Redington
13-15 Mallow Street
London EC1Y 8RD

020 7250 3331
www.redington.co.uk

Asset Swaps to Z-spreads

RSA House

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REDINGTON

Asset Swaps to Z-spreads: Overview

- Our weekly RedVision report includes charts (such as Figure 1) which show the historical Z-spreads on selected gilts
- Historically, nominal and index-linked gilts yields were below nominal and real swap rates respectively
- As a result, swaps were a very popular tool used by pension funds to hedge interest rate and inflation risks:
    - "unfunded"
    - positive spread to gilts
- The historical relationship inverted in Q3 08 – gilt yields rose materially above swap rates
- As a result:
    - presently, longer dated nominal and index-linked gilts are more attractive than swaps for interest rate and inflation hedging
    - this relationship needs monitoring to ensure that the nest opportunities are captured

The Z-spread is a theoretical spread, designed to allow a fair comparison between bond yields and swap rates

- In this session, I will introduce the various building blocks necessary to lead to an understanding of the Z-spread:
    - The swap market; calculation of present values
    - Zero coupon swaps ; the swap curve and derivation of discount factors
    - Asset swaps and different methods of asset swapping
    - Z-spreads
    - Inflation swaps & index-linked gilts

Figure 1: Historical Z-Spreads on Index-Linked Gilts

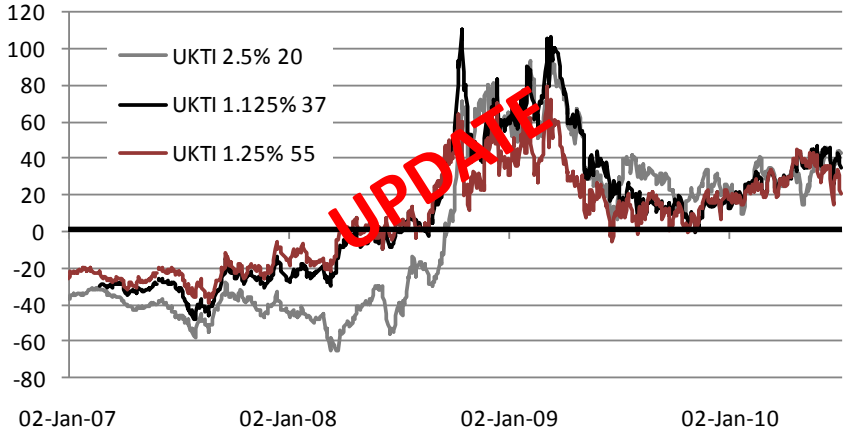
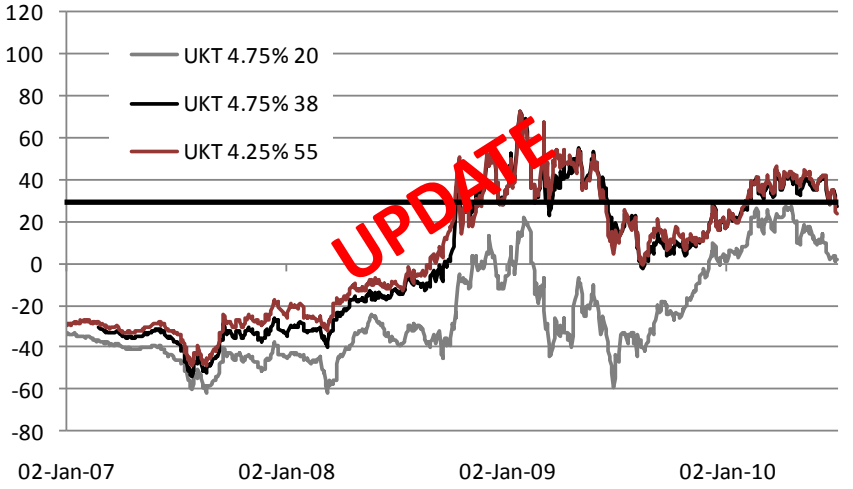


Figure 2: Historical Z-Spreads on Gilts



Source: Barclays Capital, Redington, Bloomberg

Recap – What is a Swap?

Definition

- A **swap** is an over-the-counter ("**OTC**") derivative transaction where the counterparties agree to exchange cash flows linked to specific market rates for a period of time
- One set of cash flows will typically be known – usually expressed as a fixed rate of interest
- The other set of **cash flows will be unknown** – for example, linked to short term rates or inflation
- **By definition, at the mid-market price, the present value of both sets of cash flows is the same at inception**

Standardised documentation:

- International Swaps and Derivatives Association ("**ISDA** ") agreement
- Collateral governed by Credit Support Annex ("**CSA**")

Characteristics

- An interest rate swap is an agreement to exchange **fixed** cash flows for **variable** cash flows for example, 6m **LIBOR**[1]
- Cash + swap is very similar to a bond

Comparison with bonds

- Paying LIBOR, receiving fixed rate: has similar interest rate exposure to **buying a bond**
- Paying fixed rate, receiving LIBOR: has very similar interest rate exposure to being **short a bond**

Cashflows

- **Example:** as at 5th July, 5yr GBP interest rate swap is quoted at 2.44%
- Every 6 months, in arrears, Counterparty A pays 6m LIBOR on swap notional
- Every 6 months, in arrears, Counterparty B pays 2.44% (at annual rate) on swap notional
- See slide 6 for details

