Role of technology in project manager performance model

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PAPERS

The Role of Technology in the Project Manager Performance Model

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ABSTRACT

Technology assumes importance in the context of project management due to greater challenges in today's technology-enabled work environment, where technology tools are routinely used for collaboration, communication, and deployment of project management practices. It is becoming common practice for even co-located project teams to use the electronic medium for these purposes. Notwithstanding the importance of technology, research has shown that it is difficult to associate the use of technology with business performance and the absence of such relation can be extrapolated to project performance as well. However, technology can play a major role in supporting project managers in managing projects effectively and efficiently. Several studies have addressed the importance and leadership style of project managers. However, specific roles and responsibilities of a project manager toward the project team is an area that needs further study. In this research effort, using the literature review, important people-related factors of project performance are identified. Then structured personal interviews were used to gather data for understanding relations among these factors in order to develop a project manager performance model. The model was developed employing the interpretive structural modeling (ISM) methodology. The model was used to determine the role of the project manager in managing the project team and improving the project performance. Results show that both leadership and management roles are important. This study helped to analyze underlying interactions among these factors and, consequently, understand the supportive function of technology to the project manager in improving project performance.

KEYWORDS: project performance; project leadership; interpretive structural modeling (ISM); information technology (IT); knowledge management (KM); project management (PM)

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INTRODUCTION

In the present economy—characterized by globalization, outsourcing, increased competition, and speed of service—intangible assets, such as knowledge and know-how are emerging as key value drivers for enterprises. In this technology-driven business environment, projects, due to their complexity and size, are compelled to utilize technology and tools extensively. Further, benefits of information technology (IT) and knowledge management (KM) are encouraging even co-located project teams to use technology for collaboration and communication.

Business is becoming increasingly projectized, and global spending on projects costs many billions of dollars annually (Williams, 2005). The reasons are obvious. Projects—aimed to operationalize organization's strategic objectives—are conceived and developed to develop products and services and to gain operational efficiency. Projects are also employed for implementation of new processes, capital expansion, and the management of time-to-market goals for new products (Birk, 1990). In spite of advances in the project management (PM) discipline and profession, the common experience suggests that many projects fail (Williams, 2005), which underscores the importance and the need to improve project management processes and performance. A vast body of project management knowledge has developed in recent decades; however, a peek at project management's history of development suggests that in spite of proven practices, incremental improvements are not enough to respond to today's challenges (Nidiffer & Dolan, 2005).

Firms invest in PM tools and techniques, such as computer software for sophisticated schedule and budget tracking in intricate organizational process designs like concurrent engineering (Thamhain, 1999). However, technology alone is not a solution to improving project performance. Even after spending several billions of dollars on IT, the difficulty facing organizations is how to connect their IT investments to the business performance (Marchand, Kettinger, & Rollins, 2000). Several studies have yielded evidence of a so-called "productivity paradox" (Anderson, Banker, & Ravindran, 2003; Brynjolfsson & Hitt, 1998; King, 2002) with respect to the net result of investments in IT infrastructure. Addressing these issues, a research study assessing the role of IT and KM in project performance found that the project team's goal orientation and trust should influence IT processes (Anantatmula & Kanungo, 2005) to make IT investments meaningful. Based on these research findings, it is clear that the technology role is limited to supporting complex issues and processes; Nidiffer and Dolan (2005) observed that people and processes are at the heart of project management, not tools and technology. However, technology and tools are necessary to manage teams and projects effectively.

Given that people and processes are important, many research studies have discussed the importance and/or style of project leadership (Christensen & Walker, 2004; Cleland, 1995; Day, 1998; Keegan & Den Hartog, 2004; Leban & Zalauf, 2004; Thamhain, 1999; Thite, 1999; Weiss & Anderson, 2003; Wirth, 1992) in project performance. As stated, these studies refer either to the importance or style of leadership for project performance. However, specific leadership roles and responsibilities of the project manager toward project team members to improve the performance is a gray area that needs further study.

The focus of this study is to identify a set of people-related factors that influence project success and to understand how these factors interrelate with one another. Using these interrelationships, a project manager performance model is developed in improving project performance. Further, the model is used to help identify areas where technology is important as a supporting function. Needless to say, only after discerning the project manager's role in performance can technology's supportive role be examined.

In this paper, we start with a review of literature, first to understand the limited role of technology in project performance, and then to document the importance of the project manager's role toward the project team in improving the performance as a background for the research. Using the literature research and analysis, we identify a list of people-related factors that contribute to project performance. We then present the research methodology for collecting data to develop underlying relations among these factors. As a part of our analysis, we explore the structural linkages between these factors and provide a detailed discussion about these linkages. Further, we discuss how to use these linkages to determine the project manager's role from research and practitioner's perspectives. Subsequently, we establish the critical and supportive role of technology in project manager performance. Finally, we present limitations of the research study and suggest opportunities in the future research efforts.

Background

Globalization and free market philosophy—forces that shaped our present economy—are causing far greater challenges than ever to meet customer needs. The resultant competition is compelling organizations to develop products and services faster, cheaper, and better in order to maintain competitive advantage in the market place. To attain and sustain competitive advantage, organizations focus on how they practice PM and integrate technologies, such as IT and KM in dealing with complexity while improving efficiency, effectiveness, and innovation.

Presently, outsourcing is a common business practice to gain and sustain competitive advantage because outsourcing helps acquire quality services and expertise at a lower cost. Consequently, virtual project teams are integral to many projects. A case in point is Infosys Technologies Limited, which uses technology to manage projects. It has a conference room in Bangalore, India, that can hold a virtual meeting—on a super-size screen—of the key players from its entire global supply chain to integrate project functions and work as an effective project team (Friedman, 2005). In the current economy, top management priorities are building virtual teams with a minimum of face time, clearly defining work, measuring cybernetic worker productivity, and managing employee communications across time zones (Nidiffer & Dolan, 2005). These priorities are relevant to projects as well, and they have a significant impact on the project manager's role and how projects are managed.

