J Syst Sci Syst Eng (Jun 2012) 21(2): 129-143
DOI: 10.1007/s11518-012-5190-5
ISSN: 1004-3756 (Paper) 1861-9576 (Online)
CN11-2983/N

PROJECT MANAGEMENT: RECENT DEVELOPMENTS AND RESEARCH OPPORTUNITIES

Nicholas G. HALL

Department of Management Sciences Fisher College of Business, The Ohio State University, USA

hall_33@fisher.osu.edu (✉)

Abstract

This paper studies the business process known as project management. This process has exhibited a remarkable growth in business interest over the last 15 years, as demonstrated by a 1000% increase in membership in the Project Management Institute since 1996. This growth is largely attributable to the emergence of many new diverse business applications that can be successfully managed as projects. The new applications for project management include IT implementations, research and development, new product and service development, corporate change management, and software development. The characteristics of modern projects are typically very different from those of traditional projects such as construction and engineering, which necessitates the development of new project management techniques. We discuss these recent practical developments. The history of project management methodology is reviewed, from CPM and PERT to the influential modern directions of critical chain project management and agile methods. We identify one important application area for future methodological change as new product and service development. A list of specific research topics within project management is discussed. The conclusions suggest the existence of significant research opportunities within project management.

Keywords: Project management, overview, recent practical developments, opportunities for research

1. Introduction

A project is conventionally defined as a "temporary endeavor undertaken to create a unique product or service" (Project Management Institute 2008). Alternatively, a project can be thought of as a well defined set of tasks that must all be completed in order to meet the project's goals (Klastorin 2004). In a typical project, many tasks are performed concurrently with each other. Another key feature of projects is the existence of precedence relations between the tasks. These relations typically define constraints that require one task to be completed before another starts.

Compared to many business processes, project management appears to be particularly difficult, from both theoretical and practical perspectives. From a theoretical perspective, the fundamental planning problem of resource constrained scheduling is highly intractable. From a practical perspective, the two standard objectives in project management are defined to be completion of the project on time and on budget. Yet, many projects fail to meet these two criteria, despite detailed planning before execution begins and the use of modern project management software. Further, the failure rate of projects is higher in many modern applications than in traditional ones, due to less reliable data and the more challenging characteristics that are discussed in Section 2 below. Indeed, it can be said that, despite its recent massive growth in use, project management is a difficult to manage business process. As we discuss, this is creating extremely interesting research opportunities. The purposes of this work are to outline what those opportunities are, and to provide some specific examples.

This paper is organized as follows. In Section 2, we provide a brief history of project management, document its dramatic recent growth, and discuss the new challenges presented by its greatly expanded set of applications. Section 3 summarizes the development of methodology for project management over time, from familiar techniques developed in the 1950s to more recent and newly influential ideas. In Section 4, we identify many specific research opportunities in project management. Section 5 provides a conclusion.

2. History and Growth

The use of project management as a business process goes back a long time. Indeed, the building of the Egyptian pyramids is believed by many to have been assisted by the use of simple project management principles. For much of the history of project management, the predominant application type was engineering and construction projects - for example, roads, bridges and skyscrapers. This was still the case when project management became formalized in the 1960s with the help of new computing power. A particularly impressive project management achievement at that time was the Apollo moon landing project (1961-1969), which required the coordination of about 410,000 workers at a cost of $25 billion in 1961 dollars, or $154 billion in 2011. Another impressive achievement is the organization of the Olympic Games using project management. This is an example of an event project, where the project deadline is fixed and cannot be violated.

These successes were achieved for a fairly narrow range of applications. However, the potential for project management to be applied to a much wider set of applications gradually became apparent. Important modern applications include implementing a new IT system, research and development (for example, for pharmaceuticals), the management of strategic organizational change, new product and service development, and software development.

