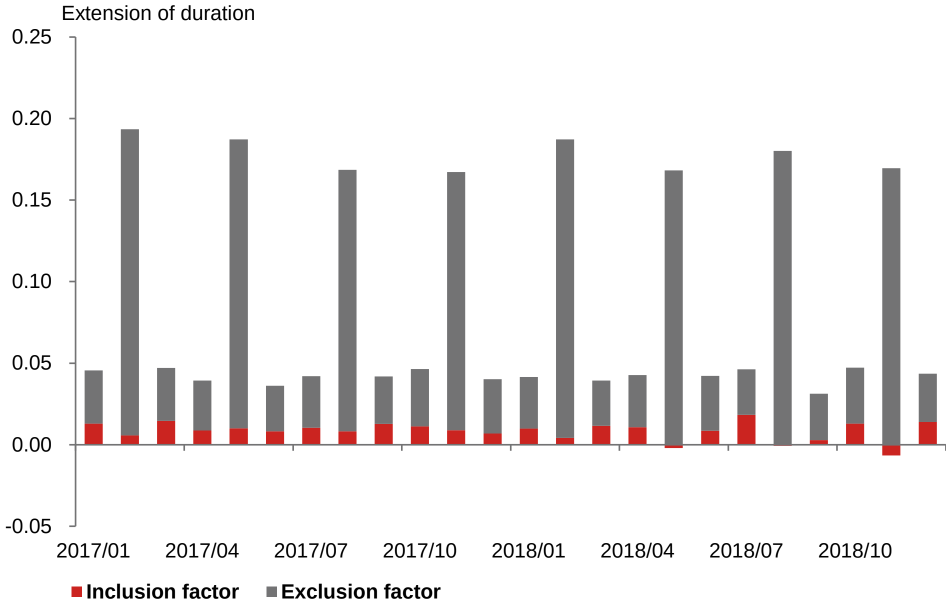
$D(t)$: Duration that is a weighted average with market value amount (incl. accrued interest) for the constituents of the current month index portfolio at time t

$D_{keep}(t)$: Duration that is a weighted average with market value amount (incl. accrued interest) for the constituent both of the current and next month index portfolio at time t

$D_{pl}(t)$: Duration that is a weighted average with market value amount (incl. accrued interest) for the constituents of the next month index portfolio at time t

eom : The end of the last business day of the current month.

Fig. 22: Extension of duration as for NOMURA-BPI



Source: Nomura
Note: Shows month-end duration extension in Jan 2017-Dec 2018

As Fig. 22 shows, duration tends to extend greatly owing to exclusion factors at the end of February, May, August and November every year. This is because JGBs that have years remaining to maturity of less than one year in the NOMURA-BPI are excluded from the index in response to redemptions of JGBs concentrated in the months of March, June, September and December.

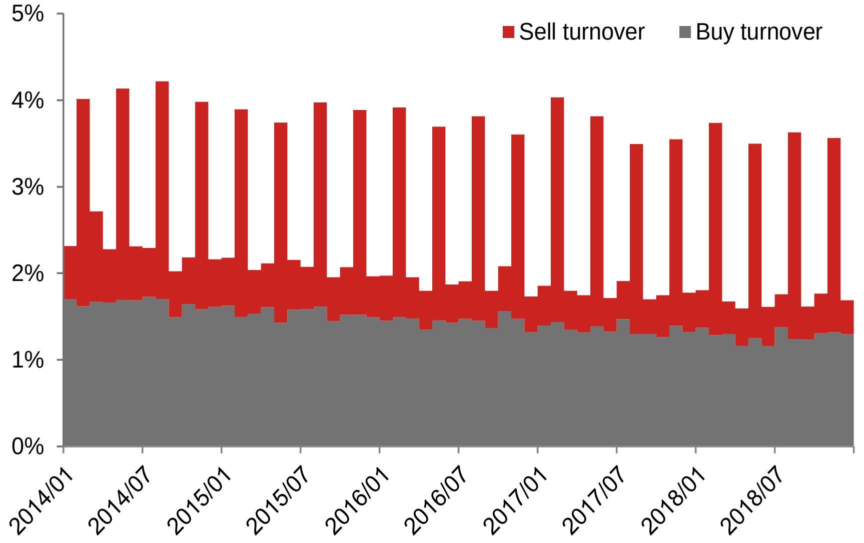
It is worth noting that none of the inclusion/exclusion factors had been negative until the inclusion factor posted a negative value at the end of May 2018 for the first time and was also negative at the end of August and November 2018. The duration of the NOMURA-BPI has been extending year by year, and as a result, the above mentioned $D_{keep}(t)$ exceeded the average duration of the issues to be incorporated.