Projects are executed in teams because they are driven by the need to integrate multiple disciplines and diverse skills to meet project objectives successfully. As such, being a member of a team is an inevitable feature of modern work life (Smith, 2001), and projects are no exception. Projects are managed using teams in a work environment that is complex for two reasons: (1) each project is unique and (2) conditions for team selection and motivation are often far from ideal (Smith, 2001). Furthermore, the organization structure poses additional problems in team selection. In most of the organizations (matrix and functional type), a project manager may not have discretion to select the project team, and it is the functional manager who plays a major role in the formation of the team. Also, some of the project team members are engaged in more than one project. The challenge for the project manager is to make best and most effective use of the team that is selected. The challenge of managing a project team does not end here. In addition to uniqueness and complexity, unfamiliarity is often considered one of the characteristics of projects. Thus, projects are often associated with change, which habitually faces resistance. Consequently, leadership is a determinant of success, as it provides vision and ability to cope with change (Kotter, 1999).

Technology and Project Management

It is true that IT facilitates storage and quick retrieval of large amounts of data and information. However, from a KM perspective, IT is useful for efficient conversion between data and information but it is a poor alternative for converting information into knowledge (Ra, 1997). Prieto and Revilla (2004), citing research studies, suggested that conversion from information to knowledge is best accomplished by human actions; however, they pointed out that humans are slow as compared to IT systems for converting data into information. KM is generally designed to address both these issues. Martin, Hatzakis, Lycett, and Macredie (2004) showed that KM can be seen as a holistic way to manage the complex relationship between business and IT. Martin et al. contend that effective KM, which promotes one vision and improved communication, will have a direct impact on the ability of firms to bridge the gap between IT and end-users, thereby impacting organizational performance. Therefore, IT in conjunction with KM can be a remedy to this issue.

In this paper, the term *technology* is used to denote both the IT and KM for two reasons: (1) KM is considered as a bridge between IT and business and (2) combining both KM and IT will provide opportunities to enhance performance in a project environment.

Many organizations invest in technology to improve organizational performance and to gain competitive advantage. Several studies attempted to link IT and/or KM methods and models to improved organizational performance (Ahn & Chang, 2002; Jennex & Olfman, 2002; King, 2002; Marchand et al., 2000). However, the relation is not always obvious.

To learn about the likely outcomes of applying technology, a comprehensive research study of IT investments and their effect on business performance was carried out by Marchand et al. (2000). The study included more than 1,000 senior managers from 98 organizations. Marchand et al. concluded that information operation, which measures an organization's capabilities to effectively manage and use information, influences business performance. Likewise, a research study to assess KM success that included 147 organizations in 21 countries identified improved communication, enhanced collaboration, improved employee skills, better decision making, and improved productivity as the most useful outcomes of KM (Anantatmula, 2005). From these studies, we can conclude that the technology role is limited to supporting a project manager's effective use of information to improve project performance.

Technology's role in project performance depends on how technology systems are designed in organizations. A recent research study (Anantatmula & Kanungo, 2005)—after identifying measures of effectiveness for technology (IT and KM) and project performance and studying the relationship among these measures—suggested that organizations should develop technology systems to meet specific business and project needs, and they should not be designed in isolation with the assumptions that people will use it for productive purposes. Anantatmula and Kanungo (2005) concluded that technology systems must be developed to meet specific business and project needs.

Technology can meet the project management needs of documenting for easy storage and retrieval, and managing organizational knowledge of the past projects. According to Kasvi, Vartiainen, and Hailikari (2003), successful project completion is influenced by accumulated knowledge and individual and collective competence. However, projects usually experience frequent personnel changes, and people involved with projects are often dispersed when projects end, which creates challenges for generating, transferring, and sharing knowledge (Karlsen & Gottschalk, 2004). Technology—IT and KM—by helping store, develop, and share information and knowledge of past and present projects helps develop detailed specifications and reduce the extent and impact of such uncertainties. Additionally, technology can help streamline and standardize project management processes.

Evidence from earlier studies suggests less than satisfactory performance in spite of many PM tools and techniques available. Christensen and Walker (2004) argued that tools and methodologies play a limited role, and project success, to a large extent, depends on the leadership. Thamhain's study (2004b), however, indicated that IT is profoundly affecting PM capabilities, scope, and leadership style. These technologies provide PM tools for planning and Web-based support systems, which are essential for communication, conflict resolution, knowledge sharing, and integration of complex projects. The shift to sophisticated PM tools, driven by factors such as project complexities and diverse cultures requiring new management skills, is having a profound impact on project leadership. These results assume importance in the present context because methods of communication, decision making, soliciting commitment, and risk sharing shift management style to a team-centered and self-directed form of project control. The current research effort is concerned with addressing this issue.

The Project Manager's Role

It is evident from the literature that people-related issues dominate the project performance. Kerzner (2006), a well-known researcher of project management discipline, stated that projects fail to meet time and cost targets due to people-related issues, such as poor morale, poor human relations, poor productivity, and lack of commitment. In addition to working across functional and organizational environments—traditionally designed to support functional managers—the project manager has other challenges, such as providing leadership without documented formal authority and working in matrix organizations where unity of command is an issue (Cleland, 1995). Consequently, project managers are perceived to be leading a diverse set of people with little direct control (Cleland & Ireland, 2002).

The importance of leadership in project performance is widely researched and documented. Cleland (1995) considered that a project's success or failure is the result of the leadership of project stakeholders. Leadership is considered a critical success factor for projects (Thite, 1999), and it is argued that there is a greater need for leadership rather than management (Day, 1998). After a study of IT projects, Thite (1999) concluded that the size of the project determines the importance of the leadership: The larger the project, the greater its importance and style. Additionally, not all project teams are the same, and they have varying consequences for leader behavior and effectiveness (Keegan & Den Hartog, 2004). From the project execution perspective, leadership style and the integration of the management tools with the team and the project management process influence project performance (Thamhain, 1999).

