Interest rate risk management 2

- Interest rate caps
- Interest rate floors
- Interest rate collars
- Interest rate swaps
- The Greeks

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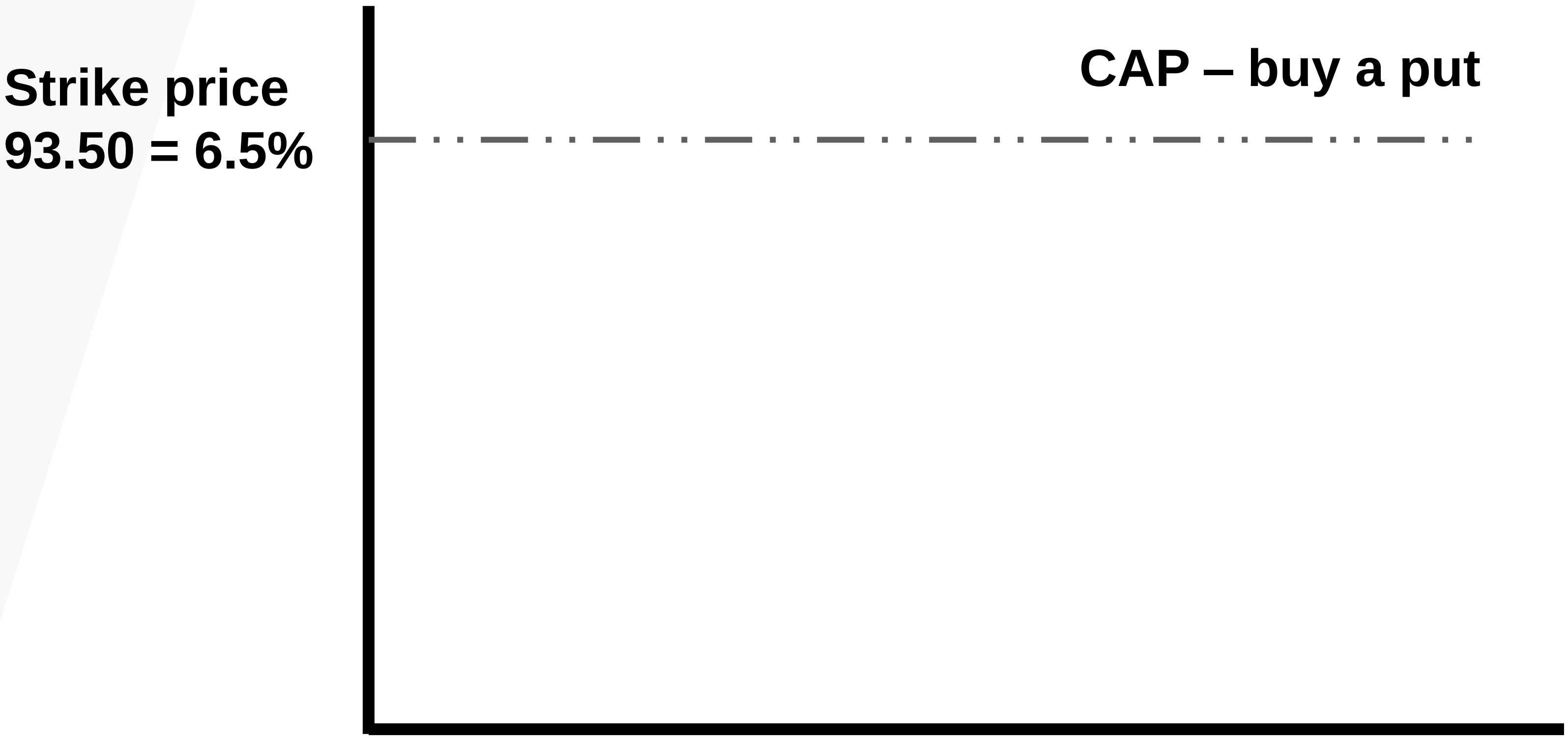
Interest rate caps

Buying a PUT option (A CAP) protects the buyer (borrowers) from a rise in interest rates, so that the effective interest cost would not exceed the strike price (rate) since the excess of the market reference rate over the Cap would be recovered from the seller.

