Real Option
An Introduction and an Application to R&D Valuation

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簡報架構

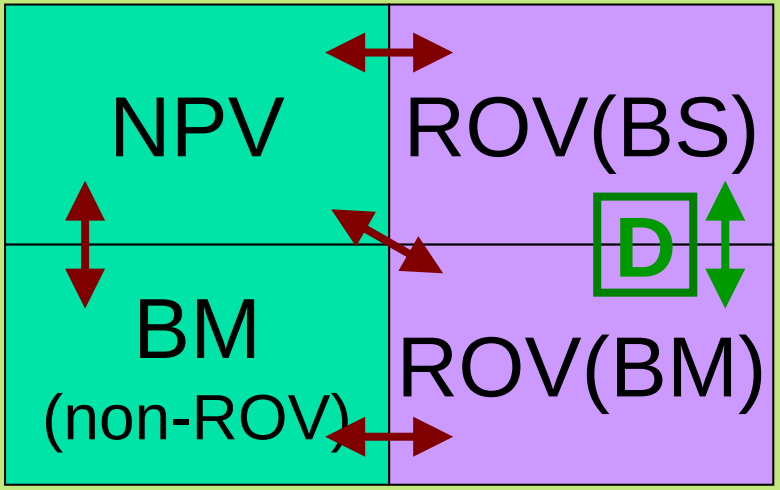
1.NPV vs ROV(B-Smodel)

2.Binomial models

2.1 NPV vs ROV

2.2 NPV vs non-ROV

2.3 ROV vs non-ROV (bio-phama)



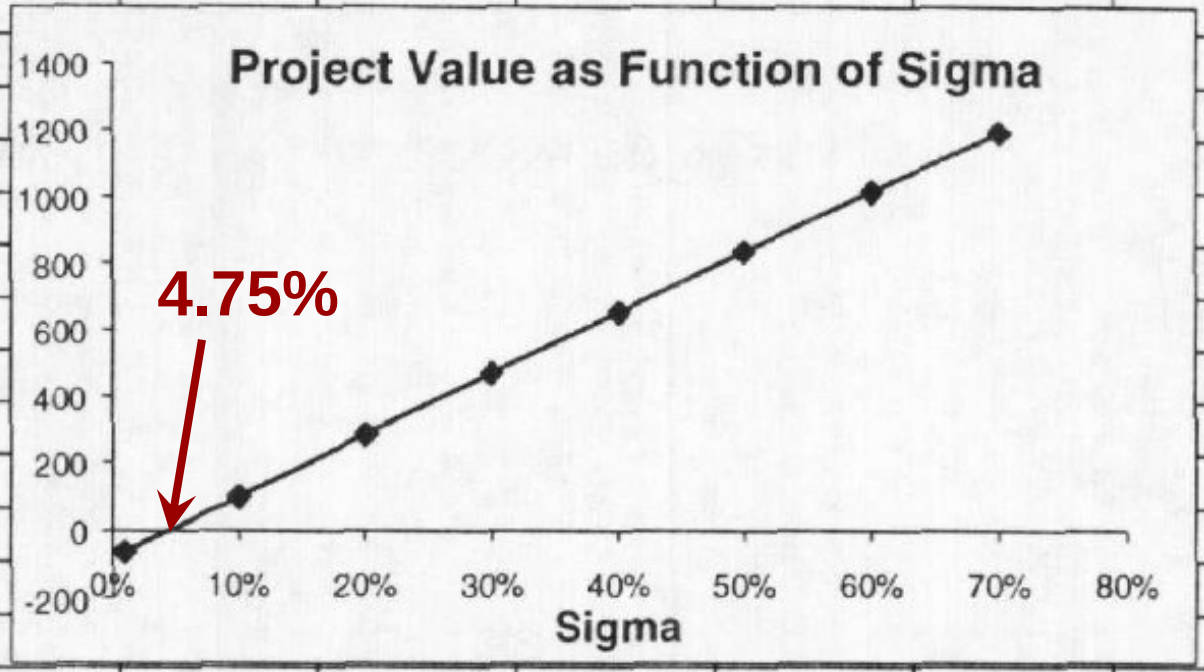
- ***DISCUSSION*** D

1.NPV vs ROV(B-Smodel)(1)

