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Introduction

There are many interest rate index series where the data are expressed as per annum interest rates, also known as yields. Some examples of these are LIBOR indices of various maturities. Maturities are expressed in number of days, weeks, months, and years.

For benchmark comparison and various other purposes, knowing the yield is often insufficient, and the return information is required. However, insufficient information exists to make a precise calculation of returns possible, but approximations can be estimated by making assumptions.

This methodology addresses the assumptions and formulas used in calculating the Total Return. This methodology is only applicable to interest rate series that are updated at a daily frequency. It is intended for interest rate indices with one or less years to maturity.
Methodology

Assumptions
Following are the assumptions that Morningstar makes in the return calculation of interest rate index series:

1. Each index consists of a single interest rate instrument; in other words, it is not a basket.
2. At the beginning of each day, an instrument is purchased at the prior day’s price, and daily return reflects the change in daily valuation of this instrument.
3. The yield curve is flat over the horizon of the holding period.
4. Day count is actual/360.

These indices’ yields at the end of the holding period are not available. For example, at the end of a one-day holding period, an instrument that had 30 days to maturity at the beginning of the day now has 29 days to maturity, and the index providers do not publish the yield of a 29-day instrument. By assuming that the yield curve is flat at this segment, the yield of a newly published 30-day instrument is used as the yield of the old instrument that has 29 days left to maturity.

Although some interest rate indices are based on day count of actual/365, the majority of the interest rate indices are stated based on day count of actual/360, and this is the general convention Morningstar is adopting for all interest rate indices.
Methodology (continued)

**Formula**

Morningstar defines price of an interest rate instrument as follows:

\[
P_t = \frac{100}{1 + \frac{y_t \cdot m_t}{100 \cdot 360}}
\]

Based on the definition of price above, the formula for total return is as follows:

\[
TR_t = \left( \frac{P_t}{P_{t-1}} - 1 \right) \cdot 100 = \left( \frac{1 + \frac{y_{t-1} \cdot m_{t-1}}{100 \cdot 360}}{1 + \frac{y_t}{100} \cdot \max\left(m_{t-1} - d_{t-1,t}, 0\right)} - 1 \right) \cdot 100
\]

Where:

- \( TR_t \) = total return for business day "t", expressed in percentage format, e.g. 0.2 means 0.2%
- \( P_t \) = price of the interest rate instrument on business day "t"
- \( y_t \) = yield, also known as interest rate, expressed in percentage format, on business day "t"
- \( m_t \) = number of days to maturity of the interest rate instrument on business day "t"
- \( d_{t-1,t} \) = number of days between business day "t" and one business day prior to "t"
- \( t \) = business day "t"
- \( t - 1 \) = one business day prior to day "t"
Methodology (continued)

Note:

► $m_t$ is the number of days to maturity of the interest rate instrument on business day "t". For example, let "t" be January 31 which is a business day in a leap year, the maturity date of a 10-month interest rate instrument is assumed to be November 30, and $m_t = 304$. Similarly, when "t" is January 30 of the same year, the maturity date of a 10-month interest rate instrument is considered November 30 as well, and $m_t = 304$. When "t" is April 30, the maturity date of a 1-month interest rate instrument is assumed to be May 31.

► $d_{t-1,t}$ is the number of days between business day "t" and one business day prior to "t". This number is one most of the time, but it can be greater than one when spanned over a weekend or holidays.

► $\max(m_{t-1} - d_{t-1,t}, 0)$ is used rather than $(m_{t-1} - d_{t-1,t})$ because the latter can be negative. An example of such situation happens when calculating return for an overnight interest rate instrument on a Monday where $m_{t-1} = 1$ and $d_{t-1,t} = 3$. Another example occurs when calculating return for a 3-day interest rate instrument on a Tuesday following a Monday that is a holiday where $m_{t-1} = 3$ and $d_{t-1,t} = 4$.

► Return is zero on a non-business day.

► Return is zero on a business day where the yield information on this day or the prior business day is not available.