- So if a company is borrowing money, then they can fix a maximum interest rate by buying a put option.
- So, for example, if they buy a put option at a strike price of 93.50 then they will be fixing a maximum interest rate of 6.5%.
- So if the actual interest rate turns out to be only 5% they do not exercise the option and they just pay the 5%. (OTM)
- But if the actual interest rate turns out to be 8% then they pay the interest at 8% but exercise the option and effectively 'claim back' 1.5 % from the seller of the put option.

Interest rate caps

The benefit of buying the option is obvious - they fix a maximum rate but they get the benefit if rates are lower. However the downside is that they have to pay a premium for the option - whether or not they end up exercising it.



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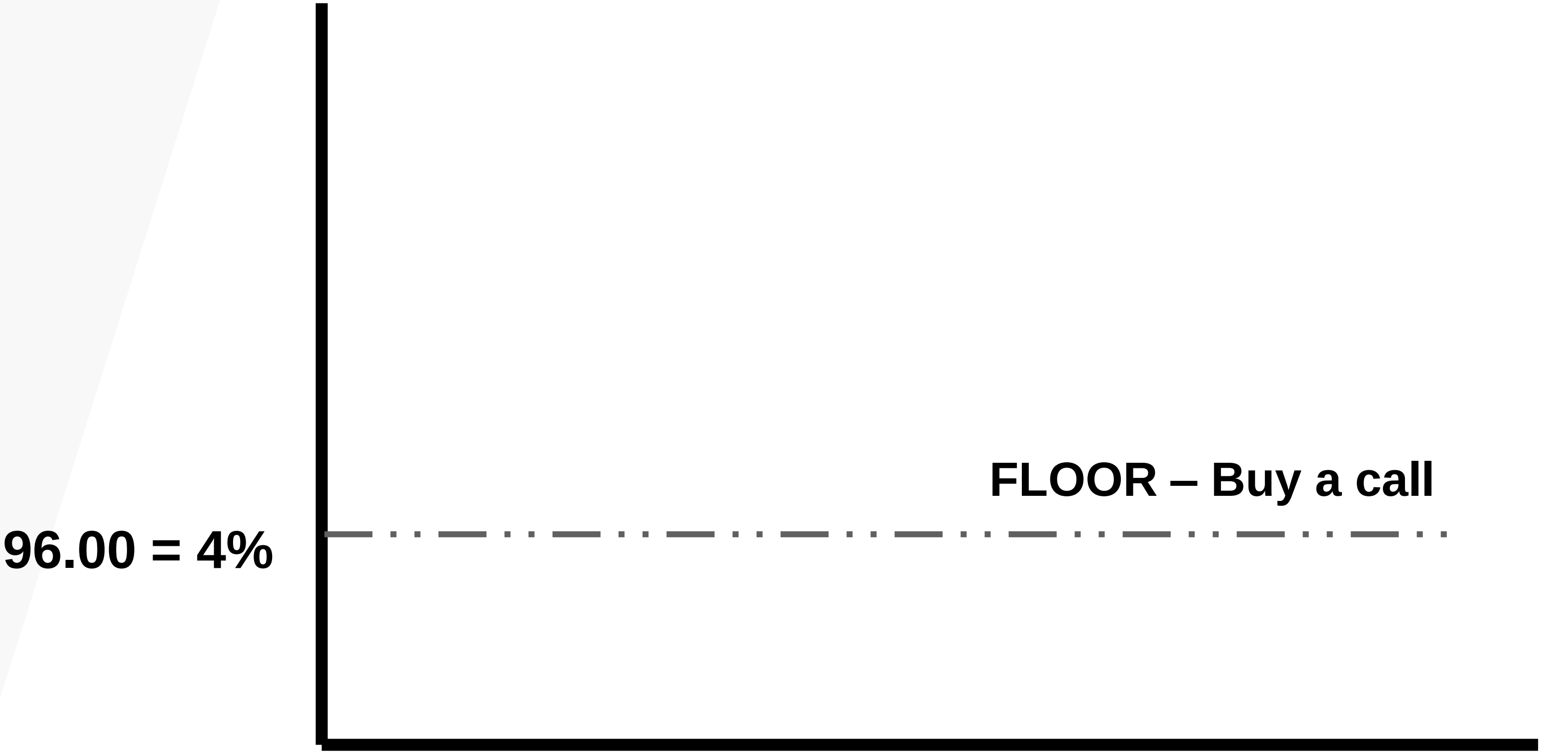
Interest rate floors

Buying a CALL option (A FLOOR) - protects the buyer (lender or depositor) from a fall in interest rates, so that the effective interest income will not fall short of the exercise price (rate) since the shortfall of the market rate from the exercise price would be recovered from the seller.