	A	B	C	D	E	F	G
1	**THE OPTION TO EXPAND**						
2							
3	Year	0	1	2	3	4	5
4	CF of single machine	-1000	220	300	400	200	150
5							
6	Discount rate for machine cash flows	12%					
7	Riskless discount rate	6%					
8	NPV of single machine	-67.48					
9							
10	Number of machines bought next year	5					
11	Option value of single machine purchased in one more year	143.98	<-- =B24				
12	NPV of total project	652.39	<-- =B8+B10*B11				
13							
14	**Black-Scholes Option Pricing Formula**						
15	S	932.52	PV of machine CFs				
16	X	1000.00	Exercise price = Machine cost				
17	r	*6.00%*	*Risk-free rate of interest*				
18	T	1	Time to maturity of option (in years)				
19	Sigma	40%	<-- Volatility				
20	d_1	0.1753	<-- (LN(S/X)+(r+0.5*sigma^2)*T)/(sigma*SQRT(T))				
21	d_2	-0.2247	<-- d_1 - sigma*SQRT(T)				
22	$N(d_1)$	0.5696	<--- Uses formula NormSDist(d_1)				
23	$N(d_2)$	0.4111	<--- Uses formula NormSDist(d_2)				
24	Option value = BS call price	143.98	<-- S*N(d_1)-X*exp(-r*T)*N(d_2)				

1.NPV vs ROV(B-Smodel)(2)

	B	C	D	E	F	G	H	I	J
27	Data Table								
28	σ	652.39	<-- Table header: =B12						
29	1%	-63.48							
30	10%	97.16							
31	20%	283.09							
32	30%	468.40							
33	40%	652.39							
34	50%	834.59							
35	60%	1014.54							
36	70%	1191.81							
37									
38									
39									
40									
41									
42									



$\sigma \uparrow$,value $\uparrow$

2.1(1) Binomial models- NPV vs ROV

$$1 = q_u * up + q_d * down$$

$$\frac{1}{1+r} = q_u + q_d$$

$$q_u = \frac{1+r-down}{(1+r)*(up-down)}, \quad q_d = \frac{up-1-r}{(1+r)*(up-down)}$$

	A	B	C	D	E
1			PRICING AN ABANDONI		
2					
3	**Market data**			**State prices**	
4	Expected market return	12%		q_u	0.3087
5	Sigma of market return	30%		q_d	0.6347
6	Risk-free rate	6%			
7					
8	**One-period "up" and "down" of market**				
9	Up	1.521962	<-- =EXP(B4+B5), note that a valid alternative is "up" = EXP(B5)		
10	Down	0.83527	<-- =EXP(B4-B5), note that a valid alternative is "down" = EXP(-B5)		
11					
12					
13	**Project cash flows**				
14					
15					150
16				100	
17					80
18			-50		
19					80
20				-50	
21					-60
22			=C16*I16		
23	**State-by-state present value**				
24					14.2981 <-- =E15*K15
25				30.8740	
26					15.6755 <-- =E17*K17
27			-50		
28					15.6755 <-- =E19*K19
29				-31.7328	
30					-24.1673 <-- =E21*K21
31					
32	**Net present value**		-29.38 <-- =SUM(A24:E30)		
33					

State-dependent present value factors

			0.0953	<-- =E4^2
	0.3087			
			0.1959	<-- =E4*E5
1				
			0.1959	<-- =E4*E5
	0.6347			
			0.4028	<-- =E5^2

2.1(2) Binomial models- NPV vs ROV

	A	B	C	D	E	F	G	H	I	J	K
35	Cash flows with abandonment						Present value with abandonment				
36											
37					150						14.29808
38			100						30.87402		
39					80						15.67551
40	-50						-50				
41					0						0
42			0						0		
43					0						0
44											
45											
46							Present value with abandonment				10.85

