JGC Vol. 12 (1), 2004

Business Strategy and Real Options in the Context of Large Engineering Projects

David N. Ford
Diane M. Lander
John J. Voyer

EXECUTIVE SUMMARY

The views of strategists and theorists of large engineering projects (LEPs) seem to be at odds with regard to real options. The latter have asserted that the large commitments needed for LEPs (for example interstate highways, bridges, large commercial buildings and commercial developments, and transportation infrastructure projects) do not allow for the flexibility gained through the use of real options after project execution starts; a flexibility deemed so precious in the strategy discipline. We assert that real options' thinking does allow for benefits to managers of LEPs, even after a project has started. Furthermore, real options thinking allows for short term, medium term and long term benefits, in a systemic way, to managers of LEPs. We discuss five reinforcing loops in this systemic relationship, and discuss potential means of further developing the application of real options to many kinds of projects.

INTRODUCTION

What is the relationship between strategy and real options in the context of large engineering projects (LEPs), which are such projects as interstate highways, bridges, large commercial buildings and commercial developments, and transportation infrastructure projects? At first blush, the answer seems to be that there is no relationship; that real options are merely a capital budgeting tool that project managers use as part of the operational (or tactical) plans to implement the business strategy of which the LEP is a manifestation (Brown & Eisenhardt, 1997). This is similar to one commonly held perspective of the role of strategy in construction project planning, termed "hyperrationality" by Miller and Olleros (2000), in which good project planning constrains and manages all important uncertainties. In this view, real options are merely an alternate method to discounted cash flow (DCF) analysis for valuing the worth of capital budgeting projects (Dixit, & Pindyck, 1994; Trigeorgis, 1995) which presumably have come about through an overarching strategic planning effort. Moreover, based on in depth studies of sixty LEPs, Miller and Olleros (2000) suggest that this narrow perspective of strategy applies to them because once project planning (project "shaping") is completed for a large engineering project, most of the strategic decision-making and potential learning would appear to be over, since "projects . . . require heavy

commitments . . . [which lock firms] . . . in on a choice, thereby giving away most of their degrees of freedom" (Miller and Olleros, 2000: 97). (Note that we distinguish between "project planning," shaping a project before implementation of the project plan begins, and "project management," the project's execution.)

However, the use of real options merely in the final stages of a planning process is not consistent with some important views of strategy. For example, Porter (1996) defines strategy as the creation, through trade-offs and the fitting together of value-creating activities, of a unique and valuable position. Strategy in this sense requires relatively long periods of investment in activities that yield advantageous positions, not merely short term use of techniques like real options. Porter's view is compatible with strategy's dominant paradigm, the resource-based view of the firm (Barney, 1986; Dierickx and Cool, 1989; Spanos & Lioukas, 2001; Wernerfelt, 1984), which holds that competitive advantage comes from the creation of valuable resources through long-term investment in value-creating activities. In this context, real options are used somewhat metaphorically to denote the opportunities that result from a particular set of path-dependent investments.

Moreover, Mintzberg and his colleagues (1998) argue that there are "descriptive" schools of thought about strategy. Probably the most important of these for our purposes is the learning school, where strategists strike a balance between planning and acting–doing some planning while allowing some of the details to emerge (Mintzberg & Waters, 1985) as they see how their plans mesh with the realities of the context in which they are operating. This school seems to be the implicit foundation of much of the work trying to connect strategy with real options, e.g., Bowman and Hurry (1993). According to this learning perspective of strategy, real options may have a role throughout an LEP, continuously facilitating learning and emergent strategy development. This leads to the key question of this paper: Can the use of real options in the management of LEPs rest only on a narrow version of strategy--as planning--or can it also be used to learn and to adapt projects after their execution has begun, to increase project value and otherwise improve the management of the project?