However, traditional and modern projects often have very different characteristics. First, the eventual configuration of traditional projects is much more transparent than for modern projects. For example, construction of a bridge or skyscraper typically does not start until very detailed blueprints have been drawn up. We say that such project management applications are *deterministic*. By contrast, the exact drug formula to be used in a new pharmaceutical is typically not known until late in the project, as a result of testing and regulatory approval. Similarly, the exact configuration of a software code is not known until its last line is written. We say that such project management applications are *nondeterministic*. Not surprisingly, the processes of scheduling and budgeting the project are considerably more difficult for nondeterministic projects than for deterministic ones. A second distinction lies in the difficulty of estimating the amount of work that has been completed so far. While a rough estimate is visually available in the case of a skyscraper, it is typically not available in the case of a software program. This lack of transparency about project progress makes it difficult to estimate time and cost variance relative to project progress, and without this information is it difficult to allocate resources that protect the performance of the project relative to its overall schedule and budget. A third defining difference lies in the time pressure under which projects are completed. By their nature, traditional projects are often of lengthy duration, whereas modern projects can be much shorter, especially for new products and services. With short product and service life cycles, for example as in the consumer electronics industry, a delay in project completion can mean that a product is simply uncompetitive.

In all the three examples considered above, the characteristics of modern projects make them substantially harder to manage, and especially to complete on time and on budget, than traditional projects. As discussed in Section 3 below, this has resulted in the development of new, alternative project management methodologies that can more effectively deal with the difficulties of modern projects.

Several reasons can be identified for the increasing importance of project management as a business process. Principal among these reasons are the following.

1. Project management effectively controls change, allowing organizations to introduce new products, processes and programs.
2. Projects are becoming more complex, making them more difficult to control without a formal management structure.
3. Projects with substantially different characteristics, especially in IT, are emerging.
4. Project management helps cross-functional teams to become more effective.
5. Companies are using project management to develop and test their future leaders.

The dominant professional organization that supports project management is the Project Management Institute, which operates branches in 180 countries. This organization had a worldwide membership of less than 10,000 in 1980, but this grew substantially to about 50,000 by 1996. Today, PMI has about 550,000 members. There are few, if any, other business processes that can demonstrate three consecutive decades of exponential growth in interest, or such a large professional interest level today. The rapid growth in project management applications has also created bottlenecks in the job market. For example, in summer 2010, there were 10,000 unfilled jobs in IT project management in Asia alone.

3. Development of Methodology

Although project management was not yet formalized as a business process at the time, a significant development occurred in 1917 when Henry L. Gantt (1861-1919) invented the Gantt chart. This chart keeps track of the progress of tasks and the allocation of resources to them over time, and is the central tool for visualizing project progress when using project management software.

The critical path method was developed by DuPont Company in the late 1950s. This method plans projects without considering either resources or uncertainty in task times. These simplifications permit the use of a simple algorithm that delivers optimal solutions. Several project management software packages, including the market leader Microsoft Project, also use this method as a key step in developing solutions.

In order to model the effect of uncertainty in task times, the consulting firm Booz Allen Hamilton developed the Program Evaluation and Review Technique (PERT), also in the late 1950s. This technique enables estimation of the impact of uncertainty in individual task times on the uncertain duration of the overall project. PERT is still used today in many companies. However, PERT relies on several strong statistical assumptions that are difficult to justify for most projects. As a consequence, the project duration estimates obtained from PERT are often unreliable and on average substantially biased towards the low side. Schonberger (1981) documents these problems. Many companies develop their own adjustment factors to account for the bias in PERT, but these factors are difficult to estimate robustly.

An alternative to PERT is Monte Carlo simulation. This methodology has been applied to project management since the 1960s, and avoids the worst problems of PERT. However, it makes stringent requirements on available data, since it requires knowledge of a probability distribution for each task time. In project management, the uniqueness of projects implies that such distributions are rarely available in practice. Although they can be estimated, it is difficult to predict the effect of choosing an incorrect distribution on the overall project duration estimate. A further problem is that companies have been reluctant to implement Monte Carlo simulation, apparently due to unfamiliarity with its statistical justifications and a possibly naive satisfaction with their existing methodology.

In recent years, there have been two significant methodological innovations in project management. Critical chain project management (Goldratt 1997) was developed by the influential consultant and business writer Eliyahu M. Goldratt (1947-2011). In order to prevent the dispersion of slack time around the project, where it may become lost due to Parkinson's Law (Parkinson 1958), slack time is collected into specific buffers. This converts the project management scheduling problem into one of buffer maintenance and management. Since the availability of software, for example ProChain, to support critical chain project management, many companies have reported significantly improved project performance as a result of using it.

