ICE U.S. DOLLAR INFLATION INDEX FAMILY

CALCULATION METHODOLOGY

13th July 2022

Preface

Document Purpose

Initial calculation methodology for proposed ICE U.S. Dollar Inflation Index Family - Feedback Period

Document History

VERSION NO.	DATE	CHANGE DESCRIPTION
V2.5	13 July 2022	Revised model to provide more flexibility in calculation periods.

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1. OVERVIEW

1.1 BACKGROUND

IBA is proposing to publish a set of U.S. Dollar Inflation Indices, based on relevant US Treasury and Swap instruments. The intention is to have a broader base for the calculation than just one instrument class, with a view to potentially launching a benchmark if market feedback is positive.

For the purposes of these indices, ”inflation” means **the annual percentage rate of increase of the Consumer Price Index**; specifically, the headline index “CPI for All Urban Consumers (CPI-U)”, published monthly by the U.S. Bureau of Labor Statistics[1]

The Inflation Indices will consist of three annualized market-implied expected inflation rates, and two Calendar Year (Dec-Dec) inflation rates, each published daily:

- **1 Year inflation (“INFL 1Y”) starting from the latest published CPI**
- **5 Year inflation, 1 Year forward (“FWD INFL 1x5Y”) from latest CPI**
- **5 Year inflation, 5 Years forward (“FWD INFL 5x5Y”) from latest CPI**
- **Current Calendar Year (Dec to Dec)**
- **Next Calendar Year (Dec to Dec)**

For example, on July 14th, 2022, these rates would be based on prices of instruments settling on July 15th. The most recent publication of CPI would be the June 2022 figures, which were published on July 13th, 2022. The calculation would estimate inflation over the following periods:

- **INFL 1Y:** June 2022 to June 2023
- **FWD INFL 1x5Y:** June 2023 to June 2028
- **FWD INFL 5x5Y:** June 2027 to June 2032
- **Current Calendar Year:** Dec 2021 to Dec 2022
- **Next Calendar Year:** Dec 2022 to Dec 2023

After the July CPI figure is published, on August 10th 2022, the first three rates would move to start/end in July of their respective years.

In deriving projections of future CPI from Treasury and Swap instruments, the model assumes T+1 settlement and uses instruments which represent a three month lagged view of CPI.

[1] See https://www.bls.gov/cpi/

2. CALCULATION

2.1 CALCULATION INPUTS

The input data will be:

- US Treasury TIPS and US Treasury bills, notes and bonds with like maturities. Taken together, a forecast inflation rate for the maturity can be implied.
    - Data for each instrument includes maturity date, coupon, and daily closing price.
    - Since TIPS do not always mature on exactly the same dates as nominal Treasuries, the Treasury yield will be interpolated from earlier and later Treasuries if needed. Where there is no earlier Treasury, the yield of the next maturing Treasury within a 45-day window will be used; and if this is not possible, then the TIPS will be excluded from the calculation.
- Daily Reference index values for all selected TIPS, as published by the US Treasury[2].
- A swap-derived inflation curve, which is calculated from zero-coupon inflation swaps and provides constant maturity rates at 1Y, 2Y, etc.
- Weightings determined by IBA for blending the implied inflation rates determined from the two source instrument types. These will be determined periodically based upon IBA's assessment of the relative volumes of TIPS versus inflation-linked swaps trading in the fixed income markets. The initial weighting is 3:1.

2.2 CALCULATION STEPS

The calculation occurs for each "Calculation Date" (any US business day), after market close, once all required inputs are available. In practice, calculation and publication are likely to occur the following morning.

2.2.1 IDENTIFY AVAILABLE TIPS INSTRUMENTS

The first step is to identify eligible TIPS instruments current on the Calculation Date, subject to the following eligibility criteria:

- Issue date is not after the calculation date
- Maturity date is at least 30 days after the calculation date. This is because prices of bonds close to maturity may be influenced by liquidity or other factors outside of their economic parameters.
- Maturity date is no more than 9000 days (approx. 24 years) after the calculation date. (This is only in order to avoid unnecessary calculations).
- Coupon is fixed and semi-annual
- Coupon does not exceed the **TIPS maximum coupon threshold**. This is currently 1.5% and will be reviewed periodically in line with the typical range of issuance.