REAL OPTIONS

As used here, options are strategies that include a right, without an obligation, to take specific actions in the future, at some cost, and contingent on how conditions, initially uncertain, evolve. Some options are called *real options* to distinguish them from options on financial assets such as stocks and commodities. For example, a contractor may plan a tunneling project so that he can begin boring using one technology and switch to a different technology later, depending on whether rock is encountered or not. Another example is the value of a new manufacturing plant that includes an option to expand capacity if sales take off, or an option to abandon production if market conditions are not favorable. As Bowman and Hurry (1993) point out in their seminal article on real options thinking in strategy, when a company invests at a given moment in a physical asset or in a particular research and development direction, it is also acquiring implicit options–opportunities to make decisions in the future, based on the outcome of things that are uncertain at the time of the initial investment.

STRATEGY AND REAL OPTIONS

Since Bowman and Hurry's initial article, many scholars have linked projects, real options, and strategy. For example, Luehrman (1998) argued that strategy was a bundle of projects that could be viewed as real options, and Amram and Kulatilaka (1999) argue that real options theory, by encouraging managers to think of decisions as carrying with them embedded options, can produce

more effective strategies. Other scholars have examined real options and strategy from a broader perspective. For example, Courtney, Kirkland and Viguerie (1997) recommend the use of real option theory in uncertain situations where managers can envision alternate futures. Brown and Eisenhardt (1997) have articulated a strategic theory based on complexity theory. They argue, among other things, for doing many of what they call "probes" (experiments) and "patching" (matching organizational capabilities to market opportunities in a fluid way) and for "modularizing" strategic thrusts, all of which fit well with real options theory. McGrath and MacMillan (2000) suggest using scouting options, which are very similar to Brown and Eisenhardt's probes. Beinhocker (1999) says that companies must form robust adaptive strategies, which involves using several tools, including real options, to create, cultivate, and commit to a population or portfolio of strategies.

On a different note, Adner and Levinthal (forthcoming) argue that real options do not apply well to strategy because they differ in important ways (especially in having a firm expiration date) from other path-dependent investment processes, which may fit better with strategic theory and practice. We agree in principle, but are not sure that this is an important distinction in practice. It is surely true that strategies, for LEPs or other types of investments, are not exactly the same thing as real options. The point is that real options *thinking* allows for flexibility that is often missing in more traditional approaches.

Most of these ideas have obvious appeal for blending real options thinking with long-term strategic management. But scholars of LEPs claim that there is a problem. Miller and Olleros (2000) point out that for LEPs

flexibility is usually not possible . . . because of their indivisibility and irreversibility. . . . Projects can rarely be broken into modules but require heavy commitments through which sponsors, partners and affected parties lock in on a choice, thereby giving away most of their degrees of freedom. (Miller & Olleros, 2000: 97)

They argue that the managers of LEPs must look for flexibility in the "shaping" of the projects, i.e., the project planning work that defines the very nature of the project (see Construction Industry Institute (1995) for a specific process description). They divide shaping into five "episodes": initiation and exploration; development of a holistic proposal; extended negotiation; confronting emerging fears; and closure on a commitable package (Miller & Olleros, 2000: 107). They point out that each of these is rooted in options thinking. For example,

The initiation and exploration episode . . . seeks to open and explore a project concept at relatively low cost. If this investment is successful, the option obtained is "exercised" by investing in an integrated project scheme that is used as a basis for negotiating a series of reciprocal commitments among the sponsor, providers of specialized services, key sources of finance, and key external stakeholders. (Miller & Olleros, 2000: 111)

Miller and Floricel (2000) discuss options built on flexibility, including technical flexibility, financial flexibility, parallel strategies and flexible contracts. Most of these options need to be worked out prior to the project's implementation, and in that sense are similar to Miller and Olleros's (2000) notion of shaping.

AN OPTIONS VIEW OF MANAGEMENT AND STRATEGY IN LARGE ENGINEERING PROJECTS

Miller and Olleros's and Miller and Floricel's work suggest that the answer to the previous question of whether there is a role for strategic planning and management after project implementation begins is, "No, strategic planning is done only in the project planning or 'shaping' phase of LEP."