Figure 2: Interest Rate Swap

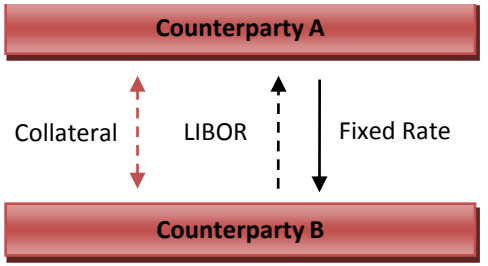
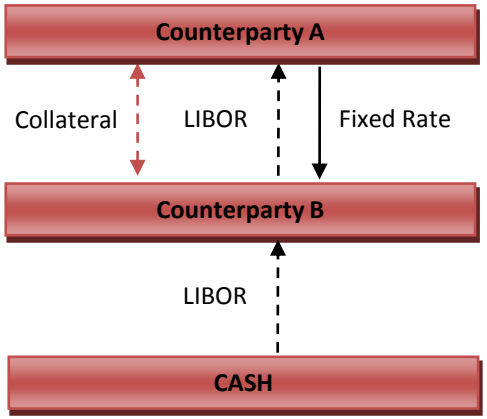


Figure 3: Cash plus Interest Rate Swap



LIBOR legs cancel out leaving Counterparty B receiving a fixed rate

[1]*London Interbank Offered Rate – the average calculated at 11:00am each day using a trimmed arithmetic mean (i.e. average after dropping the top and bottom quartiles), based on submissions from a panel of contributor banks*

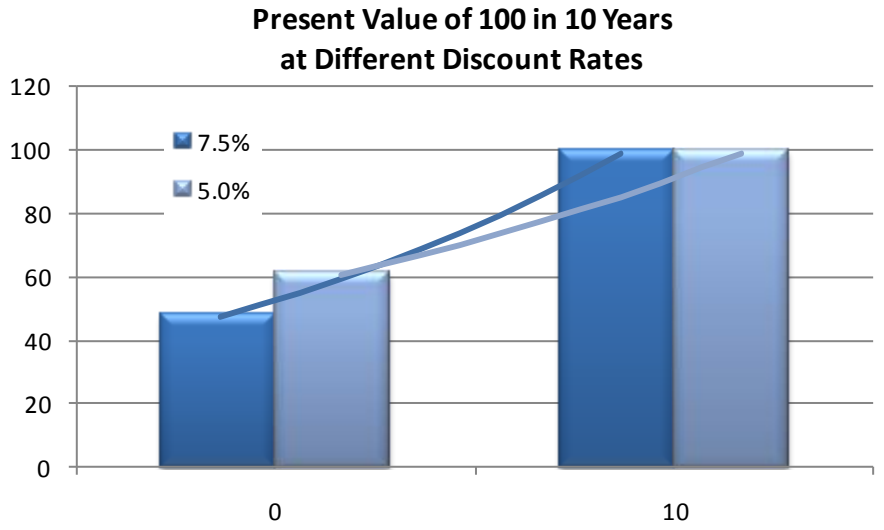
Recap – Calculation of Present Values; Discount Factors[1]

INTEREST RATE: i %

PERIOD: n years

PRESENT VALUE OF 1: $\frac{1}{(1+i)^n}$

This is also known as the "**discount factor**"

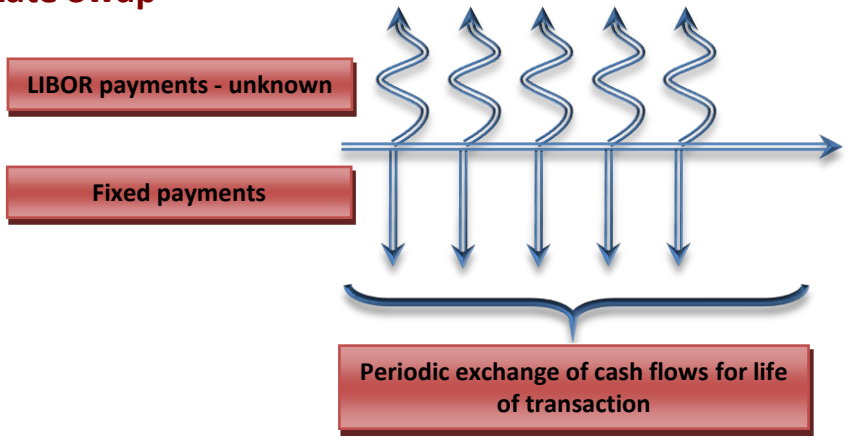


[1]*Present value and discount factor calculations for bonds and swaps require detailed knowledge of day count and compounding conventions which is beyond the scope of this presentation*

What is a Swap? Example: Cash Flows on a 5 year GBP Interest Rate Swap

Interest Rate Swap Cashflows

- All future cash flows on the fixed leg are known at inception
- LIBOR leg payments are unknown
- Forward LIBOR payments can be derived from the interest rate swap curve (see page 9)
- Discount factors can also be derived for each payment date from the swap curve (see page 9)
- **BY DEFINITION,** the present value of the fixed leg is equal to the present value of the floating leg at the time of the transaction
- Fixed rate ≈ weighted average of forward LIBOR rates over life of swap