Turnover rate

We provide the turnover rate of the index portfolio which is useful for calculating transaction costs. The turnover rate is the sum of the sell turnover rate and buy turnover rate, and each turnover rate is calculated using the follows.

$$\text{Sell turnover rate} = \text{Exclusion amount of the index portfolio in the current month}$$
$$\div \text{Total amount of the index portfolio in the current month}$$
$$\text{Buy turnover rate} = \text{Inclusion amount of the index portfolio in the next month}$$
$$\div \text{Total amount of the index portfolio in the next month}$$

Fig. 23: Turnover rate of the NOMURA-BPI

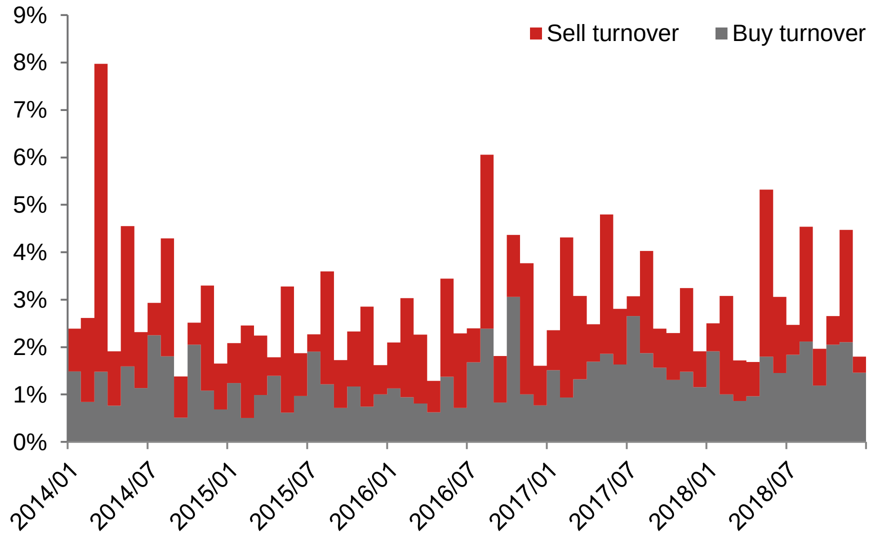


Source: Nomura
Note: Shows month-end turnover rate in Jan 2014-Dec 2018

We can see that sell turnover rates are large at the end of February, May, August and November every year, along with the redemptions of a large amount of JGBs. The sell turnover rate at the end of March 2014 was relatively large. This is because retail bonds were excluded from the NOMURA-BPI in accordance with revising the inclusion criteria.

In addition, Fig. 24 shows the turnover rate of the NOMURA-BPI corporates in the light of funds benchmarked by the NOMURA-BPI corporates.

Fig. 24: Turnover rate of the NOMURA-BPI corporate bonds



Source: Nomura
Note: Shows month-end turnover rate in Jan 2014-Dec 2018

Unlike NOMURA-BPI JGBs, the turnover rate of NOMURA-BPI corporate bonds do not have distinctive features. The turnover rate of the NOMURA-BPI corporate bonds is around 3%.

Portfolio tracking

Up to now, we have provided information to help with tracking the NOMURA-BPI precisely but, depending on the level of acceptable tracking error and financial constraints, there may be cases where we consider using slightly more simplified management. In this section, we show simulation results on the extent that tracking is possible with JGBs, interest rate swaps and JGB futures.

Fig. 25: Summary of the tracking method

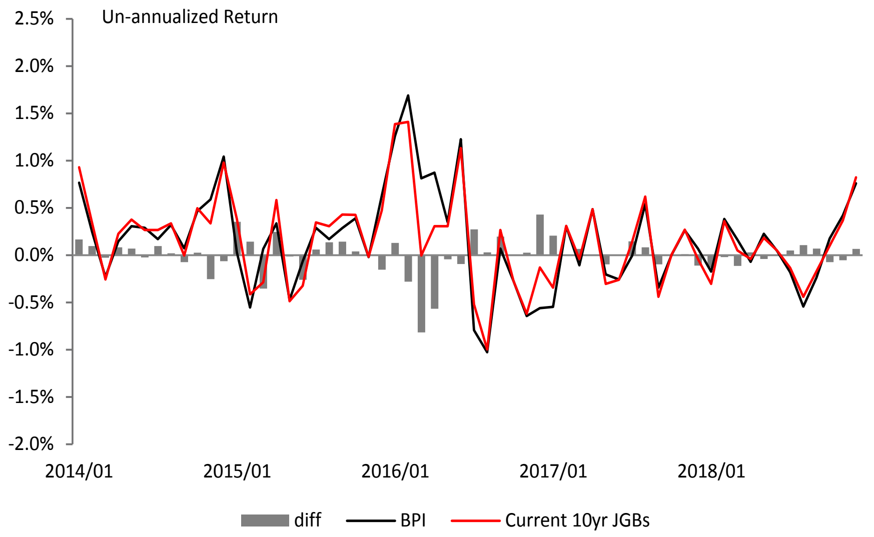
	Rebalance frequency	Risk indicator for matching
(1)Current 10yr JGBs	Monthly	Duration
(2)Current 2+5+10+20yr JGBs	Monthly	Duration of sub-indices for remaining years to maturity
(3)Five JGBs	Every 6months	Duration of sub-indices for remaining years to maturity
(4)2+5+10+20yr Interest rate swaps	Monthly	Duration of sub-indices for remaining years to maturity
(5)JGB futures	Monthly	Standard deviation based on daily return over latest 60 business days
(6)JGBs with around 30 issues by optimization method	Monthly	Maximizing compound yield based on the constraints to limit the difference between risk indicators of the tracking portfolio and the NOMURA-BPI to within a set range

Source: Nomura

(1)Tracking using current 10yr JGBs

The holding amount is determined at the end of every month so that duration of the tracking portfolio equals that of the NOMURA-BPI.

