Risk-adjusted Valuation for R&D Projects

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Is it too early to think about $ in early stage R&D projects?

- Not if you are asking for material financial support
- Not if you are competing with other fuzzy projects
- Not if you are competing with shorter-term projects
- Not if you want to assess risk
- Not if you are thinking about strategy
  - Design financing plan for startup with one core technology and 3 product opportunities

Factors Affecting R&D Project Value

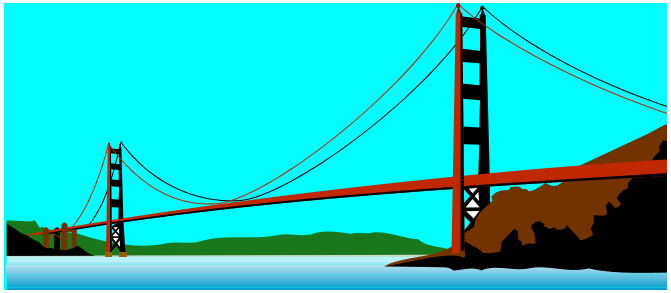
- The Time Value of Money
  (Payoff is deferred)
- R&D Costs
- R&D Risks
  - Unique Risk
  - Market Risk

Is it too difficult to do?

- No longer
- Financial statements, decision analysis, and real options can be integrated into a single step
- Sensitivities to key unknowns can be instantly tested
  - Monte Carlo may take a minute or two longer!
- Templates can be customized for your organization

$ Valuation: $
A Common Language

Science and Engineering



Business and Finance

Outline of Talk

- Economic Value
- Risk
- Decision Analysis
- Real Options Analysis

Context

New

- Integrating Decision Analysis with Real Options
- Demonstrate Integrated R&D Valuation Model

Economic Value Model

- As Net Present Value of Free Cash Flow
  - free cash flow is cash generated that is not required to achieve the business plan
  - usually assume growing perpetuity after some horizon year
  - Economic Value = FCF/(WACC – G)
    - note FCF and G are not independent!

» This approach is today's "gold standard"

WACC = Weighted Average Cost of Capital

Uses and Misuses of Economic Value

- Appropriate for assets
  - Sometimes based on forecasts
- Necessary first step for plans
- Misses the Value of Flexibility
- Inoppropriate for opportunities
  - Opportunities are options
  - They become assets only when a commitment is made
- Inappropriate for Plans
  - Plans are Options!

Characteristics of Unique and Market Risks

- Unique risk (Probability)
  - Investor can *in principle* diversify
    - Drilling syndicates
    - R&D portfolios
      - unique risk is probability of technical success
        - » estimate based on historical experience
  - Expert can estimate unique risk
    - Better risk management generates competitive advantage
- Market risk (Volatility)
  - Cannot be diversified
  - Characterized by volatility

Historical data bases (possibly proprietary) can be invaluable for estimating both market and unique risks