[2] US Treasury daily "Reference CPI" numbers for TIPS are published at https://www.treasurydirect.gov/instit/annceresult/tipscpi/tipscpi.htm

2.2.2 FIND A TREASURY YIELD FOR EACH TIPS INSTRUMENT

For each TIPS in turn, derive a nominal Treasury Yield for the same maturity date, from the available bills, notes and bonds, as follows:

- Consider only nominal Treasury Bills, Notes and Bonds meeting the criteria:
  - Issue date is not after the calculation date
  - Maturity date is at least 30 days after the calculation date.
  - Maturity date is no more than 9000 days (approx. 24 years) after the calculation date.
  - Coupon is fixed and semi-annual (or, for Bills, there is no coupon)
  - Coupon does not exceed the **Treasury maximum coupon threshold**. For nominal Treasuries this is currently 4.5%. (This will be periodically reviewed).
- If there is an eligible nominal Treasury instrument with **the same** maturity date as the TIPS, calculate Yield for this instrument and use this.
- Otherwise, if there are eligible nominal Treasuries maturing **before and after** the TIPS, calculate Yield for the nearest ones and perform a linear interpolation between them.
- Otherwise, if there are no nominal Treasuries maturing earlier than the TIPS, find the nearest-maturing Treasury bill maturing **after** the TIPS, subject to a maximum maturity date 45 days after the TIPS, and use this yield.
- If no nominal Treasury yield can be determined from the above rules, this TIPS cannot be included in the calculation.
- **Note:** There is currently no rule for selecting between nominal Treasuries of equal maturity date.

2.2.3 CALCULATE PROJECTED CPI LEVEL AT MATURITY FOR THIS TIPS

- **For each TIPS in turn:**
  - Calculations are based on T+1 settlement and Actual/Actual day count convention
  - Retrieve end of day price, maturity date and coupon for the TIPS on the Calculation Date
  - Retrieve the TIPS reference index level for the Settlement Date as published by US Treasury (NB this incorporates a three-month lag, as described below).
  - Use the previously determined nominal Treasury Yield value to calculate discount factors for each TIPS coupon date.
  - Construct a model to calculate NPV for the TIPS using the calculated discount factors, the daily reference index levels, and the TIPS end of day price, assuming an (unknown) inflation rate of R.
    - Cash flows are initial purchase price, accrued interest, coupon payments and redemption value, all discounted according to the calculated discount factors.
    - See model description below (§2.3)
    - IBA is seeking market feedback as to whether or not seasonality adjustments should be included in these calculations.
  - Find the optimal value of R which closely approximates a zero NPV for the TIPS, at the end of day price. This optimal value of R is the implied breakeven annualized inflation rate for the life of the TIPS.

- From the model, with breakeven rate R, determine the **projected CPI level at maturity** of the TIPS.

2.2.4 INTERPOLATE TIPS-DERIVED CPI LEVEL FOR RELEVANT MATURITY DATES

- **Determine the Start Date for each term rate, which is the nominal date of the most recent Consumer Price Index publication**
    - For example, on 1 May, the Start Date will be 1 March.
    - After April CPI is published (in mid-May), the Start Date will be 1 April
- **Determine start and end CPI for each of the periods required to determine the published term rates (Start date, start date + 1,5,6 and 10 Years):**
    - The index level for the start date is known, as it has already been published.
    - Determine a maturity date exactly n years from the Start Date.
    - Determine actual days to maturity from start to end date (e.g. for Start Date+1 Year this might be 365 or 366)
    - Determine a projected CPI level for the required maturity date
        - The 3-month lag in TIPS reference CPI must be taken into account, e.g. to determine the index level for 1 Jan, we would be looking for a TIPS maturity of 1 Apr.
        - If there is a TIPS with exactly the required maturity date, use the calculated index value at maturity from that TIPS;
        - otherwise, perform a straight-line interpolation between the adjacent TIPS maturities, based on maturity date.
- **For each Calendar year**, determine index levels for December the previous year and December this year.
    - The index for the start of the period:
        - might already be known, if the year being calculated is the current year and the calculation date falls after the BLS has published the previous December's index (typically in the second week of January); or
        - may be interpolated between the projected CPI at maturity of two adjacent TIPS, if their three month lagged maturity dates fall either side of December 1st; or
        - may be interpolated between the latest published CPI and the projected CPI at maturity of the earliest TIPS maturity that has a lagged maturity within the period (This might occur when the calculation is before mid-January and the next TIPS maturity is after 1 March).