- So if a company is lending money, then they can fix a minimum interest rate by buying a call option.
- So, for example, if they buy a call option at a strike price of 96.50 then they will be fixing a minimum interest rate of 3.50%.
- So if the actual interest rate turns out to be only 5% they do not exercise the option and they just receive the 5%. (OTM)
- But if the actual interest rate turns out to be 3% then they receive the interest at 3% but exercise the option and effectively 'claim back' 0.50% from the seller of the call option.

Interest rate floors



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Interest rate caps, collars and floors

A borrowing company will fix a maximum rate, but the downside is they have to pay the premium which is often too expensive.

- What they can do to reduce the cost is to also sell a call option (effectively becoming a dealer) and will therefore receive a premium from the person buying it.
- This means they still have the benefit of fixing a maximum rate (a 'cap') but the net cost of it is reduced because although they still pay the premium for the put option, they will also be receiving a premium from selling the call option.
- However, selling a call option will mean that they are accepting a minimum interest rate (a 'floor').

Interest rate (caps + floors) = collars

A collar is a combination of a Cap and a Floor

A **collar for the borrower** will involve the borrower

- buying an interest rate cap (put option) 93.50 and
- selling an interest rate floor (call option) 96.50

Unlike a raw cap, the overall premium cost is lower since the borrower receives a premium from the sale of the call option to offset part of the premium paid on the put.

However, the borrower will forgo the benefit of interest rates below the floor of 3.5%

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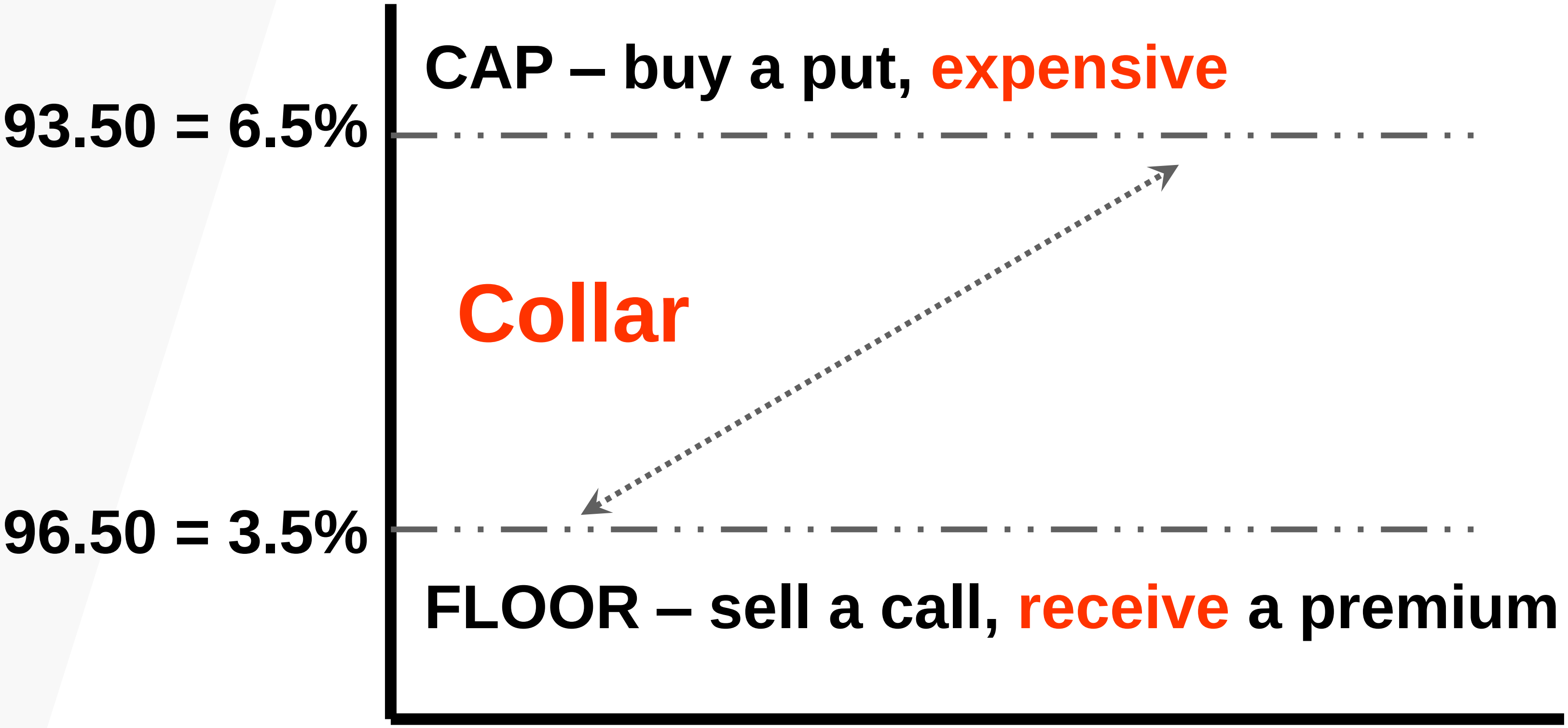
Interest rate caps, collars and floors