For a project to be successful, different types of work associated with different types of products must be managed differently. Although PM theory, practice, and accompanying tools are transportable between different types of projects, it is the specific application in the context of each project that is different (Wirth, 1992) and is determined by the project leadership. Thus, the situational leadership style to adopt project environments is considered important. However, it is interesting to note that several studies identified that transformational leadership is related to project success. Christensen and Walker (2004), after analyzing four case studies, argued that since projects are transformations, and vision is an idealization of this transformation, transformational leadership should be evident in successful projects. Another study of 24 project managers from various industries found that a project manager's transformational leadership style has a positive impact on actual project performance (Leban & Zalauf, 2004). Likewise, a study of 32 organizations (Thite, 1999) revealed that managers of successful IT projects exhibit transformational and technical leadership behaviors to a greater extent than managers of less successful IT projects. It could be attributed to the roles of IT leaders, which are strategic, with an external focus and involve change management and business problem-solving skills (Weiss & Anderson, 2003). Positive results associated with transformational leadership are not limited to IT projects alone. A study of 66 industrial R&D project groups found that transformational leadership accounts for higher project quality in research projects (Keller, 1995). However, one of the challenges of project leadership is its limited role as a transformational leader. Helping subordinates develop to their fullest potential is an integral part of transformational leadership; however, projects may offer a limited role for transformational leadership from this perspective in traditionally functional hierarchy organizations (Keegan & Den Hartog, 2004). A limited role is attributed to project formation and organizational structure that are different from those of traditional organizations, including the time-bound participation of people in multiple projects reporting to different project leaders.

There is no definitive skill and leadership style mix that is appropriate for handling different types of projects, and project leadership orientation is not related to project structure (Lee-Kelly & Leong, 2003), which brings us back to the issue that the project manager has to learn which type of leadership is effective (Keller, 1995). Keegan and Den Hartog (2004), presenting a different perspective, concluded that there are no significant differences between perceived leadership styles of line managers and project managers in terms of their transformational leadership behavior. They suggested that new leadership theories are to be developed for new forms of organizing with multiple forms of governance, commonly associated with project management. The research studies discussed thus far are directed toward the importance and style of project leadership. However, the role of the project manager as a leader toward his or her project team members is not addressed; specifically, what project leaders should do to ensure project success is a subject of interest, and the focus of this study.

Research Methodology

In this research methodology, we will first, using the literature review, identify both success and failure people factors of projects as drivers of project performance. Using these factors, we will develop a questionnaire in interpretive structural modeling (ISM) methodology that will be used to determine underlying relations among these factors.

Literature Review on Project Performance

Schultz, Slevin, and Pinto (1987) and Pinto, Slevin, and Dennis (1987) identified 10 factors of success. Among them are the following factors that influence project success:

- clearly defined goals;
- top management support of resources;
- detailed plan and implementation processes;
- consultation with clients and stakeholders to determine expectations;
- monitoring and feedback;
- adequate communication with all the stakeholders including the project team; and
- ability to handle unexpected problems.

The importance of top management support is due to the inherent features of the project. Similar to these findings, another study involving 500 development projects revealed that top management support, a clearly defined project mission, and a cohesive project team are predictors of project success (Larson & Gobeli, 1989). Fedor, Ghosh, Caldwell, Maurer, and Singhal (2003) suggested that organizational support—viable with top management support—was positively associated with project success. Hartman and Ashrafi (2002), in their study of the IT industry, also identified four factors—clearly defined mission, top management support, detailed plan, and communication—as critical for success.

A clearly defined project mission, when translated into measurable project outcomes, becomes an important people-related factor. Nonetheless, not many organizations have a formal process of evaluating project performance. Usually, the perception of failure and success is based on unspoken and personal indices. As a result, assessments by different people about the success of the same project would be different (Rad, 2002), which drives the need for a set of performance indices that formalize the evaluation process and make explicit what is implicit in these seemingly subjective evaluations.

A worldwide benchmark study of organizational PM practices involving more than 550 organizations (Mullaly, 2004) identified several key attributes and drivers of PM success and failure. Among the key attributes of PM success are: establishing an environment of trust, creating transparency of decision making, creating consistent processes, ensuring understanding of expectations, and delivering results. Drivers of PM failure include failure to define processes and roles, failure to develop and use a project selection process, failure to mandate consistent processes, and failure to manage the attainment of organizational outcomes. Project selection precedes projects and with the exception of it, the remaining factors of success and failure are people-related.

In line with Mullaly's (2004) findings, an important research study suggested that one of the most striking findings is that many factors that drive project team performance are derived from the human side (Thamhain, 2004a). Among these factors, managing conflicts and problems in projects is an important determinant of project success. The people skills focus on fostering a climate of active participation and minimal dysfunctional conflict and imply an environment of trust, consistent processes, communicating expectations, and clarity in communications. Also, it is important to define roles and responsibilities of project team members without ambiguity (Day, 1998) to avoid conflict and encourage teamwork. In his earlier study of 400 professionals, Thamhain (1999) identified the criteria for effective project team management. They are:

- understanding the tasks and roles of the project team members;
- defining each team member's individual responsibilities and role and level of accountability;
- creating an environment of trust and support in problem solving;
- motivating team members and encouraging open, effective communication; and
- providing appropriate communication tools, techniques, and systems.

With a specific focus on team leadership effectiveness in a technology-enabled project environment, Thamhain (2004b) found that satisfying personal and professional needs of team members will have the strongest effect on team performance and identified some other factors, which include ability to resolve conflict, mutual trust and respect, and communications across organizational lines.

Close communication is considered critical to the success of fast-track projects, and a clear, concise statement of project objectives is considered important (Day, 1998). Underlining the importance of communication, Fedor et al. (2003) suggested that leadership can either facilitate or constrain the free flow of information and ideas. Likewise, Weiss (2001), in his study of e-businesses, identified several barriers and drivers to project success. Barriers include poorly defined processes and communication, and drivers are effective project leadership, ability of leaders and team members to articulate and communicate problems and solutions effectively, and collaborative, fun cultures that promote satisfaction.