Decision Analysis

Accounting for the Cost and Unique Risk
of an R&D Project

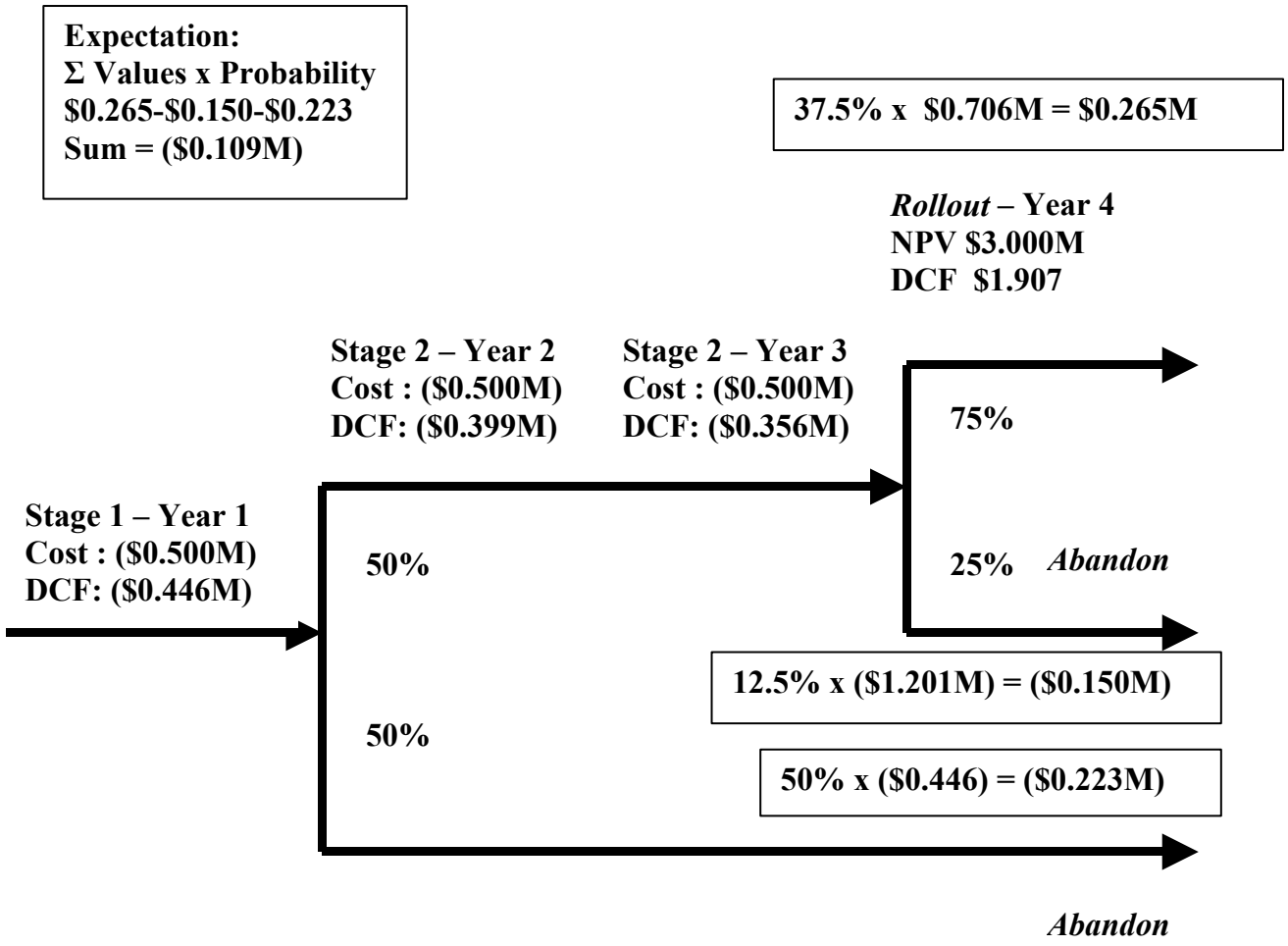
Elements of an R&D Decision Tree

- Branches are at Stagegates
- Each stage has a cost, probability of success and duration
  - All affect value
- The tree has a number of possible outcomes, each with a value and a probability
- The expected value of the proposal is the sum of the probability-weighted outcomes
- Rewards, and costs, are discounted by WACC

Example with 2 R&D Stages

- Stage 1: 1 yr, $500,000, 50%
- Stage 2: 2 yrs, $1,000,000, 75%
- Commercial Rollout: NPV = $3,000,000
- WACC = 12%

Figure 1: Project Outcomes by DCF/Decision Tree. The project has abandonment scenarios after Stages 1 and 2,and one successful outcome with a 37.5% chance of success. The expectattion value on the upper left is the weighted sum of the three possible outcomes.



Real Options Theory

Accounting for Market Risk

Options and Market Risk

- Options are the right but not the obligation to enter a transaction (e.g. make an investment)
- Financial options are a form of capital and are traded in enormous quantities
  - Valuation methods are well established
- Market volatility enhances the value of an option; while it decreases the value of a stock (the underlying security)!

