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Real options in the context of innovation and development policies and practices

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Abstract

This paper proposes to build on previous research on the use of real options in strategic decision making (Carayannis and Sipp, 2010) and instill some real options-related concepts stemming from systems design, more particularly engineering. It also builds on previously-established concepts of strategic knowledge serendipity and arbitrage and strategic knowledge co-opetition, co-evolution and co-specialization developed by Carayannis (2009). The application of real options "in" system and real options to innovation and innovation policies demonstrate how embedded real options can more effectively be identified and therefore the decision to execute them or not more effectively made.

Keywords: real options, , real options "in" system, real options "on" system, innovation, policy, strategic knowledge serendipity and arbitrage, co-opetition, co-evolution, co-specialization

Abbreviations

C3, co-opetition, co-evolution, co-specialization; RO, real options; SKARSE, strategic knowledge serendipity and arbitrage

Background

This paper proposes to build on previous research on the use of real options in strategic decision making (Carayannis and Sipp, 2010) and instill some real options-related concepts stemming from systems design, more particularly engineering.

A real option is a right but not an obligation to take an action (after paying a premium). “A real option is the right, but not the obligation, to take an action (e.g., deferring, expanding, contracting, or abandoning) at a predetermined cost called the exercise price, for a predetermined period of time – the life of the option” (Copeland and Antikarov, 2001). Or as Carayannis (2008) has framed it, real options are a set of opportunities a firm faces at inception and during its lifetime are options. Most options are related to tangible assets, yet we can also identify intangible (knowledge-based) options. From a systems perspective, real options “refer to elements of a system that provide “rights, not obligations” to achieve some goal or activity” (de Neufville 2003). For example, bi-fuel vehicles that can run either on gasoline or natural gas (unlike flex-fuel cars that run on a mix of two fuel sources) represent a real option.

From a business or management perspective, applying a real options lens to investments, and more generally decision making, relies on two basic concepts: (i) risk and uncertainty are not necessarily negative factors as they may represent a potential higher upside gain, and (ii) there is an intrinsic value to flexibility. The line between what risk, uncertainty or flexibility pertains to the actual decision making process or to the investment being considered is fuzzy at best.

In the last decade, systems engineers have started to integrate real options analysis in system design. As de Neufville (2003) explains, “uncertainty is a driver of value and can be viewed as a positive element. Correspondingly, systems design from this perspective is proactive towards risk. It seeks out opportunities to add value and commits to ongoing processes of information gathering to ensure that options can be exploited at the correct time.”

Options analysis in systems design draws an interesting parallel with decision making as "the analysis of real options […] adapts […] to the particular circumstances of systems design, which generally deals with unique projects that lack historical statistics on risk." Strategic decision making, particularly when involving strategic positioning, often involves unique opportunities and lack of historical statistics.

Cardin and de Neufville (2009) distinguish two types of real options applications to systems: real options "in" system and real options "on" system. They qualify the two types as follows:

> Real options "in" system: "they are design components embedded early on "in" the system design process – i.e. prior to fielding and operations – to enable time-to-build, scale alteration, product switching, and many other real options difficult to classify through a discrete set of categories suggested by Trigeorgis (1996). Real options "in" system require technical and engineering knowledge."
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> Real options "on" system: they focus "on managerial flexibility (e.g. investment deferral, abandonment, growth)."

Real options "in" systems and real options "on" systems do not bear the same characteristics and therefore have different implications in their application. Wand and de Neufville (2005) defined their main differences (see table 1 below).

Table 1. Comparison between real options "on" and "in" projects

Real options "on" projects	**Real options "in" projects**
Value opportunities	Design flexibility
Valuation important	Decision important (go or no go)
Relatively easy to define	Difficult to define
Interdependency/Path-dependency less an issue	Interdependency/Path-dependency an important issue

Source: Wand and de Neufville (2005)

This paper explores the application of real options "in" and "on" systems in the context of innovation practices and policies. This dichotomist approach enables managers to unbundle serial and/or embedded options, which facilitates options identification and consequently their execution, or non-execution.

