ULB
Solvay Brussels School
of Economics and Management

Advanced Corporate Finance

6. Using Options in Corporate Finance

Objectives of the session

1. Underlying assumptions of NPV rule
2. Valuing option to launch
3. Valuing option to abandon (compound option)
4. Determining the optimal timing of investment
5. Valuing option on dividend paying stocks

Valuing a company

- Standard approach: V = PV(Expected Free Cash Flows)
  - Free Cash Flow = CF from operation - Investment
  - Risk adjusted discount rate

- Another approach: V = NOPAT/r + PVGO
  - NOPAT : net operating profit after taxes
  - PVGO: present value of growth opportunities
  - = present value of future NPV

- Does it apply to Yahoo or Amazon.com?

|3

ULB
SolvayBrusselsSchool of Economics and Management

Making Investment Decisions: NPV rule

- NPV : a measure of value creation
- NPV = V-I   with V=PV(Additional free cash flows)
- NPV rule: invest whenever NPV>0
- Underlying assumptions:
  - one time choice that cannot be delayed
  - single roll of the dices on cash flows
- But:
  - delaying the investment might be an option
  - what about flexibility?

UL B
SolvayBrusselsSchool
of Economics and Management

Portlandia Ale: an example

(based on Amram & Kulatilaka Chap 10 Valuing a Start-up)

- New microbrewery

- Business plan:
  - €4 million needed for product development (€0.5/quarter for 2 years)
  - €12 million to launch the product 2 years later
  - Expected sales € 6 million per year
  - Value of established firm: €22 million (based on market value-to-sales ratio of 3.66)

DCF value calculation

Time	0.00	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00
Investment	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-0.50	-12.0
Terminal value									+22.0
PV(Investment) *r* = 5%	-0.50	-0.49	-0.49	-0.48	-0.48	-0.47	-0.46	-0.46	-10.86
PV(TermValue) *r* = 21,5%									+14.47
NPV	**-0.22**								

Would you abandon the project?

But there is no obligation to launch the product

- The decision to launch the product is like a call option
- By spending on product development, Portlandia Ale acquires
  - a right (not an obligation)
  - to launch the product in 2 years
- They will launch if, in 2 years, the value of the company is greater than the amount to spend to launch the product (€12 m)
- They have some flexibility
- How much is it worth?

Valuing the option to launch

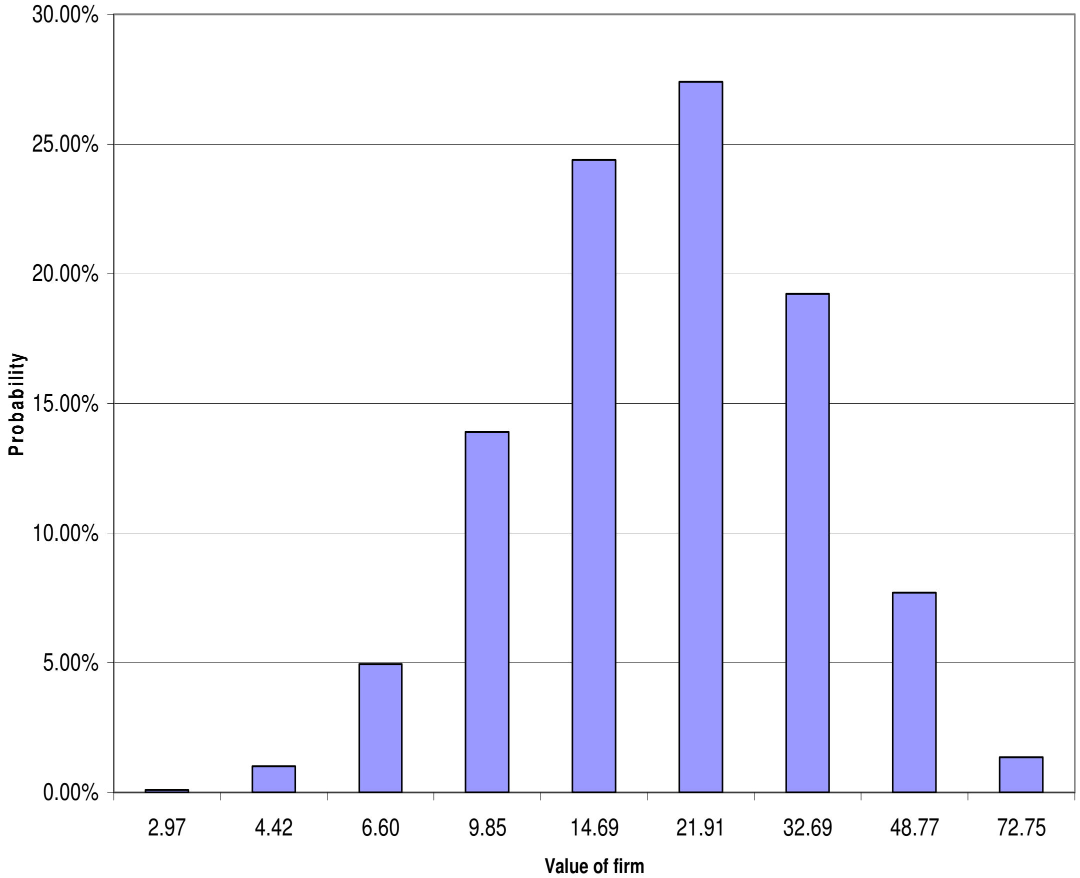
- Let use the Black-Scholes formula (for *European* options)