Fig. 26: Tracking using current JGBs (10yr)

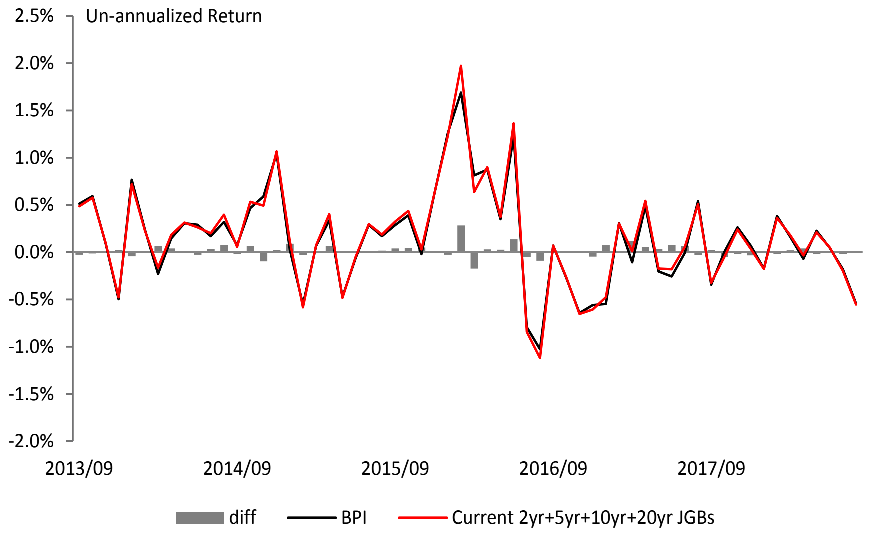


Source: Nomura
Note: Shows month-end un-annualized return in Jan 2014-Dec 2018

(2)Tracking using current 2+5+10+20yr JGBs

Holding amounts are determined so that the modified duration of the tracking portfolio matches that of the NOMURA-BPI in its breakdown by remaining maturity (1-3yrs, 3-7yrs, 7-11yrs, 11yrs +) at the end of every month.

Fig. 27: Tracking using current 2+5+10+20yr JGBs

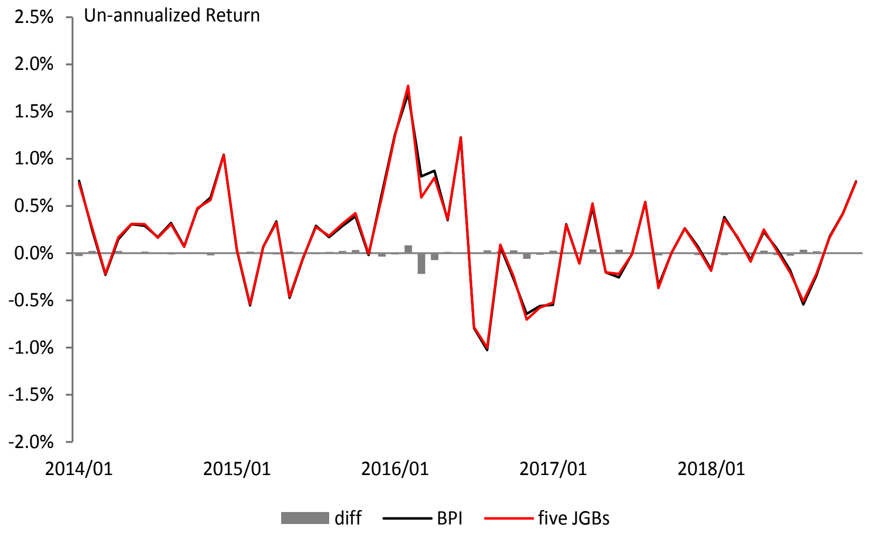


Source: Nomura
Note: Shows month-end un-annualized return in Jan 2014-Dec 2018

(3)Tracking using Five JGBs

We break down the NOMURA-BPI into five portfolios based on remaining maturity (1-3yrs, 3-7yrs, 7-11yrs, 11-25yrs, 25yrs +), and select one JGB issue whose duration is similar to that included in the portfolio of the respective maturity. Note that portfolios are rebalanced every six months, and the rollover rate is lower than in the cases where current issues are rolled over every month.