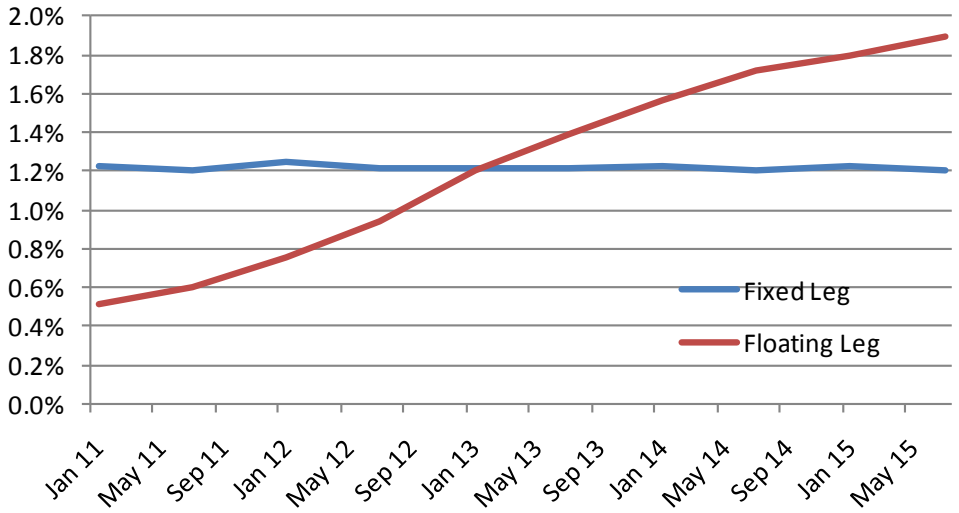


Example: 5year GBP Interest Rate Swap @ 2.44%

		Fixed Leg		Floating Leg	
Date	Discount Factor	Cash Flow	Present Value	Cash Flow	Present Value
07 Jan 11	0.99486	1.23%	1.22%	0.52%	0.51%
07 Jul 11	0.98896	1.21%	1.20%	0.60%	0.59%
09 Jan 12	0.98153	1.24%	1.22%	0.76%	0.74%
09 Jul 12	0.97235	1.22%	1.18%	0.94%	0.92%
07 Jan 13	0.96084	1.22%	1.17%	1.20%	1.15%
08 Jul 13	0.94771	1.22%	1.15%	1.38%	1.31%
07 Jan 14	0.93308	1.22%	1.14%	1.57%	1.46%
07 Jul 14	0.91730	1.21%	1.11%	1.72%	1.58%
07 Jan 15	0.90114	1.23%	1.11%	1.79%	1.62%
07 Jul 15	0.88439	1.21%	1.07%	1.89%	1.68%
		Total	**11.56%**	**Total**	**11.56%**

Source: Bloomberg, Redington

Example: 5year GBP Interest Rate Swap @ 2.44%



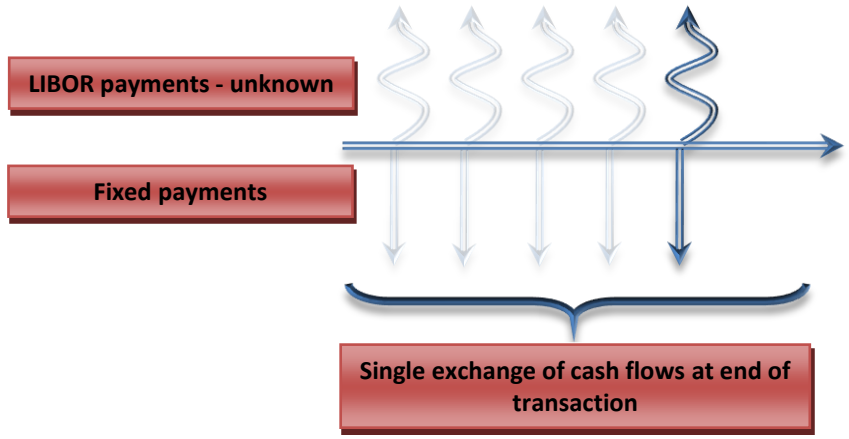
Source: Bloomberg, Redington

What is a Zero Coupon (ZC) Swap?

ZC Interest Rate Swap Cashflows

- As for a par swap, which has semi-annual payments, payments on a ZC swap are linked to periodic 6m LIBOR rates and a fixed rate
- However, instead of semi-annual exchange of cash flows, payments are compounded and exchanged at maturity

- Any desired cash flow profile can be structured using zero coupon swaps
- Zero coupon swap curve is very useful tool for calculating present value of any series of future cash flows
- A key advantage is that it takes account of the shape of the swap curve and uses a term specific rate for each cash flow
- The discount factor is derived from the zero coupon swap rate (see box)



THE MATHS[1]

- Fixed Leg: $(1+ZCswaprate)^n$
- Floating leg: $\prod_{i=1}^{n}(1+LIBOR_i)$
- Discount factor: $(1+ZCswaprate)^{-n}$

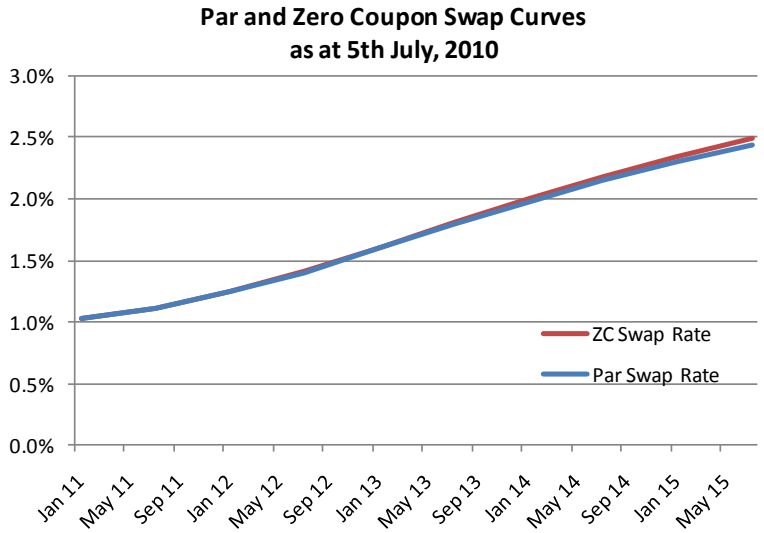
[1]*For illustration of concepts only: actual calculations require detailed knowledge of day count and compounding conventions, which is beyond the scope of this presentation*

