Introduction

This article discusses basic valuation of convertible bonds using the Binomial option pricing model discussed in the article 'Security Valuation – Option Pricing'. It starts with an introduction to bond pricing in the absence of any conversion option (required for financial reporting purposes).

Straight Bonds

Fair Value at Start of Coupon Period using Basic Pricing

The fair price of a bond (a non-callable, non-convertible bond with no other embedded options) is the 'Present Value' ('PV') of its coupon payments and principal repayment discounted at a risk adjusted rate. Traditional bond pricing uses a single discount rate: the current required 'Yield to Maturity' (YTM) or 'Gross Redemption Yield' (the Internal Rate of Return, IRR, for a given market price), which, at the date of issue, would be set with reference to some benchmark.

Assuming a valuation date ('Settlement Date') at the start of a coupon period, the price of an annual coupon paying bond will be:

$$\text{Price} = \frac{c}{(1+r)^1} + \frac{c}{(1+r)^2} + \ldots\ldots + \frac{c+P}{(1+r)^n}$$

$$= c\left(\frac{1}{r}\right)\left(1 - \frac{1}{(1+r)^n}\right) + P\,\frac{1}{(1+r)^n}$$

where
- c Equal annual coupon, starting in 1 year (coupon % x bond face value)
- P Redemption amount (principal)
- r Yield to Maturity (YTM), IRR % p.a.
- n Number of complete years until maturity

If coupons are paid more than once during the year, each coupon equals the annual coupon divided by the number of coupon periods:

$$\text{Price} = \frac{c/m}{(1+r/m)^1} + \frac{c/m}{(1+r/m)^2} + \ldots\ldots + \frac{c/m + P}{(1+r/m)^{nm}}$$

$$= c/m \left(\frac{1}{r/m}\right)\left(1 - \frac{1}{(1+r/m)^{nm}}\right) + P\left(\frac{1}{(1+r/m)^{nm}}\right)$$

where m Number of *equal length* coupon periods per year
(n x m is the number of time periods)

Fair Value at During Coupon Period using Basic Pricing

Daily interest is accrued on a bond up until the date the coupon is paid, so that, if a bond is purchased during a coupon period, the purchase price ('Dirty Price') includes accrued interest from the last coupon date to the day before the purchase or 'settlement' date (inclusive). This accrued interest is paid to the seller and recovered by the purchaser when the next coupon is paid:

$$\text{Dirty Price} = \text{Clean Price} + \text{Accrued Interest}$$

$$\text{Accrued interest} = \text{Coupon (£) p.a.} \times \frac{\text{days accrued}}{\text{days in coupon period}}$$

The price can be calculated using the Excel PRICE and ACCRINT functions, or by using the pricing formula above. In the example below, a 6 year 6.00% semi-annual coupon paying bond (5.00% YTM) maturing on 30 September 2031 is valued on 15 May 2026 (45 days into the 183 day coupon period 31/3/2026 – 30/9/2026). The price at the end of the coupon period is 104.38 (PV of future coupons) plus the 3.00 coupon on that date. This amount (107.38) is discounted back over 138 days from 30/9/2026 to the 15/5/2026 valuation date to give 105.3951. This includes the PV of the next coupon, some of which relates to the 45 day period up to the valuation date (0.7377). This example uses the 'Actual / Actual' convention, where days are calculated using actual days in the coupon period (the final "1" in the Excel formula indicates the ACT/ACT basis is to be used – another basis, used for US bonds, is 30/360).

Bond information		
Maturity date	5.381 yrs	30 September 2031
Nominal value		£100
Coupon rate		6.00%
Yield to maturity (effective p.a.)		5.00%
No. of interest payments each year		2
No of future interest payments		10
Time- next coupon to maturity		5.003 yrs

Last Coupon	Valuation	Next Coupon
31 March 2026	15 May 2026	30 September 2026
→		183.0 days
		£3.0000
→	45 days →	138 days
	£0.7377	£2.2623

VALUATION DURING COUPON PERIOD

$$\text{Bond price} = \text{Coupon} \times \left\{ \frac{1}{r/m} \times \left(1 - \frac{1}{(1 + r/m)^{mn}} \right) \right\} + \frac{\text{Nominal value}}{(1 + r/m)^{mn}}$$

Price at next coupon in 138 days

$$= £3.00 \times \left\{ \frac{1}{0.0250} \times \left(1 - \frac{1}{(1+0.0250)^{10}} \right) \right\} + \frac{£100}{(1+0.0250)^{10}}$$

$$= £26.26 + £78.12$$

Discounted back over 138 days

$$= \frac{(£104.38 + £3.00 \text{ coupon received on that date})}{(1+ 5.00\% / 2)^{(138 / 183)}}$$

	=	**£105.3951**	**dirty price**
Acc. interest		£0.7377	£6.0 x 45 days / 365
Clean price today	**=**	**£104.6574**	

USING EXCEL FUNCTIONS

Dirty price	£105.3951
PRICE(15 May 26 , 30 September 31 , 6.00% , 5.00% , £100 , 2 payments p.a. , 1)	£104.6574
ACCRINT(31 March 26 , 30 September 26 , 15 May 26, 6.00% , £100 , 2 payments p.a. , 1)	£0.7377