Finally, the notion of agile project management was first popularized by the Agile Manifesto (agilemanifesto.org 2001). Agile principles include minimal planning and documentation, the submission of deliverables in small increments to obtain user feedback, and quick response. Agile project management has so far been influential mainly for the nondeterministic applications discussed in Section 2, especially research and development and software development. However, because it has some of the features of nondeterministic projects, the application area of new product and service development offers significant potential for future expansion (Smith 2007). A challenge that remains to be solved is the difficulty of scaling agile methodology for large projects outside of the software development domain.

4. Opportunities for Research

In this section, we describe a series of important research topics for project management, along with various associated research questions. These topics are grouped as follows. Section 4.1 considers project management under uncertainty, Section 4.2 considers contractual issues in project management, and Section 4.3 considers other emerging topics.

4.1 Project Management under Uncertainty

4.1.1 Robust Optimization for Project Scheduling

In projects with tight deadlines, or those that experience delays at the execution stage, a standard technique is crashing, i.e. expediting, tasks. In practice, crashing can be accomplished by a variety of means, for example by overtime, by the application of additional resources, or by the subcontracting of tasks. A crashing decision typically represents a tradeoff between time and cost, one that can be modeled as a simple linear program where task times are known. Crashing decisions become much more complex, however, when task times are uncertain. A frequent difficulty is that the project manager does not have an exact, or even approximate, probability distribution for the times of the individual tasks. Another difficulty is that the uncertain task times may be correlated. For example, if the same resources are used for two different tasks, it is likely that their performance on those tasks will show a positive correlation. Therefore, crashing decisions need to be made against a background of substantial and complex uncertainty. Two standard approaches that are widely used to make crashing decisions are PERT and Monte Carlo simulation. However, PERT requires problematic and potentially biasing assumptions (Schonberger 1981), whereas there is considerable resistance among project managers to the use of Monte Carlo simulation (White & Fortune 2002).

In these situations, modern robust optimization techniques (Bertsimas & Sim 2004, Goh & Sim 2010) may be useful. Such techniques can be used to develop linear decision rules that convert information that is revealed over time into decisions. In this case, task times are revealed over time, and that information is converted into crashing decisions. Because these techniques do not make strong distributional assumptions, their performance is typically much more robust against unusual or extreme task time realizations. A related concept that may be useful is satisficing (Brown & Sim 2009). In evaluating the complex tradeoffs between time, cost and risk that are required for effective crashing decisions, satisficing models provide the advantage that they do not require the decision maker to specify, *a priori*, a risk aversion parameter. Moreover, some satisficing measures have desirable properties that generalize standard objectives, for example the maximization of the probability of a project meeting its total cost, which includes both crashing cost and overhead based on project completion time. Goh & Hall (2012) develop linear and piecewise linear decision rules, and a rolling horizon approach, for a total cost satisficing model.

4.1.2 Robust Optimization for Project Selection

Both statistical and informal evidence suggest that a big factor in successful project management is selection of the right projects (Cooper et al. 2000). A major justification for this statement is that well chosen projects typically run smoothly and are easy to manage, whereas poorly chosen projects not only underperform but may hurt other projects by absorbing their resources. There are two fundamentally different approaches to project selection. First, projects can be selected individually, usually based on a quantitative and qualitative evaluation of their characteristics relative to predefined benchmarks. Alternatively, a project portfolio planning approach can be used to evaluate multiple projects and make simultaneous decisions about whether to accept them. The portfolio planning approach is both more precise and more powerful, but presents modeling and computational challenges. If project returns are known, these can be addressed using the knapsack (Kellerer et al. 2004) and related models (Fox et al. 1984, Dickinson et al. 2001). However, these challenges become much greater in the presence of (a) uncertain project returns without well specified probability distributions, (b) interactions, such as synergistic value, between project returns, and (c) correlation between project returns, for example between projects in the same industry or locality.

Several classical approaches exist for financial portfolio selection. These include (a) the maximization of expected return, (b) the minimization of the probability of underperformance relative to a given target, (c) the minimization of variance subject to meeting a target expected return (Markowitz 1959), and (d) the maximization of the safety-first ratio (Roy 1952). The work of Aumann & Serrano (2008) on riskiness indices suggests a new direction related to target based choice. Intuitively, it should be possible to identify the least risky project portfolio that meets a given target in a certainty-equivalent sense. However, modeling and identifying this portfolio present formidable computational challenges. For this reason, the design of a complex methodology for identifying an optimal portfolio needs to be supported by the design of a simpler methodology that can reliably identify good quality heuristic portfolios. Hall et al. (2011) minimize the underperformance risk of the project portfolio, using absolute risk aversion as a criterion, and considering both correlation and interaction effects between project returns.