Interest rate (caps + floors) = collars

A **collar for the lender** will involve the lender

- buying an interest rate floor (call option) 96.50
- selling an interest rate cap (put option) in 93.50

Unlike a raw floor the overall net interest is higher since the leader receives a premium from the sale of the put option to reduce the premium paid on the call.

However, the lender will forgo interest rates above the cap (6.5%)

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Interest rate caps, collars and floors

- **Summary**
- **Caps** set an interest rate ceiling
- **Floors** set a lower limit to rates
- **A borrower collar** mean buying a put (cap) and selling a call (floor)
- A **lender collar** means buying a call (floor) and selling a put (cap)

Collar

Assume it is now the end of October and your company needs to borrow $15m in 3 months time and expects to make full payment in 9 months. You are concerned that interest rates may fluctuate significantly between now and the end of January although it is difficult to predict whether they will rise or fall.

The company can borrow at the relevant inter-bank plus 150 basis point. The current inter-bank rate is 5% but you believe that interest rates could increase or decrease by as much as 90 basis points over the coming months.

You want to hedge The $15,000,000 using interest rate collars.

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Collar

The following information and quotes for $ March options are provided from an appropriate exchange. The options are based on three-month $futures $1,000,000 contract size and option premiums are in annual %.

March Calls	Strike Price	March Puts
0.795	94.50	0.550
0.505	95.00	0.845

Option prices are quoted in basis points at 100 minus the annual % yield and settlement-of the options contracts is at the end of March.

The current basis on March futures is 10 points; and it is expected to be 8 at the end of. November, 6 points at the end of December, 4 points at the end of January, and 2 points at the end of February.

Collar

Set-up today – End of October

1. Date? – 3 months time is end of January hence March contracts
2. Type of contract to create a collar:
   Borrowing: Buy puts at 94.50 and sell calls at 95.00
3. Number of contracts required:
   ($15m/$1m) x (6/3) = 30 contracts
4. Net Premium
   0.550% – 0.505% = 0.045% = 4.5 ticks
5. Tick value = Tick size(0.01%) x contract size x 3/12 (contract duration) = 0.0001 x $1,000,000 x 3/12 = $25 per tick

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Collar

6. **Estimate closing futures price**

Current interbank rate	**5%**	**5%**
Expected rate in 3months – end of January ±) 0.90	5.9%	4.1%
Add 2 months unexpired basis 4 basis points	+0.04%	+0.04%
Expected interbank rate at the end of March - r	5.94%	4.14%
Expected closing futures price (100 – r)	**94.06**	**95.86**

7. Outcome if interest rates increase by 0.90% to 5.90%

	Buy a puts	**Sell a call**
Strike price	94.50	95.00
Closing futures price	94.06	94.06
Exercise?	YES	NO

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Collar

8. Cash flow if interest rates increase by 0.90% to 5.90%

	5.9% + 1.50% = 7.4%	$
Actual interest payable	$15 x 6/12 x 7.4%	555,000
Net premium	4.5 ticks x $25 x 30	3,375
Gain on exercised options	44 ticks x $25 x 30	(33,000)
Net interest	Effective = 7.005%	525,375

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Collar

Outcome if interest rates decrease by 0.90% to 4.10%

	Buy a puts	Sell a call
Strike price	94.50	95.00
Closing futures price	95.86	95.86
Exercise?	NO	YES

Collar

Cash flow if interest rates decrease by 0.90% to 4.10%

	4.1% + 1.50% = 5.6%	$
Actual interest payable	$15 x 6/12 x 7.4%	420,000
Net premium	4.5 ticks x $25 x 30	3,375
Holder of call option receives	86 ticks x $25 x 30	64,500
Net interest	Effective = 6.505%	487,875

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Interest rate swaps

This is where two parties agree to pay each other interest on a notional principal amount over a given period at a fixed or floating rate payable in the same currency as the principal.