The Black-Scholes Equation for a Call Option

Financial Option Inputs

1. Price of Underlying Security
2. Strike Price
3. Share Price Volatility (σ)
4. Time
5. Risk-free Rate

Financial Options
(Black-Scholes Calculator)

Item	Symbol	Value
Price	P	$50.00
Strike Price	X	$50.00
Risk free rate	r	5.20%
Years	t	10.000
Standard deviation of security	Sigma	20.00%
Discount factor	(1+r)^t	1.6602
Square root of time	t^0.5	3.16
Present Value (PV) of Strike Price	PV(X)	$30.12
Ratio of Price to PV of Strike Price	Y	1.6602
Log of Y	Ln(Y)	0.5069
Risk Factor	Z=sigma*t^0.5	0.632
Black-Scholes D1 Factor	D1=ln(Y)/Z+0.5Z	1.1178
Black-Scholes D2 Factor	D2=D1-Z	0.4853
NORMSDIST for D1	N(D1)	0.8682
NORMSDIST for D2	N(D2)	0.6863
Relative Value of Option	W=N(D1)-N(D2)/Y	45.48%
"Intrinsic Value" (all negatives = zero)	P- X	$0.00
Value of Option	W*P	$22.74

Real Options Theory

- Real options theory is the extension of options theory to non-financial assets
  - Physical (real) assets
  - Business plans
  - Intellectual capital
- Real options capture the value of managerial flexibility
  - **DCF Cash Flow does not consider this point**
- Important Options in Business
  - Abandonment Option (covered under Decision Analysis)
  - Call option (make an investment)
  - Flexibility Options (defer, accelerate, expand, contract)
  - Platform Options
- Real options have limited liquidity
- **For some projects optionality turbocharges valuations**

The Black-Scholes Equation for a Call Option

Stock Option Inputs

1. Price of Underlying Security
2. Strike Price
3. Share Price Volatility (σ)
4. Time
5. Risk-free Rate

Real Option Inputs

1. Present Value of Business Plan
2. Initial Investment
3. Proxy Volatility
4. Time
5. Risk-free Rate

The Mark II Case:

Brealey & Myers, *Principles of Corporate Finance*

- Investment (Mark I) $450M
- NPV: – $46M
- Mark II Option: Invest $900M 3 years later with identical pro forma economics!
- Value of Mark II Option +$55M
  - (Volatility 35%)
- Total Value +$9M

The Mark II Case: Turbocharging Valuations

- Ultra High Growth
- Value at Internet Speed:
  - 10x vs 2x (in 3 yrs)
- Value of Option Grows fivefold to $275M
- High Growth plus High Volatility
- Total Value with Internet Volatility
  - 100% vs 35%
- Value of Option Grows to $1263M

Combining Decision Trees with Real Options

Showing equivalence when

Volatility = 0

Figure 2. Project Outcome by Real Options Analysis. The Real Options calculation begins with value of a successful Rollout (top). This value is the underlying security for the Integration Study Option (lower right), which is in turn the underlying security for the Feasibility Study (lower left).