Fig. 28: Tracking using five JGBs



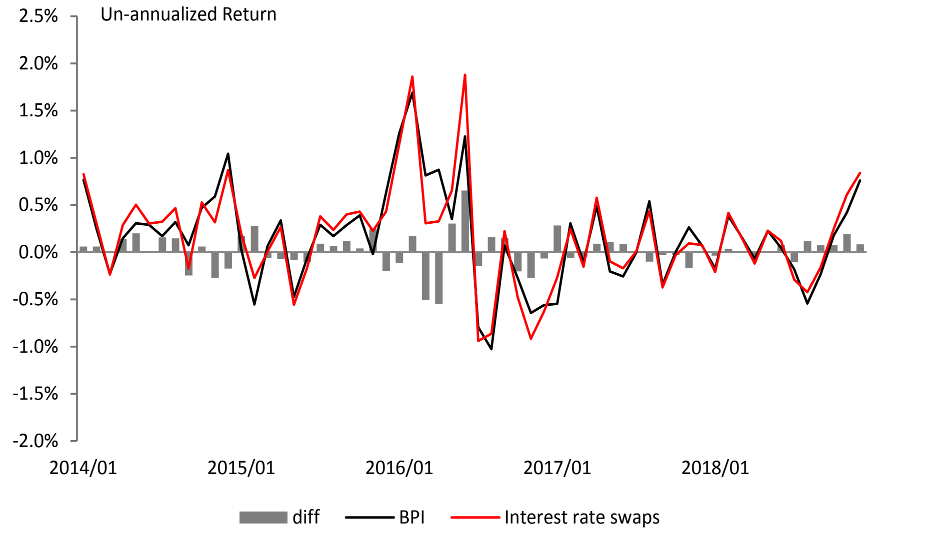
Source: Nomura
Note: Shows month-end un-annualized return in Jan 2014-Dec 2018

Even though the NOMURA-BPI includes around 7,000 issues in the calculation period, from January 2014 to December 2018, we replicated the index portfolio with around a 15bp tracking error using only five JGBs by matching the duration of sub-indices for the remaining years to maturity.
You can expect to replicate the index portfolio effectively by making good use of risk indicators.

(4)Tracking using interest rate swaps

The notional principal of interest rate swaps (for four types of maturity, 2yr, 5yr, 10yr, and 20yr) is determined so that the interest rate sensitivity of swaps matches the modified duration of the NOMURA-BPI in its breakdown by remaining maturity (1-3yrs, 3-7yrs, 7-11yrs, 11yrs and longer). Note that the portfolio is rebalanced monthly.

Fig. 29: Tracking using interest rate swaps

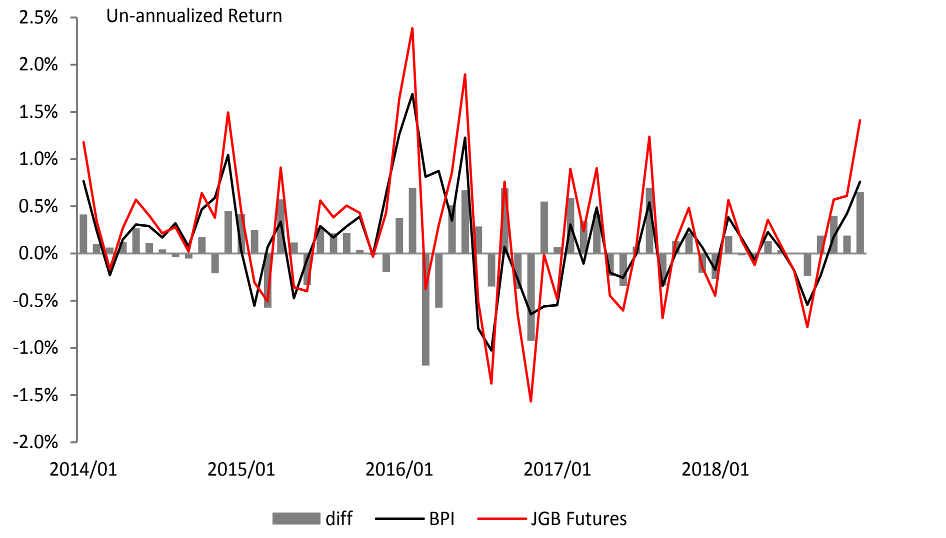


Source: Nomura
Note: Shows month-end un-annualized return in Jan 2014-Dec 2018

(5)Tracking using JGB futures

Holding amounts of JGB futures are determined using hedge ratios of JGB futures contracts to the NOMURA-BPI. The hedge ratio is a regression coefficient of a simple linear regression[4] for the NOMURA-BPI monthly return using the JGB futures monthly return, and the hedge ratio is calculated at the end of every month.

Fig. 30: Tracking using JGB futures



Source: Nomura
Note: Shows month-end un-annualized return in Jan 2014-Dec 2018

(5)Tracking by the optimization method

Tracking using the optimization method requires determining the constraints of optimization to align price movements of the portfolio and the NOMURA-BPI. Therefore, selecting indicators that show the attributes of the portfolio is important. These indicators include:

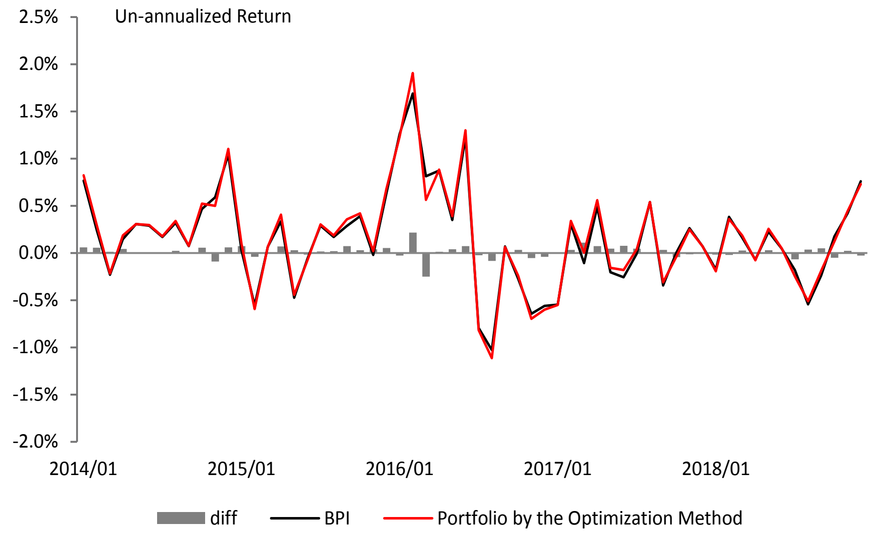
- Portfolio average duration,
- Portfolio average convexity,
- Sector distributions by term remaining to maturity, type of issue, etc,
- Average durations and average convexity within each sector,

[4] A simple regression based upon daily returns over latest 60 business days.

to note some examples.

Here, we consider selecting issues every month to maximize the compound yield to maturity of the tracking portfolio, based on constraints to limit the difference between risk indicators of the tracking portfolio and the NOMURA-BPI to within a set range. The number of issues in the tracking portfolio is around 30. Fig. 31 shows the performance of the tracking portfolio and the NOMURA-BPI and the difference in performance.

Fig. 31: Tracking by optimization method



Source: Nomura
Note: Shows month-end un-annualized return in Jan 2014-Dec 2018

At the end of this section we summarize the results. The tracking errors for the portfolio using interest rate swaps or JGB futures were relatively large because of the difference in risk characteristics. In this calculation period, we can replicate the NOMURA-BPI, whose JGB weighting is 70-80%, using five JGBs with around a 15bp tracking error as long as there is no big credit event.

Fig. 32: Tracking error as for each tracking portfolio

Tracking asset(method)	Tracking error
(1)Current 10yr JGBs (stratified sampling method)	66.3bp
(2)Current 2+5+10+20yr JGBs(stratified sampling method)	21.8bp
(3)Five JGBs(stratified sampling method)	13.1bp
(4)Interest rate swaps 2+5+10+20yr	65.1bp
(5)JGB Futures	133.3bp
(6)JGBs around 30 issues(optimization method)	20.8bp

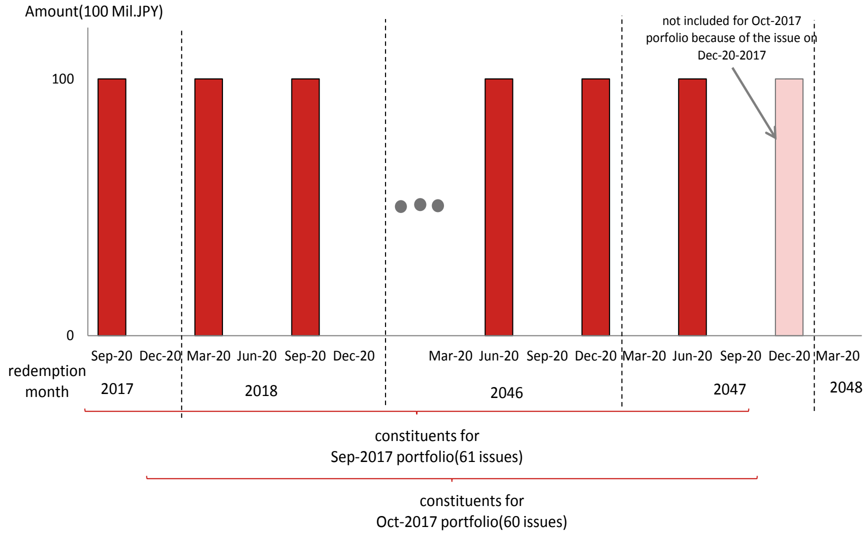
Source: Nomura
Note: The calculation using annualized return in Jan 2014-Dec 2018.

3.2 NOMURA-BPI/Ladder

Change in number of issues

The NOMURA-BPI/Ladder is a cumulative investment return index that illustrates the performance when investing in a laddered portfolio of JGBs. One key point to pay particular attention to here is the number of issues increases or decreases depending on the timing of the issuance of the new bonds. Fig. 33 shows an example for the NOMURA-BPI/Ladder 30yr. As the NOMURA-BPI/Ladder is an index that always includes bonds on a 10-billion-yen target basis, regardless of the issue amount, we remind you that it is an index that consists of equal-amount holdings.

Fig. 33: An example of changes in the number of issues in the NOMURA-BPI/Ladder 30yr



Source: Nomura

The issue that was redeemed on 20 September 2017 was included in the September 2017 index portfolio, and it was excluded at the end of September 2017 because of the redemption. After that, no new issues were included in the October 2017 index portfolio and the number of issues in the NOMURA-BPI/Ladder 30yr decreased to 59 at the beginning of October 2017. It is because there were no new JGBs issued in September 2017, whose redemption timings are in the latter part of FY2047 (Oct 2047-Mar 2048).