- 5 inputs needed:

Call option on a stock	Option to launch
Stock price	Current value of established firm
Exercise price	Cost of launch
Exercise date	Launch date
Risk-free interest rate	Risk-free interest rate
Standard deviation of return on the stock	Volatility of value

Volatility

- Volatility of value means that the value of the established firm in 2 years might be very different from the expected value



SolvayBrusselsSchool
of Economics and Management

Using Black Scholes

• Current value of established firm =	14.46
• Cost of launch =	12.00
• Launch date =	2 years
• Risk-free interest rate =	5%
• Volatility of value =	40% 🡐☝

- And, … magic, magic, … value of option = € 4.97

The value of Portlandia Ale

(all numbers in € millions)

- Traditional NPV calculation

PV(Investment before launch)	- 3.83
PV(Launch)	- 10.86
PV(Terminal value)	+14.47
Traditional NPV	**- 0.22**

- Real option calculation

PV(Investment before launch)	- 3.83
Value of option to launch	+ 4.96
Real option NPV	**+ 1.13**

ULB SolvayBrusselsSchool of Economics and Management

Let us add an additional option

- Each quarter, Portlandia can abandon the project
- This is an *American* option (can be exercised at any time)
- Valuation using numerical methods (more on this later)

- Traditional NPV calculation

Traditional NPV	**- 0.22**

- Real option calculation

PV(Investment before launch)	- 3.83
Value of options to launch and to abandon	+ 5.57
Real option NPV	**+ 1.74**

SolvayBrusselsSchool
of Economics and Management

Real option vs DCF NPV

- Where does the additional value come from?
- Flexibility
- Changes of the investment schedule in response to market uncertainty
- Option to launch
- Option to continue development
- Option to liquidate

Back to Portlandia Ale

- Portlandia Ale had 2 different options:
  - the option to launch (a 2-year European call option)
    → value can be calculated with BS
  - the option to abandon (a 2-year American option)

- How to value this American option?
  - No closed form solution
  - Numerical method: use recursive model based on binomial evolution of value
  - At each node, check whether to exercice or not.
  - Option value = Max(option exercised, option alive)

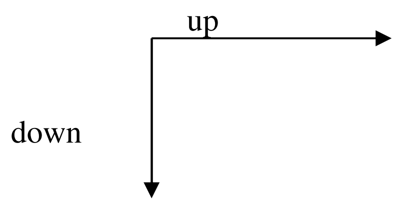
Valuing a compound option (step 1)

- Each quarterly payment (€ 0.5 m) is a call option on the option to launch the product. This is a compound option.
- To value this compound option:

1. Build the binomial tree for the value of the company

0	1	2	3	4	5	6	7	8
14.47	17.68	21.59	26.37	32.21	39.34	48.05	58.69	71.68
	11.85	14.47	17.68	21.59	26.37	32.21	39.34	48.05
		9.70	11.85	14.47	17.68	21.59	26.37	32.21
			7.94	9.70	11.85	14.47	17.68	21.59
				6.50	7.94	9.70	11.85	14.47
					5.32	6.50	7.94	9.70
						4.36	5.32	6.50
							3.57	4.36
								2.92

u=1.22, d=0.82



Valuing a compound option (step 2)