NPV: -29.38

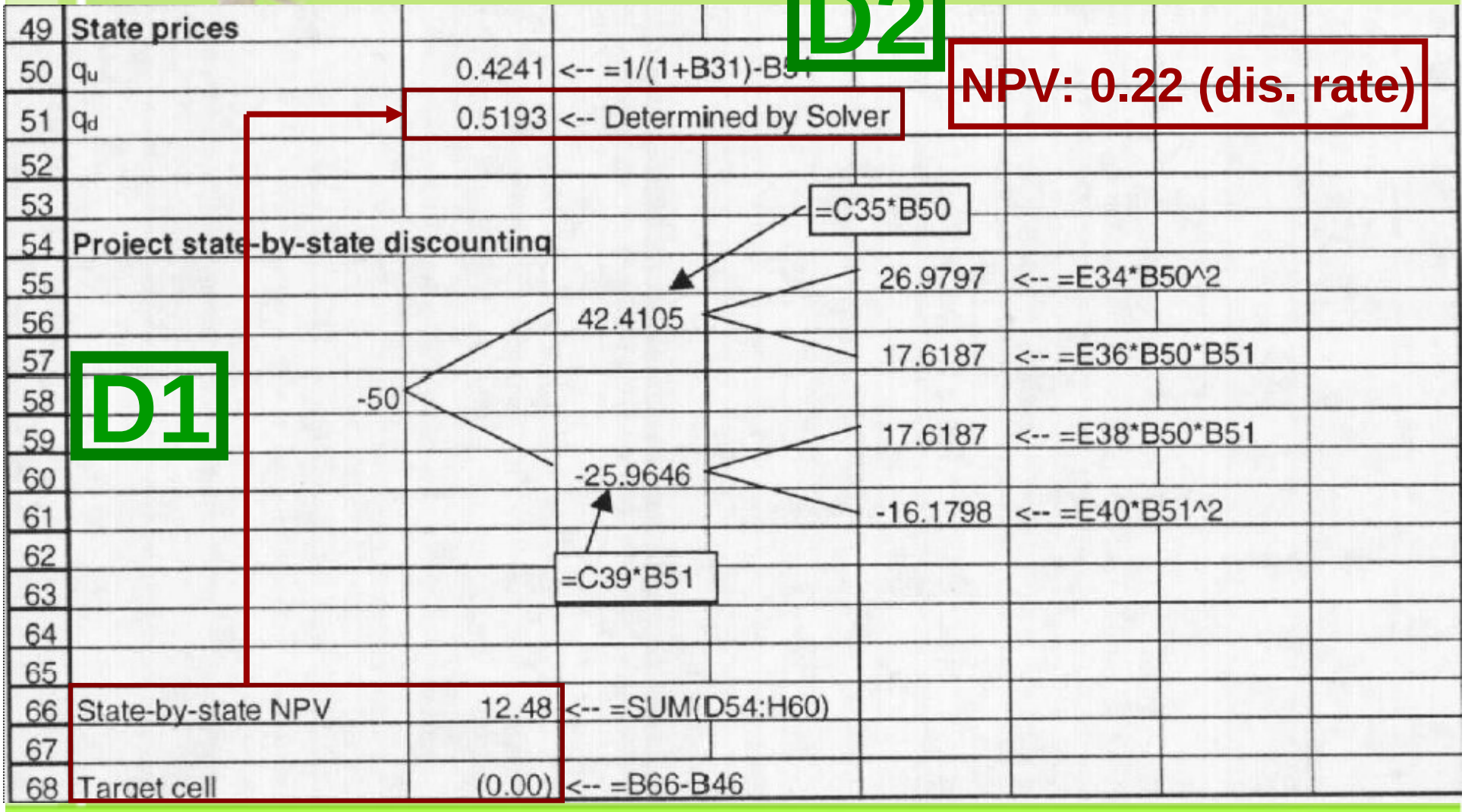
2.2(1) Binomial models- NPV vs non-ROV

	A	B	C	D	E	F	G	H
28	**Method 2**: Matching state prices to the cost of capital							
29								
30	Project cost of capital	22%	<-- This is the discount rate for the project if it has **no options**					
31	Risk-free rate	6%						
32								
33	**Project cash flows**							
34					150			
35			100					
36					80			
37	-50							
38					80			
39			-50					
40					-60			
41								
42								