Real options in innovation

The definition and execution of real options "in" innovation can be traced to the concepts of strategic knowledge co-opetition, co-evolution and co-specialization (Carayannis, 2009):

> Strategic knowledge co-opetition: "Deriving new knowledge through the healthy balance between competition and cooperation involving employees and business partners." (Carayannis, 2009)
>
> Strategic knowledge co-evolution: "Creating new knowledge through a series of interactions and changes at various levels of the organization, spurred by the co-generation and complementary nature of that knowledge." (Carayannis, 2009)
>
> Strategic knowledge co-specialization: "Learning and knowledge which encourages individuals or groups to expand their roles into new areas and new domains, in a complementary and mutually-reinforcing fashion." (Carayannis, 2009)

Real options can be used as a risk management and uncertainty filtering methodology that helps minimize downside risk and maximize upside potential of a firm's investments. Carayannis and Sipp (2010) demonstrated how strategic knowledge serendipity and arbitrage (SKARSE) can become drivers of real options "in" innovation, defining their terms and if, when and how they should be executed:

> Firms evolve in an uncertain and dynamic environment in which they use the "new knowledge [they] derived through the healthy balance between competition and cooperation involving employees and business partners" (*strategic knowledge co-opetition*, E. G. Carayannis, 2009) in the definition of their real options. These real options serve as the basis for their decision making so as to reap the full benefits of the flexibility embedded in their investments. By the exercise of their options, firms have changed the parameters of their previously temporarily stable ecosystem, resulting in a now unstable environment. Having completed the co-opetition process, firms create "new knowledge through a series of interactions and changes at various levels of the organization, spurred by the co-generation and complementary nature of that knowledge", what

> Carayannis (ibid) coined s*trategic knowledge co-evolution*. Through innovation, they also undergo *strategic knowledge co-specialization,* "learning and knowledge which encourages individuals or groups to expand their roles into new areas and new domains, in a complementary and mutually-reinforcing fashion" (ibid).

Strategic knowledge arbitrage and serendipity are real options drivers that are triggered by co-opetition, co-evolution and co-specialization in that they. contribute to better defining the content and exercise timing of the real options "in" innovation.

Real options on innovation

Real options analysis is an approach to capital budgeting that relies on option pricing theory to analyze and evaluate capital projects. Its use is motivated by the fact that ignoring the option-like features of some project can result in mistakes, primarily: (i) failing to invest in a project with valuable option characteristics, and (ii) not getting the timing right on when to invest.

Traditional discounted cash flows methods views uncertainty as a risk that reduces investment value, assigns limited value to future information, recognizes only tangible revenues and costs and assumes a clearly defined decision path. By contrast, a real options approach views uncertainty as an opportunity that increases value, values future information highly, recognizes the value of flexibility and other intangibles and recognizes a path determined by future information and managerial discretion.

The real options approach is particularly appropriate to emerging technology (Copeland and Antikarov, 2001) and innovation investments because they exhibit characteristics typically associated with options value:

- Payoffs are highly asymmetric: the greater the disparity between upside and downside outcomes, the greater the option value
- Future revenues and costs are highly uncertain: in general, the greater the uncertainties, the greater the value of managerial discretion

- Initial investments (technology development or acquisition) are relatively small in comparison with future investments (scale-up or full commercialization), increasing the benefits of flexibility
- Most technology investment decisions proceed naturally through multiple stages, or a sequence of decisions, creating multiple options and increased value, and
- Time horizons are often long, allowing increased opportunities for updated information on critical uncertainties and subsequent decisions, increasing options value; but preemptive competitor moves in the technology and/or market can have the opposite effect.

In this context, valuation is important as it will determine whether or not to move ahead with a particular innovation. This approach focuses on assigning a positive value to opportunities, options are relatively easy to define and path-dependency does not appear to be a critical issue.

Real options on innovation policies

Policy makers may adopt a wait-and-see attitude before defining and implementing certain policies, especially when facing uncertainty as to the future state they are trying to address and how the policy's implementation may affect it. Making the decision to define and implement a climate change policy is a classic example of such behavior (Chen, Funke and Glanemann, 2011).

A real options lens can be applied to policies such a climate change and mitigation as well as policies on innovation because they satisfy the conditions of uncertainty, that more information for better-informed decision making can be derived with time and options to pilot, expand or at least partially reverse can be implemented.

The type of uncertainty faced by policy makers is also known as "Knightian uncertainty." Unlike risk (known unknowns), it applies to situations where one cannot know all the information needed in order to set accurate odds (unknown unknowns).

Although one can derive new knowledge that can lead to better-informed decision making, policy makers should carefully balance this consideration against the risk of inaction. “Inaction may well be optimal when action entails discrete changes in a decision maker’s costs and future outlook. Obviously, a wait-and-see attitude affords some benefits if future developments may lead one to regret having acted: hence, when choosing whether to act, the option to wait has to be weighed against the value of action” (Bertola, 2010).

Based on the above characteristics, when deciding whether or not to design and implement an innovation policy is, for policy makers, an option “on” an innovation policy.

Real options in innovation policies

Another aspect related to real options and policies deals with how policies are implemented. Carayannis and Sipp (2010) presented how innovation and SKARSE can lead to increased competitiveness.