In the context of problems attributed to failures associated with large projects, Potts (2000) linked the severity of these problems to the ability to form teams effectively, provide appropriate leadership, understand how to persuade, select an appropriate negotiation style, achieve good communication, and develop full problem-solving behavior. Potts further argued that these "soft skills" make a considerable difference to project effectiveness and efficiency.

Citing other studies, Turner and Müller (2005) argued that success factors vary over different stages of the project life cycle. In a related and earlier study of variations in critical success factors in project life-cycle stages, client acceptance of functions at an early stage of planning was found to be significantly related to project success, underlining the importance of determining stakeholder expectations early in the project (Pinto & Prescott, 1987). Likewise, after a comprehensive literature review of critical success factors of projects from the 1960s to the present, Jugdev and Müller (2005) recommended that project managers should—early in the project—identify success indicators that include both efficiency and effectiveness, which address the needs of key stakeholders, assess them using simple measures, and develop and maintain good and effective communication with key stakeholders.

Using all the references and research studies discussed previously, we developed a summary list of significant and people-related project performance factors (Table 1). In developing this list, we identified common factors, coined new terms for some of these factors, and explained these terms in Table 1.

ISM Approach

After the set of factors that could help assess that project performance was established (Table 1), we proceeded to understand the shared underlying organizational framework in which these factors operate using ISM. Human brains are limited in dealing with complex problems involving a significant number of elements and relations among elements (Waller, 1975). However, with the use of ISM, we deal with two elements at a time.

ISM is a process that helps groups of people to structure their collective knowledge and to model interrelationships in a way to enhance our ability of understanding complexity. In other words, it helps to identify structure within a system of related elements and provides the opportunity to analyze it from several viewpoints. Figure 1 was presented to the respondents of the survey, and respondents were asked to fill out the white cells of the matrix shown in the figure by following

Factor	References	Description
Create clarity in communications	*Weiss (2001), Thamhain (1999, 2004a), Mullaly (2004), Day (1998), Schultz, Slevin, and Pinto (1987), Potts (2000), Fedor, Ghosh, Caldwell, Maurer, and Singhal (2003), Jugdev and Müller (2005), Hartman and Ashrafi (2002)*	Clarity in defining project goals and likely project outcomes is critical, specifically during the early stages of a project. Failure to do so would lead to not identifying some of the project requirements. Incorporating these requirements at a later stage of the project would lead to time and cost overruns.
Define roles and project management processes	*Weiss (2001), Thamhain (1999, 2004a), Mullaly (2004), Day (1998), Hartman and Ashrafi (2002)*	Clear assignments of roles and responsibilities without ambiguity or overlapping responsibilities are important for conflict resolution and productivity. This will lead to effective use of project team members and their expertise. It also helps functional managers to understand the project requirements and provide support.
Communicate expectations	*Weiss (2001), Thamhain (1999, 2004a), Potts (2000), Mullaly (2004), Day (1998), Schultz et al. (1987), Hartman and Ashrafi (2002), Pinto and Prescott (1987)*	Failure to define and establish expectations from all the stakeholders at the project process level is a common problem that will eventually result in both perceived and actual incidences of not delivering expected results. This is specifically true with stakeholders within and outside the project who are not actively involved with projects.
Employ consistent processes	*Thamhain (2004a), Smith (2001), Mullaly (2004), Hartman and Ashrafi (2002)*	Many organizations manage projects with no formal processes. Mandating consistent and formal processes would lead to improved risk management, reduced ambiguity, and increased project management maturity.
Establish trust	*Thamhain (1999), Mullaly (2004), Day (1998), Thamhain (2004a)*	Trust is critical for knowledge sharing and teamwork. An environment of trust is established by clear definition of roles and responsibilities and it promotes team performance. An environment of trust is influenced by the organizational culture that promotes transparency, collaboration, and openness. It ultimately leads to a cohesive project team.
Facilitate support	*Thite (1999), Thamhain (1999), Fedor et al. (2003), Schultz et al. (1987)*	Organizational willingness to help the project is an outcome of top management support and it is critical in the event of changes in project requirements. Obtaining organizational support is a challenge in traditional organizations, where resources are usually controlled by functional managers.
Manage outcomes	*Thite (1999), Rad (2002), Mullaly (2004), Fedor et al. (2003), Cleland (1995), Schultz et al. (1987), Jugdev and Müller (2005)*	A clearly defined project mission and objectives would help us develop a formal evaluation of project outcomes to determine project success. It promotes performance excellence, motivation, recognition, and synergy in teams.

Table 1: Project performance factors.

		1	2	3	4	5	6	7
1. Establish environment of trust	1							
2. Create clarity in communications	2							
3. Define processes and roles	3							
4. Communicate expectations	4							
5. Employ consistent processes	5							
6. Facilitate organizational support	6							
7. Manage outcomes	7							

Contextual relationship = leads to

What to enter in the white cells
Enter V when the row influences the column
Enter A when the column influences the row
Enter O when there is no relation between the row and the column
Enter X when row and column influence each other

Figure 1: ISM methodology—Template for data collection.

the directions provided below the matrix.

Respondents were asked to answer a total of 21 questions, with each cell representing a question. Respondents were asked to compare the column statement with the row statement for each cell and to choose a value from the set (V, A, O, or X). For example, the cell (1, 2) represents the question, "Does clarity in communications lead to establishing an environment of trust or vice-versa?" and the response (V, A, X, or O) is entered in the cell (1, 2). These symbolic values (V, A, O, or X) are translated into binary values to develop directional graph. The detailed ISM methodology used to develop the directional graph is explained in Appendix A. The contextual relation is established based on a pair-wise assessment of all the seven factors as shown in Figure 1, and the majority (75%) of the respondents agreeing to a specific relation between any two elements. With the use of this methodology, one can (a) identify the direct and indirect relationships between attributes of project performance and (b) show how to include softer variables in the analysis.