4.1.3 Earned Value Analysis

Earned Value Analysis (EVA), also known as earned value management, is an accounting and control system for projects that was developed in 1962 as part of a U.S. Department of Defense study. It is based on metrics that monitor the progress of the project, including the actual cost of work performed, the budgeted cost of work scheduled (i.e., the budget), and the budgeted cost of work performed, which is also known as earned value. The central idea in EVA is that cost and time variances should be computed relative to the progress actually completed on the project. Despite this apparently sensible justification, EVA is not widely used in industry and has significant weaknesses.

One major weakness is that it does not distinguish between critical and noncritical activities, although time variance is clearly a more serious concern for critical activities. A related weakness is that EVA assumes that tasks are independent, whereas in practice they are often dependent, and consequently variance in one task affects the performance of another. Behavioral issues also arise from the use of EVA. For example, in order to make cost variance positive, managers may decrease the actual cost of work performed (Kim & Ballard 2000). EVA has no capability to measure quality, hence a project may be delivered on time and on budget but not meet client expectations (Wikipedia 2012). A further problem is that EVA imposes substantial information requirements on projects, for example precise measurement of project progress against a very detailed work breakdown structure, that projects often fail to meet (Lukas 2008). These weaknesses and limitations of earned value analysis imply the need for a new approach that can be used more generally and more flexibly. This is particularly important in view of the increasing use of agile methodology, which is not well served by EVA (Wikipedia 2012).

4.1.4 Policies for Task Notification

In a typical project, the start and end times of tasks are set from an initially planned schedule (Klastorin 2004, Kerzner 2009). In traditional project management, these are usually defined as Early Start (ES) and Late Finish (LF) times. The ES time serves as a wake-up call to the task operator, since it represents the earliest time at which work on the task should begin. The LF time serves as a deadline by which the task operator should deliver the task to the project manager; any delay beyond this point potentially results in delay of the overall project.

During project execution, however, it often becomes necessary to adjust the ES and LS times, either earlier or later, although later is more common. However, two problems arise. First, notifying a task operator of new ES/LF times has administrative and disruption costs. Second, the information based on which the notification is made may not be final, and hence may change again. In this case, decisions that are made on the basis of a notification that subsequently changes may be costly. For example, they may result in resource reallocations that will lead to resources being underutilized if a task is not available as predicted. As another example, they may result in a loss of opportunity to improve the overall project completion time, as would occur if late ES/LF times were given but the preceding tasks were actually completed early. A policy for task notification is a set of rules for determining when one or more task operators should be notified about a change in their ES/LF times. Policies can range from the simplest one of giving notification only when information is final, to more complicated ones that consider both the current best estimate of the time when a task could start and the reliability of that estimate. In this case, reliability can be measured using a variety of statistical metrics, for example variance. The development of a task notification system that effectively balances the costs of undernotification and overnotification can greatly assist project companies in managing their resources and controlling their project costs.

4.2 Contractual Issues in Project Management

4.2.1 Cooperation in Project Management

Successful completion of a complex project requires the cooperation of many task operators or subcontractors. In either case, they need to be motivated to crash, or expedite, their activities where doing so benefits the project as a whole. However, such crashing activities incur additional cost for the task operator or subcontractor. This additional cost requires compensation from the project. The need for cooperation also arises in a second way. By sharing their resources, the task operators or subcontractors can achieve synergies that improve efficiency. However, even though the overall project benefits, not all of them will necessarily benefit, hence once again compensation is required. The structure of this problem suggests that it can be modeled as a cooperative game (Peleg & Sudhölter 2003). The more important cooperative game concepts, such as balancedness, can be applied. The literature (Brânzei et al. 2002, Castro et al. 2008) applies cooperative game theory to the problem of setting compensation in a project that has already been delayed.

