Managing Investment Risk in the Telecommunications Industry: Theory and Practice

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Main objectives

- Make a critical evaluation of the existing approaches to manage risk in capital investments.
- Highlight the real options framework.
- Review the links between embedded options and risk control.
- Lay down the four-stage approach to capital investment and risk management.
- Present a detailed illustration of how the real options approach is applied to telecommunications industry when investment decisions in network infrastructure are evaluated.
- Offer some concluding remarks.

The Context

- The telecommunications industry, used to be relatively immune to risk, especially investment risk.
- Protected from competition and employing various strategies to control the pace of technological change, the industry's long-life assets were amortized over long periods of time reducing thereby the risk of becoming rapidly obsolete and sunk
- Deregulation, technological innovation and the intensification of competition created uncertainties and opened the way to rivals to make pre-emptive moves and imitate incumbents' investments or improve on them.

The Context

- The telecommunications industry has neglected, during the hype years, many aspects of the new business reality and made many excesses by speculating on endless growth opportunities in demand for new services that were possible to offer only after heavy capital investments in new technologies.
- The speculative ventures in TMT (technology, media and telecommunications) and their desire to become "global" resulted in unsustainable debt/equity ratios and a sharp decline in their market value.

The debt/equity situation of major telecommunication firms (Sept. 12, 2002)

Rank	Network operator	Long term debt/equity ratio	Market value ($ Millions)	Share price 52-week (high/low)	Share price at the US market Close
1	Equant	0.00	$1,159.1	$14.00-$4.00	$4.10
2	Infonet	0.09	1,117.8	2.80-1.45	3.38
3	C&W plc	0.22	5,566.2	17.20-6.65	7.01
4	Sprint	0.34	9,565.0	24.29-6.65	10.23
5	Swisscom	0.42	19,351.8	30.95-25.25	26.77
6	SBC	0.57	82,628.3	47,50-22.20	24,85
7	Quest	0.60	6,037.2	21.00-1.07	3.60
8	BellSouth	0.71	44,116.1	42.95-20.10	23.57
9	Colt	0.77	1,103.3	11.409-1.90	3.00
10	Telefonica	0.86	40,796.7	42.54-23.40	26.15
11	Telstra	0.86	35,717.7	14.95-12.05	13.88
12	AT&T	0.87	47,838.2	20-8.20	12.44
13	Deutsche Telekom	0.88	42,271.4	18.30-8.06	10.07
14	NTT	0.98	59,215.4	25.27-14.01	18.35
15	Bell Canada	1.29	14,238.3	24.53-14.59	17.60
16	Telecom Italia	1.30	57,567.4	93-59.65	78.69
17	Verizon	1.56	84,690.2	55.99-26.01	31.04
18	France Telecom	2.59	11,942.2	45.39-8.80	10.35
19	Genuity	(0.21)	3.5	40.00-0.22	0.31
20	Level 3	(76.14)	1,828.9	7.82-1.89	4.50
21	British Telecom	(175.31)	26,891.3	58.25-28.40	31.20
	Global Crossing	Ch. 11 Bankruptcy	N/A	N/A	N/A

