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Managerial Real Options

Research Project Descriptions

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Public-Private Partnerships: A Study of Risk Allocation Design Envelopes

Ford, David N, I. Damnjanovic, and S. Johnson

The purpose of this chapter is to illustrate the application of policy informatics using the system dynamics modeling approach. The setting is a Public-Private Partnership (PPP) between a government agency and a private developer to deliver and operate a large toll-road transportation infrastructure project. While the PPP framework offers a broad range of contractual arrangements to produce successful outcomes, significant challenges remain with achieving equitable risk allocation among the stakeholders. The current work describes how a system dynamics simulation model was used to evaluate the risk allocation envelop (i.e., extreme risk allocation scenario where the risk is allocated to a single stakeholder) through the integration of stakeholders perspectives, objectives, and performance criteria. Transparency and evidence based explanations are achieved by explicitly modeling critical information flows of traffic, money, and information to demonstrate their causal linkage to project performance. Tipping point structures are used to explain project performance. The model and those explanations generate new PPP theory and provide support for policy analysis and policy informatics.

Keywords: Public private partnership, risk allocation, public policy, informatics, infrastructure, simulation, system dynamics

Ford, David N, I. Damnjanovic, and S. Johnson. “Public-Private Partnerships: A Study of Risk Allocation Design Envelopes”. Governance in the Information Era: Theory and Practice of Policy Informatics. Erik Johnston, Ed. Routledge Press. New York. 2015

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Real options in military acquisition: The Case Study of Technology Development for the Kingfish Unmanned Underwater Vehicle

Diana I. Angelis, David Ford and John Dillard

The Unmanned Undersea Vehicles under development by the US Navy required several immature technologies to fully develop the required anti-mine capabilities. Primary among them was a sensing technology to detect and classify Underwater Improvised Explosive Devices (UWIEDs). A real option valuation model is developed to determine how much an organization should pay for technology development options when the benefits of the option cannot be measured in dollars. The expected value of a measure of effectiveness is used to select the prefered alternative. The value of an option is calculated based on the cost to implement the prefered alternative. When more than one option is available, a method for allocating the option value based on the relative risk of option alternatives is presented. The methodology is illustrated using the Navy's Kingfish UUV development program.

Angelis, D., Ford, DN, and Dillard, J. "Real options in military acquisition: the case study of technology development for the Kingfish Unmanned Underwater Vehicle", Military Cost-Benefit Analysis: Theory & Practice. Francois Melese, Ed. Routledge Press (Taylor and Frances). New York. 2015.

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Real Options in military Systems Acquisition: A Retrospective Case Study of the Javelin Anti-Tank Missile System

Diana I. Angelis, David Ford and John Dillard

Three different technologies were considered in the technology development phase of the Javelin anti-tank missile system: a laser-beam riding system, a fiberoptic system, and a forward looking infrared system. The Army awarded three "Proof of Principle" contracts to three competing contractor teams to develop and conduct a "fly-off" technology competition. The current work analyzed the three alternatives using measures of effectiveness (MOE) to combine performance across nine acquisition objectives. These MOEs were compared with development and procurement cost estimates. No alternative dominated. Marginal benefits analysis was next used to define the trade–off space among the alternatives. Differences in the likelihood of successful development of the alternatives were evaluated, resulting in one technology appearing to dominate. However, the acquisition approach created a real option for the best alternative that could differentially add value to the alternatives. A real options model was used to analyze the value provided by investing in this competitive option. Results indicate the Army paid less than the total value of the three options, but could have increased net savings by paying different amounts to test each alternative. The analysis method provides a logical and defendable approach to the analysis of alternatives during technology development uncertainty.

Keywords: Real Options, Analysis of Alternatives, Technology Development, Javelin

Angelis, Diana I, DN Ford, and J. Dillard, (2015) "Real Options in military Systems Acquisition: A Retrospective Case Study of the Javelin Anti-Tank Missile System" accepted in Francois Melese, A. Richter, and B. Solomon (Eds.) *Military Cost-Benefit Analysis: Theory & Practice*. Routledge Press (Taylor and Francis). New York.

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Valuation of Real Options as Competitive Prototyping in System Development

Angelis, D., Ford, DN, and Dillard, J

A Real Options Valuation Model is developed to recommend how to valuate technology when benefits cannot be measured in monetary value. Expected values of effectiveness are used to select the preferred alternative. The methodology is illustrated using three guidance system technologies in the Army's Javelin program. The strategy created multiple real options that gave the Army the right (without the obligation) to select one guidance system technology based on the outcome of technology development tests. Results indicate the Army paid less than the total value of the options, but could have increased net savings by paying different amounts to test each alternative. The analysis method provides a logical and defendable approach to the analysis of alternatives under technology development uncertainty.