The swap allows a borrower to:

- Convert an existing or new floating rate liability to a fixed rate for example to hedge against rising interest rates;

- Convert an existing or new fixed rate liability to a floating rate for example to take advantage of falling interest rates;

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Question: Interest rate swaps

Assume it is now the end of October and your company needs to take a out a 5 year loan of $15m to fund a new project. You are concerned that interest rates may fluctuate significantly although it is difficult to predict whether they will rise or fall.

Your company is AA credit rated and can borrow this amount at a fixed annual rate of 3.6% or at floating annual rate based on the yield curve plus 30 basis points. The loan’s principal amount will be repayable in full at the end of the 5th year.

As head of your company's treasury you are considering to hedge the $15m loan using an over-the-counter interest rate swap.

Interest rate swaps

A bank has identified a BB+ credit rated company to act as a counterparty to the swap. The counterparty can borrow at a fixed annual rate of 4.5% or at a floating annual rate based on the yield curve plus 40 basis points.

The bank would charge a fee of 10 basis points each per annum act as the intermediary of the swap. Your company is expected to receive 70% of any benefits accruing from undertaking the swap prior to the bank charges.

Required:

Demonstrate how your company could benefit from the swap offered by the bank.

Interest rate swaps

Step1:

Work out the basis differential so as to identify the potential arbitrage gain (ie what both parties stand to save before arrangement (bank) fees.

	Fixed	Floating
Counter party BB+	4.5%	Y+0.4%
Your company AA	3.6%	Y+0.3%
Basis differential	0.9%	0.1%
Benefit to be shared before bank charges		(0.9% - 0.1%) = **0.8%**
	Your company 70%	Counter party 30%
Before bank charges	0.56%	0.24%
Bank charges	(0.10%)	(0.10%)
Net benefit per year	0.46%	0.14%

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Interest rate swaps

Step 2:

Determine who borrows what at start in the arrangement?

- Identify the debt with the higher differential (in this case the fixed) and which party could borrow this (in this case your company).
- Your company should borrow fixed at 3.6% and swap for floating
- Counter party should borrow variable at Y+0.4% and swap for fixed

Net outcome of swap – without using table		**Net cost**
Your company	(Y+0.3%) + 0.56% - 0.1% =	**(Y - 0.16%)**
Counter party	(4.5%) + 0.24% - 0.1% =	**(4.36%)**

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Interest rate swaps

Using table	Your company		Counter party
1. Actual rate of borrowing	(3.6%)		(Y+0.4%)
5. Pay to counter party	(Y)	Receive from your company	Y
6. Receive from your counter (balancing figure)	3.86%	Pay to your company	(3.86%)
4. Net cost before charges	(Y-0.26%)		(4.26%)
3. Less savings	0.56%		0.24%
2. Without swap	(Y+0.3%)		(4.5%)
7. Net cost after charges	**(Y-0.16%)**	+ 0.1% charges	**(4.36%)**

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Valuing Interest rate swaps

- An interest rate swap can also be valued as the NPV of the net cash flows under the swap
- At the start of the swap the swap contract is designed to give an NPV of zero based on the current FRA rates.
- Ie at the FRA rate the project is delivering exactly the return required

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Determining Interest rate Forwards

Supposing that a bank assesses and quotes the following rates to a company, based on the annual spot yield curve for that company's risk class:

Duration	Rate
One – year	2.5%
Two – year	3.1%
Three – year	3.5%
Four – year	3.8%

This indicates that the company would have to: pay interest at 2.50% if it wants to borrow a sum of money for one year; pay interest at 3.10% per year if it wants to borrow a sum of money for two years; pay interest at 3.50% per year if it wants borrow a sum of money for three years; and so on.

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Interest rate swaps

Alternatively, for a two-year loan, the company could opt to borrow a sum of money for only one year, at an interest rate of 2.50%, and then again for another year, commencing in one year’s time, instead of borrowing the money for a total of two years.