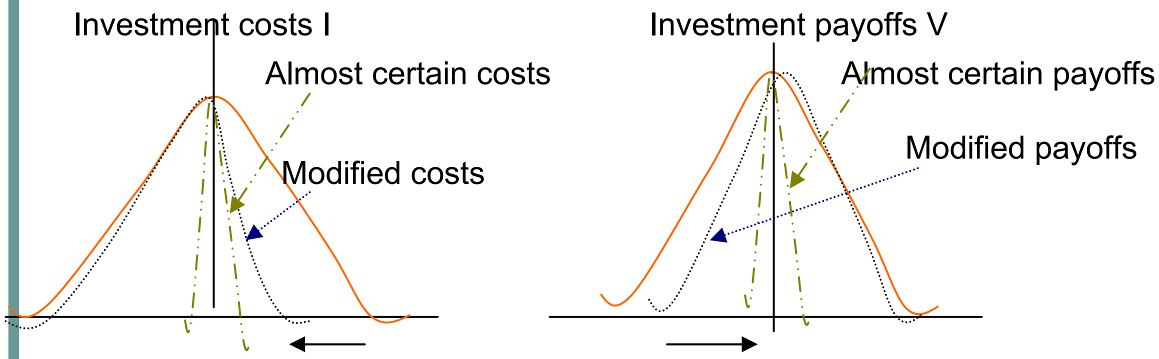
Type of risks

- Competition risk
- Market risk
- Regulatory risk
- Firm-specific risks

Investment risk and its effects

		Effect on the variability (risk) of	
Type of risk	Risk Class	Costs	Payoffs
Competition risk	Rivals can make pre-emptive moves and imitate incumbents' investments or improve on them		+++*
	Rival firms offer better quality service at more affordable price	+	+++
	Integrated rival firms have lower churn rates because they offer attractive packages		+++
	Competitors are better able to price discriminate because of their heterogeneous clientele		+++
Market risk	Demand is shifting to other services the industry is not able to offer adequately and expediently	+	+++
	The technology is changing fast and the newer one is performing better	+++	+++
	New services are offered by improving slightly the existing technologies	++	+++
Regulatory risk	Change of regulation requiring incumbents to offer bandwidth on demand	+++	++
	New entrants are allowed to compete with incumbents business	++	+++
	Differential or discriminatory regulation (different for incumbents and different for entrants)	++++	++
Firm-specific risks	The firm cannot afford the investment	+	+++
	The firm cannot train the specialized personnel (lack of technical skills) to perform the new functions of the more advanced technology (new technology is too complex and takes time for training)	+++	+
	The investment costs may not remain in line with the projected ones and the firm cannot control them	+++	+

Distribution of investment value



Strategic investments have a great impact on firms' businesses.
Management’s decisions may affect both costs and payoffs.

Investment and risk management

- Telecommunications managers need to make strategic decisions in an increasingly volatile environment where permanent investment in new technologies has become crucial for growth and satisfaction of customer demand.
- The factors which determine presently the investment decision process in the telecommunications industry are entirely different from the ones the industry was used to consider during the early days of regulation and/or state control.

Risk management: definition and tools

- Risk management is the process of measuring and/or assessing risk and the development of strategies and procedures for the management, monitoring and control of risk exposures.
- Managing the risks of capital investments in the telecommunications industry has become an important researched subject lately.
- Traditional risk management tools are judged inadequate to deal with issues of uncertainty and increased volatility of business activities of the telecommunications industry.

Value, investment and risk management

- Recent trends in competition, technological changes, network effects, exigencies of capital markets and unpredictable changes in regulatory policies are some of the factors making the investment decision process *dynamic* rather than static
- Managers need to have options and flexibility in their decisions to invest.
- The uncertainties created by the lack of information make the capital investment a risky activity and flexibility has a value.
- Generally, lack of information, uncertainties, and irreversibility are the factors for the creation of an option value.

Theoretical foundations: traditional valuation techniques

- Traditional valuation techniques in capital budgeting maximize value in a world without uncertainties and flexibility.
- To capture the risk of capital investments, these methods such as net present value (NPV) rule and other discounted cash flow (DCF) methods use the risk-adjusted discount rate based on the capital asset pricing model (CAPM).
- Although the risk-adjusted discounted rate is well understood by practitioners, nonetheless, it is not capable of capturing the complexity and the uncertainties of investments in the telecommunications sector.

Traditional valuation techniques

- The risk-adjusted discounted rate fails to incorporate the value of the managerial flexibility and the strategic importance of the investment.
- Reversibility is also one of the implicit assumptions utilized in the traditional valuation techniques creating a systematic bias against investment in new technologies.

Relative importance of DCF and real options approaches

- Busby and Pitts (1997) report that 72% of their sample companies admit that flexibility is a determining factor in their investment decisions but only 23.4% of them admit they have formal procedures to assess various types of flexibility
- The DCF approaches are still used by the majority of large manufacturing firms (75% of the 392 respondents use NPV rule to evaluate new investments according to Graham and Harvey, 2001).
- A mere 27% of the companies in their sample have indicated that they incorporate *real options* in their investment evaluation.