2.2.5 INTERPOLATE SWAP-BASED CPI PROJECTIONS FOR THE SAME DATES

- **Retrieve the swap-based Inflation Curve for annual maturities and for Calendar Years**
    - Use the rate from the swap-based inflation curve for each maturity, together with the Reference index values for the Settlement Date, to calculate a projected CPI level at maturity for each annual maturity date.
    - Interpolate Swap based CPI levels for term and calendar periods in the same manner as for TIPS-based rates.

2.2.6 CALCULATE 'BLENDED' CPI AT EACH REQUIRED DATE

- **For each required date:**

  Calculate a weighted average of the two CPI values already determined (TIPS-Derived and swap-based inflation curve)

  - Currently, the weighting is 3:1 in favour of TIPS:
    - $Blended\ CPI\ = \frac{3 \times (TIPS\ derived\ CPI) + 1 \times (Swap\ based\ CPI)}{4}$
  - The weighting ratio will be reviewed periodically (e.g. 6 monthly) to reflect IBA's assessment of the relative trading volumes of the two instrument types.

2.2.7 CALCULATE 1Y, 1X5 FORWARD AND 5X5 FORWARD RATES, AND CALENDAR YEAR RATES FOR PUBLICATION

In these calculations, 'CPI' means either published CPI (for dates up to the last published CPI); or the calculated Blended CPI projection as described above (for dates after the last published CPI).

- The Inflation Expectation rate for an annual term (e.g. 1 Year) is calculated as:
  - $\text{INFL N Years} = \left(\frac{CPI\ at\ Start+N\ Years}{CPI\ at\ Start}\right)^{\frac{1}{N}} - 1$
  - For example: on 6 June 2022, the 1Y calculation is for April 2022-April 2023 (since May CPI has not yet been published)
    - April 2022 CPI (Published May 11th) is 289.109
    - Projection of April 2023 CPI from TIPS and Swaps is 303.332
    - April-April INFL 1Y expectation is therefore:

      $$\left(\frac{303.332}{289.109}\right) - 1 = 0.049196 = 4.92\%$$

- The forward (e.g. "FWD INFL 1x5Y") rates will be calculated from the projected CPI levels as follows:
  - $\text{FWD INFL NxM Y} = \left(\frac{CPI\ at\ [Start+N+M\ Years]}{CPI\ at\ [Start+N\ Years]}\right)^{\frac{1}{M}} - 1$
  - For example, the 5 Year inflation, 1 Years forward ("FWD INFL 1x5Y") rate will be calculated from the blended rates for 1Y and 6Y as follows:
    - $\text{FWD INFL 1x5Y} = \left(\frac{CPI\ at\ [Start+6Y]}{CPI\ at\ [Start+1Y]}\right)^{\frac{1}{5}} - 1$

- The Calendar Year rates will be calculated from the CPI values for 1 Dec each year, as follows:
  - $Cal\ Year\ yyyy = \left(\frac{CPI\ at\ (1\ Dec\ yyyy\ )}{CPI\ at\ (1\ Dec\ yyyy-1Y)}\right) - 1$
  - Whether the start CPI is a projected or published CPI depends upon the timing of the calculation relative to the date in question. For example, on January 10th 2022, the December 2021 CPI has yet to be published; but on January 13th the actual Dec 2021 CPI would be used.

