Calculation Convention for Inflation Linked Bond

Bond Pricing and Product Development
The Thai Bond Market Association (ThaiBMA)

Introduction

In May 2011, Thai bond market will probably have a new type of fixed income instruments available as an alternative for long term investors, especially those that tie their expected return with inflation. The Ministry of Finance represented by the Public Debt Management Office (PDMO) has recently announced the plan to issue inflation linked bond (ILB). The structure of ILB is somewhat similar to straight bonds from the aspect of periodic coupon payments that have fixed percentage of annual coupon rate. However, instead of paying coupon as a percentage of par value for the case of straight bonds, ILB will pay coupon as a percentage of inflation adjusted par value. The inflation rate used in adjusted the par value of the ILB is derived from the Headline Consumer Price Index (Headline CPI), calculated and published by the Ministry of Commerce. In essence, the structure of ILB is the same as Treasury Inflation Protected Securities (TIPS) issued by the US Treasury. Therefore, in setting up the calculation convention used for trading ILB in primary and secondary markets, ThaiBMA has coordinated with the Bank of Thailand, the PDMO, and other market participants to come up with the ILB calculation convention by adapting the convention used for TIPS to the calculation convention used in the Thai bond market. Some differences exist resulting from the rounding convention and the day count convention in Thailand being Actual/365 instead of Actual/Actual as in the case of TIPS.

To effectively illustrate the proposed calculation convention for ILB, the following section makes use of a hypothetical ILB to clarify the derivation of coupon payment, adjusted par value, index ratio, and price-yield conversion.

Calculation Example

A hypothetical ILB with the maturity of 10 years has a par value of 1,000 Baht and pays semi-annual coupon at the rate of 1 percent annually. Assume that the ILB is issued on May 27, 2011 and the Reference CPI on the issue date is 110.

1. Determination of coupon payment date and the coupon payment amount

Period	Coupon Date	Assumed Reference CPI on coupon date	Index Ratio $\dfrac{Ref\ CPI_t}{Ref\ CPI_{Issue\ Date}}$	Coupon Payment Amount (Baht) $\dfrac{Coupon\ Rate}{100} \times \dfrac{Day}{365} \times Par\ Value \times Index\ Ratio_t$ Day is the number of days in the period
1	Nov 27, 2011	112	$\dfrac{112}{110} = 1.01818$	$\dfrac{1}{100} \times \dfrac{184}{365} \times 1000 \times 1.01818 = 5.13$
2	May 27, 2012	114	1.03636	$\dfrac{1}{100} \times \dfrac{182}{365} \times 1000 \times 1.03636 = 5.17$
3	Nov 27, 2012	115	1.04545	$\dfrac{1}{100} \times \dfrac{184}{365} \times 1000 \times 1.04545 = 5.27$
4	May 27, 2013	117	1.06364	$\dfrac{1}{100} \times \dfrac{181}{365} \times 1000 \times 1.06364 = 5.27$
19	Nov 27, 2020	146	1.32727	$\dfrac{1}{100} \times \dfrac{184}{365} \times 1000 \times 1.32727 = 6.69$
20	May 27, 2021	148	1.34545	$\dfrac{1}{100} \times \dfrac{181}{365} \times 1000 \times 1.34545 = 6.67$

Once the ILB reaches maturity date on May 27, 2021, the ILB holders will receive the par value plus inflation adjustment equals to $1,000 \times 1.34545 = 1,345.45$ Baht. However, if the inflation adjustment is negative, the ILB holders will receive the par value of 1,000 Baht.