Data Collection

A total of 54 project management professionals participated in the study. On an average, respondents have 10 years of project management experience. Of those who participated in the study, a majority of the respondents (54%) are project managers (Figure 2). The participation of consultants (23%) and senior executives (23%) presented diverse and different perspectives for the study. The respondents represented various segments of the economy, with IT (23%) and telecom (24%) industries representing nearly half of the population participating in the study. Government (15%), consulting (15%), and automotive industries (15%) have an equal level of participation (Figure 3).

Using the research data collected from these respondents and following the steps described in Appendix A, the ISM directional graph is developed (Figure 4).

The contextual relationship in Figure 4 was "leads to," and each arrow should be read as "leads to." The intermediate computations are shown in Appendix B. Respondents were also asked to denote the order of importance among these elements. The number for each box denotes the priority of the element, with 1 denoting the highest priority and 7 denoting the lowest priority. Managing outcomes is accorded the lowest priority. However, we should exercise caution in interpreting this low priority. Once all the other success elements are addressed, the project manager can focus on outcomes, and this low priority does not mean that managing outcomes is considered unimportant.

Discussion

In general, projects have to deal with complexity and change. Time and budget constraints, uncertainty, and unknowns contribute to project complexity. And the complexity demands project managers to plan and manage projects within these constraints. Further, absence of control over project team selection and lack of formal authority over project team members contribute to the challenges associated with leading a project. Projects are new and often have little precedence. When changes are significant in a project, the leadership role assumes greater importance. On the other hand, when projects are complex, the project manager's emphasis will be on planning and controlling.

Project planning, which includes identifying total work, estimating total effort and cost, and developing a schedule, is developed to make optimum use of all resources. Work packages and associated tasks require people from multiple disciplines to accomplish a task with a high degree of coordination. Under these circumstances, it is essential to define roles and responsibilities to bring stability and order. Figure 4 depicts these roles by identifying the underlying relations among critical attributes of the project manager. It makes perfect sense that respondents attached the highest priority to defining processes and roles; it is the foundation for planning and managing a project. Without such formal definition and

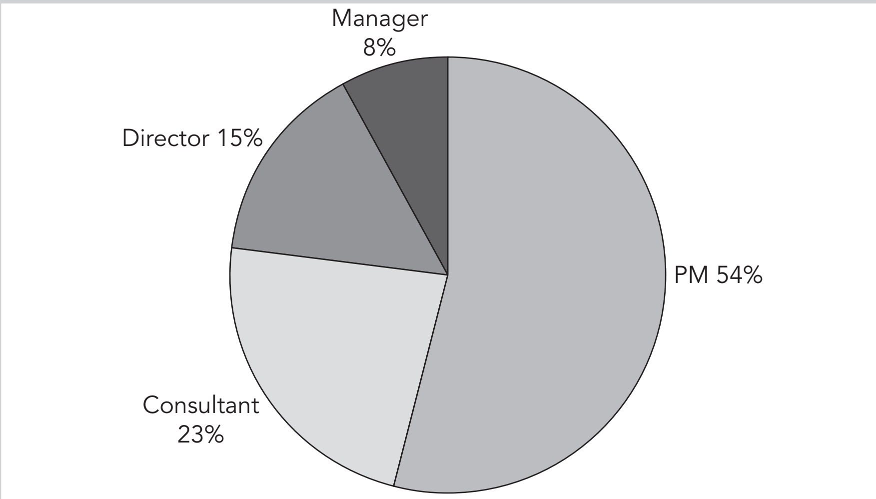

Figure 2: Respondent profile.

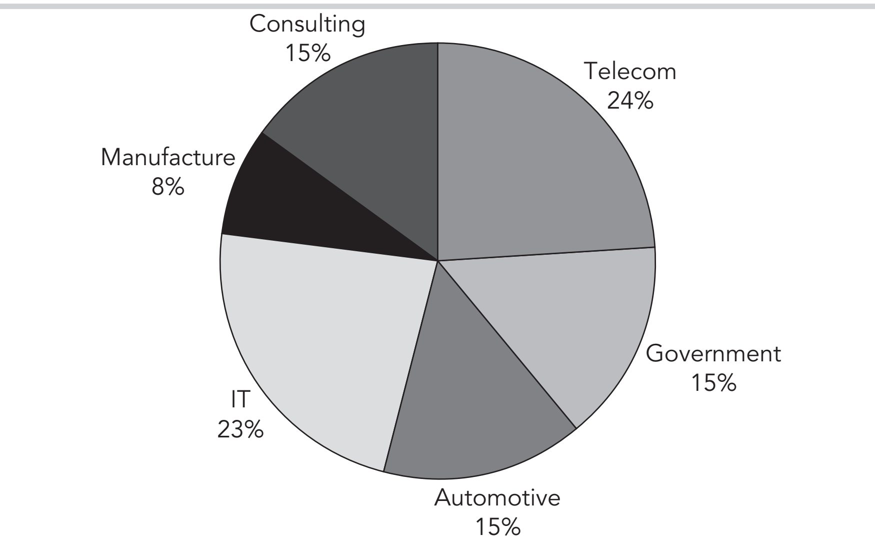

Figure 3: Industry profile.

approval of roles, projects would lack organizational and functional support. Defining the roles and processes would logically lead developing formal processes. Several tools and techniques are available for developing these formal processes.

Employing these formal and consistent processes is a different issue. Due to the nature of tasks associated with projects, project management employs a multidisciplinary approach; it needs people from different functions. Each person brings specific expertise and experience to the project team (Gray & Larson, 2005), which contributes to making the team a complex and challenging entity for the project manager to manage. Employing consistent processes aids in managing the project team of diverse skills representing different disciplines. It is worthwhile to reiterate that technology plays a crucial support role in developing and deploying standard and consistent processes.

By identifying the project's organizational support needs and garnering them, project managers can successfully lead teams and effectively accomplish the expected project outcomes. Additionally, defining the roles of project team members and all the stakeholders would help both the project team members and project stakeholders understand what is expected of them. These factors help project managers define and manage project goals and outcomes. Technology's role also assumes importance in developing, communicating, and monitoring project outcomes.