43	**Project expected cash flows**: Assumes equal state probabilities							
44	Year	0	1	2				
45	Expected CF	-50	25	62.5				
46	Project NPV	12.48	<-- =NPV(B30,C45:D45)+A37					
47								

=AVERAGE(C35:C39)

=AVERAGE(E34:E40)

2.2(2) Binomial models- NPV vs non-ROV



2.3(1) Binomial models- ROV vs non-ROV

Bio-Phama

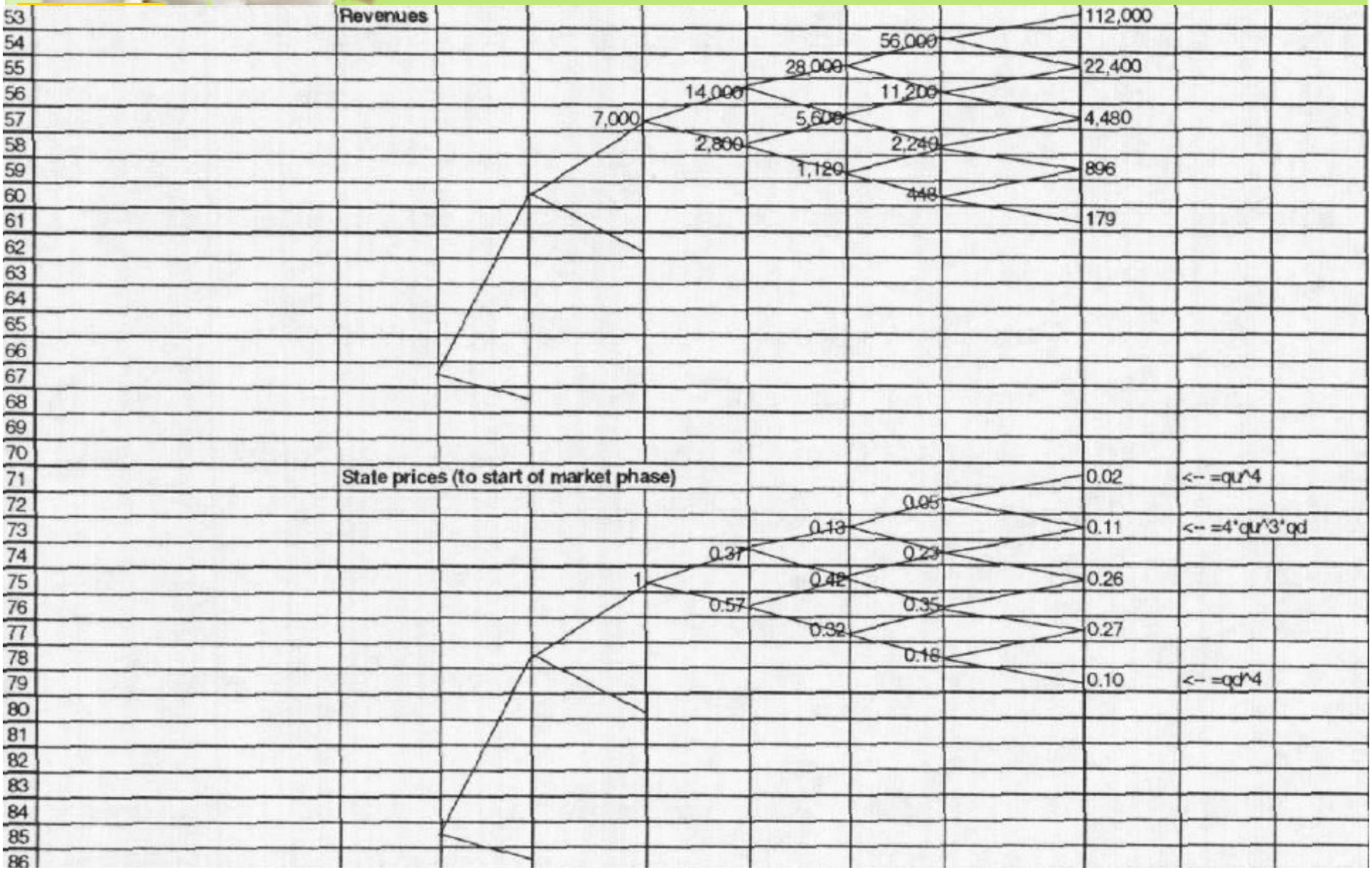
	Phase1	Phase2	Phase3(market)				
Year	1st	2nd	3rd	4th	5th	6th	7th
Cost	-1000	-2000	-3000	-3000	-3000	-3000	-3000
Earn			7000				
Pro.	50%	30%					