Discount Rates and Swap Curves

- Comparison of swaps vs. bonds:
  - **Bonds:** each coupon payment and the maturity proceeds are discounted using a single rate – the bond yield – in order to obtain the dirty price
  - **Swaps:** each cash flow discounted at a rate determined by the date on which it falls due

SWAP CURVES

- A par swap rate is the rate on the fixed leg of a "vanilla" interest rate swap for the relevant maturity
- Swap rates are available for any given maturity – however, liquidity and transparency is greatest for whole number of years maturity dates
- Zero coupon rates differ slightly from par swap rates



Term Structure of Interest Rates
Derivation of Forward LIBOR & ZC Discount Factors

Term	Par Swap Rate	Forward 6m LIBOR Rate	Implied Zero Coupon Swap Rate	Implied Zero Coupon Discount Factor
0.5	1.02%	1.02%	1.02%	0.9949
1.0	1.11%	1.20%	1.12%	0.9890
1.5	1.25%	1.49%	1.24%	0.9815
2.0	1.40%	1.89%	1.41%	0.9723
2.5	1.60%	2.40%	1.61%	0.9608
3.0	1.79%	2.78%	1.80%	0.9477
3.5	1.97%	3.13%	1.99%	0.9331
4.0	2.15%	3.47%	2.18%	0.9173
4.5	2.30%	3.56%	2.34%	0.9011
5.0	2.44%	3.82%	2.49%	0.8844

Source: Bloomberg, Redington

Derivation of Discount Factor from Swap Curve

- The dark blue bars in the chart below show the semi-annual fixed rate payments (expressed as annual rate) on a 1 year swap: 1.11%
- The first light blue bar is the 6m par swap rate: 1.02%
- As this swap has just one cash flow, the par rate is, by definition, identical to the ZC swap rate
- The second light blue bar and the 1 year ZC discount rate are derived from the fact that the **present value of the light blue cash flows must be the same as the PV of the dark blue cash flows**
- We find this comes to 1.20%
- Similar methods are applied to find each subsequent forward LIBOR rate and hence each zero coupon swap rate

THE MATHS[1]

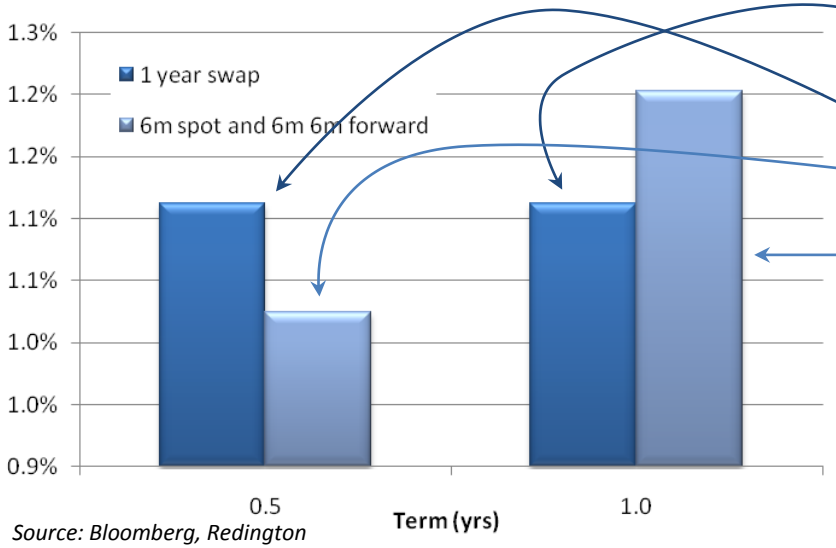
- Present value of 1 year par swap fixed leg payments = present value of spot 6m LIBOR plus present value of 6m LIBOR 6m forward

$$ParSwap_1 \times DF_{0.5} + ParSwap_1 \times DF_1 = LIBOR_{0.5} \times DF_{0.5} + LIBOR_1 \times DF_1$$

- For zero coupon swaps, payment at maturity = compounded LIBOR leg – therefore:

$$DF_1 = \frac{1}{(1+0.5\times ZCswaprate_1)^2} = \frac{1}{(1+0.5\times LIBOR_{0.5})\times(1+0.5\times LIBOR_1)}$$

- These two equations can be combined to calculate DF_1 and $LIBOR_1$
- The same process can them be applied to calculate $DF_{1.5}$ and $LIBOR_{1.5}$ in a process known as **"bootstrapping"**



Source: Bloomberg, Redington

Term Structure of Interest Rates
Derivation of Forward LIBOR & ZC Discount Factors

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2.0	1.40%	1.89%	1.41%	0.9723
2.5	1.60%	2.40%	1.61%	0.9608
3.0	1.79%	2.78%	1.80%	0.9477
3.5	1.97%	3.13%	1.99%	0.9331
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Source: Bloomberg, Redington

[1]For illustration of concepts only: actual calculations require detailed knowledge of day count and compounding conventions, which is beyond the scope of this presentation

What is an Asset Swap?