The top part of Figure 4 represents soft factors. Trust and communication are essential to nurture human relationships; predictability and openness are important factors in establishing trust (Gray & Larson, 2005). By defining processes and roles, the project manager can establish expectations from the stakeholders but also predictability and openness in communication. In the current work environment, where even co-located teams use technology tools such as the Internet and intranet, technology plays an important role in communication, and its role becomes critical in geographically dispersed project teams.

By communicating clearly, project managers can establish an environment of openness and transparency, one where team members establish practices for communicating project goals, expectations, and likely project outcomes. These factors also instill trust—among the project team—in their leader. It is interesting to note that establishing trust usually takes time but projects are time-bound; this fact heightens the project manager's challenge.

Trust, in turn, encourages project team members to collaborate, network, and innovate. Ring (1996) analyzed trust at the interpersonal level and found it a precursor to forming ongoing networks. Although it should evolve mutually, trust is more important for leaders as they try to motivate others to accomplish a vision and to realize project goals. And by establishing trust, leaders can also mitigate conflicts, a deterrent to project performance.

Role of Technology in the Project Manager Performance Model

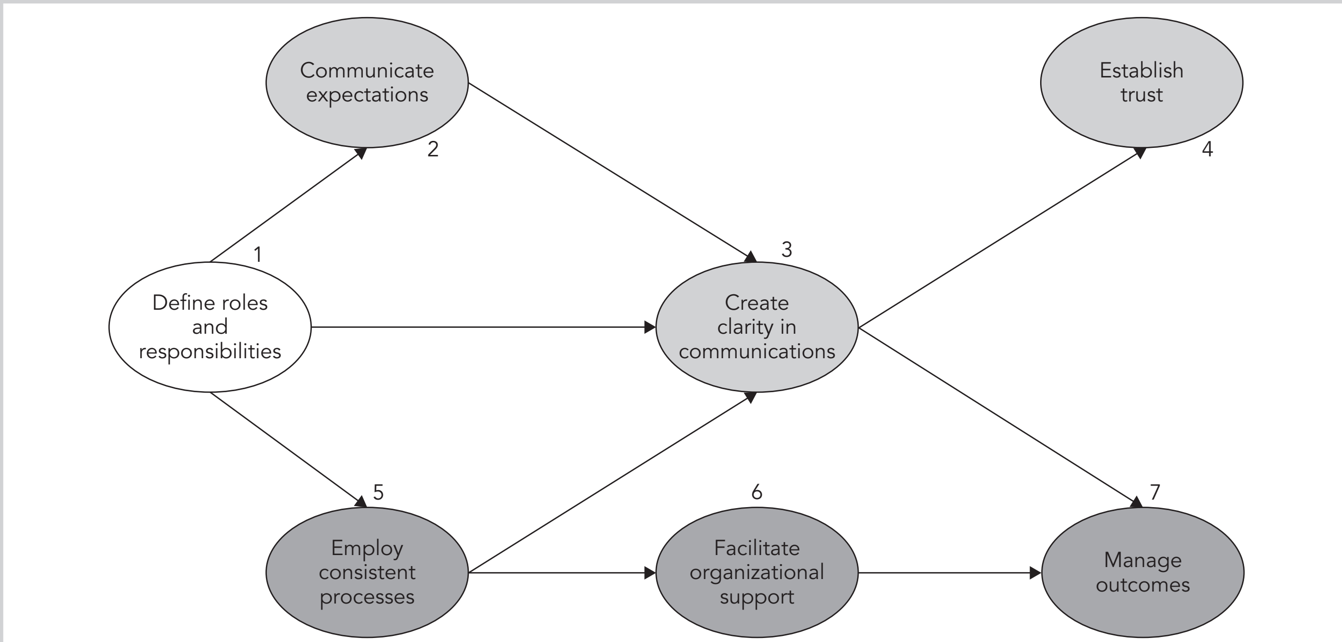

Figure 4: Project manager performances model.

Figure 4 shows that there is no direct relation between establishing trust and managing outcomes. Research shows that a relationship between trust and performance remains somewhat elusive in collaborative relationship (Nielsen, 2004). Citing several researchers, Nielsen suggested that trust has a positive though limited and indirect impact on performance.

Specific Role of Technology

In this paper, technology's role is examined in the context of the results of this study. Specifically, the project manager performance model (Figure 4) and the role of technology are viewed together in terms of communication, decision making, and collaboration in a team-centered project management and control. Much of the discussion in this section is based on the research results of this paper, our professional experience in managing technology in projects, and findings of the literature review.

Projects usually deal with large amounts of data and information. The need for data and information is driven by project complexity and size; at times it is also driven by unknown and unique concerns associated with a project. The project manager must focus on the relevance and applicability of such data and information and, more importantly, on the ways of capturing tacit knowledge of all the stakeholders. Project managers should use both IT and KM, as IT can efficiently convert data into information but cannot suitably convert information into knowledge.

In addition to capturing and storing information with easy access, technology can be used for developing and deploying project management processes and performance monitoring systems. Several project management software tools are available to manage project management processes, such as developing detailed schedules, estimating cost, allocating resources, assessing and managing risk, monitoring progress, and measuring project performance. Referring to the project manager performance model (Figure 4), technology can efficiently and effectively help project stakeholders accomplish five project management functions:

- document the defined project roles and implement related processes;
- establish formal and consistent processes;
- communicate expectations of processes and roles;
- communicate openly among all the project team members, including virtual teams; and
- monitor and manage project outcomes.