A potentially more useful application of game theory is attempting to ensure that the project is not delayed. There are various definitions of information availability that need to be considered, for example whether or not the project manager has full information about the costs and resource availabilities of the task operators or subcontractors. The full information case leads to the issue of contract design. It is necessary to specify incentives within the contract that ensure cooperation, and this can be achieved using either a common contract or one that is customized for each task operator or subcontractor. If the project manager does not have full information, then it is necessary to estimate costs and resource availabilities, and what is needed is a contract design that performs robustly against poor estimates. The possible use of strategic information by the task operators or subcontractors needs to be studied, for example whether they will report false information in order to obtain additional compensation. Conditions under which strategic reporting will not occur need to be developed. Cai et al. (2012) model the coordination problem as a cooperative game, which is shown to be balanced, and consider various contract design issues.

4.2.2 Real Options Analysis in Project Evaluation

For projects with predictable cash flows, a standard financial approach for evaluation is Net Present Value (NPV). For projects that include unpredictable outcomes, for example the results of mining exploration or of an application for regulatory approval, net present value analysis can be extended into decision tree analysis. However, both these methods ignore the effect of management options on project risk. Management options can include, for example, delaying a decision until more information becomes available, abandoning a project, or selling rights that have been acquired. These options substantially change the risk profile of a project, and hence the discount factor that should be applied in evaluating it. Yet neither of the above approaches accomplishes this. More specifically, while it is possible to use different discount rates at different stages of a project in NPV or decision tree analysis, the rates chosen would be arbitrary. However, Real Options Analysis (ROA) provides a way to calculate the value of management options and impute discount rates that correctly adjust for project risk. An introduction to the use of real options for investment decisions, including project selection, is given by Amram & Kulatilaka (1999).

ROA is widely used for financial asset evaluation, but here the analysis is easier because of the existence of multiple assets that replicate the performance of an option. By contrast, the impact of ROA on risk management in projects has been limited. A leader in the application of ROA is Hewlett-Packard, however the company apparently uses it mainly for procurement and other low risk, contract-protected decisions. ROA has been little used in high risk industries, such as pharmaceuticals. ROA is not useful if a company lacks the discipline to implement a management option. For example, ROA author N. Kulatilaka says, "Although you can make any project look good if you build in enough options, a real world approach must address two questions: when exactly do you shut it down, and is there a good mechanism in sight to do that?" For situations where such discipline does exist, however, further research is needed to take the important tool of ROA more deeply into the evaluation of projects. There are mathematical issues that need to be overcome to do this, and a greater understanding of the components of project risk needs to be obtained. Some counterintuitive results, to the effect that variability in outcomes may reduce the probability of management options ever being exercised, and thereby reduce their value, are obtained by Huchzermeier & Loch (2001).

4.2.3 Design of Early Completion Incentives

Task times in projects are typically uncertain, and may be either longer or shorter than their original estimate. Problematically, however, the effect on project completion time is not symmetric. As a result, task times that are longer than expected typically increase project completion time. Whereas, task times that are shorter than expected fail to reduce project completion time. The latter effect is primarily due to the behavioral phenomenon known as Parkinson's Law (1958). This well known principle states that "Work expands to fit the time available" (Parkinson 1955). An equivalent statement in the context of project management is that the time which it takes to complete a task is the amount of time that is made available for it (Wikipedia 2011). Goldratt (1997) proposes a project management structure, Critical Chain Project Management (CCPM), that claims to resolve the problem of Parkinson's Law. Patrick (1998) provides a detailed and supportive discussion of CCPM. However, as Raz et al. (2003) describe, there are several potential problems with CCPM. These include concerns about the behavioral effects of reducing safety margins, and also about the relative lack of progress control that arises from the removal of task deadlines.

One possible resolution to Parkinson's Law is a mechanism that is incentive compatible (Hurwicz 1972) for the agents, i.e. the task operators. A mechanism is incentive compatible if it is each agent's optimal choice, irrespective of what other agents do. Myerson (1979) shows that any equilibrium outcome of an arbitrary mechanism can be replicated by an incentive-compatible direct mechanism. This is the revelation principle, which simplifies the search for an efficient mechanism. What is needed to resolve Parkinson's Law is an incentive system that encourages task operators to report early completion of their tasks, and allocates rewards for doing so with sufficient flexibility that various considerations, such as incentives for the project manager and meeting the available budget, are respected. The design of such a scheme becomes substantially more complex if a single task operator has control over multiple tasks, and moreover those tasks are mutually dependent, for example if some are successors of others. An interesting extension would be to consider whether there is a difference between short-run and long-run incentives. For example, in the long run, early completion could result in a reduction in the time allowed for a task.