To carry out a completely passive investment, the redemption amounts for the redemption issue on 20 September 2017 need to be equally allocated to each constituent bond in the following month, and so it is necessary to prepare purchase amounts by selling an equally allocated amount in the month in which bonds are newly added. However, this method is not realistic because it inevitably results in an increase in transaction costs. For JGBs, there is always liquidity issues even without auctions, so it may be worth considering a new index that encompasses a rule that it will include the most recently issued JGBs at such time that redemption amounts are available at the end of the month.[5] Please contact us if you have any interest in such an index.

5 However, in such a case, there is a possibility that the redemption timing may not be as uniform as the NOMURA-BPI/Ladder, and so the issues may not be aligned at equal intervals in terms of remaining years to maturity, and so that the change in duration may become unstable.

4. See: Reviewing Index Investing

To calculate the deviation factor between the actual result of the index investing and the return indicated by the index, it is necessary to know the factors of the return caused by the index.

In this chapter, we show the results of the factor decomposition of the returns of various indices.

4.1 NOMURA-BPI

As mentioned in Section 2.2, bond price changes are expressed in terms of changes in yield, and the yield is broken down into the interest rate and T spread. Furthermore, even if the level of the interest rate or T spread do not change, bond estimated prices will rise (if the yield is positive) over time. In addition, for MBS (mortgage-backed securities), because of the existence of prepayment risk, with an embedded call option, a change in volatility can explain price changes.

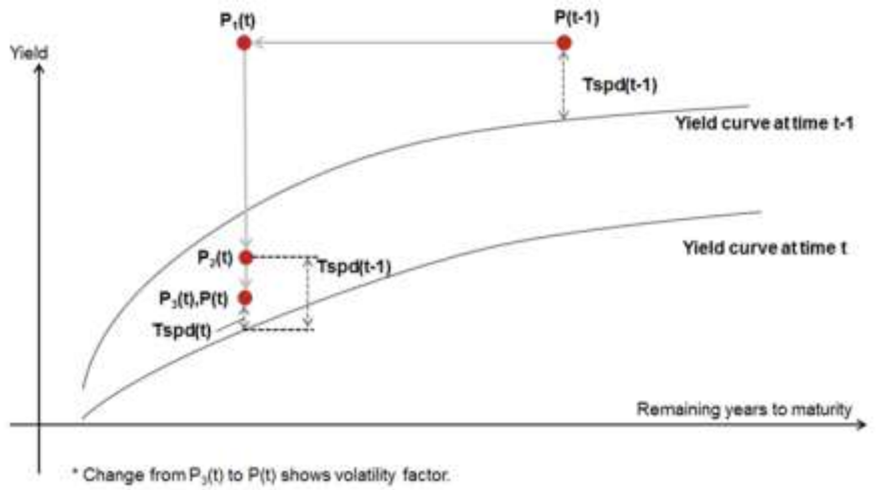
Here, we list four return factors:

- Time elapsed
- Changes in the yield curve
- Changes in T spread
- Changes in volatility[6]

First, we dissect the change from the price of an individual bond at the end of last month $P(t-1)$ to the price at the end of the current month $P(t)$ through the following four ways:

$P(t-1) \rightarrow P_1(t)$	:	Change in price due to time elapsed
$P_1(t) \rightarrow P_2(t)$	:	Change in price due to change in yield curve
$P_2(t) \rightarrow P_3(t)$	:	Change in price due to change in spread
$P_3(t) \rightarrow P(t)$	:	Change in price due to change in volatility

Fig. 34: Price changes due to individual factors



Source: Nomura

In each of these calculation processes, only the related factor is changed. That is, the parameters outlined in Fig. 35 are used to calculate price $P_1(t), P_2(t), P_3(t)$ and $P(t)$.

[6] This indicates the impact that changes in swaption volatility have on bond prices when passed through parameters.

Fig. 35: Parameters used for calculating the prices

	Yield curve	Swaption volatility	T spread
$P_1(t)$	Previous month	Previous month	Previous month
$P_2(t)$	Current month	Previous month	Previous month
$P_3(t)$	Current month	Previous month	Current month
$P(t)$	Current month	Current month	Current month

Source: Nomura

Using these prices, un-annualized returns for individual factors of individual bonds are calculated as the following.