2. Value the option to launch at maturity

3. Move back in the tree. Option value at a node is:

$$\text{Max}\{0,[pV_u + (1-p)V_d]/(1+r\Delta t) - 0.5\}$$

0	1	2	3	4	5	6	7	8
1.74	4.26	7.90	12.73	18.83	26.30	35.35	46.33	59.68
	0.43	1.95	4.59	8.37	13.33	19.51	26.99	35.99
		0.00	0.53	2.17	4.94	8.89	14.02	20.21
			0.00	0.00	0.63	2.38	5.32	9.59
				0.00	0.00	0.00	0.67	2.47
					0.00	0.00	0.00	0.00
						0.00	0.00	0.00
							0.00	0.00
								0.00

$p = 0.48$

$1/(1+r\Delta t) = 0.9876$

$=(0.48\times 2.47+0.52\times 0.00)\times 0.9876-0.5$

When to invest?

- Traditional NPV rule: invest if NPV>0
- Is it always valid?
- Suppose that you have the following project:
  - Cost I = 100
  - Present value of future cash flows V = 120
  - Volatility of V = 69.31%
  - Possibility to mothball the project
- Should you start the project?
- If you choose to invest, the value of the project is:
- Traditional NPV = 120 - 100 = 20 >0
- What if you wait?

To mothball or not to mothball

- Let analyse this using a binomial tree with 1 step per year
- As volatility = .6931, u=2, d=0.5. Also, suppose *r* = .10 => p=0.40
- Consider waiting one year

V=240 =>invest NPV=140

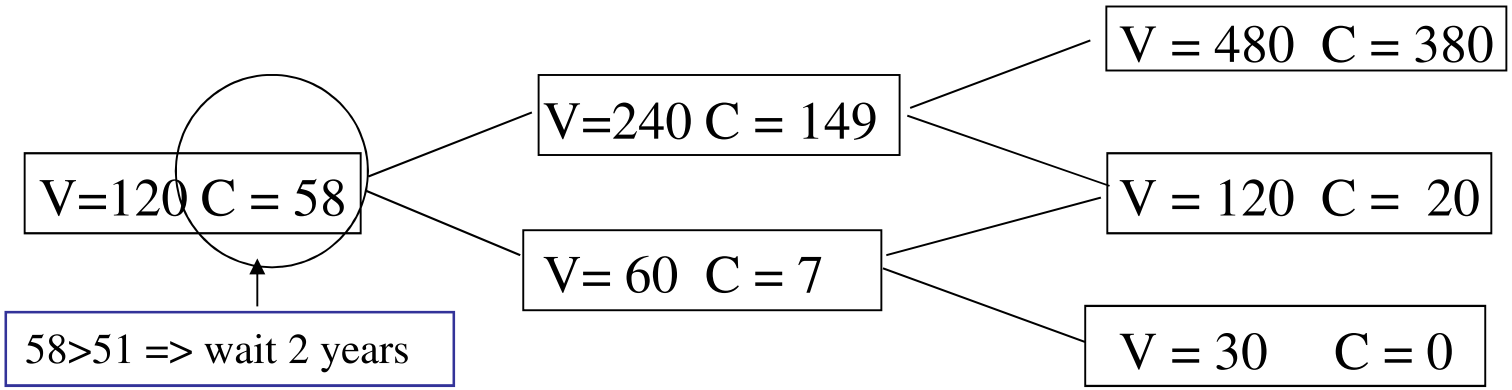
V=120

V= 60 =>do not invest NPV=0

- Value of project if started in 1 year = 0.40 x 140 / 1.10 = 51
- This is greater than the value of the project if done now (20)
- Wait
- NB: you now have an American option

Waiting how long to invest?

- What if opportunity to mothball the project for 2 years?



- This leads us to a general result: it is never optimal to exercise an American call option on a non dividend paying stock before maturity.
- Why? 2 reasons
  - better paying later than now
  - keep the insurance value implicit in the put alive (avoid regrets)

ULB

Solvay Brussels School
of Economics and Management

Why invest now then?