Alternative methodologies dealing with risk

- Various methodologies have been proposed to deal with the critiques concerning the limits of the DCF approaches
- Decision tree analysis (DTA), game theory (Howell et. al., 2001) and real options valuation (ROA) techniques are the most prominent ones (Kester, 1984, Trigeorgis, 1997, 1999, Alleman, 1997, 2001, Alleman and Rappoport, 2001, etc.)
- Real options have gotten the most attention recently and their appeal comes from their resemblance to financial options and the relative easiness to calculate them.

Methodologies dealing with risk

- Investment opportunities are analogous to ordinary call options and as such they are options on real assets.
- The value of a strategic investment is equal to the present value of expected cash flows plus the value of growth opportunities.
- The latter are greater the higher the uncertainties, as long as managerial flexibility exists.

Methodologies dealing with risk

- It is important to recognize that investment projects with negative VAN may still be valuable as long as managers can *defer* the capital investment and materialize when conditions are favourable in the future.
- Managers, in that sense, appreciate the flexibility that real options may confer.
- They can act when conditions change increasing thereby the chance of eventually “realizing the upside potential without raising the possibility of incurring the downside loss”.

Financial options versus real options

	Financial options	Real options		Option value O_v (either real or financial)
		Option to expand (call)	Option to abandon (put)	
Underlying asset	Stock price: S	Present value of expected cash flows (DCF) without the initial investment I_0	Present value of expected cash flows (DCF)	The higher the current value of the asset, the higher the option value (+)
Uncertainty	Stock price volatility: σ	Volatility of DCF: σ	Volatility of DCF: σ	The more volatile or uncertain the DCF are, the higher the value (+)
Exercise price: X	Fixed stock price	Present value of investment outlay at time T to increase the capacity: I_1	Abandonment value	The higher (lower) this amount, the lower (higher) the option value (-)
Interest rate	Risk-free rate: r	Risk-free rate: r	Risk-free rate: r	The higher this rate the more valuable the option (+)
Time to maturity (exercise time)	Fixed date: T	Time until opportunity disappears or expansion time: T	Time until abandonment opportunity disappears or abandonment time: T	The longer the life of the option the more flexibility there is and the higher the option value (+)
Payoffs	Payoff function: max $\{S_T\text{-}X,0\}$	Payoff function: max$\{E(DCF_T)\text{-} I_1,0\}$	Payoff function: max$\{I_1\text{-}E(DCF_T),0\}$	

Real options and strategic value of capital investments

- The *strategic* value of a capital investment can be viewed as an acquisition of a base asset that embeds growth opportunities.
- Growth opportunities can only arise when managers are capable to choose the right investments and at an optimal timing.
- It is almost impossible to choose every time the best options but if the cumulative expected value of future investments is close to zero, the network is unlike to be sustainable with respect to future changes.
- The more a network is able to unlock future opportunities, the more sustainable it is likely to be.

Real options and strategic value of capital investments

- Let's V be the value of the network of a telecommunications firm (where V corresponds to current stock price S).
- As the structure of the network evolves with the additional investments in infrastructure with different vintages of technology (example bandwidth), the changes in investment are assumed to enhance the network's value by $x_{i\%}$ with the follow up investment of I_{ei} (I_{ei} corresponds to an estimate of the likely cost of investment).
- This is similar to a *call option* to buy ($x_{i\%}$) of the base project, paying I_{ei} as exercise price.