Overview

- **An asset swap is a derivative transaction that results in a change in the form of future cash flows generated by an asset**
- In the bond markets, asset swaps typically take fixed cash flows on a bond and exchange them for LIBOR (i.e. floating rate payments)
- **ASSET SWAP = BOND + INTEREST RATE SWAP**

Motivations for asset swapping

BOND BUYER

- Separation of interest rate and credit spread views: by removing interest rate exposure, remaining exposure is only to credit spreads
- Better matching of liability cash flows

BORROWER

- Fixed coupon bonds can be issued to meet demand, whereas treasury management may prefer floating rate liabilities

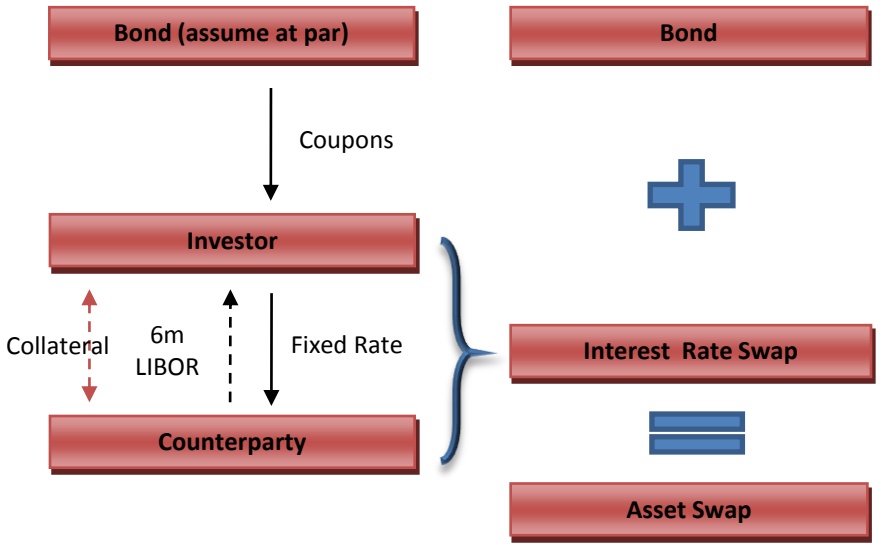
Simplified asset swap

- Buy bond at par
- Enter into interest rate swap with maturity matching bond
- Swap spread = bond yield – swap rate

Simplest "real world" asset swap

- Buy bond (price above or below par)
- Enter into interest rate swap with maturity matching bond
- Choose swap notional to duration weight
- Swap spread = bond yield – swap rate

Simplified Asset Swap



ASSUMPTIONS

- Bond priced at par
- Swap notional = bond notional
- Swap payment dates = bond coupon payment dates

NET CASH FLOWS for Investor

- Pays 100 for bond
- **Receives 6m LIBOR**
- **Receives (Coupon/Bond Yield – Swap Fixed Rate)**
- Receives 100 maturity proceeds

- If the bond coupon (yield) is above the swap rate, Investor ends up receiving cash flows equivalent to a floating rate bond with payments equal to LIBOR + swap spread

What is an Asset Swap? Example: Par/Par Asset Swap

Overview

- One of several methods to address problem of bond prices departing from par
- The "pull to par" is effectively amortised over the life of the bond:
  - For bonds below par, yield > coupon
  - For bonds above par, yield < coupon

Method

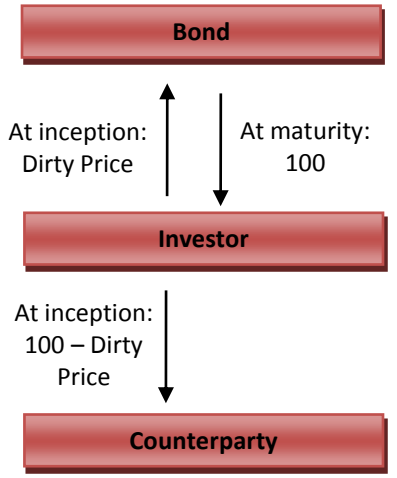
- Fixed leg of interest rate swap exactly matches the bond coupons
  - For a high coupon:
    - Bond price above par
    - Fixed leg will be worth more than the fixed leg of an interest rate swap at market rates
  - For a low coupon
    - Bond price below par
    - Fixed leg will be worth less than the fixed leg of an interest rate swap at market rates

- The difference between the coupon and the swap market rate is offset against the amortisation of the discount or premium vs. par

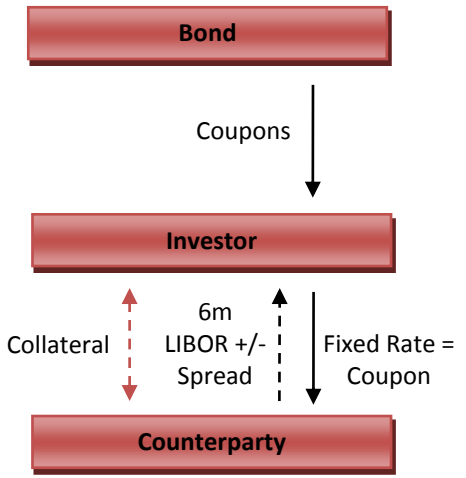
The net result is the Swap spread which is added to LIBOR leg

- To recap:
  - Part of the swap spread is amortisation of bond discount or premium vs. par
  - Remainder of swap spread is difference between bond coupon rate and interest swap rate

Par/Par Asset Swap: cash flows at inception and maturity



Par/Par Asset Swap: ongoing cash flows



ASSUMPTIONS

- Investor pays par for bond
- Swap notional = bond notional
- Swap payment dates = bond coupon payment dates

NET CASH FLOWS for Investor

- Pays 100 for bond, irrespective of price
- Receives 6m LIBOR + swap spread
- Swap fixed leg payments = coupon payments
- Receives 100 maturity proceeds

- Investor ends up receiving cash flows equivalent to a floating rate bond with payments equal to LIBOR + swap spread