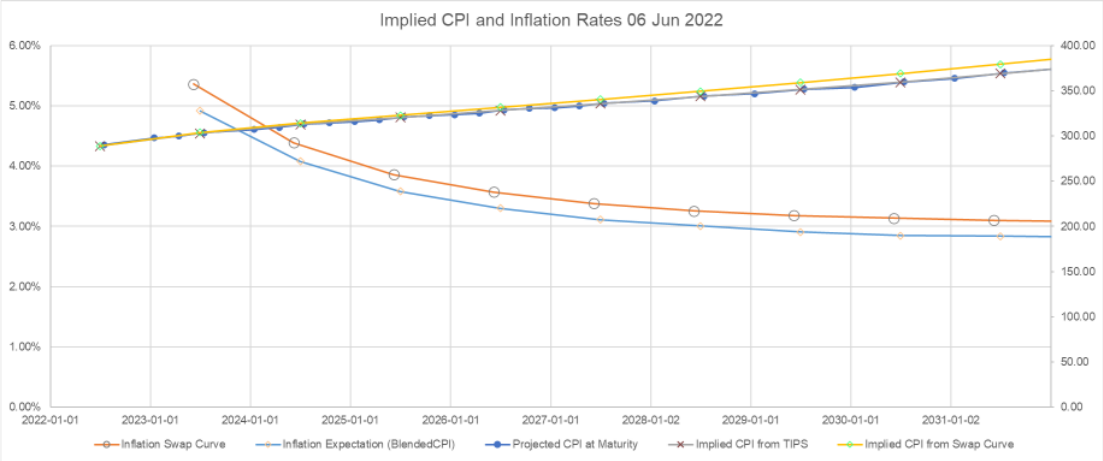
2.3 TIPS RATE MODEL

The model used to derive a rate of inflation, and thereby a projected Consumer Price Index level, from TIPS and nominal Treasury prices is as follows:

1. Determine the set of cashflow dates (0..k) for the TIPS.
    - Cashflow date 0 is the settlement date (T+1 from calculation date)
    - Cashflow dates 1..k are the semi-annual coupon dates. The final coupon date, k, is the maturity date of the TIPS, (k-1) is six calendar months earlier, and so on. Coupon 1 is the nearest coupon, which will be no more than six months after the settlement date.
2. Determine a discount factor for each cashflow date, based upon a nominal Treasury yield already identified for the same maturity.
    - Discount factor for cashflow date 0 (Settlement date) is 1.00
    $$DF_0 = 1$$
    - Discount factor for cashflow date i (i=1..k) is:
    $$DF_i = \frac{DF_{i-1}}{(1+Yield)^{\frac{actual\ days\ since\ cashflow\ date\ (i-1)}{days\ in\ calendar\ year\ ending\ cashflow\ date\ (i)}}}$$
3. Using the unknown inflation rate R, determine the reference CPI value for each cashflow date:
    - Reference CPI for settlement date $RefCPI_0$ is as published by US Treasury
    - Reference CPI for all subsequent coupon dates is:
    $$RefCPI_i = RefCPI_{i-1} * (1+R)^{\frac{actual\ days\ since\ cashflow\ date\ (i-1)}{days\ in\ calendar\ year\ starting\ cashflow\ date\ (i-1)}}$$
4. Sum the cashflows (per $100 par amount) to determine net present value (NPV)
    - For settlement date: outgoing principal payment (per par value) and accrued interest:
    $$CF_0 = -\left(Price + \$100 * \frac{Coupon}{2} * \frac{actual\ days\ since\ start\ of\ coupon\ period}{actual\ days\ in\ current\ coupon\ period}\right) * DF_0$$
    - For each coupon date, including maturity date: incoming coupon payment:
    $$CF_i[1 \le i < k] = \left(\$100 * \frac{Coupon}{2} * \frac{RefCPI_i}{RefCPI_0}\right) * DF_i$$
    - For maturity date, the incoming cashflow includes the final coupon payment and repayment of the inflation-adjusted principal:
    $$CF_k = \left(\$100 * \frac{Coupon}{2} * \frac{RefCPI_k}{RefCPI_0} + \$100 * \frac{RefCPI_k}{RefCPI_0}\right) * DF_k$$
5. Apply an optimization algorithm to select a value for the breakeven inflation rate R (the rate which gives NPV=0 to within a tolerance of $0.000001)
6. Determine the projected maturity CPI of this TIPS as the reference CPI at maturity date of the optimized model.