Specifically, technology plays a major role in helping the project manager develop and formalize project processes and establish channels of open communication. By using technological tools, the project team can access organizational and tacit knowledge of past projects and historical data; this information can help project teams improve their project performance (Figure 5). Project managers, using this model in conjunction with the technology tools, are engaged in giving and seeking information. These communication efforts often lead to improving collaboration, establishing trust, and making better decisions. Recent research results have shown that capability of making decision and giving/seeking information are the

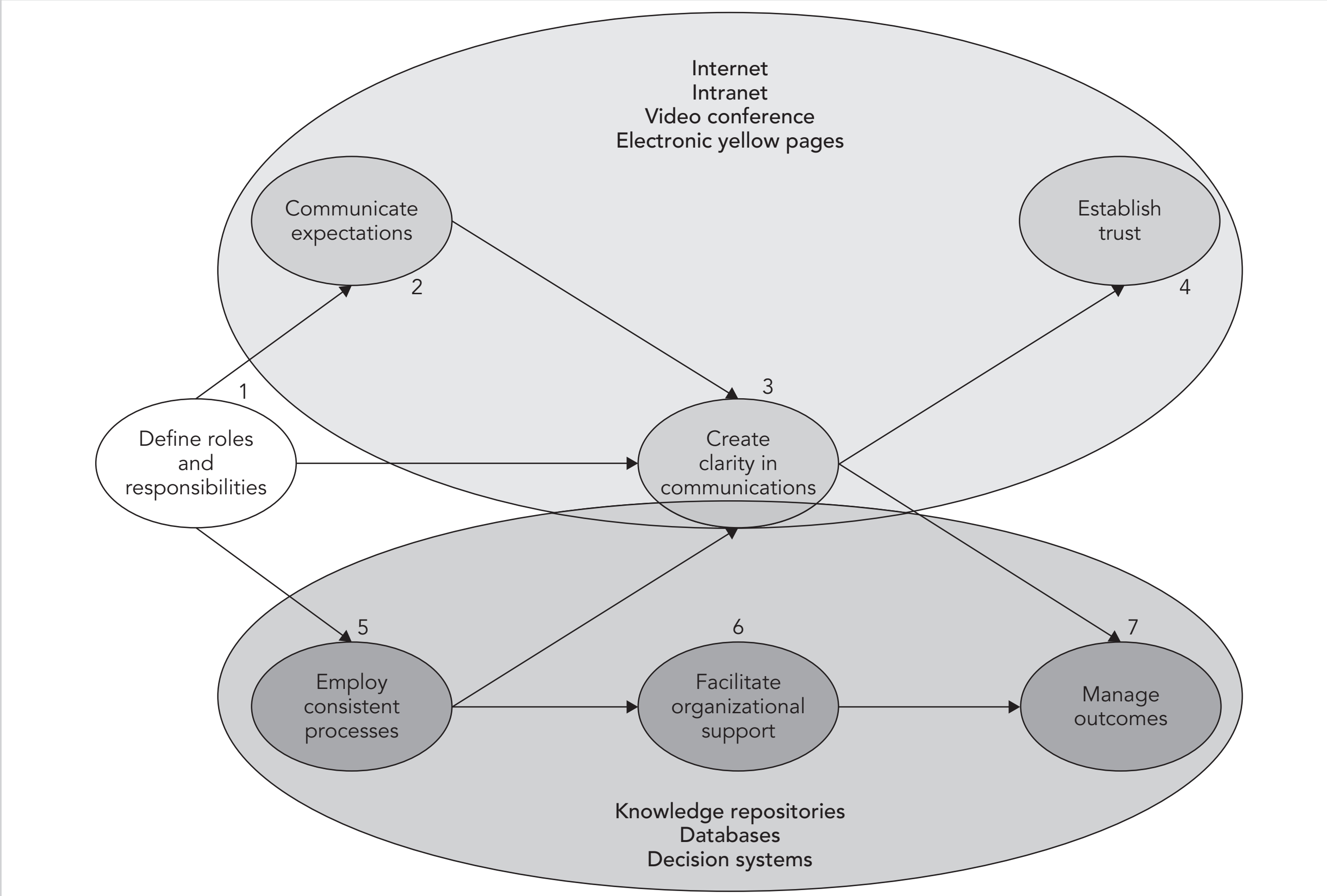

Figure 5: Role of technology in project performance.

most important leadership behaviors to a project manager (Chen & Lee, 2007), both of which require technology support. Our research results have highlighted the importance of these findings.

Encouraging open communication and establishing trust will lead to sharing experiences and knowledge. For effective capturing of lessons learned, project managers must perform project reviews throughout the project management life cycle. Likewise, project managers can also review project performance periodically during the project execution phase and document important lessons learned when ideas and experiences are fresh in the minds of the project team members. This approach will help project managers capture both tacit and explicit knowledge that their project team members possess.

The effect of using technology to improve project performance, as shown in Figure 5, suggests that project managers can use technology to not only capture data and information, but also to facilitate knowledge development and transfer. Project performance data—stemming from various project segments—can feed back into data repositories and database systems; the result is a fluid knowledge flow between project management and technology systems that facilitates learning. Project managers can achieve a level of continuous improvement in project performance by applying numerous technology tools throughout the project management life cycle:

- selecting projects by using knowledge-based decision systems consisting of quantitative and qualitative criteria;
- developing a resource breakdown structure (RBS) for the project environment and keeping it current by using resource cost information from historical project data and resource database systems;
- developing project plans and scope with the help of historical data from knowledge repositories related to project plans and scope definitions;
- estimating—accurately and realistically—project costs by using historical cost and effort estimation and earned value data of past projects;
- developing a work breakdown structure (WBS) by using standardized WBS packages maintained in database systems;
- developing a project schedule by using historical schedule data and "After Action Review" information from knowledge repositories;

- managing resources by using actual resource usage data from similar projects; and
- reducing risk.

In essence, technology can help project managers improve the project processes they use to manage project complexity, project integration, and resource utilization. Going beyond these processes, technology can help project managers promote open communication, learning, knowledge transfer, and productivity. Project managers may also choose to develop electronic yellow pages listing project experts in specific interest groups, such as scope definition, scheduling, cost estimating, and risk management. Specifically, technology, such as electronic yellow pages, video conferences, the Internet, and intranet can help project managers lead projects implemented by virtual project teams. These technologies help project managers communicate effectively with their virtual project teams and integrate project tasks effectively.