Date	Period	Days	Years	Coupons	Principal	Price	Cash Flows	DF	PV at 5.00%
15 May 2026	0					(105.3951)	(105.3951)		
30 Sep 2026	0.7541	138	0.38	3.00			3.0000	0.9816	2.9447
31 Mar 2027	1.7541	182	0.89	3.00			3.0000	0.9576	2.8728
30 Sep 2027	2.7541	183	1.40	3.00			3.0000	0.9343	2.8028
31 Mar 2028	3.7541	183	1.91	3.00			3.0000	0.9115	2.7344
30 Sep 2028	4.7541	183	2.41	3.00			3.0000	0.8892	2.6677
31 Mar 2029	5.7541	182	2.92	3.00			3.0000	0.8675	2.6026
30 Sep 2029	6.7541	183	3.43	3.00			3.0000	0.8464	2.5392
31 Mar 2030	7.7541	182	3.93	3.00			3.0000	0.8257	2.4772
30 Sep 2030	8.7541	183	4.44	3.00			3.0000	0.8056	2.4168
31 Mar 2031	9.7541	182	4.95	3.00			3.0000	0.7860	2.3579
30 Sep 2031	10.7541	183	5.46	3.00	100.00		103.0000	0.7668	78.9790
		1,964		**33.00**	**100.00**	**(105.3951)**	**27.6049**		**105.3951**

Pricing a bond at issue date must factor in whether the first coupon period is shorter or longer than subsequent coupon periods, which will require different adjustment formulae.

Straight Bond Carrying Value in Financial Statements under IFRS

Under IAS 32, a financial liability includes a liability (a present legal or constructive obligation arising from a past 'obligating' event that results in an outflow of economic benefits – IAS 37) that is a contractual obligation to deliver cash to another entity where the company has no unconditional right to avoid delivery of that cash. Such contractual financial liabilities (which would include many types of preference share capital) are financial instruments that are measured and recognised by the issuer under IFRS 9 initially at fair value (the price that would have to be paid to transfer the liability in an orderly transaction in the market – IFRS 13) and thereafter, subject to some exceptions, at 'Amortised Cost'.

A bond (or loan), therefore, would usually be recognised on the issuer's balance sheet at amortised cost, calculated using the 'Effective Interest Method'. The fair value initially recognised (the clean price calculated in the previous sections) would increase over the reporting period by the excess of interest charged using the 'Effective Interest Rate' (the Yield to Maturity, YTM) applied to the opening amount over the coupon paid.

As discussed earlier, the IRR of a bond is the discount rate (YTM) that discounts future expected cash flows to the price or fair value of the bond. The YTM changes as the required yield changes in the market, increasing (after yields fall) or decreasing (after yields rise) the price of the bond. However, the EIR is calculated on recognition and is not re-calculated unless the financial liability is substantially modified.

The EIR will equal the interest or coupon rate if the instrument is initially recognised at face value. It represents the effective cost of debt, and may differ to the cash rate (such as a zero coupon instrument), and the resulting amortisation charge is the interest expense booked to the income statement.

Fair Value on recognition (FV_0)	x
Add: EIR % x FV_0 (P&L)	x
Less: interest or coupon paid (cash flow statement)	(x)
Amortised cost at end of year 1 (FV_1) (balance sheet)	x
Add: EIR % x FV_1	x
Less: interest or coupon paid	(x)
Amortised cost at end of year 2 (FV_0)	x
Etc	

At any date, the book value and fair value (market value) will equal the remaining cash flows discounted at the EIR and YTM, respectively. Book value and market value will differ, therefore, if the YTM on initial recognition (the EIR) has changed since recognition.

A simple example follows:

A 5.0% p.a. 5 year bond (Face Value 'FV' = Redemption Amount 'RA' = 100) is issued at 100 (Market Value 'MV' or 'PV'), with a YTM of 5.0%.

EIR = coupon rate:
∴ BV = FV

YTM is constant:
∴ BV = MV

		1	2	3	4	5
Required rate of return		5.0%	5.0%	5.0%	5.0%	5.0%
Discount factor	=	1.0000	0.9524	0.9070	0.8638	0.8227
		1 + 5.00%	1 + 5.00%	1 + 5.00%	1 + 5.00%	1 + 5.00%
	=	0.9524	0.9070	0.8638	0.8227	0.7835
Coupon	5.0%	5.00	5.00	5.00	5.00	5.00
Redemption Amount		-	-	-	-	100.00
PV of cash flows	100.00	4.76	4.54	4.32	4.11	82.27
PV at each period (excl. coupon)		100.00	100.00	100.00	100.00	100.00

(100.00 + 5.00) / (1 + 5.00%) = 100.00

Effective Interest Method						
Amortised Cost at Start		100.00	100.00	100.00	100.00	100.00
Interest at EIR	5.0%	5.00	5.00	5.00	5.00	5.00
PV at each year end		105.00	105.00	105.00	105.00	105.00
Interest paid		(5.00)	(5.00)	(5.00)	(5.00)	(5.00)
Amortised Cost at End (Book Value)		100.00	100.00	100.00	100.00	100.00

Note: to allow for varying discount rates, $DF_n = 1 / \{(1 / DF_{n-1}) \times (1 + r_n)\} = DF_{n-1} / (1 + r_n)$

If the coupon is 1.0% and YTM still 5.0%, the redemption amount will have to increase to 122.10 for the price to equal 100.