Z-spreads

We can now move on to the calculation of Z-spreads

Definition

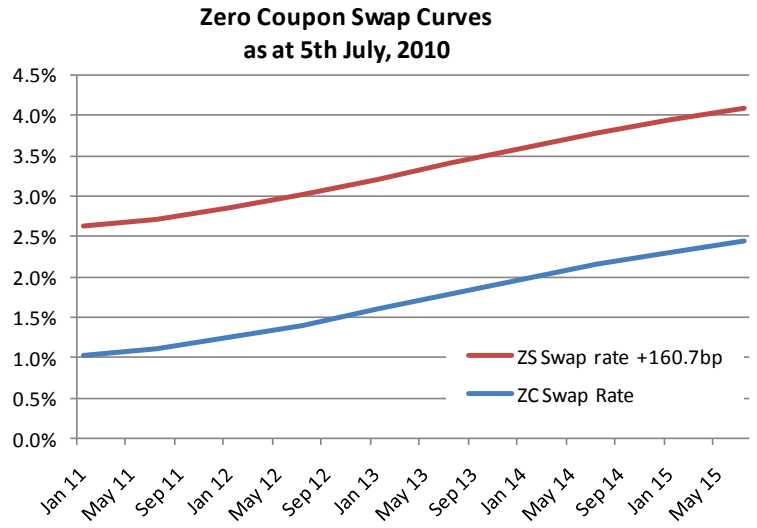
- The Z-spread is a **purely theoretical concept** designed to allow a bond yield to be compared to a swap rate **as fairly as possible**
- The Z-spread is defined as the size of the shift in the zero coupon swap curve such that the present value of a bond's cash flows is equal to the bond's dirty price

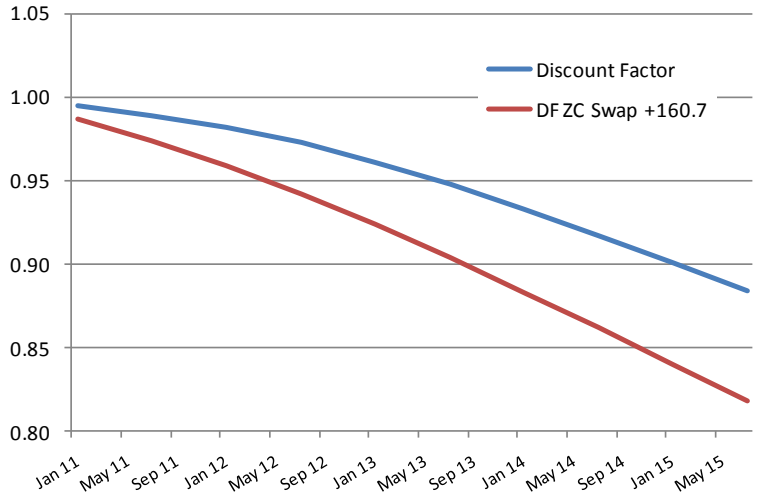
- Z-spreads are useful measure of asset swap relative value

Z-Spread Calculation - 4% 5 year GBP bond at Par

Term	Par Swap Rate	Par Swap + Z-spread (160.7bp)	Bond Cash Flow	Present Value
0.5	1.02%	2.63%	2.00%	1.97%
1.0	1.11%	2.72%	2.00%	1.95%
1.5	1.25%	2.85%	2.00%	1.92%
2.0	1.40%	3.01%	2.00%	1.88%
2.5	1.60%	3.21%	2.00%	1.85%
3.0	1.79%	3.41%	2.00%	1.81%
3.5	1.97%	3.60%	2.00%	1.77%
4.0	2.15%	3.79%	2.00%	1.72%
4.5	2.30%	3.94%	2.00%	1.68%
5.0	2.44%	4.09%	102.00%	83.45%
				100.00%

Source: Bloomberg, Redington





Source: Bloomberg, Redington

What is a Zero Coupon Inflation Swap?

Definition

- As for all swaps, an inflation swap is an OTC agreement where the counterparties agree to exchange known cash flows for unknown cash flows
- In the case of inflation swaps a fixed rate is exchanged for inflation

Characteristics

- A zero coupon inflation swap is an agreement to exchange a fixed cash flow for an unknown cash flow equal to the change in the RPI index over the period

Comparison with index-linked bonds

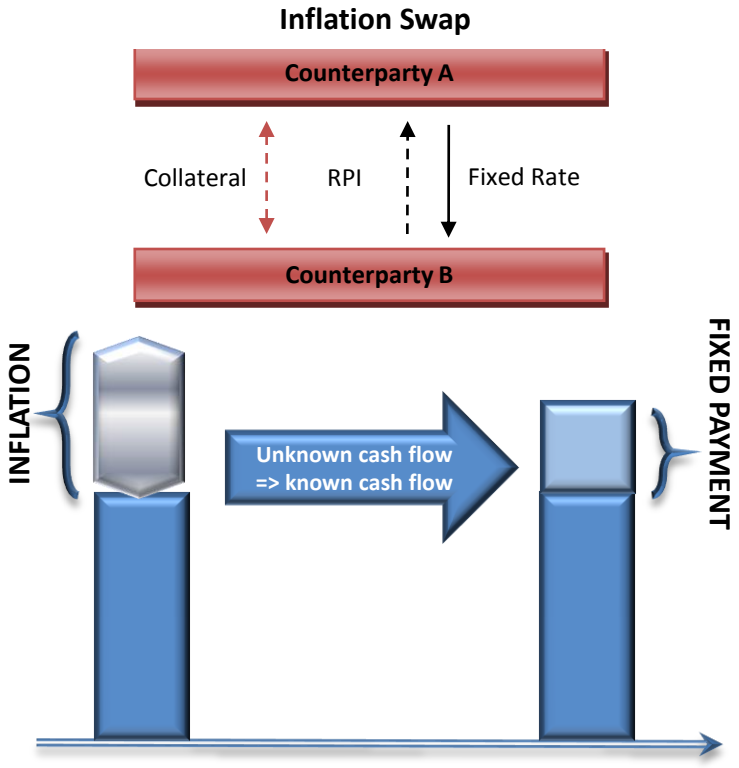
- The direct comparison with index-linked gilts is less straightforward than for an interest rate swap