4.3 Other Emerging Topics

4.3.1 Learning between Projects

A popular view of projects is that each is unique. However, when considered at the task level, many projects have tasks that are similar or even identical to those in other projects. This similarity makes it worthwhile for companies to consider investing in learning activities between projects (Kotnour 2000). Some companies use a Project Management Office partly for this purpose. Several project learning methods have been developed, and their success rates investigated (Schindler & Eppler 2003). Different learning strategies are discussed by Pich et al. (2002). However, business pressures, especially the need for project managers to start work on a new project, tend to limit investment in learning from completed projects. It is indeed the case that investment in learning may delay the start of a later project. Therefore, there exists a significant tradeoff in finding the amount of learning between projects that is optimal, or even reasonably appropriate.

Research is needed to evaluate this tradeoff. The main variable to be considered is how much investment, measured by time and resources, should be made in learning on completion of a given project. This amount necessarily depends on the similarity of the completed project to future planned or anticipated projects; the greater the similarity, the more investment is worthwhile. Diminishing returns to time and resources invested in learning need to be considered. The cost of learning should be modeled. Because time spent in learning may delay the start of the next project, the time value of money should be considered. The completion times of future projects will depend on their makespan values, which need to be modeled as a function of previous learning and project similarity. Finally, depending on contract design, these values may have revenue and/or penalty implications.

4.3.2 Scalability of Agile Methodologies

The Agile Manifesto (agilemanifesto.org 2001), proposes a new methodology for software development projects, but has since become more widely applicable. Its principles include valuing: individuals and interactions over processes and tools, working software over comprehensive documentation, customer collaboration over contract negotiation, and responding to change over following a plan. Agile project planning is especially useful for nondeterministic projects, i.e. those where the final configuration of the product or service being developed is not known at the start of the execution stage and only reveals itself as a result of subsequent developments. Examples of nondeterministic projects include research and development, software development, and pharmaceutical drug development. There are many well documented success stories for agile methodology in projects involving small project teams (objectmentor.com 2012). However, the implementation of agile methods for large projects is more problematic. A generic idea, forming teams of teams, has been tested but not extensively researched. For software development applications specifically, there are some solutions related to appropriate architecture design (MSDN Blogs 2009). However, these solutions apparently do not extend to the broad and expanding range of project management applications where agile methodology is now being used.

An important issue, therefore, is to what extent it is possible to model and evaluate the scalability of agile project management methodology. Such models would necessarily include both economic and behavioral components, because of the importance that agile methodology places on interactions and communications. An interesting potential extension would be to develop a model that could be used, for a given project management application, to inform a choice between traditional project management and agile methodology. The dynamic, synergistic aspects of agile methodology would need to be included in such a model.

4.3.3 Sustainable Project Management

The footprint of the world's economic activity exceeded the earth’s biocapacity by 50% in 2007 (WWF 2010). In the U.K., for example, the main source of pollution is construction and demolition of buildings (Royal Commission on Environmental Pollution 2007); these activities are almost always organized as projects. An interesting research question is how a regulator can incentivize multiple projects to pollute less without unnecessarily increasing their costs. This problem has been studied under voluntary standards, especially the Leadership in Energy and Environmental Design (LEED) program (Corbett & Muthulingam 2007). However, it has apparently not been studied under explicit environmental regulatory constraints.

A typical regulatory constraint model involves two levels. At the higher level is a regulator who acts as the decision leader. The regulator sets limits on pollution of different types. The regulator optimizes a social welfare function that may include project costs, environmental benefits, and some investment in green technology. At the lower level are multiple project managers, who optimize their project costs, given the limits set by the regulator. Since the project managers act independently, the regulator may need to provide a subsidy to ensure optimization of its social welfare function. Among the issues to be overcome is the design of incentives for truth telling. For example, the project managers may exaggerate some of their costs, in order to receive less strict regulation. Ultimately, the most successful design of the system will (a) encourage truthful reporting, and (b) coordinate the decisions of the regulator and the project managers. Because of both the growing problem of industrial pollution, and the increasing use of project management in a wide variety of business applications, the development of an effective environmental regulation system for projects is an important issue.

5. Conclusions

Several conclusions can be drawn from this work.