The model shown in Figure 5 demonstrates the significance of establishing trust in relation to managing and leading project teams. Research has shown a positive relationship between trust and learning capacity when moderated by IT (Prieto & Revilla, 2004); IT facilitates interaction between organizational members, encourages discussions, and promotes the flow and collection of knowledge. Several studies have shown that trust is also positively associated with knowledge sharing. KM promotes communication, employee skills, collaboration, decision making, and productivity. Consequently, technology (IT and KM) helps project leaders promote project performance, team development, and competency.

In summary, the study showed that defining project processes and roles is the first and most important step for managing and leading projects successfully. This will lay the foundation to communicate expectations, employ consistent processes, and create clarity. The research effort also identified management actions that are prerequisites to defining and monitoring project outcomes. While technology promotes knowledge sharing, team development, efficiency, and effectiveness, motivating factors that can lead to knowledge sharing, team development, and innovation are dependent on the project leadership role in establishing trust and open communications.

Limitations and Suggestions for Future Research

In this study, we interviewed 54 project management professionals from a wide variety of industries in the United States. This study can further be expanded to include more professionals to confirm these results. Additionally, the leadership and technology roles could be different based on the disposition of project characteristics and the industry in which the project is executed. Likewise, leadership roles could be industry-specific due to differing industry-specific work cultures and competitive environments. Future research efforts should consider project leadership roles for different types of projects and different industries.

Conclusion

The project manager performance model developed in this research effort—showing the dependency relations among important critical factors—can be used as a template for managing projects effectively by integrating technology systems and tools. Technology supports the project manager in managing project teams and projects successfully. Integrating technology will also help reduce the duration of the project management life cycle. ■

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Appendix A

ISM analyzes a system of elements and resolves these in a graphical representation of their directed relationships and hierarchical levels. The elements may be *objectives of a policy, goals of an organization, factors of assessment,* etc. The directed relationships can be in a variety of contexts (referred to as contextual relationships), such as Element (i) *"is greater than"; "is achieved by"; "will help achieve"; "is more important than";* Element (j). The following is a brief description of the different steps of ISM:

i) ***Identification of Elements***: The elements of the system are identified and listed. This may be achieved through research, brainstorming, etc.

ii) ***Contextual Relationship***: A contextual relationship between elements is established, depending upon the objective of the modeling exercise.

iii) ***Structural Self-Interaction Matrix (SSIM)***: This matrix represents the respondents' perception of element-to-element directed relationship. Four symbols are used to represent the type of relationship that can exist between two elements of the system under consideration. These are:

V ... for the relation from element E_i to E_j, but not in the reverse direction;
A ... for the relation from E_j to E_i, but not in the reverse direction;
X ... for an interrelation between E_i and E_j (both directions);
O ... to represent that E_i and E_j are unrelated.

iv) ***Reachability Matrix (RM)***: A reachability matrix is then prepared that converts the symbolic SSIM Matrix into a binary matrix. The following conversion rules apply:

If the relation E_i to E_j = V in SSIM, then element $E_{ij} = 1$ and $E_{ji} = 0$ in RM
If the relation E_i to E_j = A in SSIM, then element $E_{ij} = 0$ and $E_{ji} = 1$ in RM
If the relation E_i to E_j = X in SSIM, then element $E_{ij} = 1$ and $E_{ji} = 1$ in RM
If the relation E_i to E_j = O in SSIM, then element $E_{ij} = 0$ and $E_{ji} = 0$ in RM

The initial RM is then modified to show all direct and indirect reachabilities, that is if $E_{ij} = 1$ and $E_{jk} = 1$ then $E_{ik} = 1$.

v) ***Level Partitioning***: Level partitioning is done in order to classify the elements into different levels of the ISM structure. For this purpose, two sets are associated with each element E_i of the system—a *Reachability Set (R_i)* that is a set of all elements that can be reached from the element E_i, and an *Antecedent Set (A_i)*—that is, a set of all elements that element E_i can be reached by.

In the first iteration, all elements, for which $R_i = R_i \cap A_i$, are Level I Elements. In successive iterations, the elements identified as level elements in the previous iterations are deleted, and new elements are selected for successive levels using the same rule. Accordingly, all the elements of the system are grouped into different levels.

vi) ***Canonical Matrix***: Grouping together elements in the same level develops this matrix. The resultant matrix has most of its upper triangular elements as 0, and lower triangular elements as 1. This matrix is then used to prepare a digraph.

vii) ***Digraph***: Digraph is a term derived from **Di**rectional **Graph** and, as the name suggests, is a graphical representation of the elements, their directed relationships, and hierarchical levels. The initial digraph is prepared on the basis of the canonical matrix. This is then pruned by removing all transitivities to form a final digraph.

viii) ***Interpretive Structural Model***: The ISM is generated by replacing all element numbers with the actual element description. The ISM, therefore, gives a very clear picture of the system of elements and their flow of relationships.

Appendix B

i) Elements identified can be seen in Figure 1.

ii) The contextual relationship is “leads to.”

iii) The SSIM is the following

Element A:	X A A A A O O
Element B:	X X A A A O V
Element C:	X X X V V V V
Element D:	X X X X O O V
Element E:	X X X X X V V
Element F:	X X X X X X V
Element G:	X X X X X X X

iv) The reachability matrix is

Element A:	1 0 0 0 0 0 0
Element B:	1 1 0 0 0 0 1
Element C:	1 1 1 1 1 1 1
Element D:	1 1 0 1 0 0 1
Element E:	1 1 0 0 1 1 1
Element F:	0 0 0 0 0 1 1
Element G:	0 0 0 0 0 0 1

v) Level partitions

Element	Level
1	A, G
2	B, F
3	D, E
4	C

vi) Canonical matrix

Element A:	Level 1:	1 0 0 0 0 0 0
Element G:	Level 1:	0 1 0 0 0 0 0
Element B:	Level 2:	1 1 1 0 0 0 0
Element F:	Level 2 :	0 1 0 1 0 0 0
Element D:	Level 3:	1 1 1 0 1 0 0
Element E:	Level 3:	1 1 1 1 0 1 0
Element C:	Level 4:	1 1 1 1 1 1 1

The resulting digraph and the ISM are shown in the main body of the paper.