- Up to now, we have ignored the fact that by delaying the investment, we do not receive the cash flows that the project might generate

- In option's parlance, we have a call option on a dividend paying stock
- Suppose cash flow is a constant percentage per annum δ of the value of the underlying asset
- We can still use the binomial tree recursive valuation with:

  $p = [(1+r\Delta t)/(1+\delta\Delta t)-d]/(u-d)$

- A (very) brief explanation: in a risk neutral world, the expected return r (say 6%) is sum of capital gains + cash payments
- So: $1+r\,\Delta t = pu(1+\delta\Delta t) + (1-p)d(1+\delta\Delta t)$

ULB

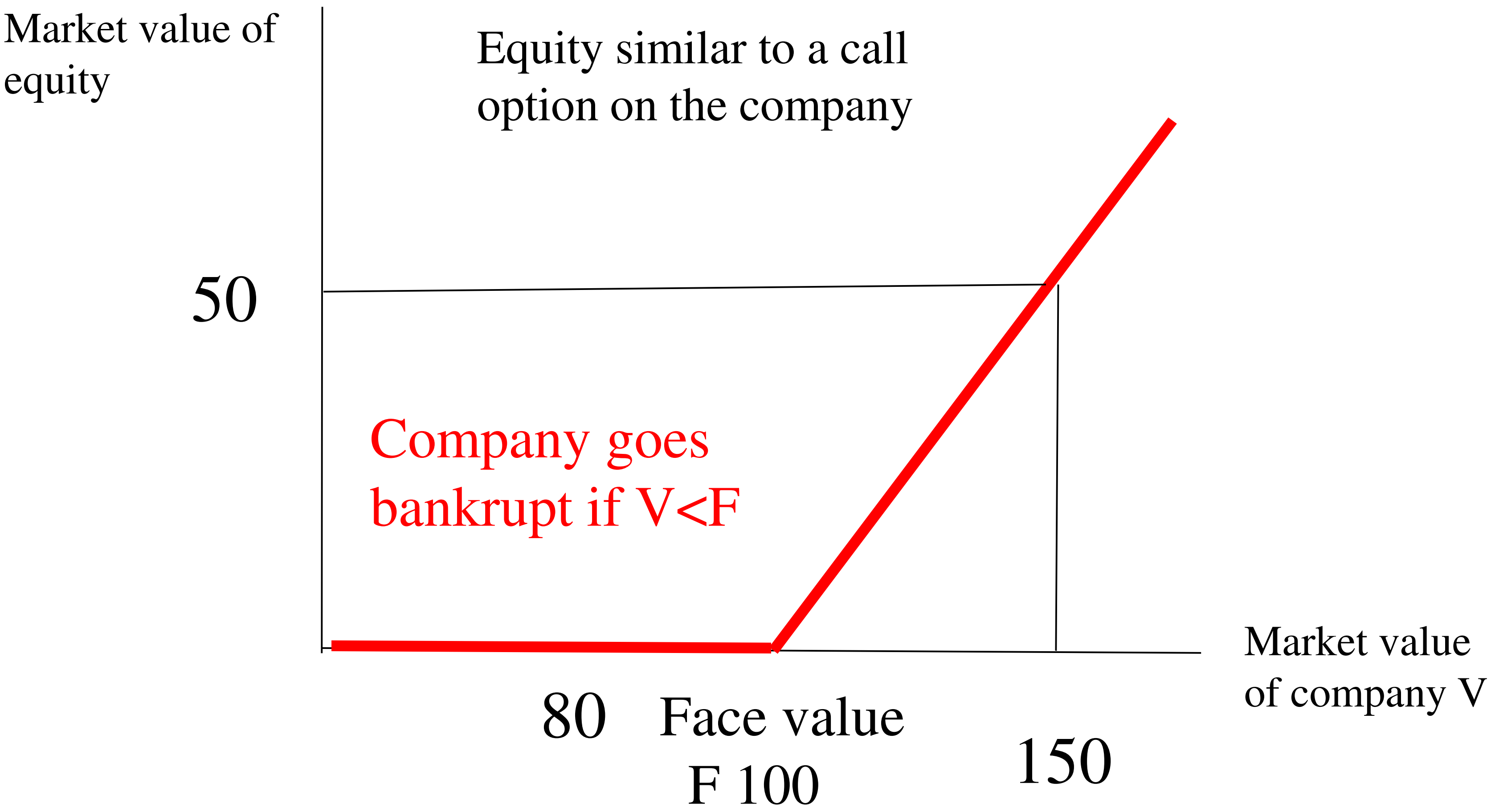
Solvay Brussels School of Economics and Management

Options and risky debt

- Options may also be used in other contexts…
- Many insights (even though beware of « optionitis »)
- One major application => risky debt!