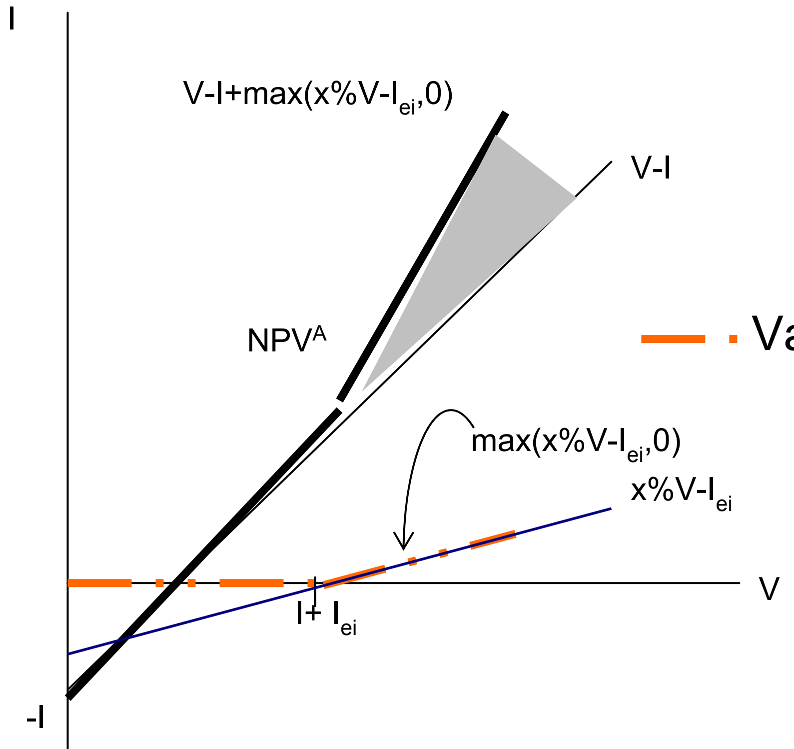
Real options and strategic value of capital investments

The value of the constructed call options gives an indication of the flexibility of the network to endure the likely changes in investments $\{i_1, i_2, \ldots, i_n\}$

In that way, the value of the network includes both the expected value and the exercise costs of the i_i investment, i.e., the options may be out or in the money

Value of the network	**Options payoffs**	
$V + \sum_{i=0}^{n} E[\max(x_i V - I_{ei}, 0)\}$	in the money	out money
	$x_k V$ is higher than the exercise cost I_{ek} i.e., $\max(x_k V - I_{ek}, 0) > 0$	$x_k V$ is lower than the exercise cost I_{ek} i.e., $\max(x_k V - I_{ek}, 0) = 0$
Network's sustainability	Sustainable network	Network threatened

Real option to expand



NPV^P=V-I

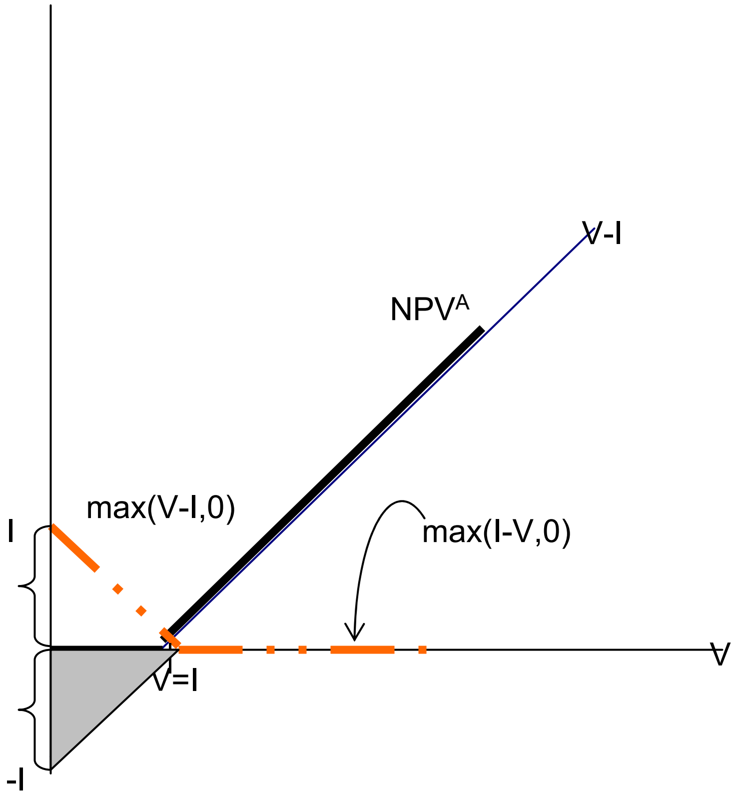
NPV^A= NPV^P+option value

Value contribution of an option to NPV^A

Cut out or enhanced branches in the binomial tree

I_{ei} is the likely cost of investment, i.e. the exercise price and x% is the percentage change in value of the network when the telecommunications firm makes an I_{ei} investment (expands)