Although the company would be uncertain about the interest rate in one year’s time, it could request a forward rate from the bank that is fixed today – for example, through a 12v24 forward rate agreement (FRA).

The question then arises: how may the value of the 12v24 FRA be determined?

Determining Interest rate Forwards

Supposing that a bank assesses and quotes the following rates to a company, based on the annual spot yield curve for that company's risk class:

Duration	Rate
One – year	2.5%
Two – year	3.1%
Three – year	3.5%
Four – year	3.8%

Required:

Estimate the forward rates using the spot yields above

Explain the options available to a company needing to borrowing for a period of three years.

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Determining Interest rate Forwards

Year	Rate	Compound factor		Annual forward rates
1	2.5%	$(1.025)^1 = 1.0250$	$1.025 – 1 = 2.5\%$	
2	3.1%	$(1.031)^2 = 1.06296$	$((1.031)^2 / (1.025)^1) – 1 =$	3.7%
3	3.5%	$(1.035)^3 = 1.10872$	$((1.035)^3 / (1.031)^2) – 1 =$	4.3%
4	3.8%	$(1.038)^4 = 1.16089$	$((1.038)^4 / (1.035)^3) – 1 =$	4.7%

Supposing the company wants to borrow a sum of money for three years on the basis of the above rates:

i. it could pay annual interest at a rate of 3.50% in each of the three years, or

ii. ii. it could pay interest at a rate 2.50% in the first year, 3.7% in the second year and 4.3% in the third year, or

iii. it could pay annual interest at a rate of 3.10% in each of the first two years and 4.3% in the third year.

Interest rate swaps

A company has issued a debt finance is in the form of a floating rate bond, with a face value of $320 million, redeemable in four years. The bond interest, payable annually, is based on the spot yield curve plus 60 basis points. The next annual payment is due at the end of year one.

The company is concerned that the expected rise in interest rates over the coming few years would make it increasingly difficult to pay the interest due. It is therefore proposing to either swap the floating rate interest payment to a fixed rate payment.

A bank has offered the company an interest rate swap, whereby the company would pay the bank interest based on an equivalent fixed annual rate of 3·76¼% in exchange for receiving a variable amount based on the current yield curve rate. Payments and receipts will be made at the end of each year, for the next four years. The bank will charge an annual fee of 20 basis points if the swap is agreed.

Interest rate swaps

The current annual spot yield curve rates are as follows:

Year	1	2	3	4
Rate	2.50%	3.1%	3.5%	3.8%

The current annual forward rates for years two, three and four are as follows:

Year	2	3	4
Rate	3.7%	4.3%	4.7%

Required:

i. Based on the above information, calculate the amounts the company expects to pay or receive every year on the swap (excluding the fee of 20 basis points).

ii. Demonstrate that the company's interest payment liability does not change, after it has undertaken the swap, whether the interest rates increase or decrease. (Assume yield curve rates of 3% or 4%)

Answer: Interest rate swaps

Gross amounts of annual interest receivable by the company from the bank based on year 1 spot rate and years 2, 3 and 4 forward rates:

Year 1	0·025 x $320m = $8m
Year 2	0·037 x $320m = $11·84m
Year 3	0·043 x $320m = $13·76m
Year 4	0·047 x $320m = $15·04m

Gross amount of annual interest payable by the company to the bank:
= 3·76¼% x $320m = **$12·04m**

At the start of the swap, the company will expect to receive or (pay) the following net amounts at the end of each of the next four years:

Year 1: $8m – $12·04m = $(4·04m) payment
Year 2: $11·84m – $12·04m = $(0·20m) payment
Year 3: $13·76m – $12·04m = $1·72m receipt
Year 4: $15·04m – $12·04m = $3m receipt

Interest rate swaps

	% impact	Yield interest 3%	Yield interest 4%
	%	$m	$m
Borrow at Yield + 60bp	(Y + 0.6%)	(11.52)	(14.72)
Receive Yield	Y	9.6%	12.84
Pay fixed	(3.7625)	(12.04)	(12.04)
Fee	(0.2)	(0.64)	(0.64)
Net cost	(4.5625)	(14.60)	(14.60)

At the start of the contract, the value of the swap will be zero. The terms offered by the bank equate the discounted value of the fixed rate payments by the with the variable rate payments by the bank.