We do not agree. We offer an alternate, more integrated, perspective of strategic planning and LEP that allows a broader application of strategic planning and management in LEP. We suggest that a real options approach can provide strategic benefits during project execution as well as during project planning. These benefits are derived from improvements in four areas of managerial thinking: 1) project objectives, not solutions, 2) multiple project futures, 3) continuous strategy testing and evolution, and 4) valuing developing project flexibility.

1. **Project objectives, not solutions:** Large engineering project planners and managers often fall into a trap of committing to specific solutions and thereby prematurely reducing their flexibility. Miller and Olleros (2000) claim that "project sponsors, partners, and affected parties lock in on a choice, thereby, giving away most of their degrees of freedom" because projects can rarely be modularized in project planning. However, many important choices remain after execution has begun about the solutions in LEPs or how strategies should be changed based on information developed after the start of a project. But even these later choices are vulnerable to solution bias. A real options perspective facilitates the development of a wider range of potential solutions, thereby helping keep managerial focus on fulfilling project requirements (functional, economic, etc.) and not on specific solutions (physical, organizational, etc.). Doing this allows project planners and managers to see, recognize, and identify multiple possible actions, often times many more than if they locked into one solution early on".

For example, the primary operational goal of the Department of Energy's National Ignition Facility project is to get high amounts of energy on a small target (Moses, 2001). Traditionally, building larger and larger lasers was the solution to increasing energy-on-target and was an easy solution onto which the project could lock. However, building such a large laser presented many challenges, including costs that increase with the cube of the laser diameter. But focusing on the operational requirement, instead of on how to build a larger laser, allowed the project planners to consider and eventually select a design of modular sets of smaller lasers, largely because of the options that modularity provided. In this regard, real options thinking provides benefits similar to those provided by systems engineering, which emphasizes the value of requirement development and management and understanding the interaction of project components (see Malqvist, 2001; Parth, 1998).

2. **Multiple project futures:** A real options perspective facilitates managers' envisioning multiple possible futures through uncertain conditions, even as those conditions are evolving. This contrasts sharply with the traditional project management perspective of planning a single desired journey through the future to the project objectives (e.g. with critical path method schedules, budget allocation, and earned value management systems). Projects that are only managed toward a single, pre-determined path without the flexibility available by seeing multiple paths to a set of goals can fail, because of uncertainties evolving outside the envelopes envisioned, or hoped for, during the planning of the desired path. Real options facilitates not falling into this strategic trap by requiring planners and managers to identify, specify, and assess a wide variety of potential future conditions which one or more options can be designed to address.

For example, an LEP planner considering the futures possible for a construction project facing uncertain concrete prices could envision scenarios in which the capacity of suppliers shrinks because of aggressive pricing competition, or supplier capacity expands because of new entrants, or capacity is privatized through the building of project-specific plants by owner/developers, or demand increases or decreases as other project needs and economic conditions change, or combinations of these conditions. Continuously envisioning multiple, realistic possible futures helps managers become more able to adapt to whatever future *does* come about. In this regard, real options' thinking provides benefits similar to those provided by scenario planning (Schwartz, 1991).

3. **Continuous strategy testing and evolution:** Things change and what seemed advisable during the planning stages may seem ill advised after the first phase of a large project. Implementing a

real option includes monitoring information from an uncertain environment, translating that information into signals related to project value, comparing signals to baselines, and taking actions in response to that analysis. Therefore, a real options approach requires the continuous testing of evolving conditions for project improvement. In the case of American options in which an action can be taken at any time, this practice can represent regular probes (Brown & Eisenhardt, 1997) of possible project values if certain actions are taken. A real options approach encourages managers to take the same attitude toward project strategies as is used to implement previously designed options. It does so by seeing project conditions and information and data collection efforts as opportunities to learn, to test project strategies, and to investigate potential strategy changes for project improvement.

For example, a manager can view additional geotechnical investigations as a tool for improving the construction cost estimate. However, if the manager uses a real options approach he or she will see the investigation also as a probe to test the implicit options taken to build the facility in the proposed location, build it with the proposed foundation technology, or build the facility at all. If the geotechnical investigations reveal very high foundation costs the manager and planners may exercise their options to switch locations or technologies, or abandon the facility. This practice leads to learning and the continuous evolution of the project strategy in response to conditions. This can potentially increase project value when compared to implementing flexible strategies that are developed only in project planning but are not allowed to change thereafter, even in when information developed during the project may indicate a better strategy.

