Greening the Supply Chain through the use of the Real Options analytical framework

Anytos Angelis
University of Aegean, School of Environmental Studies, Mytilene, Greece

How to manage uncertainty and promote a positive environmental performance relying on

- Environmental Management Accounting (EMA) as a validating tool for strategic and operational corporate environmental planning

- The Supply Chain (SC) as the flexible prevalent organizing principle

Objectives

- Identifying and documenting an application setting fostering individual or collective environmental investments and contractual agreements on environmental performance improvements

- Uncovering the components of flexible management that might corroborate an environmentally responsive supply chain

Outline

- A complexity theory approach on SC organizational coordinates
- Environmental management issues under an extended corporation
- Uncertainty and the flexible organization
- Real Options (RO) as an investments and operations valuation framework
- Application examples

Complexity and partition (1)

- the fundamental constituent element of SCs is the autonomously cooperative entity
- This is an evolutionary step of the vertical enterprise which minimizes the complexity of the system control and determines, to a large extent, the long run system-wide cost efficiency

Complexity and partition (2)

- ✓ Self interested agents are bonded together through communication and negotiation
- ✓ the actions of any entity directly affect the behavior and the available alternatives of any other entity in the network
- ✓ investments and production processes take the form of distributive projects in order to take advantage of specialized competencies and potential synergies

SCs and environmental management (1)

Emerging challenges cause changing attitudes for their control

Loss of direct control may cause importable environmental burden

The requisite environmental qualities may be transferred in upstream tiers via learning collaboration or motivated contractual agreements on environmental performance targets

SCs and environmental management (2)

Emerging challenges cause changing attitudes for their control

Fragmented environmental drivers may exist in different system nodes

Bring forth integrated solutions by capitalizing on local optima

SCs and environmental management (3)

Emerging challenges cause changing attitudes for their control

Agents' specialization may cause technological breakthroughs

Unresolved macroscopic environmental problems may be tackled

How efficiency adds up with flexibility (1)

- A first degree efficiency is already attained with the emergence of SCs
- A second degree efficiency lies in the flexibilization of local decision systems (the SC nodes)
- What exactly we need is a decision rule that maximizes environmental-economic efficiency in presence of significant uncertainty which characterizes environmental matters

How efficiency adds up with flexibility (2)

- Stochastic Efficiency depends on time and information completeness

- A flexible rule that follows this progression sets forth an expectation of maximums

$$E_0\ MAX(at\ t = T)[0, V_T - X]$$

This is the Real Options framework of analysis

A strategy rule: the Real Options valuation framework (1)

Beyond economic expediency, the use of RO could indirectly promote a positive environmental performance. Developing **an environmental value at risk management strategy** through RO may be accomplished in the following ways:

A strategy rule: the Real Options valuation framework (2)

- Promoting a greater level of environmental flexible mediations in the network
- Exploiting the synergies derived from global coordination of distributive environmental investments, network design decisions and global sourcing

A strategy rule: the Real Options valuation framework (3)

- Leveraging each other's competitive strengths in the development of environmental technologies
- Contractually allocating risks to the supply chain partners best able to manage these risks

The Real Options mechanics (1)

- ✓ an option exists when a decision maker has the right, but not the obligation, to perform an act
- ✓ Financial options, give the owners the right, but not obligation, to buy or sell financial assets at a predetermined price
- ✓ Real options, by analogy, refer to the fact that firms have similar rights with regard to real assets

The Real Options mechanics (2)

- ✓ Options add value as they provide opportunities to take advantage of an uncertain situation as the uncertainty resolves itself over time
- ✓ Options allow to redesign investment and operating strategies along two key dimensions: timing and scope

The Real Options mechanics (3)

- ✓ On the temporal dimension, options are created by postponing or sequencing investments or operating decisions in order to make them in as “informed” a way as possible
- ✓ The scope dimension involves introducing an array of choices, such as different product configurations or suppliers, which creates an option to choose what turns out to be the value/environmental performance maximizing alternative in the future

A maximum of expectations or an expectation of maximums?

In case of environmental investments accompanied by technological or other uncertainties

- According to the prevailing Discounted Cash Flow rule a maximizing solution is selected from a set of mutually exclusive hypotheses, right away
- A high discount interest-rate "protects" against uncertainty which in practice cancels out medium-or long-term investments expectations

This is maximizing the expected returns

$$MAX(at\ t = 0)[0, E_0 V_T - X]$$

A maximum of expectations or an expectation of maximums?