Angelis, D., Ford, DN, and Dillard, J. "Valuation of Real Options as Competitive Prototyping in System Development", Defense Acquisition Research Journal. Vol. 21, Issue, 3, pp. 668-694. July, 2014.

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Real Options in Infrastructure Projects: Theory, Practice and Prospects

Michael J. Garvin and David N. Ford

Developed from financial options theory and pricing models, real options have evolved to become a mainstream area of academic inquiry. This account traces the field generally from its origins to present day. Research has demonstrated the potential for real options to enhance project value by managing uncertainty through investment, structuring and design decisions. Despite this, real options theory is not widely used as a whole or within the discipline of infrastructure development and construction project management. The creation of infrastructure occurs almost exclusively in a project-based environment. Not surprisingly, project managers play a pivotal role in the success of such projects and make frequent decisions that shape and reshape implementation strategies. Perhaps, the path towards disseminating real options into infrastructure project practice is to improve the understanding of the managerial environment and behaviour. Hence, the characteristics of infrastructure projects and project management underpin six propositions, which need further investigation to aid bridging the chasm between the notion of real options and its application in actual project settings. Each proposition is linked to the literature and project management practice.

Keywords: real options, infrastructure, project management

Garvin, M. and Ford, D. "Real Options in Infrastructure Projects: Theory, Practice and Prospects" Engineering Project Organization Journal. Vol. 2, Issue 1-2. Pp. 97-108. Jan 24, 2012.

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Real Option Perceptions among Project Managers

David N. Ford and Diane M. Lander

Effective and efficient planning for and management of project risk requires the management of uncertainty. Real options can be an effective tool for managing uncertainty and thereby increasing project value. As most managers do not use real options, but instead intuitively manage uncertainty, understanding the similarities and differences between decision maker perceptions of real options and real options theory is critical for improving the use of real options for risk management. In the current work, an experiment using a simple uncertain development project and a simulation model capture managers' perceptions of real options, including option values. Results show that subjects valued flexibility and conceptually understood option values in ways consistent with theory. Implications for real options research and development are discussed.

Keywords: risk management, real options, uncertainty, flexibility, simulation

Ford, DN and Lander, DM, "Real options perceptions among project managers" Risk Management, An International Journal. Vol. 13, No. 3, pp. 122-146. 2011.

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Computer Simulation of Innovation Implementation Strategies

Peter S. Hovmand and David N. Ford

Many interventions that are effective in one setting may be ineffective or even harmful in other settings. This poses a problem for organizations and communities engaged in planning the implementation of social interventions. This paper introduces the use of managerial real options combined with system dynamics models to design strategies for implementing community interventions when their effectiveness may be uncertain. A new notation for representing implementation strategies using real options is introduced. The approach is illustrated with an example of domestic violence community interventions. Results show that there are potential benefits to using a real options approach.

Hovmand, P.S., and Ford, DF "Computer Simulation of Innovation Implementation Strategies" in Rossetti MD, Hill RR, Johansson B., Dunkin A., and Ingalls, RG, (Eds.) Proceedings of the 2009 Winter Simulation Conference. Austin, Tx.

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Barriers to Real Options Adoption and Use in AEC Project Management Practice

Michael J Garvin and David N Ford

The limited adoption and use of real options by practicing managers in the architecture/engineering/construction (AEC) industry remains an important challenge. This chapter describes a risk-rich managerial practice in which real options can add value but are not fully exploited. This setting is used as a basis for identifying and describing specific barriers to widespread real options adoption and use by practicing project managers. These barriers are used to suggest tools, methods, and approaches that may reduce those barriers.

Ford, DN and Garvin, M. "Barriers to Real Options Adoption and Use in AEC Project Management Practice" Chapter 7 in Harriet Black Nembhard (Ed.) Real Options in Engineering Design, Operations, and Management. CRC Press 2009.