3. SAMPLE RESULTS

Example: CPI & Rate curves by Days to Maturity for a single day



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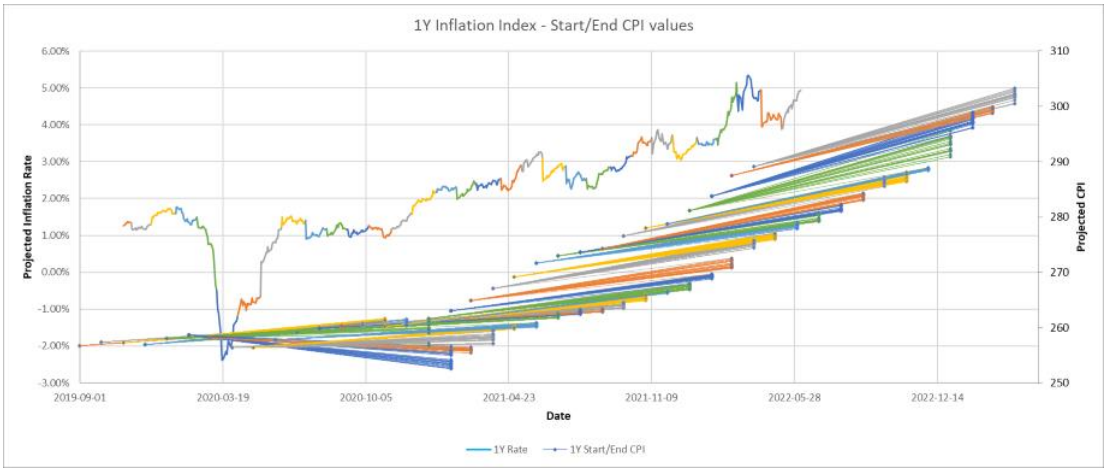
Example: Illustration of 1 Year term periods over time



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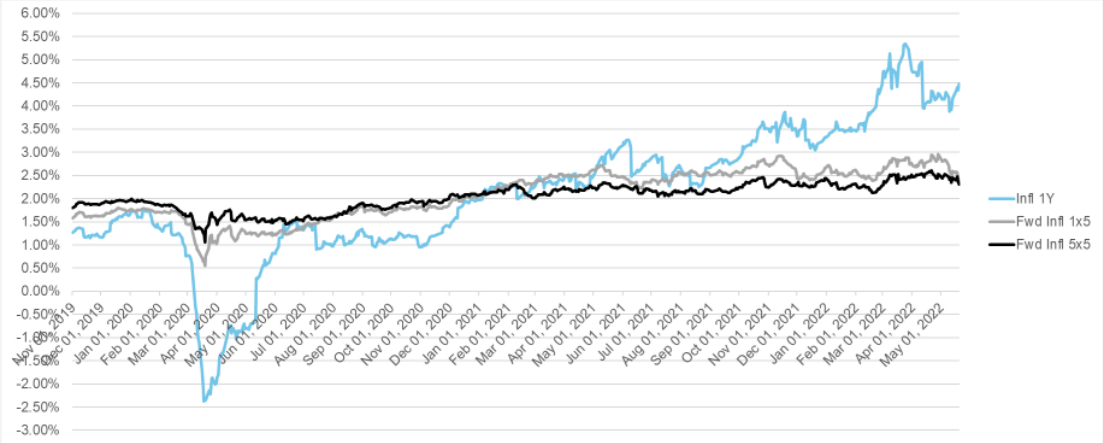
Example: Backtesting results – 1 Year & Forward rates



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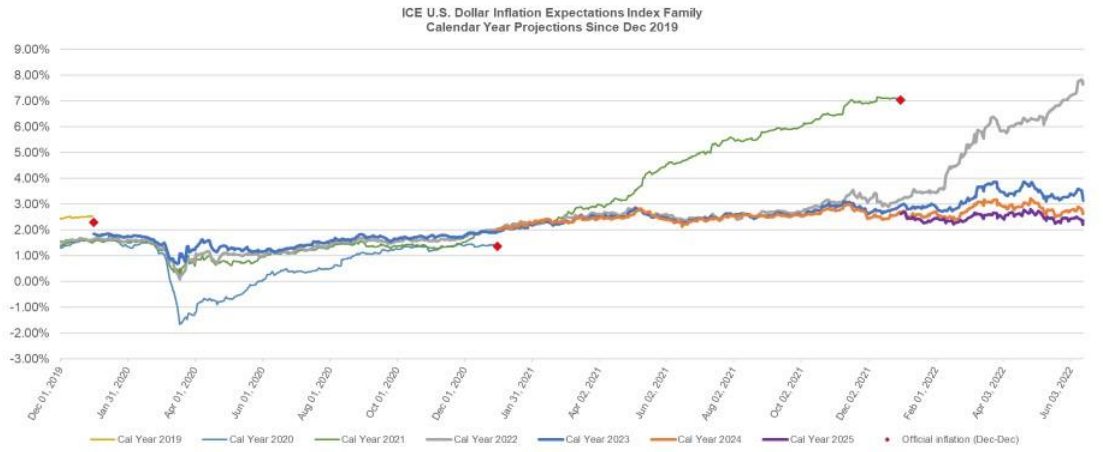
Example: Calendar Year projections over time



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