$\neq$

- Following the RO rule, alternative solutions are shaped according to time and scope
- The expectation consists in applying the maximizing solutions, if appropriated and in due time

This is an expectation of maximums

$$E_0\ MAX(at\ t = T)[0, V_T - X]$$

The Real Options mechanics (4)

Steps in the RO valuation process

1. Identify the traditional DCF model
2. Identify and parameterize the key sources of uncertainty
3. Identify the opportunities that management has to respond to the key uncertainties
4. Combine the identified key uncertainties and flexibilities in a valuation framework

The Real Options mechanics (5)

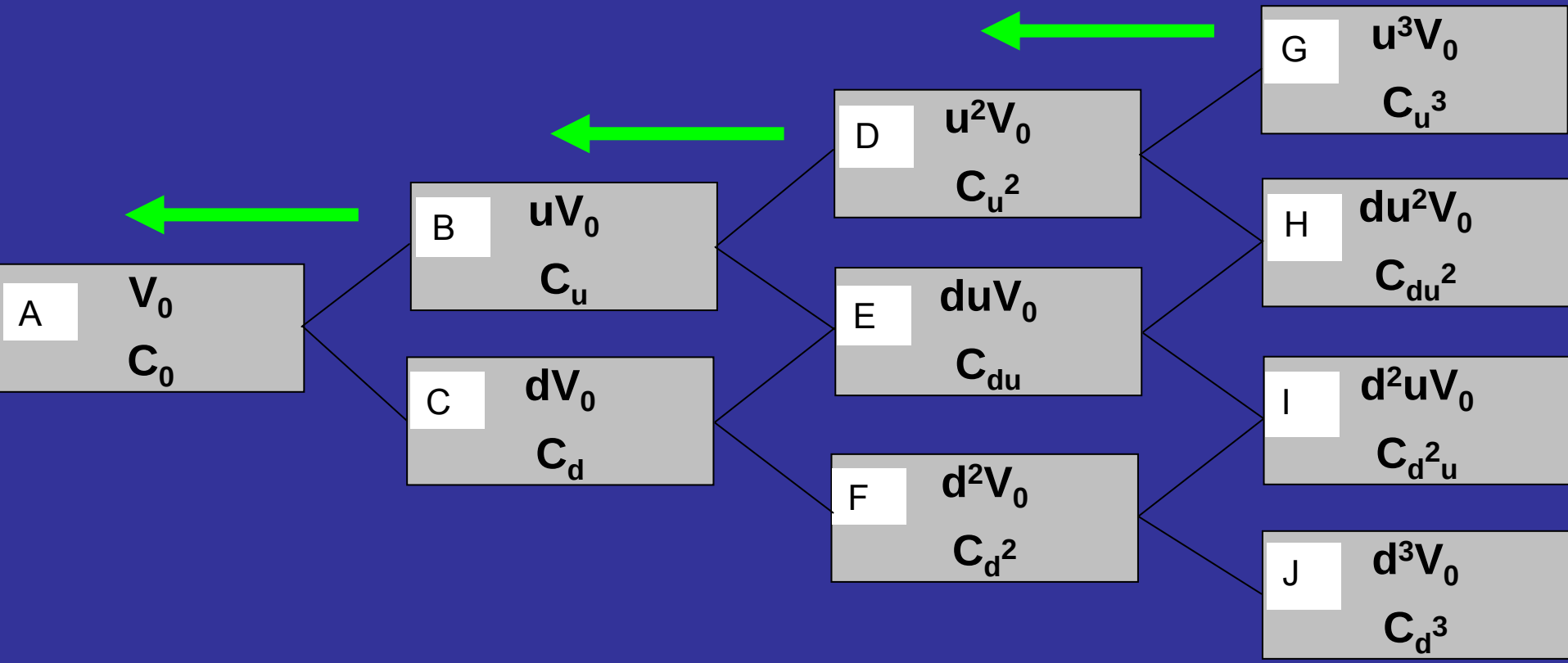
Steps in the RO valuation process

5. Solve for the expected value of the RO identified in the analysis

6. Add the RO value to the DCF value to provide a more accurate version of the true expected value of the environmental investment or contractual agreement under scrutiny

The Real Options mechanics (6)

In a simplified expression an option valuation problem may follow the subsequent **binomial lattice formalism**



The Real Options mechanics (7)

- the value of the underlying risky asset:

$$MAX[0, u^n d^{T-n} V_0 - X]$$

- given the expression for Binomial probabilities:

$$B(n \mid T, p) = \binom{T}{n} p^n (1-p)^{T-n}$$

- multiplying the payoffs by the probabilities and summing across all possible payoffs the algebraic solution is:

The Real Options mechanics (8)

$$C_0 = \frac{\sum_{n=0}^{T} \frac{T!}{(T-n)!n!} p^n (1-p)^{T-n} MAX[0, u^n d^{T-n} V_0 - X]}{(1+r_f)^T}$$

C_0 = the option value, T = the total number of periods
n = the number of upward movements, p = the probability of rise in the project's cash flows, 1-p = the probability of fall in the project's cash flows, u = the magnitude of the up movement in the project's cash flows, d = the magnitude of the down movement in the project's cash flows (d and u express the project volatility), V_0 = the project starting value, X = the option exercise price (the investment outflow), rf = the risk free rate
and the normalized probabilities p and 1-p are as follows:

$$p = \frac{(1+r_f)-d}{u-d} \qquad 1-p = \frac{u-(1+r_f)}{u-d}$$

RO in the service of EMA (1)

- ✓ A **spread** is the difference between the price at which a company is able to sell a product with a particular environmental configuration and the cost of delivering it.