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Modeling Open Architecture and Evolutionary Acquisition: Implementation Lessons from the ARCI Program for the Rapid Capacity Insertion Process

John T. Dillard and David N. Ford

Providing system interoperability and evolving technologies in major DoD systems are two important acquisition challenges in preparing the military to meet current and future demands. The Acoustic Rapid COTS Insertion (ARCI) program successfully addressed many of the associated challenges. That program was studied as the basis for modeling the planned Rapid Capability Insertion Process (RCIP) approach for continuous, reduced-cost upgrading of assets. ARCI used atypical methods in the face of atypical program requirements and conditions. A previously developed acquisition program model was adapted to reflect ARCI and used for model validation. This model was then changed to reflect the basic conditions expected to be faced by RCIP programs. The model demonstrated the potential of RCIP to significantly improve program performance. However, implementation risks are identified that may degrade potential performance, including increased oversight, the use of more new development, and the resulting integration scope and risk. When incorporated into the model, these risks were shown to significantly decrease RCIP performance. Means for successfully managing the RCIP design based on the ACRI program and RCIP operations are suggested for use in addressing the identified implementation risks.

Ford, DN and Dillard J "Modeling Open Architecture and Evolutionary Acquisition: Implementation Lessons from the ARCI Program for the Rapid Capacity Insertion Process" Acquisition Research Program. Naval Postgraduate School. Monterey, Ca. Report #NPS-AM-09-043. April 22, 2009.

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Modeling the Performance and Risks of Evolutionary Acquisition

John T. Dillard and David N. Ford

Evolutionary acquisition mandates incremental development for all programs. This policy seeks to improve development project performance, but may increase some risks. Computational modeling using systems dynamics reveals that evolutionary acquisition can increase concurrency and the need for coordination. The result is earlier delivery of the first increment, but later and more costly delivery of subsequent increments than in a single-step methodology. Modeling reveals and explains how deliberate work deferral reduces the initial increment's cost and schedule, but rework and transaction costs cause inefficiency in successive increments. Program managers must be aware of the risks of evolutionary acquisition and take additional steps to mitigate them with disciplined change-control measures, organizational accommodations, and accountability for configuration management.

Ford, D.N. and Dillard J. "Modeling the Performance and Risks of Evolutionary Acquisition" *Defense Acquisition Review Journal.* 16(2):143-158. July, 2009.

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Modeling the Integration of Open Systems and Evolutionary Acquisition in DoD Programs

John T. Dillard and David N. Ford

Open Systems and Evolutionary Acquisition are two recent innovations designed to improve program performance with flexibility. The full potential of these approaches has not been captured, partially because of integration challenges during implementation. The current work investigates the impacts of open systems and evolutionary acquisition on DoD development programs. Changes required to use both Open Systems and Evolutionary Acquisition are used to identify and describe impacts of implementation on program process and management. A dynamic simulation model of a program using both Evolutionary Acquisition and Open Systems is described and used to map the impacts. Simulation results generally support previously suggested impacts and provide a possible explanation for changes in program performance. Implications for practice relate to changes in the types and timing of risk and a potential trading of design obsolescence risk for standards obsolescence risk

Keywords: Open Systems, Evolutionary Acquisition, DoD development programs

Ford, D.N. and Dillard, JT “Modeling the Integration of Open Systems and Evolutionary Acquisition in DoD Programs” 5th *Acquisition Research Symposium*. Naval Postgraduate School. Monterey, Ca. May 14-15, 2008.

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Managing Tipping Point Dynamics in Development Projects

Timothy R. B. Taylor and David N. Ford

Complex construction projects are vulnerable to tipping points. Tipping points are conditions that, when crossed, cause system behaviors to radically change performance. Previous research identified tipping point dynamics as capable of explaining the failure of some nuclear power plant construction projects. These dynamics can also threaten the success of other large, complex construction projects. The current work uses a dynamic project model to test policies for managing tipping point dynamics. The Limerick Unit 2 nuclear power plant project is used to test model usefulness. Sensitivity analysis reveals the rework fraction, strength of sub-system interdependence, and sensitivity of the project to schedule pressure as potential high-leverage points for policy design. The model is used to test policies for managing tipping points that were used to complete the Limerick Unit 2 nuclear power plant after a tipping point threatened project completion. Implications for construction project design and management and research opportunities are discussed.

Keywords: Project management; dynamic models; simulation models; change management; errors; nuclear power plants; system dynamics

Taylor, TR and Ford, DN. "Managing Tipping Point Dynamics in Development Projects". *ASCE Journal of Construction Engineering and Management*. Vol. 134, No. 6, pp. 421-431. June, 2008.