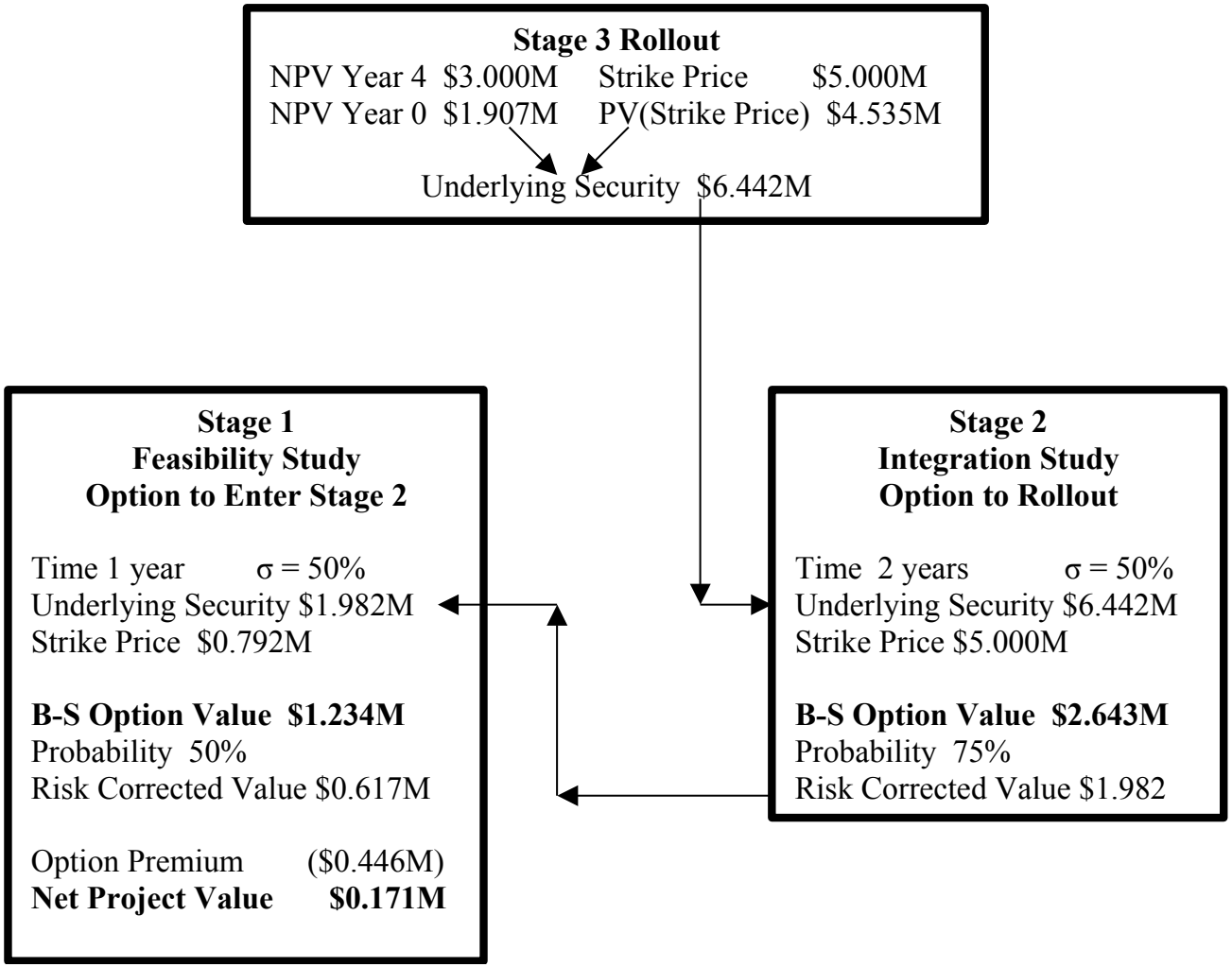
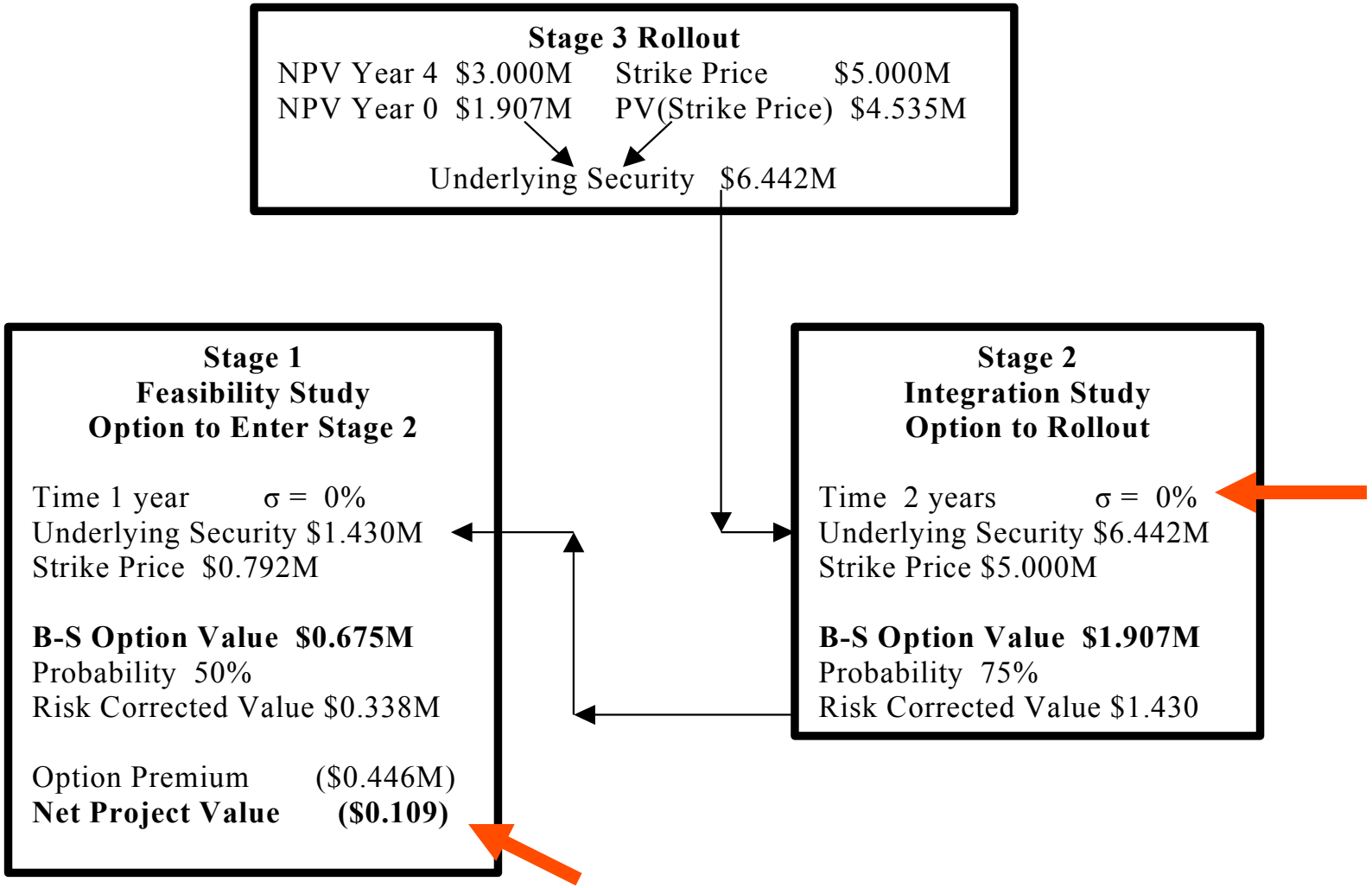