$\mu = 20\%$, $\sigma = 80\%$

Cost of capital = 16%

	A	B	C	D	E	F	G	H	I
38						Note: The expected return and variance of return			
39	Initial revenue	7,000				is given by:			
40	Up	100%							
41	Down	-60%				Expected	20%	<-- =AVERAGE(B40:B41)	
42						σ	80%	<-- =STDEVP(B40:B41)	
43	State prices								
44	q_u	0.3665							
45	q_d	0.5681							

2.3(2) Binomial models- ROV vs non-ROV



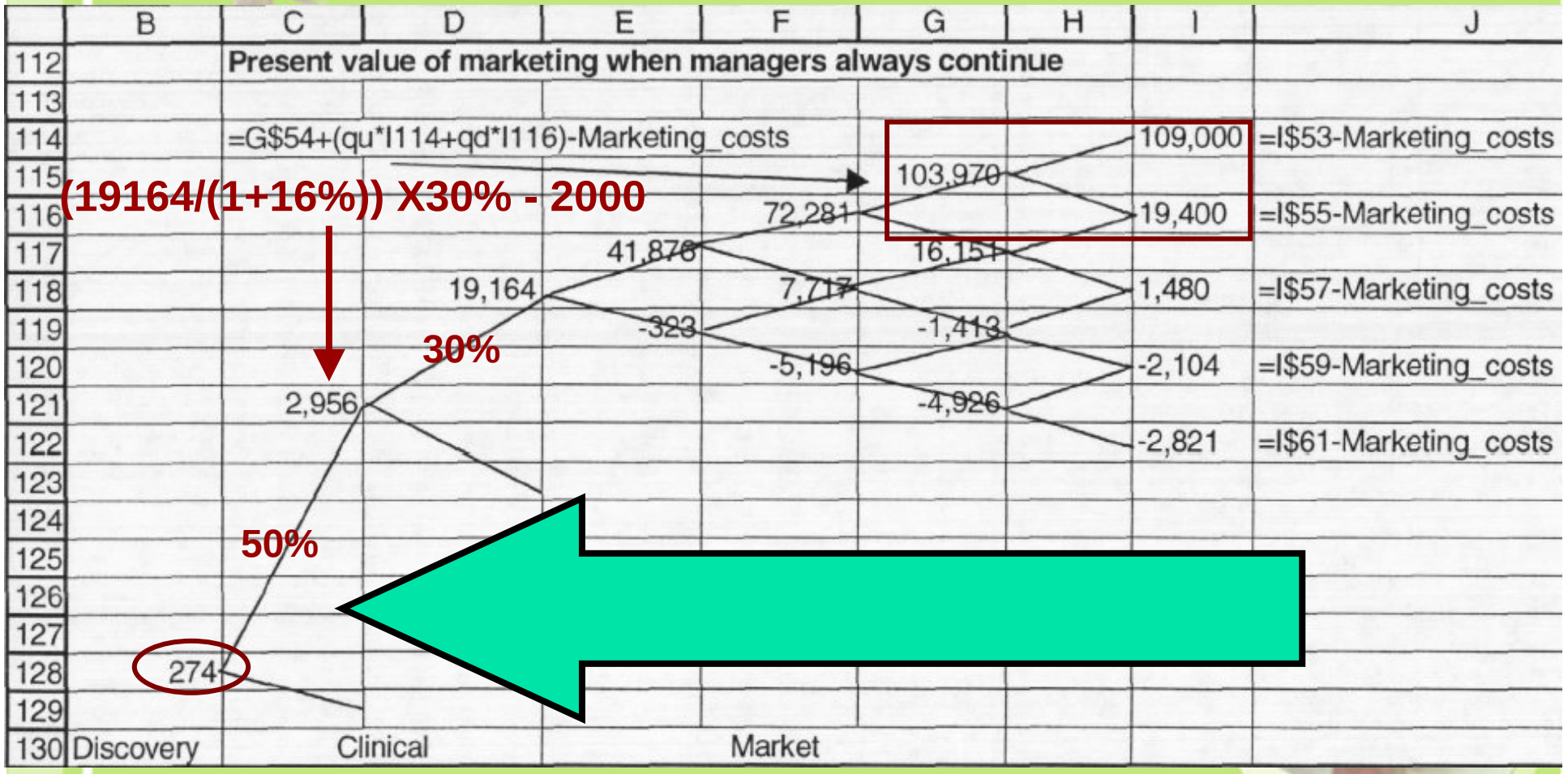
2.3(3) Binomial models- ROV vs non-ROV

Binomial model

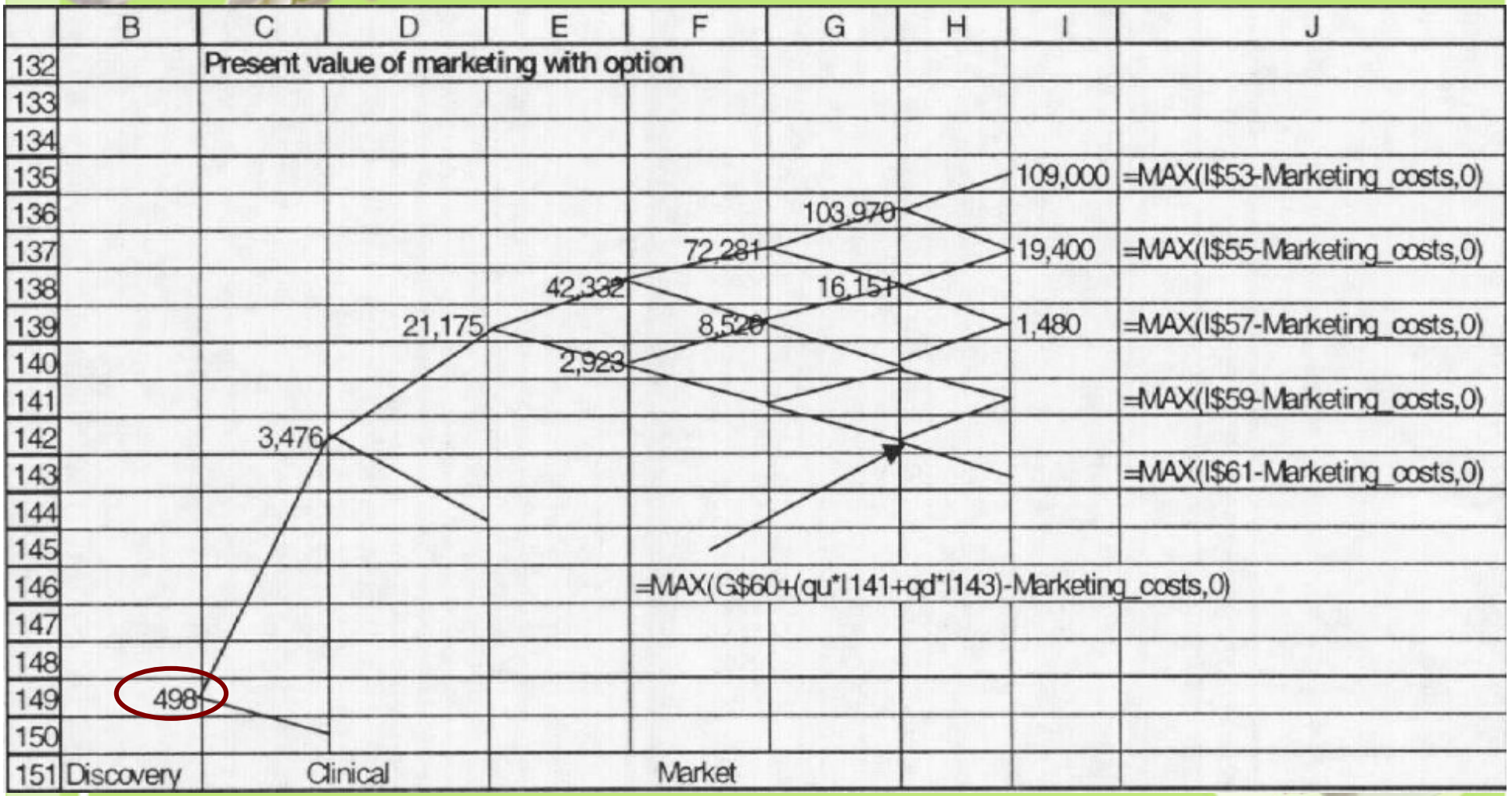
