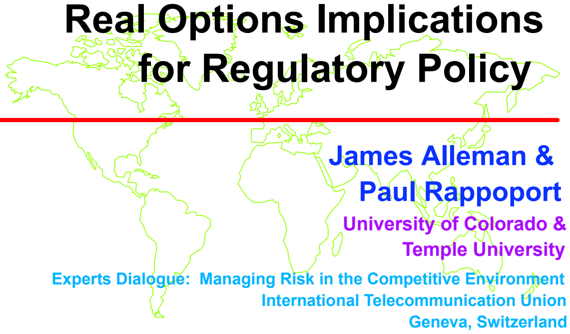
Real Options Implications for Regulatory Policy



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Experts Dialogue: Managing Risk in the Competitive Environment
International Telecommunication Union
Geneva, Switzerland
28-29 October 2004

Objectives

- Uncertainty Modelled
- Dynamic Models
- Regulation Modelled
- Cost of Regulation Estimated

Agenda

- Overview/Literature Review
- Real Options
- Regulatory Distortions
- Investment Criterion
- Implications for Regulation
- Future Research

Overview/Literature Review

- Regulatory Models
- Dynamic Models
- Real Options Approach

Regulatory Models

- Investments Distortions
  - Wrong incentives
  - Averch-Johnson
- Static/Comparative Static
- Certainty

Dynamic Models

- Growth Models
- Certainty
  - Complete information
  - Exogenous depreciation

Real Options

- Valuation Models
  - Project valuations
  - No retail pricing
- No Regulatory Models

Agenda

- Overview
- Real Options
  - What are they?
  - Types of Options

What Are Real Options?

- Financial Option Analogy
  - Right
  - Not obligation
  - Upside potential (profit)
  - Limit downside risk (loss)

Types of Options

- Defer
  - To wait to determine if a "good" state-of-nature obtains

Types of Options

- Defer
- Abandon
  - To obtain salvage value or opportunity cost of the asset

Types of Options

- Defer
- Abandon
- Shutdown & Restart
  - To wait for a "good" state-of-nature and re-enter

Types of Options

- Defer
- Abandon
- Shutdown & Restart
- **Time-to-build**
  - To delay or default on project - a compound option

Types of Options

- Defer
- Abandon
- Shutdown & Restart
- Time-to-build
- **Contract**
  - To reduce operations if state is worse than expected

Types of Options

- Defer
- Abandon
- ...
- Contract
- **Switch**
  - To use alternative technologies depending on input prices

Types of Options

- Defer
- ...
- Contract
- Switch
- **Expand/Growth/Learn**
  - To expand if state-of-nature is better than expected

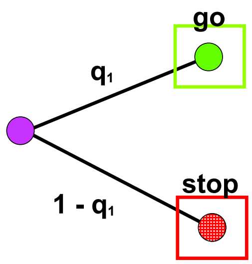
Types of Options

- **Defer**
- **Abandon**
- **Shutdown & Restart**
- **Time-to-build**
- **Contract**
- **Switch**
- **Expand/Growth/Learn**

Agenda

- Overview/Literature Review
- Real Options
- **Regulatory Distortions**

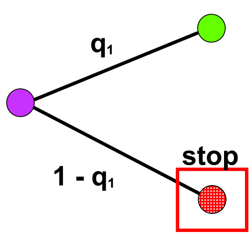
Assumptions/Model



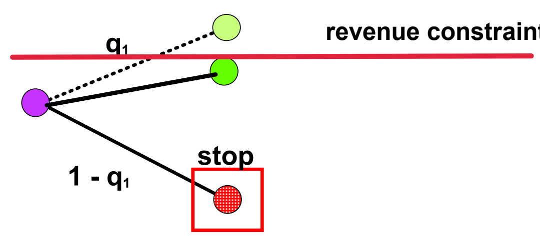
Regulatory Distortions

- Revenue Constraint
  - Rate-based, rate-of-return
  - Price Caps
  - Interconnection prices
  - UNEs price ceiling
  - Modelled as "Good" Ceiling

Regulatory Distortions



Regulatory Distortions



Regulatory Distortions

- Revenue Constraint
  - Rate-based, rate-of-return
  - Price Caps
  - UNEs price ceiling
  - Modelled as "Good" Ceiling
- **Defer**

Regulatory Distortions

- Defer: To wait to determine if a "good" state-of-nature obtains

Delay: Waiting to Invest

- Value in Waiting
- Like Call Option
- Influences:
  - uncertainty
  - foregone profits
- Choice:
  - Max [immediate investment, waiting, 0]