Figure 3. Project Outcome by Real Options Analysis – Zero Volatility. The dynamics are identical to Figure 2, with volatility set equal to zero. The result equals that of Figure 1.



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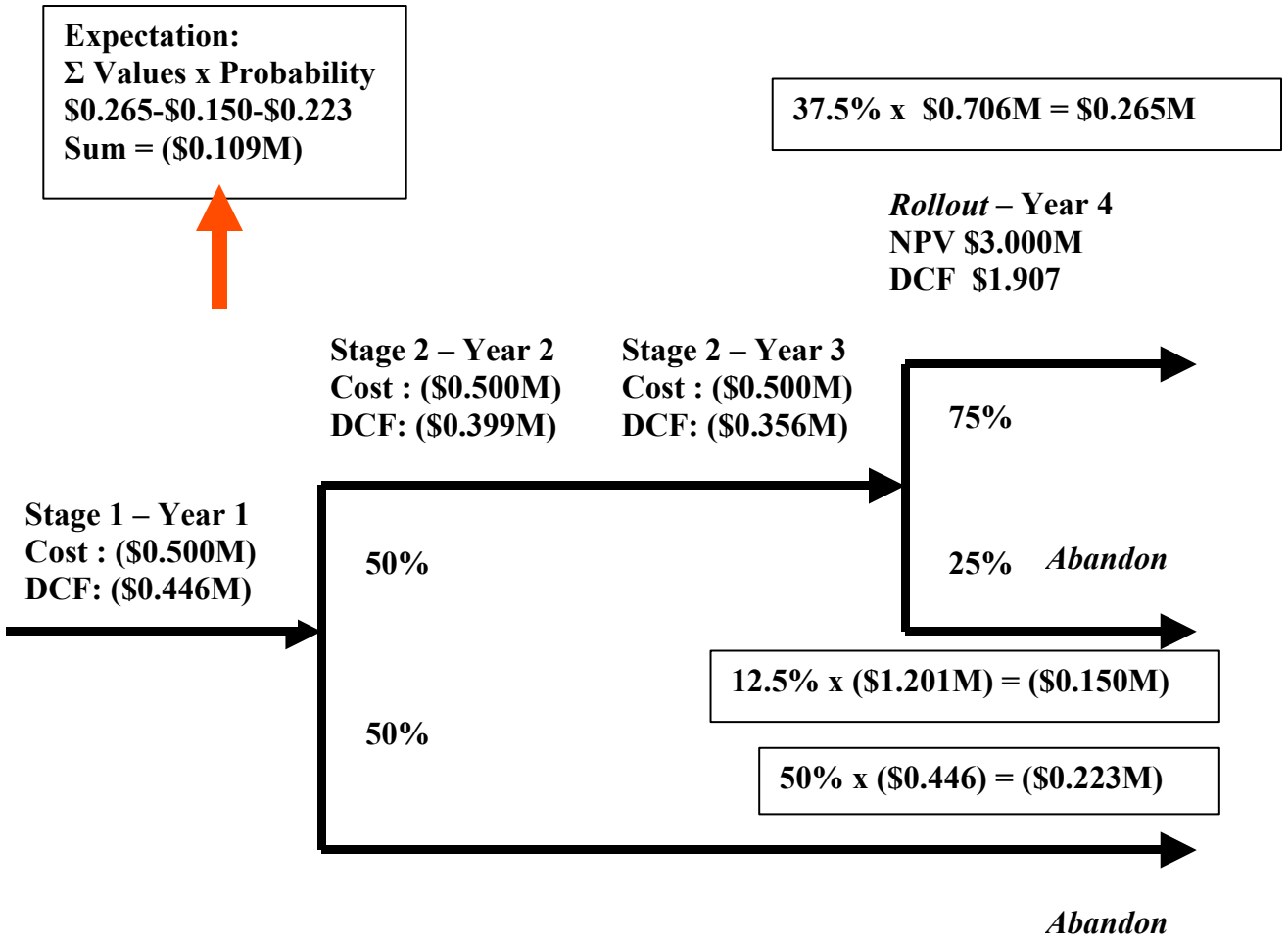