However, the value of the swap will not remain at zero. If interest rates increase more than expected, the company will benefit from having to pay a fixed rate and the value of the swap will increase. The value of the swap will also change as the swap approaches maturity, with fewer receipts and payments left.

Interest rate swaps

Uses of interest rate swaps

- Switching from paying one type of interest to another
- Raising less expensive loans
- Securing better deposit rates
- Managing interest rate risk
- Avoiding charges for loan termination

Interest rate swaps

Complications with interest rate swaps

- Bank commission costs
- One company having better credit rating in both relevant markets
- Should borrow in comparative advantage market but must want interest in other market

Interest rate swaps

- Companies may decide to use a **swap** rather than terminating their original loans
- Costs of termination and taking out a new loan may be too high

Interest rate swaps

Disadvantages of interest rate swaps

- Counterparty risks
- If assume floating rate commitment, vulnerable to changes in rates
- No secondary market, therefore difficult to liquidate

The Greeks

- **Delta** – change in call option price/change in value of share
- **Gamma** – change in delta value/change in value of share
- **Theta** – change in option price over time
- **Rho** – change in option price as interest rates change
- **Vega** – change in option price as volatility changes

The Greeks

Delta

- Used to measure slope of option value line at any point in time
- Long call and short put deltas are between 0 and 1
- Long call and short put deltas approach 1 if option is the money, 0.5 if it is at the money and 0 if it is out of the money
- Short call and long put deltas are between 0 and –1
- Short call and long put deltas approach –1 if option is the money, –0.5 if it is at the money and 0 if it is out of the money

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Delta – factors influencing value

These are:

- The exercise price of the option relative to the share price (ie its intrinsic value)
- The time to expiration
- The risk-free rate of return
- The volatility of returns on the share

Delta hedging

- Determines number of shares required to create the equivalent portfolio to an option, and hence hedge it
- The writer of a call option can use delta hedging to manage its exposure to the risk of the asset increasing in value
- Delta hedge ensures that the option writer also owns the underlying asset which will show a gain as the price rises

Delta hedging

Shares in For4Fore plc are currently trading at 444p. The standard deviation of the share price is 25% and the continuously compounded risk free rate of return is 4.17%. There are European style options to buy shares in For4Fore at 385p per share in exactly 4 months' time.

$$C_0 = P_a N(d_1) - P_e N(d_2) e^{-rt}$$

$$d_1 = \frac{1n(P_a / P_e) + (r + 0.5s^2)t}{s\sqrt{t}}$$

$$d_2 = d_1 - s\sqrt{T}$$

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Delta hedging

Required

(a) Using the Black Scholes Option pricing model, calculate the value of these call options

(b) How many shares should an options writer hold to create a delta hedge on his position on a call option for 1,000 shares?

(c) Would it be more appropriate to offer managers call options or put options as part of an incentive package?

Delta hedging

(a)

Pa = 444 Pe = 385 T= 0.3333 r = 0.0417 σ = 0.25

e^{-rt} = 0.9862

d_1 = 1.16

d_2 = 1.16 – 0.25 × $\sqrt{.333}$ = 1.01

$N(d_1)$ = 0.8770

$N(d_2)$ = 0.8438

Call value = (444 × 0.8770) – (385 × 0.9862 × 0.8438) = 69p

Delta hedging

(b) Delta is N(d1) = 0.8770

The number of shares required is 1000 × 0.8770 = 877

(c) Call options are preferred – the value of a put option will rise as the share price falls!

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The Greeks

Gamma

- Higher for share which is close to expiry and 'at the money’
- **+ve gamma** means that a position benefits from movement
- **–ve gamma** means the position loses money if the underlying asset price does not move

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Theta

- Measures how much value is lost over time, how much option holder will lose through retaining option
- At the money options have greatest time premium and greatest theta. Theta increases as rate of date of expiration approaches
- If option is very in or out of the money, theta will decline in straight line
- Generally options with a –ve theta have a +ve gamma and vice-versa

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The Greeks

Rho

- Amount of change in value for 1% change in risk-free interest rate
- +ve for calls, -ve for puts
- Generally least significant influence on change in price
- Long-term options have larger rhos than short-term options

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Vega

- Change in value of option resulting from 1% change in volatility
- Measures consequences of incorrect estimation of volatility
- Longer-term options have greater vegas than short-term options, reflecting greater uncertainty
- Vega is largest for at the money options, smaller for deeply in or out of the money options