Risky debt: Merton model

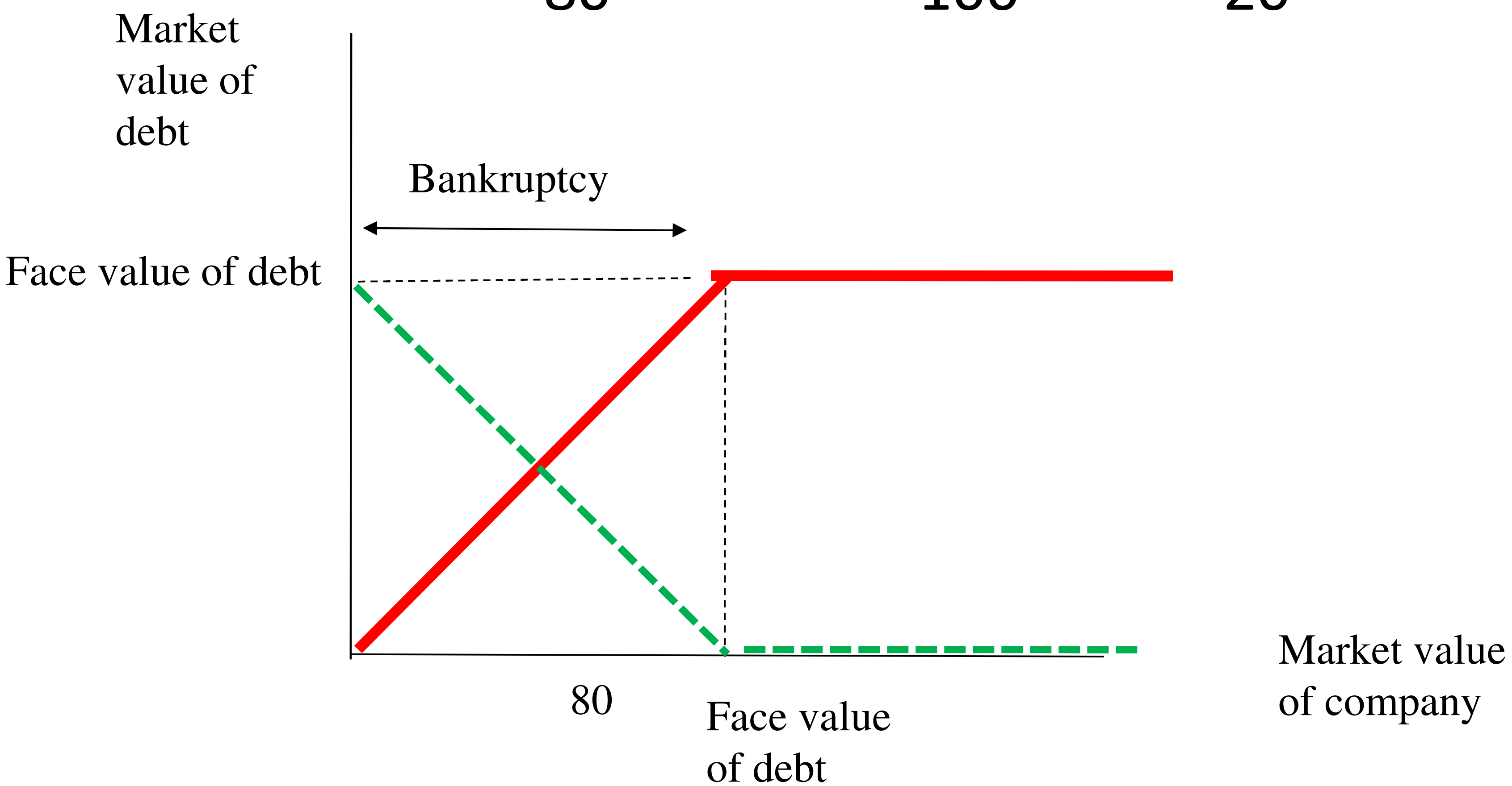
- Limited liability: rules out negative equity



Risk debt decomposition

Risky debt = Risk-free debt – Put

80 = 100 - 20



Example

- Asset value => 100
- Decision to issue a debt (face value) = 70 (zero coupon bond payable in exactly a year)

- Other parameters

  - Sigma of asset variations (per year): 40%
  - Risk-free rate: 5%

- Value of the debt? And Equity?