EIR ≠ coupon rate:
∴ BV ≠ FV

YTM is constant:
∴ BV = MV

		1	2	3	4	5
Required rate of return		5.0%	5.0%	5.0%	5.0%	5.0%
Discount factor	=	1.0000	0.9524	0.9070	0.8638	0.8227
		1 + 5.00%	1 + 5.00%	1 + 5.00%	1 + 5.00%	1 + 5.00%
	=	0.9524	0.9070	0.8638	0.8227	0.7835
Coupon	1.0%	1.00	1.00	1.00	1.00	1.00
Redemption Amount		-	-	-	-	122.10
PV of cash flows	100.00	0.95	0.91	0.86	0.82	96.45
PV at each period (excl. coupon)		104.00	108.20	112.61	117.24	122.10

(117.24 + 1.00) / (1 + 5.00%) = 112.61

Effective Interest Method						
Amortised Cost at Start		100.00	104.00	108.20	112.61	117.24
Interest at EIR	5.0%	5.00	5.20	5.41	5.63	5.86
PV at each year end		105.00	109.20	113.61	118.24	123.10
Interest paid		(1.00)	(1.00)	(1.00)	(1.00)	(1.00)
Amortised Cost at End (Book Value)		104.00	108.20	112.61	117.24	122.10

If at a future date yields change, BV ≠ MV. Assume the YTM 'spot rate' increases to 6.0%, at the start of year 3, the 108.20 price at the end of year 2 will immediately fall and years 3 and 4 prices will be lower. BV will stay the same, whatever market yields do.

		1	2	3	4	5
Required rate of return		5.0%	5.0%	6.0%	6.0%	6.0%
Discount factor	=	1.0000	0.9524	0.9070	0.8557	0.8073
		1 + 5.00%	1 + 5.00%	1 + 6.00%	1 + 6.00%	1 + 6.00%
	=	0.9524	0.9070	0.8557	0.8073	0.7616
Coupon	1.0%	1.00	1.00	1.00	1.00	1.00
Redemption Amount		-	-	-	-	122.10
PV of cash flows	97.27	0.95	0.91	0.86	0.81	93.75
PV at each period (excl. coupon)		104.00	108.20	110.50	116.13	122.10

(116.13 + 1.00) / (1 + 6.00%) = 110.50

Yield Fluctuations

If the bond is traded, the market yield can be implied from the bond trading price. Market yields can be used to estimate the fair value of a non-traded bond by choosing a traded bond with identical pricing inputs (coupon amount / currency / timing, term, repayment, default risk, other risk). These yields represent the return required by bond holders for the perceived bond risk, as reflected in the component of the yield ('risk premium' or 'spread') in excess of the risk free rate (usually a government bond yield). As yields change due to changes in the risk free rate, the risk characteristics of the issuer and supply and demand factors, so the bond price will change (inversely to yield changes). Measures of price volatility include 'Duration' and 'Convexity' (not discussed here).

Yields may fall below the coupon rate (typically set to equal each other on issue, when fair value equals face value), increasing the bond price above face value, meaning an investor would purchase the bond at a premium (if held to maturity, the receipt of the face value on redemption will be less than the purchase price, however this capital loss will be offset by the extra coupon in excess of the yield). A rise in yields will mean the investor purchases the bond at a discount, with the held to maturity capital gain offsetting the lower coupon rate. Bond prices will change over the term, ignoring yield changes, as the time to maturity decreases, increasing the PV of the redemption amount but decreasing the PV of the remaining coupon payments will fall as less coupons remain.

Variable Discount Rates

Basic bond pricing uses a constant YTM to discount each period's cash flow on the assumption this yield will be realised if the bond is held to maturity. An alternative approach (used in practice) assumes the YTM is only achieved if interim coupon receipts can be reinvested at this yield and discount rates must be chosen that do not have this 'reinvestment risk', such as the yield on a 'Zero Coupon' bond that does not pay any coupon (the yield is achieved via capital gain on the receipt of the only cash in-flow, the redemption amount). The return ('Zero Coupon Rate' or 'Spot Rate') is the effective annual yield based on the purchase price and maturity sum. For example, a 3 year Zero Coupon bond purchased for 75.13 and redeemed in 3 years at 100 has a yield of 10% (= $(100.00 / 75.13)^{(1/3)} - 1$). It is the rate that compounds the purchase price to the redemption amount.

For a coupon-paying bond, the cash flows could be 'stripped' and treated as separate zero coupon bond cash flows with maturities of 1, 2, 3, etc up to the maturity date. Each cash flow would have a discount factor ('DF') based on the effective periodic zero coupon rate for the relevant period (1^{st} period coupon x 1^{st} period DF + 2^{nd} period coupon x 2^{nd} period DF + …… + final period coupon plus redemption sum x final period DF). The spot rate 'Yield Curve' shows spot rates for each period. Discounting can be done using discrete rates (as above) or continuous rates.

It is beyond the scope of this article to discuss how spot rates can be estimated over the life of the bond (nice!), but they need to be derived from market rates that can be observed or estimated (via interpolation and yield curve construction techniques) and that do not allow any arbitrage profits to be made. Whereas spot rates measure the annual yield from the valuation date (spot date) to a future maturity date (e.g. time T_0 to time T_6), 'Forward Rates' measure the periodic return starting at some point in the future up to any date (e.g. T_5 to T_6) and have their own 'Forward' yield curve. Forward rates can be implied from spot rates. For example, if the spot rate $T_0 \rightarrow T_1$ and $T_0 \rightarrow T_2$ are known, the forward rate $T_1 \rightarrow T_2$ must be the rate that gives the same return under the two investment strategies: (1) invest at spot rate $T_0 \rightarrow T_2$ and (2) invest at the spot rate $T_0 \rightarrow T_1$ (effectively the forward rate for the first period) and reinvest (with interest) over $T_1 \rightarrow T_2$ at the forward rate. If the forward rates are known, then the spot rates can be implied. 'Bootstrapping' is a technique, based on these principles, that calculates theoretical spot rates from forward rates, starting at the shortest maturity and gradually increasing.