Return due to time-elapsed factor: R_{TIME}

With the passage of time, not only does price change from $P(t-1)$ to $P_1(t)$, interest payments and principal redemption must also be considered.

$$R_{TIME} = \frac{P_1 F(t) - P(t-1)F(t-1) + CF}{P(t-1)F(t-1)}$$

$F(t)$: Remaining amount at time t

CF : Interest payments and principal redemption$(= C/100 \cdot F(t-1) + F(t-1) - F(t))$

C : Interest paid during month for JPY100 of face value

Return due to yield curve factors: R_{YC}

$$R_{YC} = \frac{(P_2(t) - P_1(t))F(t)}{P(t-1)F(t-1)}$$

Return due to T spread factor: R_{SPREAD}

$$R_{SPREAD} = \frac{(P_3(t) - P_2(t))F(t)}{P(t-1)F(t-1)}$$

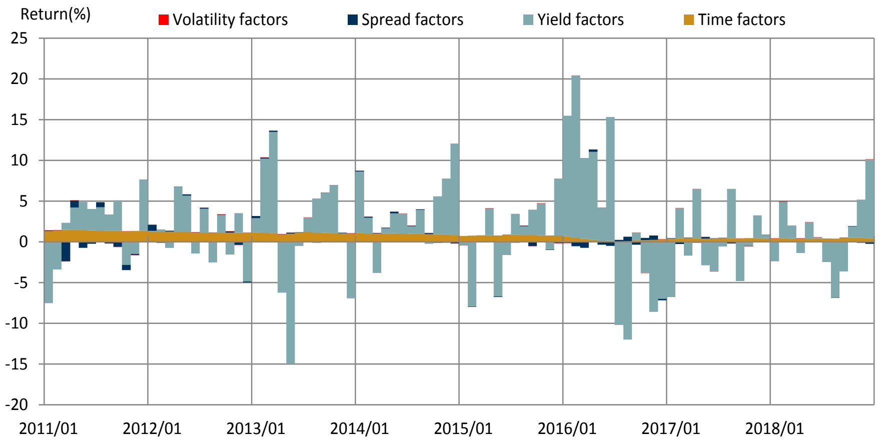
Return due to volatility factor: R_{VOL}

$$R_{VOL} = \frac{(P(t) - P_3(t))F(t)}{P(t-1)F(t-1)}$$

The return of the index is broken down by factor in the following procedure: 1) calculating the returns for individual factors of individual bonds using the above methods, and 2) calculating the weighted average of these returns by using the remaining amount of the bond as of the end of the previous month.

A dissection of the return results are shown below for the NOMURA-BPI, the NOMURA-BPI corporates, and the NOMURA-BPI MBS. Note that annualized data are shown in Fig. 36-38.

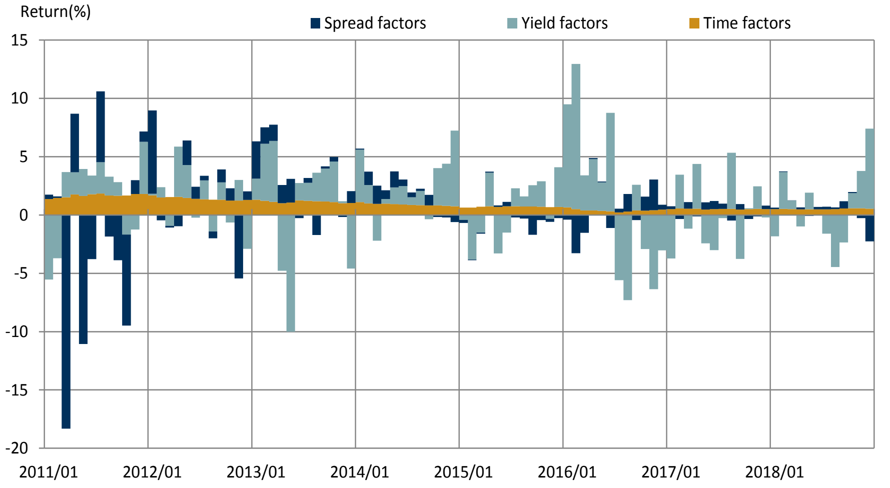
Fig. 36: Return factor analysis of the NOMURA-BPI



Source: Nomura
Note: Shows month-end return in Jan 2011-Dec 2018

We see that in the NOMURA-BPI, of which up to 80% consists of JGBs, more than half of the returns are due to the yield curve factor and the time elapsed factor. Furthermore, the time elapsed factor decreased along with the downward shift in yields.

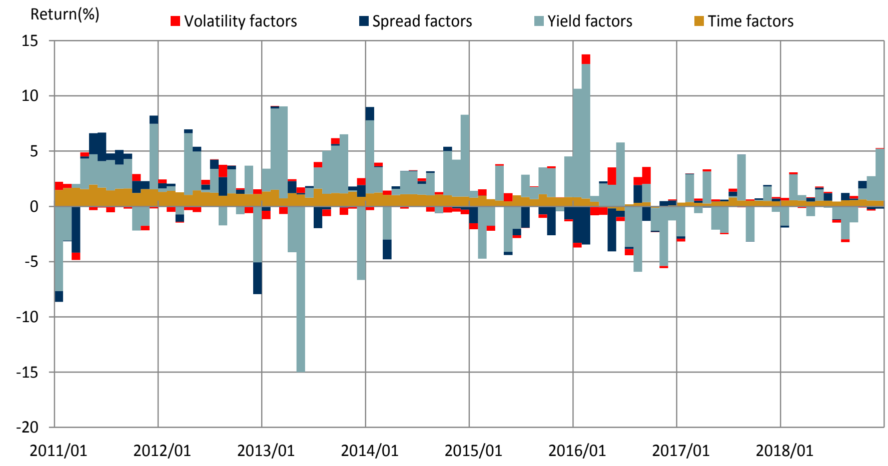
Fig. 37: Return factor analysis of the NOMURA-BPI corporates



Source: Nomura
Note: Shows month-end return in Jan 2011-Dec 2018. Volatility factor is not calculated with Corporate bonds.