Description of Options

- Revenue Constraint
- Defer: To wait to determine if a "good" state-of-nature obtains
- Abandon: To obtain salvage value or opportunity cost of the asset

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Regulatory Distortions

- Price Ceilings
  - Revenue constraints
  - Price setting (UNEs/Interconnection)
- Obligation to Serve
  - Universal service

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Regulatory Distortions

- Price Ceilings
  - Revenue constraints
  - Price setting (UNEs)
- Obligation to Serve
  - Universal service
    - Lack of delay

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Regulatory Distortions

- Price Ceilings
  - Revenue constraints
  - Price setting (UNEs)
- Obligation to Serve
  - Universal service
    - Lack of delay
    - Lack of abandonment

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Regulatory Distortions

- Price Ceilings
  - Revenue constraints
  - Price setting (UNEs)
- Obligation to Serve
  - Universal service
  - Pay telephones

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Regulatory Distortions

- Price Ceilings
  - Revenue constraints
  - Price setting (UNEs)
- **Obligation to Serve**
  - Universal service
  - **Pay telephones**
    - **Lack of abandonment**

Regulatory Distortions

- Price Ceilings
  - Revenue constraints
  - Price setting (UNEs)
- **Obligation to Serve**
  - **Universal service**
    - **Lack of delay**
    - **Lack of abandonment**
  - **Pay telephones**
    - **Lack of abandonment**

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Regulation Distortions

- **Costly**
  - **Cash flow constrained**
  - **Delay-cash flow constrained**
  - **Abandon-cash flow constraint**
- **Unrecognized Cost**

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Agenda

- Overview/Literature Review
- Real Options
- Regulatory Distortions
- **Investment Criterion**

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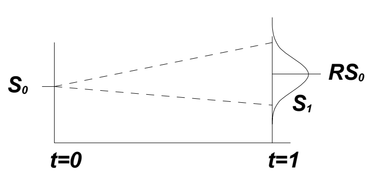
A Risk-Neutral Model (Continuous Additive)



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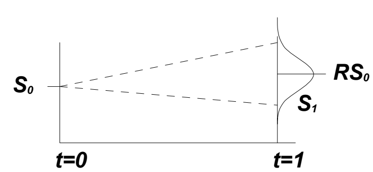
A Risk-Neutral Model (Continuous Additive)



$$E\left[\frac{S_1}{R}\right] = \frac{1}{R} RS_0 = S_0$$

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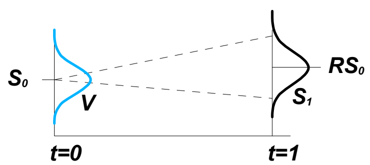
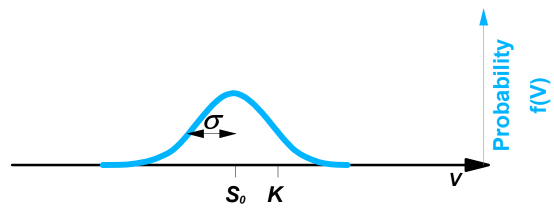
A Risk-Neutral Model (Continuous Additive)