Convertible Debt

Introduction

A convertible bond or note is a debt instrument that can be converted at the investor's option into shares of the issuing company, subject to agreed terms and conditions. On conversion, investors effectively pay an exercise price by surrendering the bonds in exchange for a stated number of shares for each bond ('Conversion Ratio'). The value received from converting ('Conversion Value' or 'Parity' = Conversion Ratio x share price) should exceed the value received from any alternative strategy (i.e. the value of the bond if held to maturity and not converted, its 'Investment Value'). The possibility of a 'payoff' means convertible investors will accept a lower coupon (or even a zero coupon) compared to an otherwise identical non-convertible debt.

Early Redemption

Most issuers will have the right to service notice to redeem ('Call') the bonds early at pre-agreed dates and prices, usually after some time has elapsed ('Non-Call Period") and at a price that preserves the economic benefit for the holder (the Investment Value). For the investor, early redemption means the potential upside gain on conversion is lost and redemption proceeds may have to be reinvested at a lower yield. The fair price of a callable bond will, therefore, be less than the fair price of an otherwise identical non-callable bond (similar coupon, maturity and risk), due to this extra risk (the difference being the value of the issuer's call option).

Early redemption allows an issuer to refinance bonds at a lower cost, following a fall in market yields. The bonds are unlikely to be called if the call price exceeds the bond trading price (otherwise it would be cheaper to repurchase them in the market), unless there are clear economic benefits from refinancing the old bonds at that price (on an after-tax NPV basis, net of all repurchase costs). For a Convertible, the call provision can be conditional on certain events occurring ('Soft Call'), such as the underlying share price reaching specified levels, or unconditional ('Hard Call'). The serving of a notice to call a bond should force investors to convert if the call price is less than the Conversion Value ('Forced Conversion'), so that they receive a higher amount, although any accrued interest on the bond would be foregone on conversion. Forcing conversion allows the issuer to avoid a cash payout on redemption, and allows the Convertible to be seen as a form of deferred equity financing (but with less dilution than a straight upfront issue of shares due to the lower number of shares being issued, assuming share prices have risen).

Convertible Fair Value

The fair price of a convertible bond can be viewed as its value as a straight bond without any conversion feature (Investment Value) plus the value of the embedded option to convert to equity, except at maturity the value will be either equal its equity value (when a high share price means the Conversion Value exceeds the Investment Value) or its Investment Value (the opposite at a lower share price).

At any date before maturity, it may be optimal to delay conversion due to the 'Time Value' of the conversion option (discussed in the article on Option pricing), in which case the Convertible fair price would exceed the Conversion Value and would reflect the 'Continuing Value' of the Convertible. When the Conversion Value is much greater than the Investment Value, the Convertible fair price will reflect the value of the underlying equity and its volatility, and the bond's value as straight debt will be less relevant (i.e. the impact of changes in market yields and interest rates will be less); conversely, when the Conversion Value is less than the Investment Value, the Convertible fair price will equal the Investment Value (the fair price should never fall below its value as straight debt).

The option embedded nature of a convertible means it can be valued using an option pricing model, such as the Binomial Model or Black-Scholes Model. Building the convertible binomial tree would typically involve the following steps (a Trinomial tree can also be used):

1. Value the bond as a straight bond without any conversion feature.

2. For each coupon payment period until maturity, forecast share prices using the Binomial approach (applying up and down factors to the prior node ex-dividend share price) and deduct any dividend assumed (this could be a yield %) to arrive at the ex-dividend share price (the yield can alternatively be deducted in the risk neutral probability calculation). This gives the Conversion Value (ex. div.share price x Conversion Ratio).

3. At the last node (maturity date), calculate the Investment Value (the redemption amount plus final coupon). At the previous node discount this back at the risk adjusted rate and add the coupon to determine the prior period Investment Value. Carry on backwards until time 0.

4. At the last node, the Convertible fair price will be the greater of the Conversion Value (when conversion is certain and the bond would be priced as 100% equity) and the Investment Value (when the bond is priced as 100% debt).

5. At the penultimate node, the convertible price will be the greater of the Conversion Value, the Investment Value and the present value of the Convertible fair price if conversion occurred at some future date (the 'Continuing Value', 'V' or 'Rollback' value). V is the present value of the risk-neutral probability weighted convertible fair price ('C') at the next period:

$$\text{Continuing Value } V_t = \frac{p \,.\, C_{t+1u} + (1-p).\, C_{t+1d}}{1+r} + \text{coupon}$$

where t+1u, t+1d up and down states at next node after node t
p risk-neutral probability
r discount rate

The same calculation is then carried out at the previous node and all others, going backwards.