2. Derivation of Reference CPI on Day t

Since Headline CPI values are issued once a month, the attempt to find reference CPI values on a daily basis is done by linear interpolation between the Headline CPI values of two consecutive months. The following formula is used for deriving the Reference CPI on Day t.

$$Ref\ CPI_t = CPI_{M-3} + \left\{ \frac{D-1}{TD} \times (CPI_{M-2} - CPI_{M-3}) \right\}$$

Where
Ref CPI$_t$ = CPI on day t in month M
CPI$_{M-3}$ = CPI in the 3 months prior to month M
CPI$_{M-2}$ = CPI in the 2 months prior to month M
D = Day t in month M
TD = Total number of days in month M

Sample Calculation of Ref CPI in January 2011

Given CPI of October 2010 as 108.52
Given CPI of November 2010 as 108.75
Ref CPI on January 1, 2011 = $108.52 + \left\{ \frac{1-1}{31} \times (108.75 - 108.52) \right\}$ = 108.52000

Ref CPI on January 15, 2011 = $108.52 + \left\{ \frac{15-1}{31} \times (108.75 - 108.52) \right\}$ = 108.62387

Ref CPI on January 31, 2011 = $108.52 + \left\{ \frac{31-1}{31} \times (108.75 - 108.52) \right\}$ = 108.74258

3. Price-Yield Conversion and Settlement Amount Calculation

To determine the trading price of ILB, the price-yield conversion of straight bonds can be adapted with the following steps. First, the unadjusted gross price of ILB is calculated as a percentage of par value by generating real cash flows (Cash flows that have not been adjusted by inflation) and discounting the real cash flows with real yield to maturity. The price-yield conversion formula for ILB is expressed below. Please note that this formula is used for ILB with no irregular coupon payment period (No first odd coupon and no last odd coupon payments).

$$Unadjusted\ GP = \sum_{i=0}^{n-1} \frac{\frac{g}{h}}{\left[1 + \left(\frac{y}{100 \times h}\right)\right]^{\left[i + \left(\frac{DSC \times h}{365}\right)\right]}} + \frac{100}{\left[1 + \left(\frac{y}{100 \times h}\right)\right]^{\left[n-1 + \left(\frac{DSC \times h}{365}\right)\right]}}$$

Unadjusted Accrued Interest (%) = g x DCS/365 (Not in XI period)

= -g x DSC/365 (XI Period)

Unadjusted Clean Price (%)	= Unadjusted Gross Price (%) – Unadjusted Accrued Interest (%)
Adjusted Clean Price (%)	= Unadjusted Clean Price (%) x Index Ratio on Settlement Date
Adjusted Accrued Interest (%)	= Unadjusted Accrued Interest (%) x Index Ratio on Settlement Date
Adjusted Gross Price (%)	= Adjusted Clean Price (%) + Adjusted Accrued Interest (%)
Settlement Amount (Baht)	= Adjusted Gross Price (%) x Par Value x Unit

Where
	DSC	Number of days from settlement date to next coupon date
	DCS	Number of days from last coupon date to settlement date
	y	Real yield to maturity (%)
	h	Coupon frequency (Per year)
	g	Annual coupon rate (%)
		(If settlement occurs in XI period, the next coupon payment is excluded, g/h when i = 0 is zero)
	n	Remaining number of coupon payment from settlement date until maturity

To demonstrate the use of price-yield conversion formula and the calculation of settlement amount, three scenarios have been elaborated using the information from hypothetical ILB and the assumed real YTM as well as index ratio.

<u>3.1 Settlement date is on issue date (May 27, 2011)</u>

Assume the following trade transaction:

Real Yield to Maturity	= 1.05%
DSC	= 184 days (From May 27, 2011 to Nov 27, 2011)
DCS	= 0 days (From May 27, 2011 to May 27, 2011)
Index Ratio	= 1.00000
Unit	= 100,000 Units

$$Unadjusted\ GP = \sum_{i=0}^{20-1} \frac{\frac{1}{2}}{\left[1+\left(\frac{1.05}{100\times2}\right)\right]^{\left[i+\left(\frac{184\times2}{365}\right)\right]}} + \frac{100}{\left[1+\left(\frac{1.05}{100\times2}\right)\right]^{\left[20-1+\left(\frac{184\times2}{365}\right)\right]}}$$