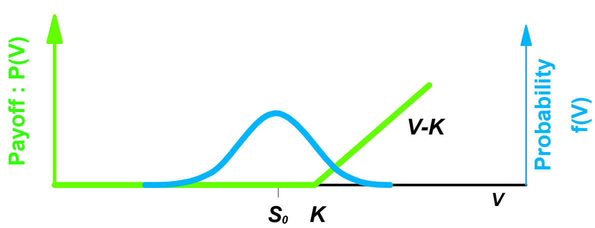


$$\frac{S_1}{R} \equiv V$$

Call Option

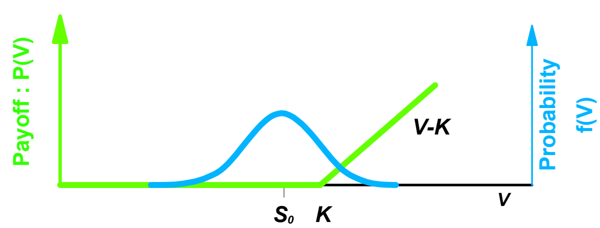


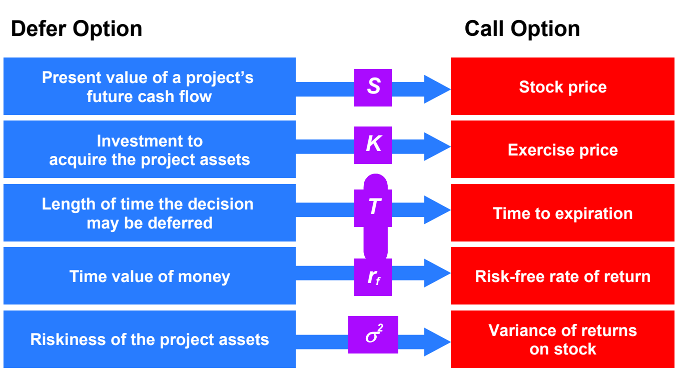
Call Option



Call Option Price

$$C = \hat{E}[P(V)] = \int_{-\infty}^{+\infty} P(V) f(V) dV$$





Example

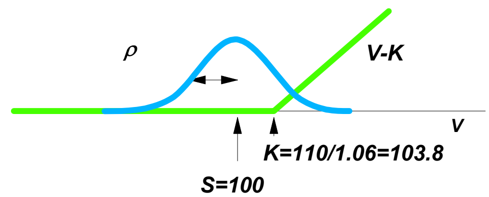
Defer Option	Variable	
Present value of operating future cash flow	S	\$100 million
Investment to Equipment at time T=1	K_T	\$110 million
Length of time the decision may be deferred	T	1 year
Risk-free rate	r_f	6%
Riskiness of the project	σ	\$30 million

Net Present Value

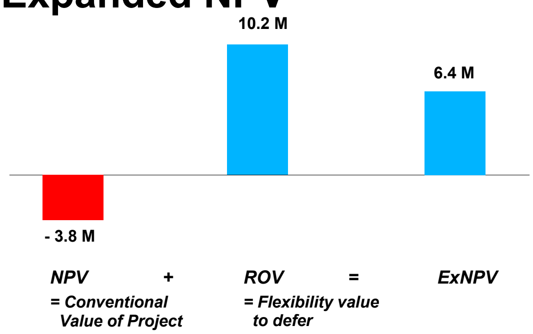
- PV[Cash out] = PV[K_T]
  = 110/1.06
  = 103.8
- PV[Cash in] = S
  = E[PV[S_1]]
  = 100
- NPV = PV[cash in] – PV[cash out]
  = 100 – 103.8
  = - 3.8

ROV (Real Option Value)

$$C = \int_{K}^{+\infty} (V - K) f(V) dV = 10.2$$



- Expanded NPV



Methodology

- When is ExNPV = 0, when NPV < 0?

Methodology

- When is ExNPV = 0, when NPV < 0 ?

ExNPV > 0	*ExNPV < 0*
Wait and watch the market!	*Do not invest*

ExNPV = 0

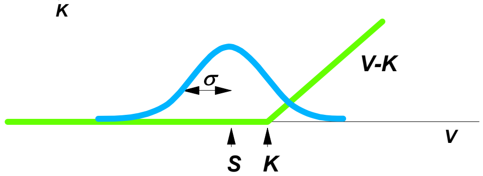
Methodology

- *If NPV < 0, when is ExNPV = 0? i.e.*
- *ExNPV = ROV + NPV = 0*

Methodology

- *When is ExNPV = 0, give NPV < 0?*
- *ExNPV = ROV + NPV = 0*

$$\int_{K}^{+\infty}(V-K)f(V)dV+(S-K)=0$$



Solve

$$v=\frac{V-S}{\sigma}$$ *: Normal distribution (0,1): $f_N(v)$*

$$D\equiv\frac{|S-K|}{\sigma}=\frac{|NPV|}{riskiness}$$

Solve

$$\int_{K}^{+\infty}(V-K)f(V)dV+(S-K)=0$$

$$\downarrow$$

$$\int_{D}^{+\infty}(v-D)f_N(v)dv-D=0$$

LHS (left hand side)

Solve

$$\int_{K}^{+\infty}(V-K)f(V)dV+(S-K)=0$$

$$\downarrow$$

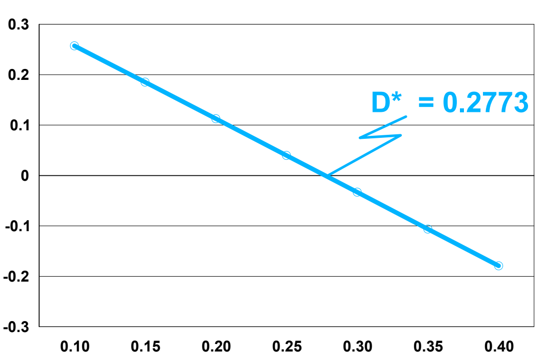
$$\int_{D}^{+\infty}(v-D)f_N(v)dv-D=0$$

$$\downarrow$$

$$\frac{1}{\sqrt{2\pi}}\exp\left(-\frac{1}{2}D^2\right)-D\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{-D}\exp\left(-\frac{1}{2}v^2\right)dv-D=0$$