1. We identify the following trends making project management harder: increased competition, shorter product and service life cycles, tighter budgets, unfamiliar and more complex applications, globally distributed and multicultural project teams.
2. In contrast, several trends are making project management easier: better project management training, publication of best practices information, and better software support. The relative impact of these two effects varies from application to application.
3. Underestimation of the value of project management as a planning methodology over the last 20 years has led research to fall behind recent business innovation and the growing range of applications.
4. Important recent developments on the business innovation side of project management are not yet well supported by research.
5. Leading journals in operations research and operations management have published few articles on project management in the last 10 years, compared to many other topics of comparable practical importance.
6. Practice and research have diverged, and few new researchers have entered the project management field.

Our overall conclusion is that a confluence of these factors has resulted in numerous interesting research opportunities in project management for at least the next 10 years.

Acknowledgments

This research is supported in part by the Summer Fellowship Program of the Fisher College of Business, The Ohio State University. Preliminary versions of this paper were presented as plenary addresses to ICSSSM'2011, Tianjin, China (June 2011) and to Taishan Academic Forum, Rizhao, China (July 2011).

References

[1] agilemanifesto.org. (2001). Manifesto for Agile Software Development. Available via DIALOG. http://agilemanifesto.org/

[2] Amram, M. & Kulatilaka, N. (1999). Real Options: Managing Strategic Investment in an Uncertain World. Harvard Business School Press, Boston, MA

[3] Aumann, R. & Serrano, R. (2008). An economic index of riskiness. Journal of Political Economy, 116: 810-836

[4] Bertsimas, D. & Sim, M. (2004). The price of robustness. Operations Research, 52: 35-53

[5] Brânzei, R., Ferrari, G., Fragnelli, V. & Tijs, S. (2002). Two approaches to the problem of sharing delay costs in joint projects. Annals of Operations Research, 109: 359-374

[6] Brown, D.B. & Sim, M. (2009). Satisficing measures for analysis of risky positions. Management Science, 55: 71-84

[7] Cai, X., Hall, N.G. & Zhang, F. (2012). Cooperation and contract design in project management. Working paper, Department of Systems Engineering and Engineering Management, Chinese University of Hong Kong

[8] Castro, J., Gómez, D. & Tejada, J. (2008). A polynomial rule for the problem of sharing delay costs in PERT networks. Computers & Operations Research, 35: 2376-2387

[9] Cooper, R.G., Edgett, S.J. & Kleinschmidt, E.J. (2000). New problems, new solutions: making portfolio management more effective. Research-Technology Management, 43: 18-33

[10] Corbett, C. & Muthulingam, S. (2007). Adoption of voluntary environmental standards: the role of signaling and intrinsic benets in the diffusion of the LEED green building standards. Working paper, Anderson Graduate School of Management, UCLA

[11] Dickinson, M.W., Thornton, A.C. & Graves, S. (2001). Technology portfolio management: optimizing interdependent projects over multiple time periods. IEEE Transactions on Engineering Management, 48: 518-527

[12] Fox, G.E., Baker, N.R. & Bryant, L.J. (1984). Economic models for R&D project selection in the presence of project interactions. Management Science, 30: 890-902

[13] Goh, J. & Hall, N.G. (2012). Total cost control in project management via satisficing. Working paper, revised for publication, Fisher College of Business, The Ohio State University, Columbus, Ohio

[14] Goh, J. & Sim, M. (2010). Distributionally robust optimization and its tractable approximations. Operations Research, 58: 902-917

[15] Goldratt, E.M. (1997). The Critical Chain. North River Press, Great Barrington, MA

[16] Hall, N.G., Long, Z., Qi, J. & Sim, M. (2011). Managing underperformance risk in project portfolio selection. Working paper, Fisher College of Business, The Ohio State University, Columbus, Ohio

[17] Huchzermeier, A. & Loch, C.H. (2001). Project management under risk: using the real options approach to evaluate exibility in R&D. Management Science, 47: 85-101

[18] Hurwicz, L. (1972). On informationally decentralized systems. In: McGuire, C.B., Radner, R. (eds.), Decisions and Organization. North-Holland, Amsterdam, Netherlands

[19] Kellerer, H., Pferschy, U. & Pisinger, D. (2004). Knapsack Problems. Springer, Berlin, Germany

[20] Kerzner, H. (2009). Project Management: A Systems Approach to Planning, Scheduling, and Controlling, 10th edition. Wiley, Hoboken, NJ