Fig. 37 shows that in the NOMURA-BPI corporates, there was the great impact on the index return owing to the T spread factor after March 2011, when the Great East Japan Earthquake occurred.

Fig. 38: Return factor analysis of the NOMURA-BPI MBS



Source: Nomura
Note: Shows month-end return in Jan 2011-Dec 2018

Unlike other NOMURA-BPI sub-indices, the volatility factor is reflected in the NOMURA-BPI MBS. We have seen when the T spread factor has had a big impact between 2015 and 2016, along with the widening of the T spread caused by negative interest rate policy.

4.2 NOMURA J-TIPS Index

As mentioned in Section 2.2, nominal JGBs and the rise in bond prices (positive bond returns) have meant a decline in (nominal) yields. Conversely, for JGBi, when the nominal price of JGBi[7] (inflation-adjusted prices) rises, whether expressed in terms of an increase in the indexation coefficient or in the real price (that is to say, in the price before inflation adjustment) rising (that is, there is a decrease in the real yield), it means that one or the other of them is occurring. An increase in the indexation coefficient is caused by a rise in the inflation rate that occurred from the past time to the valuation date, and a decline in the real yield is due to a decrease in the nominal yield or to a rise in the BEI (break-even inflation), which is considered as the expected inflation rate, or is the result of the existence of both these factors.

Here, we list four return factors:

- Changes in the past inflation rate
- Time elapsed
- Changes in nominal yield
- Changes in BEI(expected inflation rate).

The definitions of each symbol are as follows.

[7] The nominal price (price after inflation adjustment) of inflation-linked government bonds is expressed as the product of the indexation coefficient and the real price (price before inflation adjustment). For this point, please also refer to "Nomura Inflation-linked JGB Index: Index Construction Rule Book".

$R(t)$	:	Total return of NOMURA J-TIPS Index at time t
$DP(t)$	:	Dirty price unadjusted for inflation at time t
$ADP(t)$	:	Dirty price adjusted for inflation at time t
$IR(t)$	:	Index ratio at time t
$r(t)$	:	Real compound yield at time t
$\pi(t)$	:	Break-even inflation rate at time t
$n(t)$	:	Nominal compound yield at time t
Δt	:	Elapsed time between time $t-1$ and time t
$D(t)$		Duration[8] at time t

Note that each equation indicates as follows

(1) Changes in the past inflation rate

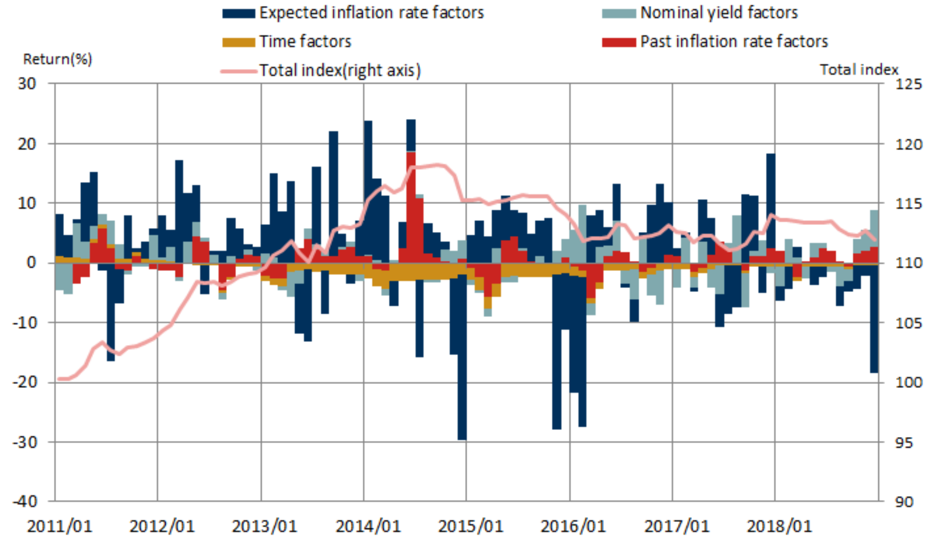
(2) Time elapsed

(3) Changes in the nominal yield

(4) Changes in the expected inflation rate.

Fig. 39 shows the result of the return decomposed into four factors.

Fig. 39: Return factor analysis of the NOMURA J-TIPS Index



Source: Nomura
Note: Shows month-end return in Jan 2011-Dec 2018. Total index is rebased so that end-Dec 2010 = 100.

We can see that the impact of the changes of the expected inflation rate was big when the NOMURA J-TIPS Index performed well in 2004 and became worse in the latter half of 2015 and the former half of 2016.

[8] Unlike other chapters in this document, "Duration" in this chapter stands for duration, what we call Macaulay duration, not modified duration. The definition of "duration" is placed in "NOMURA J-TIPS Index Rulebook".

Appendix A-1

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