LHS (left hand side)

Solve



Criterion

ExNPV > 0 | *ExNPV < 0*

Criterion

ExNPV > 0 | ***ExNPV < 0***
$\downarrow$ | $\downarrow$
LHS > 0 | ***LHS < 0***

Criterion

ExNPV > 0 | ***ExNPV < 0***
$\Updownarrow$ | $\Updownarrow$
LHS > 0 | ***LHS < 0***
$\Updownarrow$ | $\Updownarrow$
D < D* | ***D > D****

Criterion

ExNPV > 0 | ***ExNPV < 0***
$\Updownarrow$ | $\Updownarrow$
LHS > 0 | ***LHS < 0***
$\Updownarrow$ | $\Updownarrow$
D < D* | ***D > D****

where $D \equiv \frac{|S-K|}{\sigma} = \frac{|NPV|}{riskiness}$

Criterion

ExNPV > 0 | ***ExNPV < 0***
$\Updownarrow$ | $\Updownarrow$
LHS > 0 | ***LHS < 0***
$\Updownarrow$ | $\Updownarrow$
D < D* | ***D > D****

Wait and watch the market!

where $D \equiv \frac{|S-K|}{\sigma} = \frac{|NPV|}{riskiness}$

Criterion

ExNPV > 0 | ***ExNPV < 0***
$\Updownarrow$ | $\Updownarrow$
LHS > 0 | ***LHS < 0***
$\Updownarrow$ | $\Updownarrow$
D < D* | ***D > D****

Wait and watch the market! | ***Do not invest***

where $D \equiv \frac{|S-K|}{\sigma} = \frac{|NPV|}{riskiness}$

Criterion

where $d \equiv \frac{S-K}{\sigma}$

d axis: ***-D**** (***-0.276***) — ***0*** — ***D**** (***0.276***)

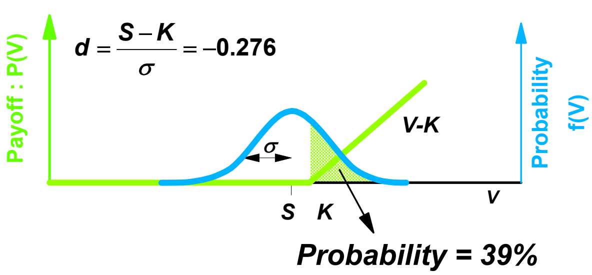
Not Invest | ***Wait and watch the market*** | ***Invest carefully*** | ***Invest***

- d = NPV/riskiness
-
  - Uncertainty adjusted NPV
  - Risk normalized NPV

- d = NPV/riskiness
-
  - Uncertainty adjusted NPV
  - Risk normalized NPV
- d = D*
  - The point of ExNPV = 0
  - Break-even point of NPV plus ROV

Loss Function

If d = - D*, what is the probability the project payoff > 0 ?



- Decision index d = NPV/Riskiness gives uncertainty adjusted NPV
- d = D* = 0.277 gives the break-even point of NPV plus ROV
- Make decision by observing d

Agenda

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- **Implications for Regulation**

Implications for Regulation

- Impact on "riskiness"
- Reduces σ

Implications for Regulation

- Impact on "riskiness"
- Reduces σ

$$v = \frac{V - S}{\sigma}$$

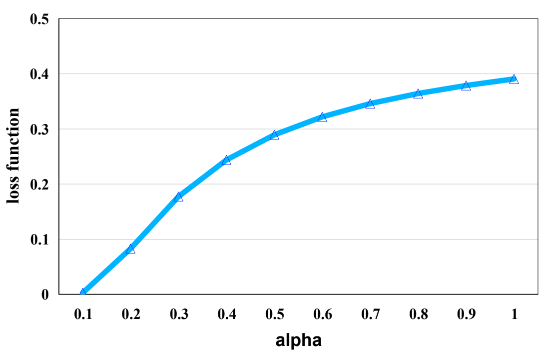
Implications for Regulation

- Impact on "riskiness"
- Reduces σ

$$v = \frac{V - S}{\sigma}$$

let α equal regulatory constraint on σ i.e. ασ

Loss Function



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- **Future Research**

Future Research

- Empirical Estimates
- Investment
  - Endogenous
  - Economic depreciation
- Ramsey Pricing

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