Combining Decision Trees with Real Options

- Decision Analysis can be seamlessly integrated with the Black-Scholes Equation
- Real Options comes along for the ride
- Because plans are options, this approach gives a complete analysis of risk-adjusted value
- The remaining task for complete integration is to calculate NPV

Integrated Model for Risk-adjusted Valuation of R&D Projects

Integrated Model Structure

1. Financial Statement (FS) for Commercial Business
   - Requires:
     - Revenue Model, Cost Estimates, Capital Estimates
     - Cost of Capital, Choice of Horizon Value Method
2. Feed NPV into DT/RO Calculation
   - Requires:
     - Cost, Duration, Probability of Success for R&D Stages
     - Volatility, Risk-free-rate
3. Can Feed Capitalization Table
   - For valuation of startups and technology acquisitions

Inputs (millions)		Outputs (millions)		
Units Sold Yr 1	6	Growth Rate Years 1-5	68.18%	
Units Sold Yr 5	48	Growth Rate Yrs 5-10	15.81%	
Units Sold Yr 10	100	Long- Term Growth Rate	5.00%	
Long- Term Growth Rate	5.00%	FCF Multiplier (MF)	14.29	
Sales Price/Unit	$1.00	Var. Cost as % Revenues	57.00%	
Variable Cost/unit	$0.57	Mfg OH as % Fixed Capital	11.43%	
Manufacturing Overhead/unit	$0.08	Turnover Ratio	142.86%	
Initial Fixed Capital/unit	$0.70	Initial Investment	$34.28	
Initial Annual Capacity (units)	48			
Incremental FC/unit	$0.50	Business Value in First Commercial Year		
Asset Life (yrs)	10	Horizon Value Method	IRR	NPV
Selling, Admin and R&D	10.00%	1. HV = Working Capital	14.19%	$4.73
Days Inventory	30	2. HV = Book Value	15.82%	$9.04
Days Receivables	36	3. HV = EBITDA * ME	24.93%	$52.02
Days Payables	25	4. HV = Net Income*PE Ratio	25.17%	$53.73
Tax Rate	35.00%	5. HV = FCF *MF	26.76%	$65.94
Cost of Capital	12.00%	ROIC (ave)	18.55%	
EBITDA Multiplier (ME)	7	10-Yr IRR	7.07%	
PE Ratio	12.5	10-YR NPV (no HV)	($7.23)	
Risk-Free Rate	5.00%	Current Value		
Volatility	30.00%			
Choice of HV Method (1-5)	5	Current Value as Rifle Shot		($1.01)
R&D Parameters		Current Value by DT		$1.76
Duration Stage 1	2	Value Added by DT		$2.77
Duration Stage 2	2	Current Value by DTRO		$1.82
Duration Stage 3	2	Value Added by RO		$0.06
Duration Stage 4	2			
Pretax Cost Stage 1	$0.75	Cumulative Probability		10.42%
Pretax Cost Stage 2	$1.50	Cumulative R&D Cost (AT)		$7.31
Pretax Cost Stage 3	$3.00			
Pretax Cost Stage 4	$6.00	Value Progression		
Probability Stage 1	33.33%	Value after Stage 1		$6.63
Probability Stage 2	50.00%	Value after Stage 2		$14.60
Probability Stage 3	75.00%	Value after Stage 3		$20.83
Probability Stage 4	83.33%	Value after Stage 4		$65.94