Unadjusted Accrued Interest (%)	= 1 x 0/365	= 0.000000% (Rounded to 6 Decimal Places)
Unadjusted Clean Price (%)	= 99.52224928% – 0.000000%	
	= 99.522249% (Rounded to 6 Decimal Places)	
Adjusted Clean Price (%)	= 99.522249% x 1.00000	
	= 99.522249% (Rounded to 6 Decimal Places)	
Adjusted Accrued Interest (%)	= 0.000000% x 1.00000	
	= 0.000000% (Rounded to 6 Decimal Places)	
Adjusted Gross Price (%)	= 99.522249% + 0.000000%	
	= 99.522249%	
Settlement Amount (Baht)	= 99.522249% x 1,000 x 100,000	
	= 99,522,249.00 Baht (Rounded to 2 Decimal Places)	

3.2 Settlement Date falls during the life of ILB and not in XI period

Assume the following trade transaction:

Real Yield to Maturity	= 0.98%
Settlement Date	= August 15, 2011
DSC	= 104 days (From Aug 15, 2011 to Nov 27, 2011)
DCS	= 80 days (From May 27, 2011 to Aug 15, 2011)
Index Ratio	= 1.00923
Unit	= 10,000 Units

$$Unadjusted\ GP = \sum_{i=0}^{20-1} \frac{\frac{1}{2}}{\left[1+\left(\frac{0.98}{100\times2}\right)\right]^{\left[i+\left(\frac{104\times2}{365}\right)\right]}} + \frac{100}{\left[1+\left(\frac{0.98}{100\times2}\right)\right]^{\left[20-1+\left(\frac{104\times2}{365}\right)\right]}}$$

Unadjusted Accrued Interest (%)	= 1 x 80/365	= 0.219178% (Rounded to 6 Decimal Places)
Unadjusted Clean Price (%)	= 100.40094323% – 0.219178%	
	= 100.181765% (Rounded to 6 Decimal Places)	
Adjusted Clean Price (%)	= 100.181765% x 1.00923	
	= 101.106443% (Rounded to 6 Decimal Places)	
Adjusted Accrued Interest (%)	= 0.219178% x 1.00923	
	= 0.221201% (Rounded to 6 Decimal Places)	
Adjusted Gross Price (%)	= 101.106443% + 0.221201%	
	= 101.327644%	
Settlement Amount (Baht)	= 101.327644%x 1,000 x 10,000	
	= 10,132,764.40 Baht (Rounded to 2 Decimal Places)	

3.3 Settlement Date falls during the life of ILB and in XI period

Assume the following trade transaction:

Real Yield to Maturity	= 1.15%
Settlement Date	= November 23, 2011
DSC	= 4 days (From Nov 23, 2011 to Nov 27, 2011)
DCS	= 180 days (From May 27, 2011 to Nov 23, 2011)
Index Ratio	= 1.01775
Unit	= 1,000 Units

$$Unadjusted\ GP = \sum_{i=1}^{20-1} \frac{\frac{1}{2}}{\left[1+\left(\frac{1.15}{100\times 2}\right)\right]^{\left[i+\left(\frac{4\times 2}{365}\right)\right]}} + \frac{100}{\left[1+\left(\frac{1.15}{100\times 2}\right)\right]^{\left[20-1+\left(\frac{4\times 2}{365}\right)\right]}}$$

First coupon payment (i=0) is excluded since settlement is in XI period

Unadjusted Accrued Interest (%)	= -1 x 4/365	= -0.010959% (Rounded to 6 Decimal Places)
Unadjusted Clean Price (%)	= 98.64134443% – (-0.010959%)	
	= 98.652303% (Rounded to 6 Decimal Places)	
Adjusted Clean Price (%)	= 98.652303% x 1.01775	
	= 100.403381% (Rounded to 6 Decimal Places)	
Adjusted Accrued Interest (%)	= -0.010959% x 1.01775	
	= -0.011154% (Rounded to 6 Decimal Places)	
Adjusted Gross Price (%)	= 100.403381% + (-0.011154%)	
	= 100.392227%	
Settlement Amount (Baht)	= 100.392227%x 1,000 x 1,000	
	= 1,003,922.27 Baht (Rounded to 2 Decimal Places)	