There are two other factors to consider

- As discussed above, issuers will usually require the right to call the bonds. If the convertible fair price or trading price (if quoted) rises above the call price (as yields fall), the bonds could be redeemed ('hard call') and refinanced at a lower coupon at less cost that buying them back in the market. In practice, issuers may call the bonds to force bond investors to convert if this is the best action to take (compared to doing nothing or having the bonds redeemed).The convertible fair price should reflect the higher of the Conversion Value and the lower of the Continuing Value (if not converted or called) and Call Price (a call is only likely if the Call Price is less than the Continuing Value):

Convertible fair price = MAX (Conversion Value, MIN {Continuing Value*, Call Price*})

* plus Coupon

- As the Convertible is a hybrid instrument whose value reflects the underlying investment value (which acts as a floor) and equity value (with upside potential), its fair price could be calculated with suitable discount rates that reflect these two components. As in the option pricing model, the equity component can be discounted at the risk free rate; the discount rate for the debt portion should reflect the issuer's credit risk and would therefore be the risk free rate plus a credit risk premium.Two approaches that have been suggested in the past are as follows:

  - Discount the next period probability weighted equity and debt components at the risk free and risk adjusted rates, respectively (this requires working backwards from the final node, when the bond will be priced 100% debt or equity, and discounting back using these rates to arrive at the equity and debt values at the prior node etc):

$$V_t = \frac{p \,.\, E_{t+1u}) + (1\text{-}p).\; E_{t+1d}}{1 + r} + \frac{p.\, D_{t+1u} + (1\text{-}\,p)\; D_{t+1d}}{1 + r + CRP}$$

Where:

t+1u, t+1d	up and down states at next node after node t
p	risk-neutral probability
r	risk free rate
CRP	credit risk premium

(Tsiveriotis and Fernandes (1998) and Hull (2003))

- Discount the next period probability weighted convertible fair value (equity and debt) at a blended rate that varies as the equity and debt components change, respectively:

$$\text{Blended rate} = r.\,w + (r + CRP)(1 - w)$$

Where:

r	risk free rate
CRP	Credit Risk Premium
w	a measure of the equity component embedded in the next period convertible fair price, which can be estimated using the convertible's 'delta' or the probability of conversion:

[1] Delta

$$\text{Delta} = \frac{\text{Convertible Price}_u - \text{Convertible Price}_d}{\text{Conversion Value}_u - \text{Conversion Value}_d}$$

(Woodson (2002), Philips (1997))

[2] Prob. of conversion

$$\text{Prob. of conversion} = P_u \,.\, p + P \,.\, (1\text{-}\,p)$$

P_u, P_d	probability of conversion at next period up and down states
p	risk neutral probability

(Goldman Sachs (1994))

An example is given in Appendix 1 (see the article 'Security Valuation – Option Pricing' for a discussion on option pricing methods). This is a hypothetical 2.00% annual paying convertible bond that matures 6 years after the 31/7/2025 valuation date and is convertible into 5 ordinary shares at any date. A dividend is payable on the underlying shares (1.00% yield p.a.), which have a valuation date share price of €14.37 and volatility of 40%. The cost of straight debt is 6.00% (continuous rate), being the 5.00% risk free rate and 1.00% credit risk premium. The redemption amount of the bond is €129.318. This gives a value for the bond ignoring the conversion option of €100. The convertible is callable at time periods 4 and 5 (at €118.352 and €123.670). Using the Goldman Sachs (1994) blended rate / conversion probability and CRR methodology, the convertible fair price is €115.00, being the value as straight debt (€110.00) and value of the conversion component (net of the call option) (€15.00).

Convertible Bond Carrying Value in Financial Statements under IFRS

Under IAS 32, the issuer of a convertible bond (a 'Compound Financial Instrument') is required to separate the convertible fair value on initial recognition into a liability component (the PV of debt cashflows without any conversion feature - 'host contract') and a residual equity component (the conversion option, being the fair value of the convertible less the value as straight debt). If there are other embedded features, such as a call option or early redemption right, these must be separated out as well. Under IFRS 9, an investor in a convertible (a 'hybrid') is not required to separate the two components, and can recognize the convertible at fair value if certain conditions are met.

In its balance sheet, the issuer must recognise the debt component at amortised cost and the equity component relating to the conversion feature as equity (and not subsequently remeasure it), but only if it meets the definition of equity. If treated as an equity derivative, the 'fixed-for-fixed' criterion would need to be met for equity classification, otherwise it is treated as an embedded derivative, and, like non-equity derivatives such as a call option, would be included as part of the liability if 'closely' related to the host contract under IFRS 9 – a call option to redeem the convertible at par or approximately amortised cost would be closely related.

Conversion is not anticipated until it occurs, when the carrying amount of the debt component is transferred to equity (the consideration given by the convertible holder for the shares received on conversion is the present value of future cash flows on the convertible that the issuer is no longer required to make).

Finally, convertibles will affect the diluted Earnings Per Shares as calculated under IAS 33.

(See EY International GAAP (2025) p.3,535, p.3,540, and p.2,888 – 2,894 for further discussion on these issues).

Suggested reading

Books:

Calamos, J. (1998) *Convertible Securities*. McGraw-Hill.
Choudry, M., Moskovic, D.,Wong, M. & Zhuoshi, S.B, (2014) *Fixed Income Markets: Management, Trading, Hedging* (2nd ed.) Wiley
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Overview

This model illustrates one method to estimate the fair value of a convertible bond, using a binomial option pricing approach (see the article 'Security Valuation – Option Pricing'), where the convertible can convert into a specified number of shares at given dates, assuming future up or down share price movements (6 year, 6 time step lattice). 200,000 2.00% p.a. coupon paying bonds, maturing in 6 years at 129.318% of face value, are issued with each bondolder having an option to convert 1 bond into 5 shares at any year end at a €20.00 Conversion Price (39.74% premium to the €14.31 share price on issue). The issuer has the right to redeem the bond early (call) at amortised cost from year 4. The yield for a similar bond without any conversion feature is 6.184% (effective rate), giving a PV of €100 for the straight bond less 4.15 for call option = 95.85 + 19.15 for the conversion option (volatility is 40.0%). The estimated price of the bond is 115.00 (the issue price), being the value of the bond as straight debt (100.00) and the equity conversion component, net of the embedded call option value (15.00)[1]. The Goldman Sachs (1994) blended discount rate and probability of conversion method is used, not the Tsiveriotis and Fernandes (1998) approach (debt and equity components being valued separately).