Real option to defer



Value contribution of an option to NPV^A

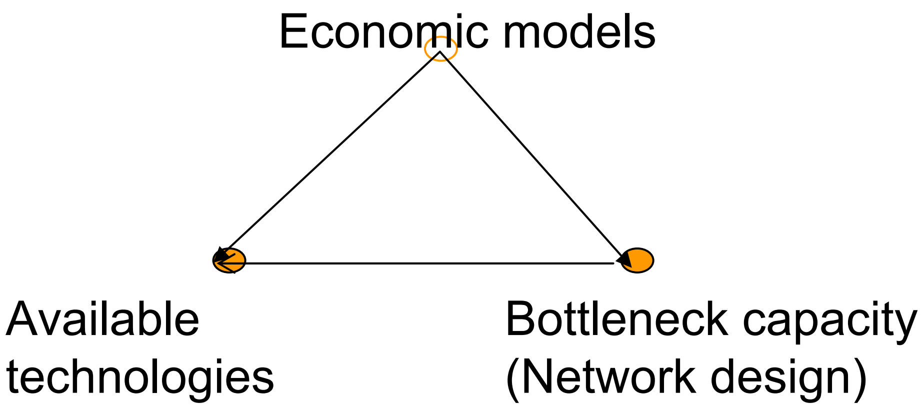
Embedded options and risk control

- When an investment opportunity has uncertain payoffs the embedded options may alter the value profile of the investment and control the risk by favourably changing the probability distribution of the underlying asset.
- The options to embed in a capital investment depend on the type of risk.
- Recognizing and assessing the specific risks that affect an investment opportunity will determine the capability to create options and will help to configure the investment in such a way as to maximize the active net present value of the telecommunications firm.

Recognizable risks and options to embed (bandwidth upgrade)

Type of risk	Investment decision and options to embed	Effect
• Market risk • Competition risk • Organizational risk • Regulatory risk	Decision: no capital investment or defer investment Ex.: Eircom in Ireland	• Learning-by-waiting • Avoid taking excessive risk prematurely
• Market risk • Development risk • Organizational risk • Regulatory risk	Decision: incremental investment or partial investment Options: • pilot the project • prototype Ex.: Mondex	• Learning-by-doing • Transfer risk across parts
• Market risk • Development risk	Decision: full investment Options: • lease • outsource	• Transfer risk to third party • Lower the probability of risk occurrence • Lower the consequences of risk (save residual costs of investment)
• Market risk • Competition risk • Organizational risk • Regulatory risk	Decision: dis-invest/re-invest Options: • abandon • alter scale Ex.: Bell Canada Emergis, Teleglobe	• Redirecting resources to more profitable investment opportunities

The process of investment planning



•Economics and technology interact and they are the determining factors in the design of the telecommunications network.
•Optimal bandwidth capacity is determined depending on market conditions and managers' desire to have the flexibility in the decision making in response to changing market, regulatory and technology conditions.
• When these real options are exercised the management deploys the new systems and adopts a pricing strategy for the company under regulatory and market constraints

Real options in a four-stage approach

Stage 1

Available technologies and their characteristics:
Continuous innovations
Exponential increase in capacity
Cost decrease
Risks identification and estimation

Economics:
Demand characteristics
Prices
Regulatory requirements
Risks identification and estimation

Stage 2

Optimization techniques and real options:
Optimize timing of investment by taking into account:
growth rate (μ)
uncertainty (σ)
market price of risk (κ)
decay factor (α)
price per month per mile per Mbps
risk free rate (r)
costs (maintenance, upgrading, etc)