[21] Kim, Y.W. & Ballard, G. (2000). Is the

earned-value method an enemy of work flow? Working paper, Department of Civil and Environmental Enginering, University of California at Berkeley, Berkeley, CA

[22] Klastorin, T.D. (2004). Project Management: Tools and Trade-Offs, 1st edition. Wiley, Hoboken, NJ

[23] Kotnour, T. (2000). Organizational learning practices in the project management environment. International Journal of Quality & Reliability Management, 17: 393-406

[24] Lukas, J.A. (2008). Earned value analysis - Why it doesn't work. AACE International Transactions, EVM.01.1-EVM.01.10

[25] Markowitz, H.M. (1959). Portfolio Selection: Efficient Diversification of Investments. Wiley, New York

[26] Myerson, R. (1979). Incentive compatibility and the bargaining problem. Econometrica, 47: 61-73

[27] MSDN Blogs. (2009). Architecture makes agile processes scalable. Available via DIALOG. http://blogs.msdn.com/b/nickmalik/archive/2009/05/19/architecture-makes-agile-processesscalable.aspx. Cited May 19, 2012

[28] objectmentor.com. (2012). Agile/XP object mentor success stories. Available via DIALOG. http://www.objectmentor.com/omSolutions/agile_customers.html

[29] Parkinson, C.N. (1955). Parkinson's law. Economist, November 19

[30] Parkinson, C.N. (1958). Parkinson's Law: The Pursuit of Progress. John Murray, London, UK

[31] Patrick, F.S. (1998). Critical chain scheduling and buffer management: getting out from between Parkinson's rock and Murphy's hard place. Available via DIALOG. http://www.focusedperformance.com

[32] Peleg, B. & Sudhölter, P. (2003). Introduction to the Theory of Cooperative Games. Kluwer, Boston, MA

[33] Pich, M.T., Loch, C.H. & De Meyer, A. (2002). On uncertainty, ambiguity, and complexity in project management. Management Science, 48: 1008-1023

[34] Project Management Institute. (2008). A Guide to the Project Management Body of Knowledge, 4th edition

[35] Raz, T., Barnes, R. & Dvir, D. (2003). A critical look at critical chain project management. Project Management Journal, 36: 24-32

[36] Roy, A.D. (1952). Safety-first and the holding of assets. Econometrica, 20: 431-449

[37] Royal Commission on Environmental Pollution. (2007). The urban environment. Available via DIALOG http://www.official-documents.gov.uk/document/cm70/7009/7009.pdf

[38] Schindler, M. & Eppler, M.J. (2003). Harvesting project knowledge: a review of project learning methods and success factors. International Journal of Project Management, 21: 219-228

[39] Schonberger, R.J. (1981). Why projects are always late: a rationale based on manual simulation of a PERT/CPM network. Interfaces, 11: 66-70

[40] Smith, P.G. (2007). Flexible Product Development: Building Agility for Changing Markets. John Wiley, Hoboken, NJ

[41] White, D. & Fortune, J. (2002). Current

practice in project management: an empirical study. International Journal of Project Management, 20: 1-11

[42] Wikipedia. (2011). Parkinson's law. Available via DIALOG. http://en.wikipedia.org/wiki/Parkinson's_Law

[43] Wikipedia. (2012). Earned value management. Available via DIALOG. http://en.wikipedia.org/wiki/Earned_value_management

[44] WWWF. (2010). Living planet report. Available via DIALOG. http://wwf.panda.org/about_our_earth/all_publications/living planet report

Nicholas G. Hall is Professor of Management Sciences in the Fisher College of Business at The Ohio State University. He holds B.A., M.A. degrees in economics from the University of Cambridge, a professional qualification in accounting, and a Ph.D. (1986) from the University of California at Berkeley. His main research interests are in tactical operations issues, especially project management, scheduling and pricing, public policy and sports management problems. He is the author of over 70 refereed publications, and has given over 260 academic presentations, including 88 invited presentations in 20 countries, 6 conference keynote presentations and 6 INFORMS tutorials. A 2008 citation study ranked him 13th among 1,376 scholars in the operations management field. He is a Fellow of the Institute for Decision Making under Uncertainty of the Chinese Academy of Sciences. He won the Faculty Outstanding Research Award of the Fisher College of Business in 1998 and 2005.