Conversion option			19.15
Call option			(4.15)
Straight debt			100.00
Value of Convertible - undiluted		€	115.00
Conversion option	Equity		3,830,132
Debt (incl. call option)	Liability		19,169,879
Fair value (200,000 x 115.00)		€	23,000,011

Conversion option x1/ (1 + dilution factor)	18.19
Call option	(4.15)
Straight debt	100.00
Value of Convertible - diluted	114.04
New shares issued = Bonds x Conversion Ratio	26,263,525
Enlarged shares after conversion	526,263,525
Bond dilution factor (= Extra shares / Old shares)	5.25%

Valuation Approach

The approach involves the following steps:

- Calculate the straight bond value (Investment Value), assuming no conversion. As the valuation date is the bond issue date, accrued interest is zero.
- Forecast future share prices, assuming prices at any time step can either go up or down by factors calculated from binomial parameters. This gives the Conversion Value at each 'node'. The dividend is calculated as a % yield of the price (which is assumed to be the cum-div price, from which the divided is deducted to get the ex-div price). The alternative would be to adjust the risk neutral probability.
- Calculate the value at the final maturity date for each Conversion Value scenario, being the higher of the Conversion Value or Investment Value.
- At previous nodes calculate the optimal action (continue, convert, call)

MAIN ASSUMPTIONS

Issue Date			Thu 31 Jul 2025
Valuation Date			Thu 31 Jul 2025
Maturity date			Thu 31 Jul 2031
Maturity			6.00 years
Principal Amount (Face Value)	FV	€	100.000
Redemption Amount	RA	€	129.318
Coupon			2.000%
Coupon dates (1 = Annual, 2 = Semi-Annual)			1
Last coupon			Thu 31 Jul 2025
Next coupon - first period			Fri 31 Jul 2026
Accrued interest		€	0.0000
Total number of future coupon payments			6
Yield per coupon period		Effective	6.184%
Daycount (0=30/360, 2=actual/360, 3=actual/365)			3

Share Price	S	€	14.374578
Equity Volatility			40.0%
Conversion Premium	P		39.13%
Conversion Price = S x (1 + P)	CP		20.0000
Conversion Ratio (Parity) = FV / CP	CR		5.00 shares
Risk Free Rate (nominal)	Rf	Continuous	5.000%
Credit Risk Premium	CRP	Continuous	1.000%
Time steps	t		6.00
Time step (fraction of year)			1.00
Dividend yield			1.00%
Discount Conv Price at blended rate[1] or Debt/Equity[2]			Blended Rate
Blended rate using Delta or Probability of Conversion			Probability
Coupon added to Convertible Price?			Yes
Coupon paid when called?			Yes

1 Goldmand Sachs (1994), 2 Tsiveriotis & Fernandes (1998)

VALUE AS STRAIGHT BOND (NO CALL)

Time	Date	Cash Flows	Disc F 6.184%	PV at t0	PV at at tn	Call Price (excl.coupon)
0	31-Jul-25				100.0000	
1	31-Jul-26	2.0000	0.9418	1.884	106.1837	104.1837
2	31-Jul-27	2.0000	0.8869	1.774	110.6260	108.6260
3	31-Jul-28	2.0000	0.8353	1.671	115.3431	113.3431
4	31-Jul-29	2.0000	0.7866	1.573	120.3518	118.3518
5	31-Jul-30	2.0000	0.7408	1.482	125.6703	123.6703
6	31-Jul-31	131.3176	0.6977	91.617	131.3176	129.3176
				100.000		

Using Excel functions

PRICE(31 July 2025 , 31 July 2031 , 2.00% , 6.1837% , £100 , 1 payments p.a.)	100.0000
ACCRINT(31 July 25 , 31 July 26 , 31 July 25, 2.00% , £100 , 1 payments p.a. , 1, 1)	0.0000
Dirty price	100.0000

CALL & DIVIDEND ASSUMPTIONS

CONVERSION	EARLY REDEMPTION		DIVIDENDS		
Convertible	Callable	Call Price £	Dividend Date	Dividend Yield	Period
Yes			Yes	1.00%	1
Yes			Yes	1.00%	2
Yes			Yes	1.00%	3
Yes	Yes	118.352	Yes	1.00%	4
Yes	Yes	123.670	Yes	1.00%	5
Yes	Yes	129.318	Yes	1.00%	6

The assumed share price was increased from 14.31 in the Business Valuation V paper to 14.37 here due to a minor error concerning coupon treatment that was spotted after posting (the adjustment ensures the price remains 115.00)

BINOMIAL PARAMETERS

Risk Free per step	= EXP(5.00% x 1.0) - 1	5.1271%
Credit Risk Adjusted per step	= EXP(6.00% x 1.0) - 1	6.1837%
1 + Risk-Free Rate	= 1 + 5.1271%	1.051271
1 + Risk-Adjusted Rate	= 1 + 6.1837%	1.061837
Up-move factor (u)	= EXP(40.0%*SQRT 1.00)	1.491825
Down-move factor (d)	= 1/1.4918	0.670320
Risk-Neutral Probability	= (1.051271 - 0.670320)/(1.491825 - 0.670320)	0.463724

Based on Cox, Ross, Rubinstein (1979)

RESULTS

Conversion option (net of call option)		15.00
Straight debt		100.00
Value of Convertible - undiluted	€	115.00