Cashflows[1]

- **Example:** as at 5th July, 5yr GBP zero coupon inflation swap is quoted at 3.20%
- After 5 years, Counterparty A pays the change in the RPI index (= RPI_5 / RPI_0) on swap notional
- After 5 years, Counterparty B pays 3.20%, compounded for 5 years (=1.032^5 = 127.7%) on swap notional

Other forms of inflation swap

- There are other forms of inflation swap – for example with annual inflation linked cash flows
- The ZC swap is the most useful and common form



THE MATHS[1]

- Fixed Leg: $(1+ZCRPIswaprate_n)^n$
- Inflation Leg: $\frac{RPI_n}{RPI_0}$

[1]*For illustration of concepts only: actual calculations require detailed knowledge of day count and compounding conventions, inflation index publication lags & seasonality which is beyond the scope of this presentation*

Index-Linked Gilts – Real Yields, Asset Swaps and Z-Spreads

Key Features

- Index-linked gilt coupons (see chart) and principal payments are linked to inflation (with a lag)

Real Yields

- The real yield can be calculated in two stages:
  - Estimate future coupon and principal payments using an assumed inflation rate e.g. 3%
  - Find the interest rate at which the present value of these payments is equal to the dirty price (i.e. price plus accrued)
- Real yield = nominal yield – inflation rate[1]
- It turns out that the real yield is not very sensitive to small changes in the assumed inflation rate

ASSET SWAPPING INDEX-LINKED GILTS

- In order to do an asset swap, we need to be able to swap a fixed rate (i.e. the coupon on a nominal bond) against a floating rate
- Therefore, asset swapping linkers is a two stage process:
  - Swap inflation linked payments to fixed payments using a series of zero-coupon inflation swaps, one for each payment
  - Swap the fixed payments for floating payments using interest rate swaps
- The Z-spread is then defined as before – i.e. the parallel shift in the ZC swap curve such that the present value of the fixed payments derived above is equal to the dirty price of the bond

Source: Redington – illustrative only

[1]*There are other more sophisticated ways to do this calculation*

What are Drivers of Z-Spreads on Government Bonds?

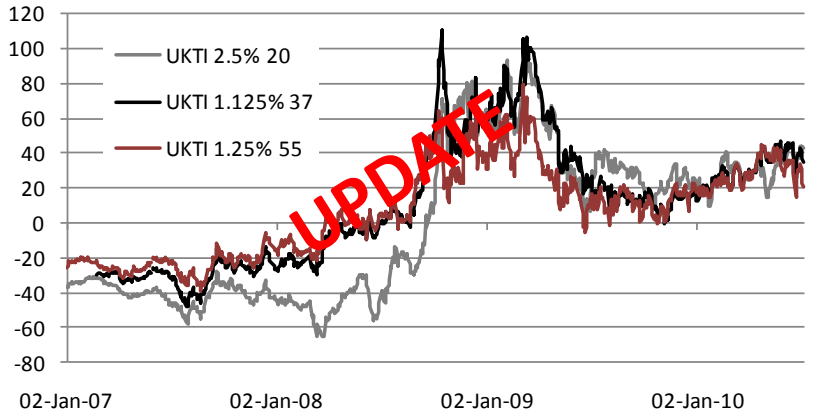
History

- Swap rates exceeded government bond yields
- Key drivers:
  - **Supply & demand** – note 2001 when, in UK, huge quantities of long dated funding by Telcos bidding for 3G licences moved swap spreads to >100bp
  - **Market participation** – trend tightening of swap spreads on back of LDI activity in mid-2000s
  - Collateralised counterparty risk on mark-to-market vs. government risk on coupons and principle
- Banking crisis inverted relationship – **new paradigm?**

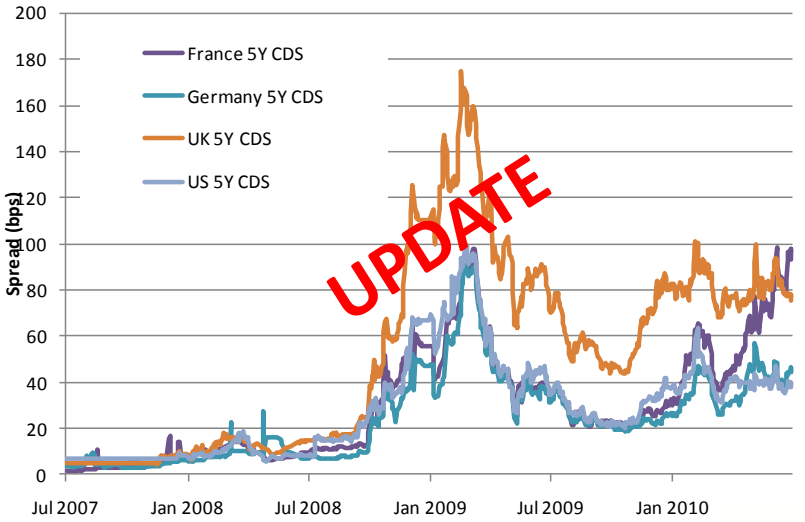
Recent developments

- Banking crisis **forced deleverage** of bank balance sheets and **extensive de-risking** by hedge funds
- Implications
  - unwinding of long bond/short swap positions
  - natural counterparties to take advantage of dislocation were the same way around
  - relatively **large bank holdings of index-linked gilts** as largest source of inflation to hedge inflation swaps
  - issuance of inflation linked debt dried up due to issues with monoline insurers who had wrapped much of this debt
- Bank balance sheets rapidly delevered – since then, other drivers:
  - Sovereign credit risk
  - Large budget deficits => **massive supply of government bonds**
  - Corporate consolidations => little corporate bond supply

Historical Z-Spreads on Index-Linked Gilts



Historical Sovereign Credit Default Swap Rates



Source: Barclays Capital, Redington, Bloomberg

What are Drivers of Z-Spreads on Government Bonds - continued?