Features of Model

- Sensitivities at a Glance
- Show Build up of Value as Risks are Eliminated
- Quantifies Decision Tree Contribution
- Quantifies Real Option Contribution

Total Value

Economic Value

Cash Flow Generated by *in-place* Physical, Intellectual and Financial Capital

(measure as NPV)

Strategic Value

Value of Intellectual Capital Incorporated in *Unrealized* Business Plans

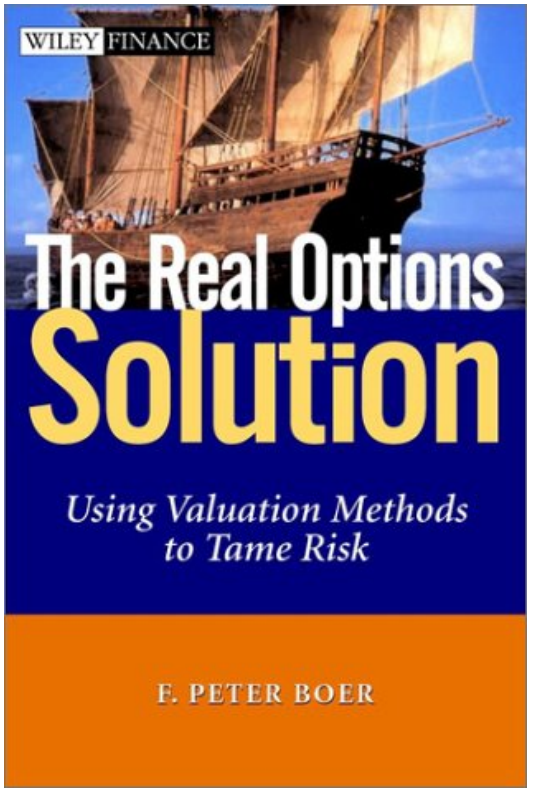
(measure as Options)

Total Value

R&D Transforms Capital

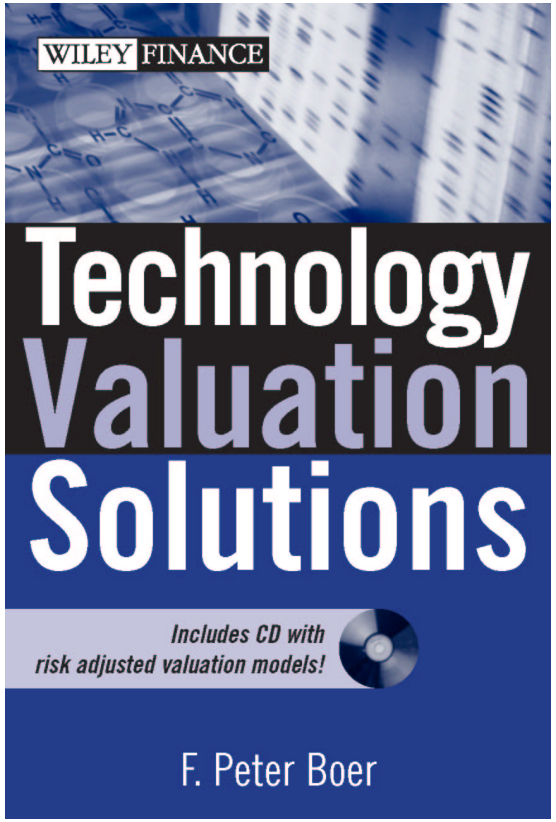
- **Economic capital is transformed into strategic capital via investment in new opportunities**
  - **Without investment, Free Cash Flow would be higher**
- **Strategic capital is realized when it is converted into economic capital**
  - **By executing the business plan**
  - **By liquidating failing efforts**

Books, Papers, and Courses



http://www.tigerscientific.com

New !



Opportunity

Beyond Conventional Wisdom

F. Peter Boer

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