4. **Valuing the development of project flexibility:** Increasing project flexibility during project execution is not sufficient to capture the increased project value created by that flexibility. The flexibility must also be acknowledged, described, discussed, and valued. Adopting a real options approach during project execution can increase captured project value by keeping the project flexibility--incorporated during project planning and developed during project execution--visible and valued. This is done by providing a shared language of flexibility, based on an established set of concepts, that can be directly related to LEP theory and practice. A real options approach also provides a framework for valuing the economic benefits of flexibility in a manner more appropriate than the DCF method.

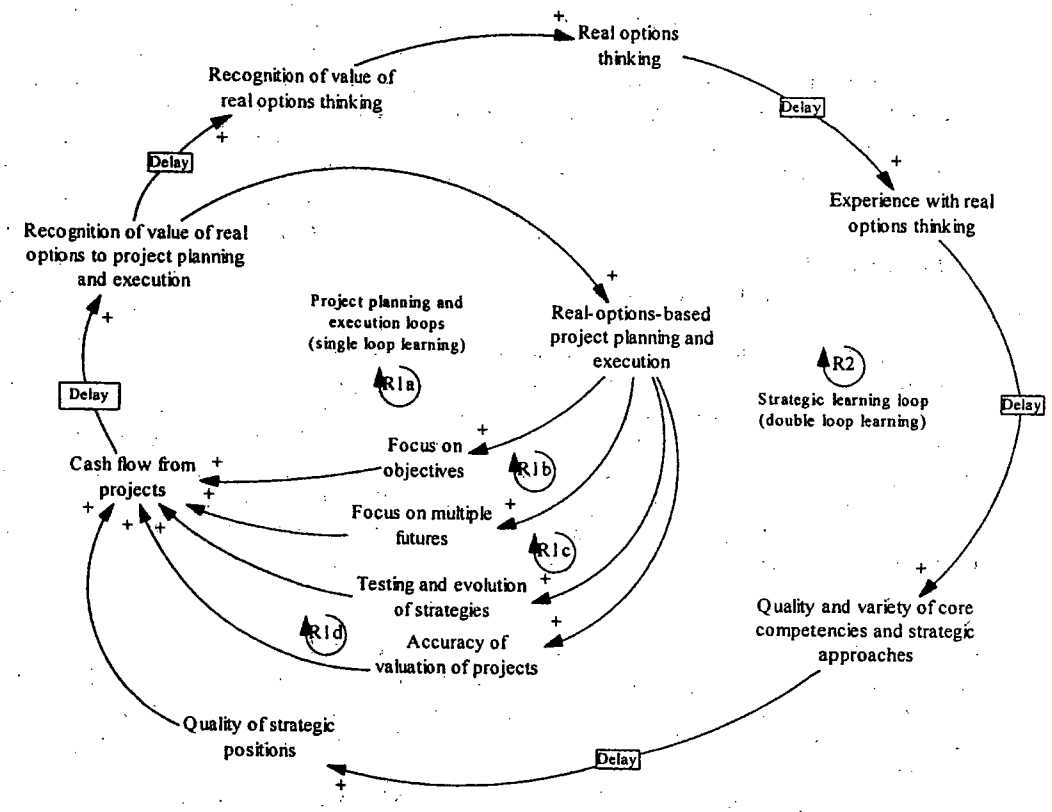
Summary. Real options are not merely a short-term alternative to discounted cash flow analysis, usable by managers of LEPs only in the pre-execution stages of the projects. Nor are they merely creators of long-term opportunity, built up over time as firms invest in value-creating activities. Real options also serve an intermediate term, allowing for better strategic management choices even as an LEP unfolds. They encourage: an emphasis on outcomes, not solutions; an emphasis on multiple futures, even after an LEP has started; an emphasis on continuous testing of the strategy as it evolves; and the proper valuation of the flexibility built into an LEP managed using real options thinking.