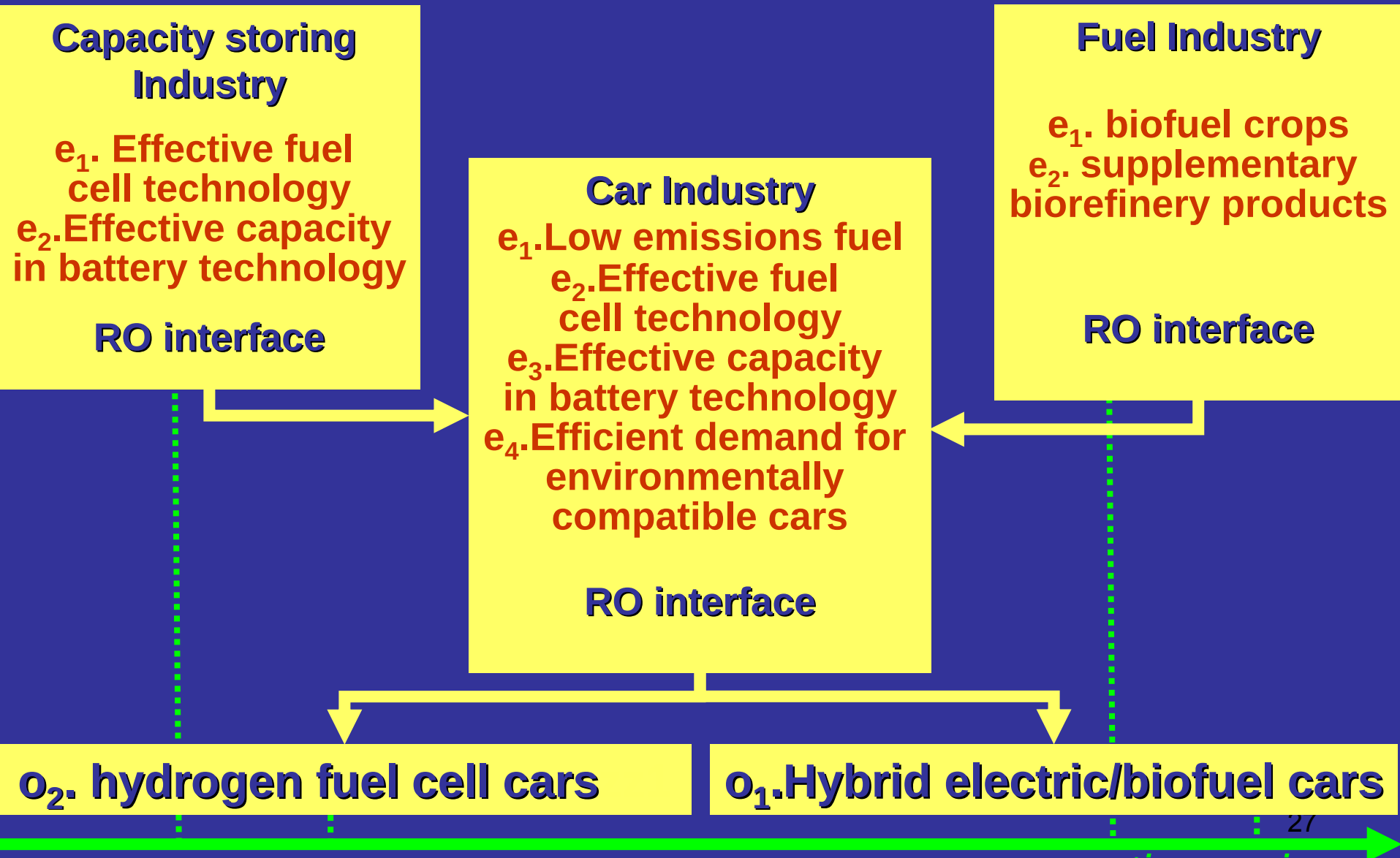
- ✓ By analogy the **environmental spread** is the difference between the targeted environmental performance and the cumulative environmental burden introduced from supplies and subsequently depreciated or appreciated by in-house processes

RO in the service of EMA (2)