Funded vs. Unfunded Exposure

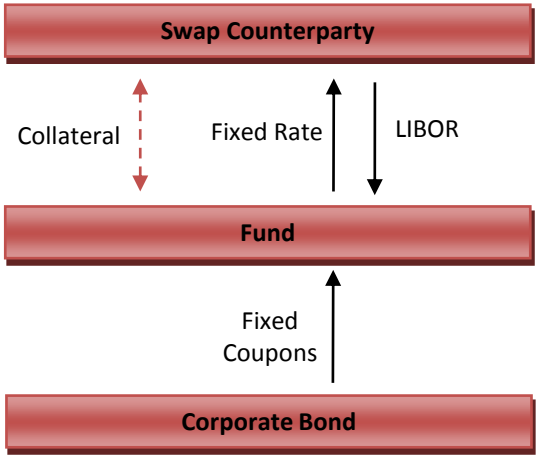
- **Government bonds**
  - Investing in a government bond results in **full credit exposure to the government** for both coupons and principal
  - In event of default or debt restructuring, coupon and principal payments will be impaired to varying degrees

- A similar consideration applies to **corporate bonds**
  - Balance sheet constraints resulted in corporate bond spreads widening materially more than credit default swap rates => substantial negative basis
  - **Liquidity premium**

- **Interest rate swaps**
  - Interest rate swaps are **unfunded**
  - The net present value (NPV) or price of a swap is by definition zero at inception
  - Counterparty exposure arises as **mark-to-market fluctuates** through time
  - Such exposures are **fully collateralised** under the terms and conditions of the CSA
  - Therefore, for a loss to arise, an adverse market move AND a counterparty default are required **simultaneously**
  - A further consideration is transactions costs associated with replacing the trade in adverse market conditions

What is a corporate bond asset Swap Spread?

- Exactly the same methodology can be used for corporate bond asset swap calculations
  - Historically, this is where the bulk of asset swap market activity occurred
  - The inversion of the relationship between government bonds and swaps resulted in a big pick up in activity in government bond asset swaps



Credit spreads

- Traditionally:
  - Credit spread = corporate bond yield – gilt yield

- Corporates treasurers often swap fixed rate issuance back into floating rate, based on a funding target of LIBOR +x%
  - Relative shape of swap curve and gilt curve drive issuance opportunities
- Gilt vs. swap spread a significant driver of gilt vs. corporate spread

OUTCOME
- Market looks at asset swap spreads of corporates

ANALYSIS OF CREDIT SPREADS
- Representing compensation for:
  - Default risk – loss of coupons and principal
  - Illiquidity
  - Risk premium
  - Incremental return volatility
  - Cost of funding

- Corporate bond exposure is usually unsecured and uncollateralised
- Fund therefore has default risk exposure to the corporate bond
- Average recovery rates in default have historically been assumed to be 40% but recent experience suggests worse recovery rates

CONCLUSION
Z-Spreads are Useful Theoretical Model to Enable Comparison of Relative Value of Corporate Bonds

Asset Swaps – Alternative Methods

- The table below summarises a range of methods used to calculate asset swap spreads

Method	Definition	Yield Curve Exposure	Directionality	Simplicity	Use for Relative Value
Yield/Yield	• Spread = difference between bond yield and same maturity swap rate • Duration weighted	• Spread widens as curve steepens for bonds above par	• Convexity not hedged – therefore hedge ratio needs adjusting on large rate moves	• The most simple ASW method	• Good for flat curves • Poor for comparing bonds with very different coupons in steep curve environment
Par/Par	• Spread added to floating leg such that swap NPV = 100 – Bond dirty price • Bond bought for par • Swap fixed leg = bond coupons • Floating leg notional = bond notional	• For given bond price, par/par swap spread falls as swaps curve steepens	• Par/par spread falls as yields rise • Trade not duration neutral	• Relatively complex • Widely used, therefore good market familiarity	• Spread highly dependent on dirty price of bond therefore not idea l for RV use
Market Value Accrued or Proceeds	• Spread added to floating leg such that swap NPV = 100 – Bond dirty price • Bond bought for dirty price • Swap fixed leg = bond coupons • Floating leg notional = bond dirty price • Original dirty price – 100 paid to ASW buyer at maturity	• For given bond price, par/par swap spread falls as swaps curve steepens	• MVA spread rises as yields rise • Trade not duration neutral	• Hard to estimate P&L • Not frequently trades	• Spread depends on dirty price of bonds – but not as much as par/par, especially for high coupon bonds • Not widely traded, but preferred to par/par for RV calculations
Z - spread	• Spread when applied to zero coupon swap curve such that when used to PV bond cash flows, results in bond dirty price	• Some exposure to changes in relative steepness of government and swap curves	• Not directional	• Straightforward to calculate for most risk systems	• Generally preferred for relative value use

Source: Morgan Stanley, "Using and Trading Asset Swaps", 11th May, 2006

Contacts

Redington
13-15 Mallow Street
London EC1Y 8RD

Direct Line: +44 (0) 20 3326 7147
Telephone: +44 (0) 20 7250 3331

David Bennett
Director | Investment Consulting

david.bennett@redington.co.uk
www.redington.co.uk

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