	0	1	2	3	4	5	6
Date	31-Jul-25	31-Jul-26	31-Jul-27	31-Jul-28	31-Jul-29	31-Jul-30	**31-Jul-31**
1 + Risk Free	105.1271%	105.1271%	105.1271%	105.1271%	105.1271%	105.1271%	105.1271%
1 + Risky	106.1837%	106.1837%	106.1837%	106.1837%	106.1837%	106.1837%	106.1837%
Call Price		-	-	-	118.35	123.67	129.32
Div Yield		1.00 %	1.00 %	1.00 %	1.00 %	1.00 %	1.00 %
Straight bond value	100.000	106.184	110.626	115.343	120.352	125.670	131.318
Add coupon		Yes	Yes	Yes	Yes	Yes	Yes
Accrued interest / coupon	-	2.00	2.00	2.00	2.00	2.00	2.00

	0	1	2	3	4	5	6
Share Price (Cum Div)	14.37	21.44	31.67	46.78	69.08	102.03	150.69
Dividend	-	0.21	0.32	0.47	0.69	1.02	1.51
Share Price (ex div)	14.37	21.23	31.35	46.31	68.39	101.01	149.18
Conversion Value	71.8729	106.1495	156.7729	231.5389	341.9614	505.0450	745.9041
CONVERTIBLE PRICE	**115.0000**	**136.2627**	**170.2077**	**231.5389**	**341.9614**	**505.0450**	**745.9041**
Continuing value + Coupon	115.0000	136.2627	170.2077	231.2236	340.5418	501.9945	-
Call Price + Coupon	-	-	-	-	120.3518	125.6703	131.3176
Holder action		Continue	Continue	Convert	Convert	Convert	Convert
Probability of Conversion	0.2601	0.4457	0.7124	1.0000	1.0000	1.0000	1.0000
Blended rate per period	5.908795%	5.712773%	5.430964%	5.127110%	5.127110%	5.127110%	5.127110%

	1	2	3	4	5	6
Share Price (Cum Div)	9.64	14.23	21.02	31.04	45.84	67.71
Dividend	0.10	0.14	0.21	0.31	0.46	0.68
Share Price (ex div)	9.54	14.09	20.81	30.73	45.39	67.03
Conversion Value	47.6961	70.4426	104.0372	153.6531	226.9313	335.1563
CONVERTIBLE PRICE	**109.2848**	**117.4833**	**130.4792**	**153.6531**	**226.9313**	**335.1563**
Continuing value + Coupon	109.2848	117.4833	130.4792	165.3280	226.6620	-
Call Price + Coupon	-	-	-	120.3518	125.6703	131.3176
Holder action	Continue	Continue	Continue	Convert	Convert	Convert
Conversion Forced?	-	-	-	Forced		
Probability of Conversion	0.0997	0.2150	0.4637	1.0000	1.0000	1.0000
Blended rate per period	6.078297%	5.956456%	5.693710%	5.693710%	5.127110%	5.127110%

	2	3	4	5	6
Share Price (Cum Div)	6.39	9.44	13.95	20.60	30.42
Dividend	0.06	0.09	0.14	0.21	0.30
Share Price (ex div)	6.33	9.35	13.81	20.39	30.12
Conversion Value	31.6519	46.7469	69.0408	101.9668	150.5954
CONVERTIBLE PRICE	**110.6260**	**115.3431**	**120.3518**	**125.6703**	**150.5954**
Continuing value + Coupon	110.6260	115.3431	120.3518	134.7016	-
Call Price + Coupon	-	-	120.3518	125.6703	131.3176
Issuer action	-	-	-	Call	-
Holder action	Continue	Continue	Continue	Continue	Convert
Probability of Conversion	0.0000	0.0000	0.0000	0.0000	1.0000
Blended rate per period	6.183655%	6.183655%	6.183655%	5.693710%	5.127110%

	3	4	5	6
Share Price (Cum Div)	4.24	6.27	9.26	13.67
Dividend	0.04	0.06	0.09	0.14
Share Price (ex div)	4.20	6.20	9.16	13.53
Conversion Value	21.0047	31.0220	45.8166	67.6669
CONVERTIBLE PRICE	**115.3431**	**120.3518**	**125.6703**	**131.3176**
Continuing value + Coupon	115.3431	120.3518	125.6703	-
Call Price + Coupon	-	120.3518	125.6703	131.3176
Issuer action	-	-	-	-
Holder action	Continue	Continue	Continue	Redeem
Probability of Conversion	0.0000	0.0000	0.0000	0.0000
Blended rate per period	6.183655%	6.183655%	6.183655%	6.183655%

	4	5	6
Share Price (Cum Div)	2.82	4.16	6.14
Dividend	0.03	0.04	0.06
Share Price (ex div)	2.79	4.12	6.08
Conversion Value	13.9391	20.5867	30.4047
CONVERTIBLE PRICE	**120.3518**	**125.6703**	**131.3176**
Continuing value + Coupon	120.3518	125.6703	-
Call Price + Coupon	120.3518	125.6703	131.3176
Holder action	Continue	Continue	Redeem
Probability of Conversion	0.0000	0.0000	0.0000
Blended rate per period	6.183655%	6.183655%	6.183655%