Merton Model: example using binomial pricing

Data:
Market Value of Unlevered Firm: 100,000
Risk-free rate per period: 5%
σ = 40%

Company issues 1-year zero-coupon
Face value = 70,000
Proceeds used to pay dividend or to buy back shares

Binomial option pricing: review
Up and down factors: $u = e^{\sigma\sqrt{\Delta t}} = 1.492$ $d = \frac{1}{u} = .670$

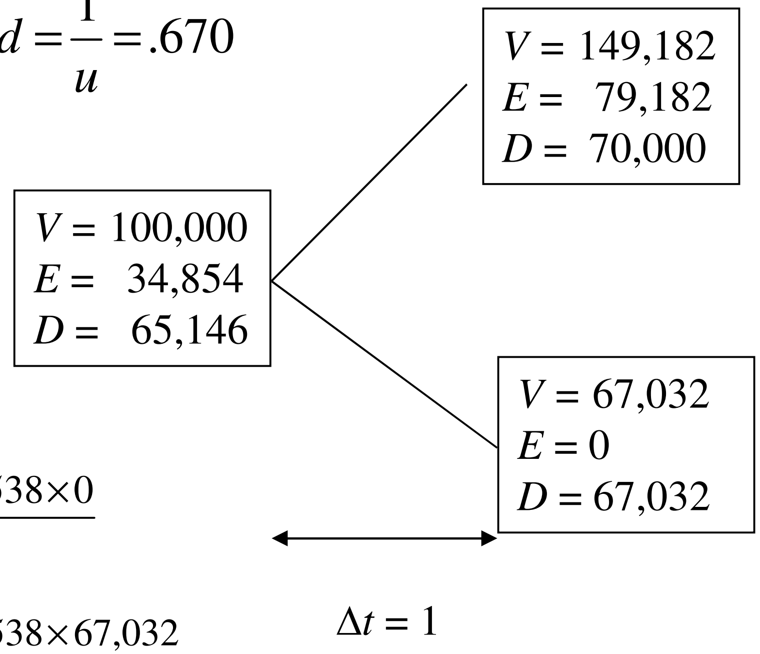
Risk neutral probability :

$$p = \frac{1 + r_f - d}{u - d} = \frac{1.05 - .67}{1.492 - 0.670} = .462$$

1-period valuation formula

$$E = \frac{0.462 \times 79{,}182 + 0.538 \times 0}{1.05}$$

$$D = \frac{0.462 \times 70{,}000 + 0.538 \times 67{,}032}{1.05}$$



Calculating the cost of borrowing

- Spread = Borrowing rate – Risk-free rate
  - Borrowing rate = Yield to maturity on risky debt
  - For a zero coupon (using annual compounding):

$$D = \frac{F}{(1+y)^T}$$

- In our example:

$$65,146 = \frac{70,000}{1+y}$$

- => y = 7.45%
- Spread = 7.45% - 5% = 2.45%

Decomposing the value of the risky debt

In our simplified model:

$$D = \frac{F}{1+r_f} \times p + \frac{V_d}{1+r_f} \times (1-p)$$

$$D = \frac{70{,}000}{1.05} \times 0.462 + \frac{67{,}032}{1.05} \times .538$$
$$= 66{,}667 \times 0.462 + 63{,}840 \times .538$$
$$= 65{,}146$$

$$D = \frac{F}{1+r_f} - \frac{(1-p)(F-V_d)}{1+r_f}$$

$$D = \frac{70{,}000}{1.05} - \frac{70{,}000 - 67{,}032}{1.05} \times .538$$
$$= 66{,}667 - 2{,}827 \times .538$$
$$= 65{,}146$$

F: Face value of the bond

V_d : recovery if default

$F - V_d$: loss given default

$(1 - p)$: risk-neutral probability of default