46	Project value, beg. marketing stage	32,326	<-- =SUMPRODUCT(I53:I61,I71:I79)+SUMPRODUCT(G54:G60,G72:G78)+SUMPRODUCT(F55:F59,F73:F77)								
47	Expected proceeds		7000	8400	10080	12096	14515.2				
48	NPV of proceeds evaluated at project cost of capital, r_p	32,326	<-- =NPV(rp,C47:G47)								
49	Value of project, yr 3	19,164	<-- =B46-PV(rf,C6,-B6,,1)								
50	Expected project NPV	-55	<-- =B46/(1+rp)^(C4+C5)*D4*D5-B17								

D

2.3(4) Binomial models- ROV vs non-ROV



2.3(5) Binomial models- ROV vs non-ROV



Non-ROV: 274 (224)

DISCUSSION：技術(專利)鑑價模型

- RO在技術鑑價的使用缺陷
- BS-model vs Binomial model (states?)
- 6-fold compound option (2003)
- BS-model
  - 公式意涵
  - 美式 vs 歐式
  - 技術價值(S)的估計：公司市價→技術貢獻率
  - 技術價值(S)的變動性(N(d1))
  - 新技術如何尋找對比技術 (有/無市場資料)
- Other issue & suggestion

$$C = SN(d1) - k(1+r)^{-T} N(d2)$$

$$d1 = \frac{\ln \frac{S}{k} + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}}$$

$$d2 = \frac{\ln \frac{S}{k} + (r + 0.5\sigma^2)T}{\sigma\sqrt{T}} = d1 - \sigma\sqrt{T}$$

C：買權目前的理論價值
S：目前的股價
K：履約價格
r：無風險利率（以年為標準）
T：到期日之長短（以年為單位）
ln：自然對數
δ：股價報酬波動率（以年為標準）

簡報結束，敬請指正！

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