	0	1	2	3	4	5	6
Date	31-Jul-25	31-Jul-26	31-Jul-27	31-Jul-28	31-Jul-29	31-Jul-30	**31-Jul-31**
1 + Risk Free	105.1271%	105.1271%	105.1271%	105.1271%	105.1271%	105.1271%	105.1271%
1 + Risky	106.1837%	106.1837%	106.1837%	106.1837%	106.1837%	106.1837%	106.1837%
Call Price		-	-	-	118.35	123.67	129.32
Div Yield		1.00 %	1.00 %	1.00 %	1.00 %	1.00 %	1.00 %
Straight bond value	100.000	106.184	110.626	115.343	120.352	125.670	**131.318**
Add coupon		Yes	Yes	Yes	Yes	Yes	**Yes**
Accrued interest / coupon	-	2.00	2.00	2.00	2.00	2.00	**2.00**

	5	6
Share Price (Cum Div)	1.87	2.76
Dividend	0.02	0.03
Share Price (ex div)	1.85	2.73
Conversion Value	9.2502	13.6617
CONVERTIBLE PRICE	**125.6703**	**131.3176**
Continuing value + Coupon	125.6703	-
Call Price + Coupon	125.6703	131.3176
Holder action	Continue	Redeem
Probability of Conversion	0.0000	0.0000
Blended rate per period	6.183655%	6.183655%

	6
Share Price (Cum Div)	1.24
Dividend	0.01
Share Price (ex div)	1.23
Conversion Value	6.1386
CONVERTIBLE PRICE	**131.3176**
Continuing value + Coupon	-
Call Price + Coupon	131.3176
Holder action	Redeem
Probability of Conversion	0.0000
Blended rate per period	6.183655%

Final bottom node calcs: provide merely to show that the calculations are quite lengthy

Share Price (Cum Div)	1.24	=IF(R$6=0,0,IF($D$20=1,P125*ASSUMPTIONS!$G$68,IF($D$21=1,(P125-P$22)*ASSUMPTIONS!$G$68+R$21+R$22,P125*ASSUMPTIONS!$G$68)))
Dividend	0.01	=IF(R$6=0,0,IF(R$19=1,IF($D$20=1,R142*R$20,IF($D$21=1,R$21,0)),0))
Share Price (ex div)	1.23	=R142-R143
Conversion Value	6.1386	=IF(R144*ASSUMPTIONS!$M$10<=R$11,0,R144*ASSUMPTIONS!$M$10)
CONVERTIBLE PRICE	**131.3176**	=IF(R$6=0,0,IF(R$7=1,MAX(R145,R$23),IF(R$17>0,MAX(R$23,R145,R151+IF(ASSUMPTIONS!$M$28=1,R$25,0),MIN(R149,R150)),MAX(IF(ASSUMPTIONS!$M$16=1,(T148*ASSUMPTIONS!$G$69+T167*(1-ASSUMPTIONS!$G$69))/(1+R159)+IF(ASSUMPTIONS!$M$18=1,R$25,0),(R146+R147)),R$23,R145))))
Continuing value + Coupon	-	=IF(OR(R$6=0,R$7=1),0,(T148*ASSUMPTIONS!$G$69+T167*(1-ASSUMPTIONS!$G$69))/(1+R159)+IF(ASSUMPTIONS!$M$18=1,R$25,0))
Call Price + Coupon	131.3176	=IF(OR(R$6=0,R$8=0,R144*ASSUMPTIONS!$M$10<R$13),0,R$17+IF(ASSUMPTIONS!$M$28=1,R$25,0))
Holder action	Redeem	=IF(R148=R150+IF(ASSUMPTIONS!$M$28=1,R$25,0),"Call",IF(R148=R151+IF(ASSUMPTIONS!$M$28=1,R$25,0),"Put",IF(R148=R145,"Convert",IF(R148=R$23,IF(R$7=1,"Redeem","Continue"),"Continue"))))
Conversion Forced?	-	=IF(R153="Convert",IF(AND(R150>0,R149>R145),"Forced",""),"-")
Probability of Conversion	0.0000	=IF(ISERROR(IF(OR(R$6=0,R153="Put",R153="Call",R$10=0),0,IF(R$7=1,IF(R145>R$23,1,0),IF(R$6=1,IF(ASSUMPTIONS!$M$17=1,(T148-T167)/(T145-T164),IF(R148=R145,1,IF(OR(R148=R$23,0,R148=R150),0,(T155*ASSUMPTIONS!$G$69+T174*(1-ASSUMPTIONS!$G$69))))),0)))),0,IF(OR(R$6=0,R153="Put",R153="Call",R$10=0),0,IF(R$7=1,IF(R145>R$23,1,0),IF(R$6=1,IF(ASSUMPTIONS!$M$17=1,(T148-T167)/(T145-T164),IF(R148=R145,1,IF(OR(R148=R$23,0,R148=R150),0,(T155*ASSUMPTIONS!$G$69+T174*(1-ASSUMPTIONS!$G$69))))),0))))
Blended rate	6.18%	=(1+R159)^(1/ASSUMPTIONS!$M$14)-1
Blended rate per period	6.183655%	=IF(R$6=0,0,(IF(R$7=1,IF(R145>R$23,1,0),IF(ASSUMPTIONS!$M$17=1,(T148-T167)/(R145-R164),T155*ASSUMPTIONS!$G$69+T174*(1-ASSUMPTIONS!$G$69))))*R157+(1-IF(R$7=1,IF(R145>R$23,1,0),IF(ASSUMPTIONS!$M$17=1,(T148-T167)/(R145-R164),T155*ASSUMPTIONS!$G$69+T174*(1-ASSUMPTIONS!$G$69))))*R156)

Note: The probability of conversion formula is certainly not best practice, as it is too long. It would be simplified!