A SYSTEMIC VIEW OF REAL OPTIONS IN THE EXECUTION AND STRATEGIC MANAGEMENT OF LARGE ENGINEERING PROJECTS

As mentioned at the outset, the views of strategy theorists and LEP project management theorists seem to be at odds with regard to real options. Strategy has viewed real options as a tool for long-term thinking and the creation of strategic resources. LEP project managers have asserted that the large commitments needed for LEPs do not allow for the flexibility gained through the use of real options after initial project planning, a flexibility deemed so precious in the strategy discipline. We have shown the latter to be overly

FIGURE 1
The Systemic Relatinship between Real Options as a Project Management Tool and as a Strategic Thinking Tool.

Note: Arrows indicate the direction of causality. Signs indicate the polarity of relationships, a "+" sign meaning that, all else equal, if the cause increases (decreases), the effect increases above (decreases below) what it would otherwise have been. Loops are labelled "R" for "reinforcing," signifying that increases or decreases in the value of any variable in a series of connected variables are ultimately amplified ("reinforced") as their effects are traced through that connected series.



narrow, and we assert furthermore that real options thinking allows for short term, medium term and long term benefits, in a systemic way, to managers of LEP-oriented companies. Figure 1 depicts this systemic relationship, in the form of two major reinforcing loops.

There are four variants of the Reinforcing Loop R1, the "Project planning and execution loops." These depict the quintessential short or medium term use of real options as described earlier--improving performance by focusing on objectives (R1a), focusing on multiple futures (R1b), continuously testing an evolving strategy (R1c) and valuing flexibility (R1d). In these loops, Real-Options-Based Project Planning and Execution lead to higher Cash Flow, eventually leading to a greater Recognition of the Value Of Real Options To Project Planning and Execution, which, to close the loop, encourages more Real-Options-Based Project Planning and Execution. In other words, using real options to manage an LEP increases the possibility that a project will be successful, partly for classic financial capital budgeting reasons, and partly because of the reasons given in the previous

section, e.g., not locking into solutions, making implicit options explicit. As a result, cash flow from projects increases, which in turn creates the opportunity for more projects, and so on. These loops seem to imply that real options thinking can be used only for single project capital budgeting, but the next loop, Reinforcing Loop R2, shows that it also plays a role in multiple projects and enterprise-wide strategizing.

Loop R2, the "Strategic Learning Loop," depicts the view expounded by the strategy discipline. Firms that use a lot of real options (for reasons given in Loop R1) gain experience with them and become better at using them. Over time, this increases the quality and variety of core competencies possessed (e.g., being able to profit in highly uncertain circumstances) and strategic approaches taken by the firm (e.g., risk-seeking for opportunity). In accordance with the resource-based view of the firm, this improves the quality of the firm's strategic positions, which increases the probability that LEP-oriented companies will be financially successful. This is an example of double loop learning (Argyris & Schon, 1978; Argyris, 1993), since it moves the company well beyond the standard hyperrational planning approach to LEP project management and strategy, and towards a more flexible, options-based approach to those activities. This is a significant departure for engineering-oriented LEP project managers.

The time scales of the loops increase between R1 and R2. Changes in single projects caused by Loop R1 might be measured in months. Changes in enterprise competencies from Loop R2 would probably be measured in (possibly many) years. This span of time scales of potential real options applications, from strategically short (months) to long (many years), supports our assertion that real options are not limited to the pre-execution stages of individual LEP.

CONCLUSION

Our intention in this paper was to show that real options can have benefits for both the short term and long term strategic management of large engineering projects (LEPs). In the short term, projects improve because real options lead to a greater focus on objectives (not solutions), a greater focus on multiple futures, continuous strategy testing and evolution, and more accurate capturing of project value. In the longer term, as firms become more comfortable with and more cognizant of the benefits of real options thinking, greater competencies are built and strategic positions are improved. Even though the focus of this paper has been on LEPs, its lessons may apply even more strongly to other, less constraining projects. The benefits listed in the previous paragraph would be even more potent for projects that have more inherent flexibility.