Stage 3

Business/market decisions:
Capacity expansion/contraction
Pricing strategies

Stage 4

Revision-implementation:
Project revised as events unfold & executed

Stage 1: Identify opportunities and evaluate their risks

- At this stage, managers should state the investment goals and requirements by examining the organizational, economic and technological impact of the investment opportunity and the nature of risks and how are going to affect the firm's costs and revenues.
- In the case of our example, the risks may be:
  - *market (*great uncertainty about the expected demand for bandwidth*)*
  - *competition risk (loss of* customers who switch supplier)
  - *regulatory risk (*mandatory investment, ex. Eircom, in Ireland)
  - *firm-specific (*capability to integrate the investment opportunity, capacity of the firm to get finance *)*

Stage 2: Create shadow options depending on identifiable risks

- Once investment opportunities and their respective risks have been identified, ROA proceeds with the creation of options.
- These options are not necessarily real at this stage.
- They are *potential or shadow* options and they can become real only when the management has made some sort of commitment, i.e., has made a small pre-investment cost outlay.

Shadow options and risk identification

Type of risk	Risk valuation	Defer	Stage	Abandon	Shutdown-restart	Lease	Contract	Switch	Expand	Growth
Market (economic)	High growth rates in demand	+							+	
	Demand overpasses the existing capacity	+		+		+			+	+
	Customer bypass and development of their own solutions	+		+		+	+	+		
	Low growth rates in demand	+			+	+	+	+		
Competition risk	First-mover advantage								+	+
	Competitors' pre-empt movement		+	+				+		
	Firm looses its battle over customers with its existing technology			+	+			+		
Regulatory risk	Unpredictable regulatory policy	+		+		+			+	
Firm-specific risks	Too high investment cost	+		+		+				
	Investment too complex to implement		+	+			+			
	Investment incompatible with the existing generation of technologies			+				+		

Stage 3: Identification of alternative investment configurations

- The next step consists in eliminating the possible options which seem to be unviable and set up the investment configurations that are the most probable to materialize with the lowest risk and the highest return.
- To identify the best alternative investment configurations we should consider the ones with the greatest value to the firm. More than one option may be present at each investment configuration.

Stage 4: Options valuation & investment configurations

- The last stage is to find the most valuable investment configurations among the set of viable configurations identified at previous stage.
- Depending on the assumptions about costs, payoffs and flexibility embedded in the options, the configurations that contribute most to the value of the firm, given an accepted level of risk, will be chosen (and vice versa).

Stage 4: Options valuation & investment configurations

- A simple way to estimate the contribution of each factor to the risk (volatility) of V is to calculate the expression

$$\sigma_V = \sum_i \sigma_{R_i} \sqrt{\sum_{i=1}^{n} \sum_{j=1}^{n} \sigma_{R_i} \sigma_{R_j} \rho_{R_i R_j}}$$

EXAMPLE CASE

UPGRADE BANDWIDTH

Example: Hypotheses

- Let's deal with a telecommunications company facing an investment decision in additional capacity for providing Internet, data and other bandwidth services.
- The bandwidth market is growing very fast and is becoming the next large commodity market.

Example: Market Characteristics

- Market demand for capacity is very volatile.
- Demand volatility for bandwidth is estimated to be in the range of 80% to 150% per year compared to 20% to 40% volatility of major stock market indexes.
- Managers need to develop risk. management strategies and systems for capital investment decisions.