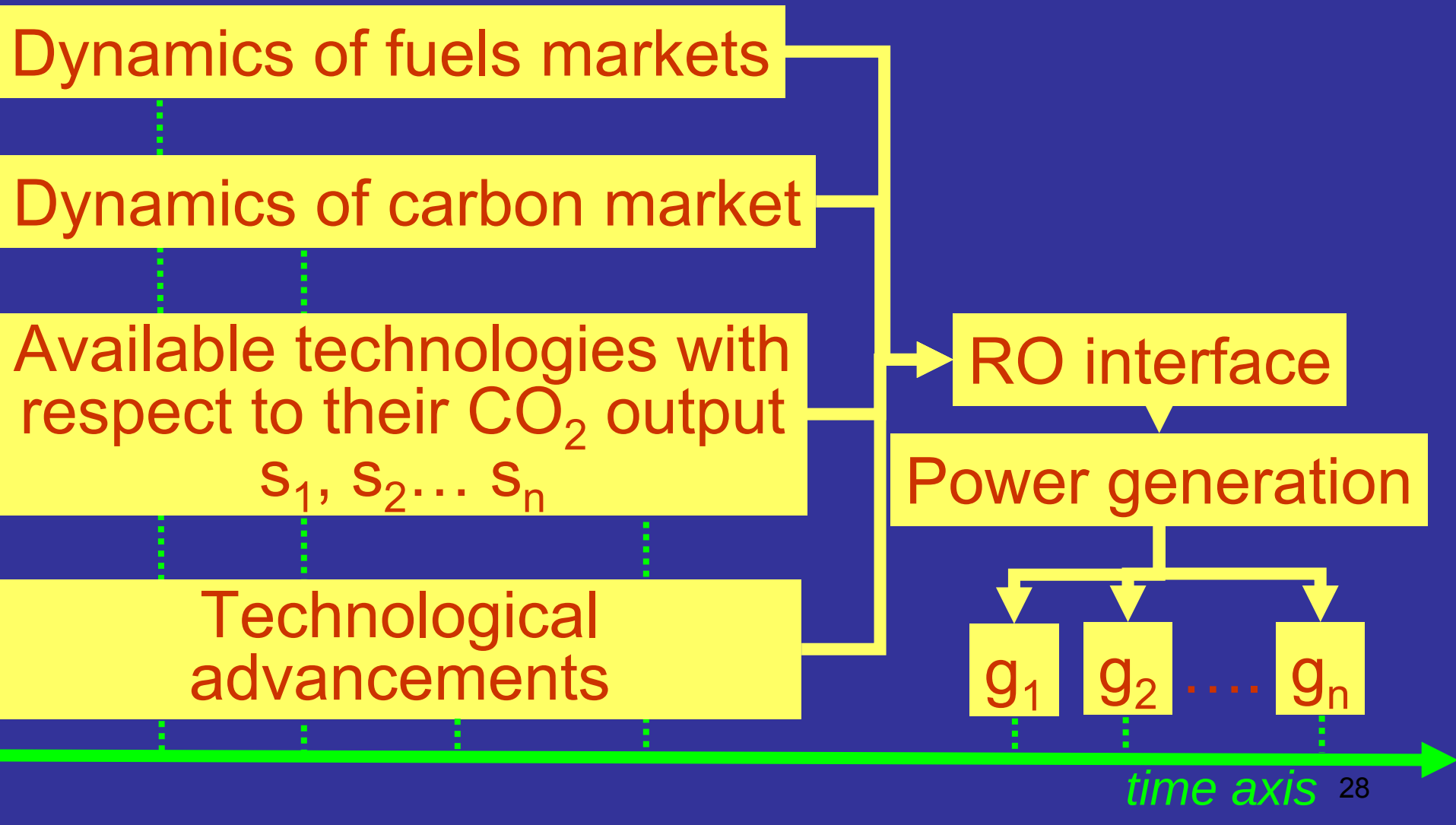
✓The management of the end-to-end supply chain amounts to maximize the value of a series of “spread options” across time that span suppliers, manufacturing and distribution capacity, sales channels, and customers

✓The option involves a choice between one of several possible alternatives. While the customers ultimately exercise the options by choosing a specific product configuration, the customers’ choices take place only after the company has exercised its own discretion in making particular components and environmental specifications

Example 1: The Car Industry



Example 2: The Power Sector



Summary

- A set of advanced decision techniques may foster environmental investments and supply network operations aiming at positive environmental performance
- Supply Chains are composed with flexibility elements that may turn to advantage if tackled in a formal quantitative way under strategic intent
- The Real Options valuation framework is a management accounting tool whereby distributed capabilities and network participants' synergies may be synthesized towards environmental profitability

Thank you

Anytos Angelis
University of Aegean, School of Environmental Studies, Mytilene, Greece