REFERENCES

Adner, R. and Levinthal, D.A. (forthcoming). What is not a real option: Identifying boundaries for the application of real options to business strategy. *Academy of Management Review.*

Amram, M. and Kulatilaka, N. (Jan/Feb 1999). Disciplined decisions: Aligning strategy with the financial markets. *Harvard Business Review,* 77, 95-104.

Argyris, C. (1993). On organizational learning. Cambridge, MA: Blackwell.

Argyris, C. and Schon, D. (1978). Organizational learning: A theory of action perspective. Reading, MA: Addison-Wesley.

Barney, J.B. (1986). Strategic factor markets: Expectations, luck, and business strategy. *Management Science,* 32, 1231-1241.

Beinhocker, E. D. (1999). Robust adaptive strategies. *Sloan Management Review,* 40, 95-106.

Bower, J. L. (1970). Managing the resource allocation process: A study of corporate planning and investment. Boston: Division of Research, Graduate School of Business Administration, Harvard University.

Bowman E.H. and Hurry, D. (1993). Strategy through the options lens: An integrated view of resource investments and the incremental-choice process. *Academy of Management Review,* 18, 760-782.

Brown, S. L. and Eisenhardt, K.. (1997). The art of continuous change: Linking complexity theory and time-paced evolution in relentlessly shifting organizations. *Administrative Science Quarterly,* 42, 1-34.

Construction Industry Institute. (1995). Pre-project planning handbook. Austin, TX.

Courtney, H., Kirkland, J and Viguerie, P. (Nov/Dec 1997). Strategy under uncertainty. *Harvard Business Review,* 75, 66-78.

Dierickx, I. and K. Cool. (1989). Asset stock accumulation and sustainability of competitive advantage. *Management Science,* 35, 1504-1511.

Dixit, A.K. and Pindyck, R.S. (1994). Investment under uncertainty. NJ: Princeton University Press.

Luehrman, T. (Sept/Oct 1998). Strategy as a portfolio of real options. *Harvard Business Review,* 76, 89-99.

Malqvist, J. (2001). Implementing requirements management: A task for specialized software tools or PDM Systems. *Systems Engineering,* 4(1), 49-57.

McGrath, R.G. and I. MacMillan. (2000). The entrepreneurial mindset. Boston, MA: Harvard Business School Press.

Miller, R. and Olleros, X. (2000). Project shaping as a competitive advantage. In Miller, R. and Lessard, D. The strategic management of large engineering projects. Cambridge, MA: MIT Press.

Mintzberg, H. (1994). The fall and rise of strategic planning. *Harvard Business Review,* 72, 108-114.

Mintzberg, H., Ahlstrand, B.W. and Lampel, J. (1998). Strategy safari: A guided tour through the wilds of strategic management. New York: Free Press.

Mintzberg, H. and Waters, J. (1985). Of strategies, deliberate and emergent. *Strategic Management Journal,* 6, 257-272

Moses, Ed. (2001). Personal conversation with a co-author, November 6, 2001.

Parth, F. R. (1998). Systems engineering drivers in defense and in commercial practice. Systems Engineering, 1(1), 82-89.

Porter, M. (1985). Competitive advantage. New York: The Free Press.

Porter, M. (Nov/Dec, 1996). What is strategy? *Harvard Business Review,* 74, 61-78.

Schwartz, P. (1991). The art of the long view. New York: Currency/Doubleday

Spanos, Y.E. & Lioukas, S. (2001). An examination into the causal logic of rent generation: Contrasting Porter's competitive strategy framework and the resource-based perspective. *Strategic Management Journal,* 22, 907-934.

Wernerfelt, B. (1984). A resource-based view of the firm. *Strategic Management Journal,* 5, 171-180.

John J. Voyer is a Professor of Business Administration, University of Southern Maine in Portland, Maine.

David N. Ford, University of Southern Maine in Portland, Maine.

Diane M. Lander, University of Southern Maine in Portland, Maine.