> Strategic knowledge co-specialization enables firms to develop *sustainable entrepreneurship* (E. G. Carayannis, 2008), that is “the creation of viable, profitable and scalable firms that engender the formation of self-replicating and mutually enhancing innovation networks and knowledge clusters leading towards what we call robust competitiveness.” As such, firms are enabled to develop a temporarily “unfair” competitive advantage. In this context, firms now evolve in a temporarily stable environment, s*ustainable entrepreneurship* (ibid), a “state of economic being and becoming that avails systematic and defensible “unfair advantages” to the entities that are part of the economy and is built on mutually complementary and reinforcing low-, medium and high technology, public and private sector entities (government agencies, private firms, universities, and non-governmental organizations).”

Carefully implemented innovation policies can trigger increased innovation at the firm level and trigger a chain reaction towards more macro levels and culminate in

improved competitiveness. As demonstrated in the case of environmental pollution policy (Lin, Ko and Yeh, 2007 and Saphores and Carr, 2000), a real options perspective add value when analyzing the implementation timing of the various elements composing the innovation policy. This represents a real option "in" innovation policy.

Conclusions

This paper looked at how real options are applied to innovation and considered the following elements of analysis:

- Different systems, that is different levels at which options can be applied – namely at the innovation level or at the policy level, and
- Options "in" a system and options "on" a system for each level.

Integrating a systems design approach to a decision and policy making issue made possible the identification of a four-level innovation real options portfolio: (i) "in" the innovation project, (ii) "on" the innovation project, (iii) "on" the innovation policy, and (iv) "in" the innovation policy. This brought about the decoupling of embedded options and improved the options' definitions. This is particularly important in light of Day and Shoemaker's (2000) recommendations on how to manage real options. They recommend following four steps (as shown in figure 1):

1. Adopting an options perspective:

This refers to recognizing opportunities through an "options perspective", which applies to most investments as most non-financial investment offer some possibilities for management discretion to affect future developments.

2. Creating & structuring real options:

This refers to structuring decisions formally to create future managerial flexibility, i.e. looking for opportunities to unbundle decision as most investment projects involve multiple decisions or a sequence of decisions. It is also conducive to considering additional possibilities for future action (acquisitions, divestitures, strategic partnerships, technology licenses, etc.).

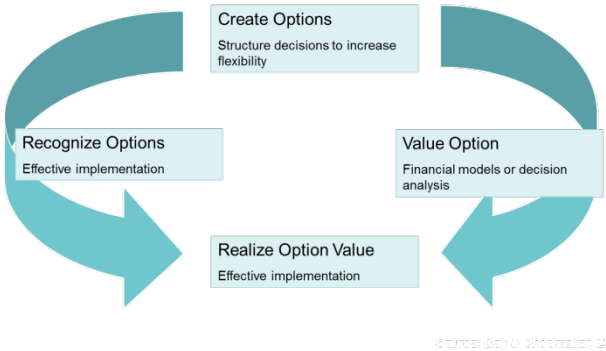
3. Valuing real options:

This refers to complementing discounted cash flows methods if they fall just below the established threshold. Possible complementary methods should combine managerial judgment and quantitative analysis, such as strategic positioning, financial models (Black-Scholes variations with replicating portfolios), decision analysis (binomial/quadrinomial trees), or threshold assessment.

4. Implementing the real options approach:

This refers to realizing the value of the options through their systematic implementation. Real options and their values are not static; the decision is not of a "now or never" kind and can be reconsidered at a later time based on the monitoring of the project progress, continuous testing and updating assumptions, and eventually exercising the option.

Figure 1. Four steps to managing real options



Source: Day & Shoemaker, 2000

More accurately and effectively identifying the real options at play in innovations practices and policies is the first step to Day and Schoemaker's (2000) process to manage real options.This implies adopting a more entrepreneurial behavior and proactively seeking real options rather than identifying them after the fact through sense making (Bowman and Hurry, 1993). Sipp and Carayannis (forthcoming) presented evidence "that strategic knowledge serendipity and arbitrage allows companies to better define the content and exercise timing of their real options, as they take part in the co-opetition, co-evolution and co-specialization processes. In

doing so, they leverage real options as risk management and uncertainty filters that will allow them to perform better over the longer term." Improved performance, facilitated by the systematic application of real options, can prove to be a key decision making argument, particularly when faced with the challenge of optimizing the allocation of scarce resources with timing, selection and sequencing decisions. The systematic application of real options could lead to improved cost-benefit and cost-efficiency in the public sector.

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