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Using System Dynamics to Extend Real Options Use: Insights from the Oil & Gas Industry

Scott T Johnson Tim Taylor David N Ford

The current work examines the application of system dynamics to real options through work with a major energy firm to apply real options. Five key challenges facing the real options community are presented and potential system dynamics contributions to these challenges are discussed. Two cases from a BP research project illustrate how system dynamics can be used to develop and value real options. The work shows that the use of systems dynamics in real option development and valuation can 1) address key challenges facing the real options community and increase the use of real options in the oil and gas industry 2) allow system dynamicists to offer increased value in developing and valuing flexibility and 3) open system dynamics to new markets of research collaboration and potential clients.

Keywords: real options; flexibility; system dynamics; Georgetown Challenge

Johnson, S., Taylor, T, and Ford, DN "Using System Dynamics to Extend Real Options Use: Insights from the Oil & Gas Industry" 2006 International System Dynamics Conference, Nijmegan, The Netherlands. July 23-27, 2006.

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Project Management Quality and the Value of Flexible Strategies

David N. Ford and Shilpa Bhargav

Construction strategies for competitive bidding and operations are used to avoid the consequences of poor schedule performance such as delay penalties. Flexible strategies in the form of options can increase project value if uncertain conditions cannot be adequately forecasted before operations begin. However, project management purposefully manipulates the project performance that drives the use of options and thereby the value added by options. Therefore project management quality may influence option values. This research investigates the interaction of project management and option value by operationalizing a common use of real options in construction and valuing the option with different levels of project management quality. A simple but realistic dynamic simulation model of a project is described and exercised to reveal some impacts of project management on option value. Results support a hypothesis that increased project management quality decreases option value and that real options in managing construction projects can be explained with real options theory. The model structure suggests causal explanations that are consistent with real options theory. Results suggest that practicing managers can significantly increase project value by structuring managerial flexibility and thereby improving their evaluation, development, and use of flexibility. However, ignoring the multiple means of managing uncertainty that are often available can distort valuation. Results also suggest that researchers of strategic flexibility in projects should consider multiple forms of uncertainty in modeling options. Increasing the number of available options or the effectiveness of options in a multiple-option environment can decrease individual option values.

Keywords: flexibility, real options, risk management, project management, system dynamics, strategy

Ford, DN and Bhargav, S "Project Management Quality and the Value of Flexible Strategies Engineering", Construction and Architectural Management, Vol. 13, No. 3.pp. 275-289. Spring, 2006.

NOTE: This paper won the "Highly Commended" Award of Excellence from Emerald Literati Network 2007

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Adapting Real Options to New Product Development by Modeling the Second Toyota Paradox

David N. Ford and Durward Sobek

Uncertainty in product development projects creates significant challenges for managers who are under intense competitive pressures to increase product quality while reducing development time and costs. Traditional wisdom dictates the early selection of a single design in order to freeze interfaces between product subsystems so that team members can work effectively in parallel, resulting in more productive product development efforts. Prior research, however, uncovered a paradoxical case. Toyota Motor Corporation achieves the fastest development times in its industry by intentionally delaying alternative selection, a strategy termed set-based development. The current work adapts real options concepts to product development management to partially explain this paradox. A formal simulation model is used to show that converging too quickly or too slowly degrades project value. Furthermore, the model demonstrates that the wisdom of set-based strategies can be explained by the application of a real options approach to product development management. Implications for managers and directions for future work are discussed.

Keywords: flexibility, product development, project management, real options, risk management, set-based concurrent engineering, system dynamics

Ford, D.N. and Sobek, D.N. “Adapting real options to new product development by modeling the second Toyota Paradox” IEEE Transactions on Engineering Management. Vol. 52, No. 2, pp. 1-11. May, 2005.

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Perceptions of Real Options in Large System Acquisition: Empirical Descriptions and Comparison with Theory

Yanzhen Wu and David N. Ford

Effective and efficient development of large complex acquisition projects requires proactive management of uncertainties to meet performance, schedule, and cost targets. Flexibility in the form of real options can be an effective tool for managing uncertainty and thereby adding value to acquisition projects. But real options can be both difficult to recognize, design and evaluate and expensive to obtain, maintain, and implement. Real options theory suggests a general approach and has developed precise valuation models that demonstrate the potential of options to add value. But these models of simplified real options (compared to managerial practice) have failed to significantly improve practice, presumably because of a lack of knowledge and understanding of real options use by practicing managers. In contrast, practicing managers identify, design, value, and implement real options as a regular part of acquisition. Understanding the similarities and differences between current practice and theory is critical for developing operational real option theories that can improve management practice. In the current work an experiment using a simple uncertain acquisition project and a simulation model is used to capture managers' perceptions of real options. Subjects valued flexibility and conceptually understood the impact of uncertainty on option values. Future needs for expanding real options theory into the operational management of acquisition and management implications are discussed.