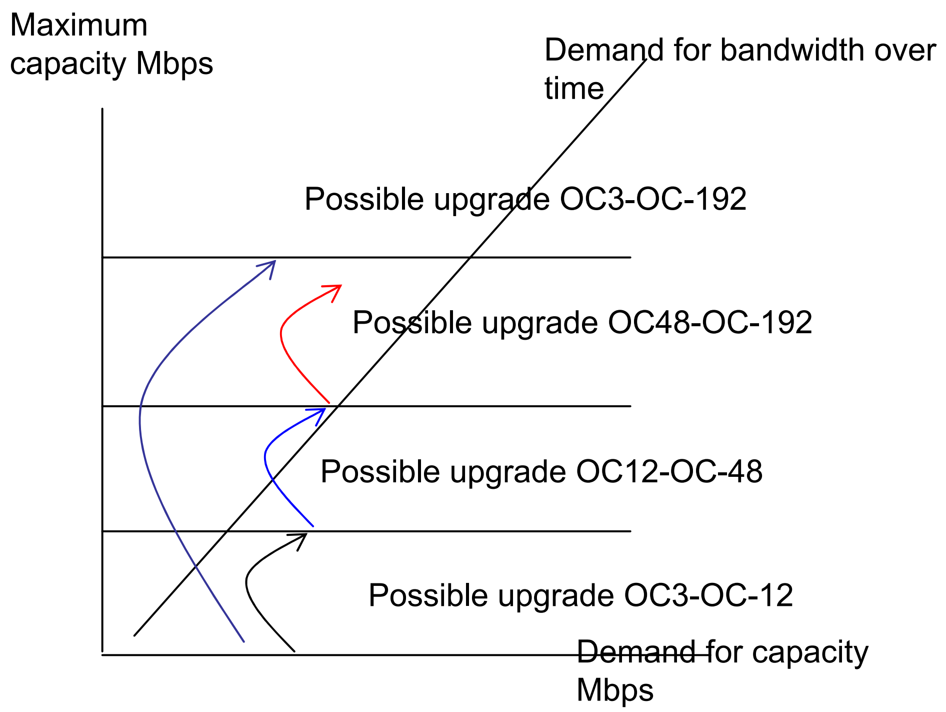
Example: Market Characteristics

- The optimal timing of investment is critical and the decision to invest now either in the maximum available technology or in the intermediary technology would have a great impact on firm's profitability and its competitive position.
- The dilemma is that the ever increasing technological changes decrease costs while demand increases exponentially.
- This creates inefficiencies in the bandwidth market and the current wave of deregulation has had as an effect to compound these inefficiencies since most consumers pay for capacity and not for consumption.

Example: Variables to estimate

- Uncertainty estimates (the variability in demand for bandwidth), the growth rates in demand, the risk free rate, the telecom market price for risk and the various costs (upgrading, maintenance, early adoption of new technologies, etc) are all important variables to take into account in determining the optimal timing in investing (upgrading) in bandwidth technology.
- Management's dilemma is whether it is worthwhile to wait and see how the demand evolves and then upgrade to the maximum transmission technology or to upgrade gradually (incremental upgrading) as demand evolves at lower usage.

Options to upgrade bandwidth



The BS model to value options in bandwidth

- Let Q be the variable for demand in capacity.
- Following d'Halluin et al. (2004), the paths followed by the demand can be modelled as

$$dQ = \mu(Q,t,\bar{Q})Qdt + \sigma(Q,t)QdZ$$

The BS model to value options in bandwidth

- The partial differential equation (the value of the investment) $(V(Q, t, \bar{Q}))$

is $$\frac{\partial V}{\partial t} + \frac{1}{2}\sigma(Q,t)^2 Q^2 \frac{\partial^2 V}{\partial Q^2} + (\mu(Q,t,\bar{Q}_i) - \kappa\sigma(Q,t))Q\frac{\partial V}{\partial Q} - r(t)V = 0$$

The BS model to value options in bandwidth

- A set of partial differential equations (PDEs) is solved for each upgrade possibility i = 1, 2,..., n (where n is the maximum number of types of line).

$$\frac{\partial V_i}{\partial \tau} = \frac{1}{2}\sigma(Q,\tau)^2 Q^2 \frac{\partial^2 V_i}{\partial Q^2} + (\mu(Q,\tau,\bar{Q}_i) - \kappa\sigma(Q,\tau))Q\frac{\partial V_i}{\partial Q} - r(\tau)V_i$$

τ = T- t which indicates the evolution of the investment horizon from date T to the present date (backward transformation)