Yanzhen, W. and Ford, D.N. " Perceptions of Real Options in Large System Acquisition: Empirical Descriptions and Comparison with Theory" Proceedings of the 2nd Annual Acquisition Research Symposium. May 18-19, 2005.

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

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

The views of strategists and theorists of large engineering projects (LEPs) seem to be at offs 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 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.

Ford, D.N., Lander, D. and Voyer, J., "Business Strategy and Real Options in the Context of Large Engineering Projects," Journal of Global Competitiveness. 12 (1): 1-9. 2004.

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Managing Risk and Uncertainty in Complex Capital Projects

Todd M. Alessandri, David N. Ford, Diane M. Lander,
Karyl B. Leggio, and Marilyn Taylor

In evaluating capital budgeting decisions, quantitative approaches, such as traditional discounted cash flow modeling and real options valuations, are useful when there is a presumed probability distribution for the future forecasted outcomes or for when there are lower levels of uncertainty. As uncertainty increases and forecasting becomes difficult, the value of financial modeling techniques decreases. Borrowing from the strategic management literature, we argue that it may be useful to employ a qualitative approach to evaluate capital projects when faced with high levels of uncertainty. In order to illustrate our argument, we use a derivative of scenario planning and qualitative real options to evaluate non-quantifiable factors in a project for the National Ignition Facility.

Keywords: capital budgeting, flexibility, qualitative analysis, real options, risk management, scenario planning

Alessandri, T., Ford, D.N., Lander, D. Leggio, K., and Taylor, M., “Managing risk and uncertainty in complex capital projects” Quarterly Review of Economics and Finance. 44(5): 751-767.

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Using Options to Manage Dynamic Uncertainty in Acquisition Projects

David N. Ford and B. Kagan Ceylan

Uncertainty in acquisition projects and environments can degrade performance. Traditional project planning and management tools and methods can effectively deal with uncertainties in relatively stable environments. But in more uncertain environments conditions can evolve beyond the assumptions used in pre-project planning and require major deviations from initial plans. Important uncertainties often cannot be identified and described adequately during pre-project planning to design optimal strategies. Therefore rigid project strategies prepared solely based on the most likely outcomes as perceived during pre-project planning can result in sub-optimal performance. In these cases acquisition planners must explicitly incorporate flexibility into project plans to keep effective strategies available until uncertainty resolves adequately to reveal the best choice. Options can provide an effective framework for designing, evaluating, and implementing flexible acquisition project strategies and therefore can improve project performance. A large complex defense project illustrates the potential and challenges of options and research needs to expand and improve their use to manage uncertainty.

Keywords: project management, real options, risk management, strategic management, strategic planning

Ceylan, K. and Ford, D.N. and, "Using Options to Manage Dynamic Uncertainty in Acquisition Projects," Acquisition Review Quarterly, Vol. 9, No. 4, pp. 243-258, Fall, 2002.

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A Real Options Approach to Valuing Strategic Flexibility in Uncertain Construction Projects

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

To maximize project value managers of construction projects must recognize, plan for, and strategically manage uncertainty. Current construction planning, estimating, and management practices regarding uncertainty can undervalue projects by failing to exploit opportunities to increase project value as well as minimize risks. Dynamic uncertainties are described as project conditions that cannot be adequately resolved through improved description or planning for pre-project strategy selection. A real options approach is proposed for proactively using strategic flexibility to recognize and capture project values hidden in dynamic uncertainties. An example of a proposal for a toll road project demonstrates a method of valuing managerial flexibility to evaluate and select strategies. Impacts of real options in other domains, along with this example, are the basis for concluding that using a structured real options approach in construction management can increase returns through improved project planning and management. Potential impacts of the use of real options are discussed and challenges in valuing real options in construction projects are identified as the basis for future research.

Keywords: flexibility, project management, project planning, real options, risk management, strategic planning, strategy

Ford, D.N., Lander, D.N. and Voyer, J. “A Real Options Approach to Valuing Strategic Flexibility in Uncertain Construction Projects” Construction Management and Economics. 20(4): 343-351. June, 2002.

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