The BS model to value options in bandwidth

- The payoff of an investment in a certain line with capacity $\bar{Q}_i$ is not independent of the price the service fetches in the market.
- Assuming a decreasing spot price for bandwidth P(τ) = Pexp(-α(T- τ)) where α is a decay parameter determining the rate of decrease of the spot price.
- The cash flow (Π_i (Q, τ_p)) at each payment date τ_p (say a month) is the difference between the proceeds received and the maintenance costs and is simply given by the equation
- $\Pi_i (Q, \tau_p) = \min (Q,) P(\tau_p) - M_i$

Parameter values for estimating usage in bandwidth

Parameters	Description	Values
α	decay factor	50%
P	spot price for OC-12 per month per mile per Mbps	0.1$
r	a risk free rate of	5%
μ	drift factor	92%
σ	uncertainty parameter	79%
κ	telecom market price of risk	10%,

The optimal timing in investment in bandwidth

Real options considered/ Model used (B-S algorithm**)**	**Variables and parameter values**	**Telecommunications industry benchmark**	**Optimal investment time (T)**	**Risk control**	**Value of the payoff function**
Volatility values (σ)	Δ in σ from 20% to 300% (μ= 92% annually)	Usage 50% capacity, invest in bandwidth (to the next available transmission rate)	Defer investment (Invest later)	Technology, market, firm-specific risk	Option value decreases (so does the payoff function)
Drift values (μ)	Δ in μ from 20% to 125% (σ = 79% annually)		Invest earlier (to the highest transmission rate possible)	Market risk	Option value grows
Downtime	Δ in the number of months for upgrade (1, 2, 3 months)		Invest earlier (to the highest transmission rate possible)	Competition risk	
Self regulation or mandatory (congestion penalty)			Invest earlier (to the highest transmission rate possible)	Competition, regulatory risk	

Results: Practice versus theory

- Experience has shown that, managers prefer to proceed to upgrading when usage reaches 50% of the maximum transmission rate.
- The estimates of the model indicate that, when demand is highly sensitive and the technology evolves to ever lower cost (therefore the risk is at its highest point), it is more optimal for the firm to wait until capacity usage has reached the highest level possible (95%) and then proceed to the next available technology.

Results: Practice versus theory

- The decreasing upgrade cost and the risk surrounding the demand for bandwidth are thus important factors in determining the optimal timing of investment.
- When uncertainty (volatility in demand) is high, as it is in the bandwidth case, while the growth rate is held constant, the investment decision to upgrade the network is done later than sooner.

Results: Practice versus theory

- When uncertainty (volatility in demand) is kept constant while the growth rate is allowed to increase, the investment decision to upgrade the network is done at a lower usage.
- When the operator uses performance guarantee contracts or regulatory constraints exist requiring the incumbent to guarantee access to its clients, sound option and financial analysis dictate that the investment decision to upgrade the network would be done sooner than later.

Decision to upgrade

Bandwidth usage rate and decision to upgrade		
<50%	50%	>50%
Demand stable Growth increases	Industry practice	Demand highly volatile Growth stable
Mandatory regulatory requirements Self-imposed guarantee contracts		

Conclusions

- Risk management best practices have undergone major changes in the last twenty-five years.
- These reflect the continuously and deeper understanding, among theoreticians and practicing professionals, of the importance of capital investments and the issues for risk management.

Conclusions

- Systems optimization, decision tree analysis, game theory and lately real options analysis are the major strands of tools used by managers and professional practitioners to evaluate and measure the risks of capital investment and design policies to manage these risks.

Conclusions

- Real options analysis can identify the best real options available to managers when they decide to investment in an area characterized by increasing volatility in usage and rapid technological changes and regulatory uncertainties.
- In such circumstances, and according to the model estimates, the real option to defer investment till usage has attained the maximum capacity possible is the best investment solution.
- This is different from the usual belief in the industry that investment in capacity must be realized when usage reaches 50% of the installed capacity.

Conclusions

- Regulatory, market, competition and other constraints may force the firm to deploy faster rather than later its technology in bandwidth.
- Real options analysis seems to be a powerful tool to be used for managing risk in capital investment decisions in the volatile telecommunications sector.
- The ever expanding and improving stock of computer-based models and methods (dynamic programming, Monte Carlo simulations, etc.) makes the use of real options more and more realistic.