

Enterprise Resource Planning Systems for Project-Based Firms: Benefits, Costs & Implementation Challenges

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Enterprise Resource Planning (ERP) systems are configurable enterprise-wide information system packages that integrate information and information-based processes within and across functional areas in an organization. They have been widely adopted in many organizations and accepted as a de facto industry standard for the replacement of legacy systems. This paper analyzes and presents the costs and benefits of ERP systems for project-based industries, which have lagged behind other major industries in adopting ERP systems due to their project-centric nature and the high stakes involved in ERP implementation. The challenges during the process of ERP implementations are also identified as part of the effort to understand the implied costs of an ERP system. The evidence of the costs and benefits are drawn from previous studies and the analysis of the prevailing working practices in project-based firms. The classification of the costs and benefits constitutes a cost and benefit taxonomy which can be used to enable executives in project-based firms to make informed decisions on their ERP system investments.

Keywords: Enterprise Resource Planning (ERP) System, Cost-Benefit Analysis, Project-based Organizations, System Implementation.

Introduction

Since the 1990s, Enterprise Resource Planning (ERP) systems have become a de facto industry standard for replacing legacy systems and been perceived as the prevailing form of business computing for many large organizations in the private and public sectors (Gable 1998, Parr & Shanks 2000). ERP systems are designed and configured to achieve seamless integration of all of the information flowing through an organization, by integrating information-based processes within and across different functional departments, such as accounting, finance, human resources, manufacturing and distribution. They also connect the organization to its customers and suppliers and thus enable the integration beyond organizational boundaries. They are multifunctional in scope, integrated in nature, and modular in structure (Mabert et al. 2001). According to an AMR research, the total application revenue in the global ERP market was \$28.8 billion in 2006; it was projected to increase to \$47.7 billion in 2011 (Jacobson et al. 2007). Indeed, the ERP market is the largest segment of the applications budget (34%) in business organizations, with ERP penetration at 67% among large companies (Sirkisoon & Shepherd 2002). ERP is also increasingly deployed in small- and medium-sized companies, as ERP vendors turn their sights to smaller enterprises with tailored products for new business growth.

The adoption of ERP systems in project-centric industries appears to have lagged behind other major industry sectors, such as manufacturing and financial services. Project-based organizing is

found in a wide variety of industries, including architectural & engineering design, construction, aerospace & defense, professional services, entertainment, technology, and so on. In project-based firms, the project, which is defined as “a temporary endeavor undertaken to create a unique product, service, or result” (PMI 2008), is the primary unit for production organization, innovation, and competition. Hence project-based firms are distinguished from those organizations that are primarily based on and profitable from continual business operations, in which ERP system implementations have been more often documented. A study on ERP adoption by European midsize companies indicates that the project industry had the lowest ERP penetration rate at the time the survey was conducted (Van Everdingen et al. 2000). Another study states that very few organizations in the construction industry, which is ubiquitously composed of project-based firms, have implemented ERP systems, despite the wide awareness about such systems (Ahmed et al. 2003). There is also room for growth in the ERP market in aerospace and defense companies, many of which are project-oriented (Botta-Genoulaz & Millet 2006).

ERP systems, if successfully implemented, can bring substantial benefits to organizations. By providing real-time, organization-wide information access, ERP systems have the potential to improve organizational effectiveness and productivity, enable the management to make informed decisions, and enhance the competitiveness of the organization in the marketplace. However, their implementations are often characterized with large capital outlay, long implementation period, high complexity, and proneness to failure. It has been reported that the average implementation time of an ERP project was between 6 months and 2 years and that the average cost was about US\$ 1 million (PMP Research 2001). This might keep many project-based companies from adopting ERP systems due to their limited financial, technical and human resources, and aversion to risks. Without essential awareness of the benefits ERP systems can bring and the stakes involved, project-based firms either rush to implement an unsuitable ERP system that might fail in the forms of overrun budget, prolonged schedule, abandonment of implementation, or unrealized returns; or simply refuse to take advantage of ERP systems and risk losing business competitiveness and growth opportunity in the market. Therefore, it is very important to fully understand and thoroughly evaluate the costs and the benefits of ERP systems before making the decision on whether to adopt an ERP system in the organization or which ERP packages and modules to be selected and implemented.

Research Design

The main objective of this study is to identify and analyze a full spectrum of costs and benefits of ERP systems in the context of project-based firms. Enumeration of costs and benefits is the prerequisite of sound cost-benefit analysis and many other kinds of economic or financial techniques in capital project decision making, such as Net Present Value (NPV) and Internal Rate of Return (IRR) methods. The identified costs and benefits of ERP systems constitute a comprehensive taxonomy. In addition, the challenges to ERP implementation in project-based firms are discussed, considering the specific conditions of such firms.

The costs and benefits of ERP systems are identified and analyzed from the point of view of senior management and/or owners of project-based firms, who make the decisions on ERP investment. The evidence of ERP costs and benefits are primarily drawn from extant literature.

There have been a large number of journal articles and conference papers related to ERP systems and their evaluation, selection, implementation, and use in recent years. However, most of them are placed in generic organizational environments and few address ERP systems in project-based firms specifically. In this study, the costs and benefits of generic ERP systems are considered to apply to project-based firms. Further, those costs, benefits, and issues more likely to be associated with project-based firms are elaborated in conjunction with the analysis on the prevailing practices and characteristics of project-based firms. There are also numerous publications generated by ERP vendors and consulting firms, in the forms of white papers, case studies, presentations, etc. These publications, although suffering from the lack of independence and objectivity, have been cited by researchers now and again and could provide useful references as well.

Benefits of ERP Systems

The benefits of ERP systems have been constantly advocated and reported by ERP vendors and consultants. These benefits are generally supported by the post-implementation performance of ERP systems and improvement of productivity and profitability of the hosting organizations. Davenport et al. (2002) propose a pyramid illustrating how the value from enterprise solutions, among which ERP system is the backbone, is achieved (Figure 1).

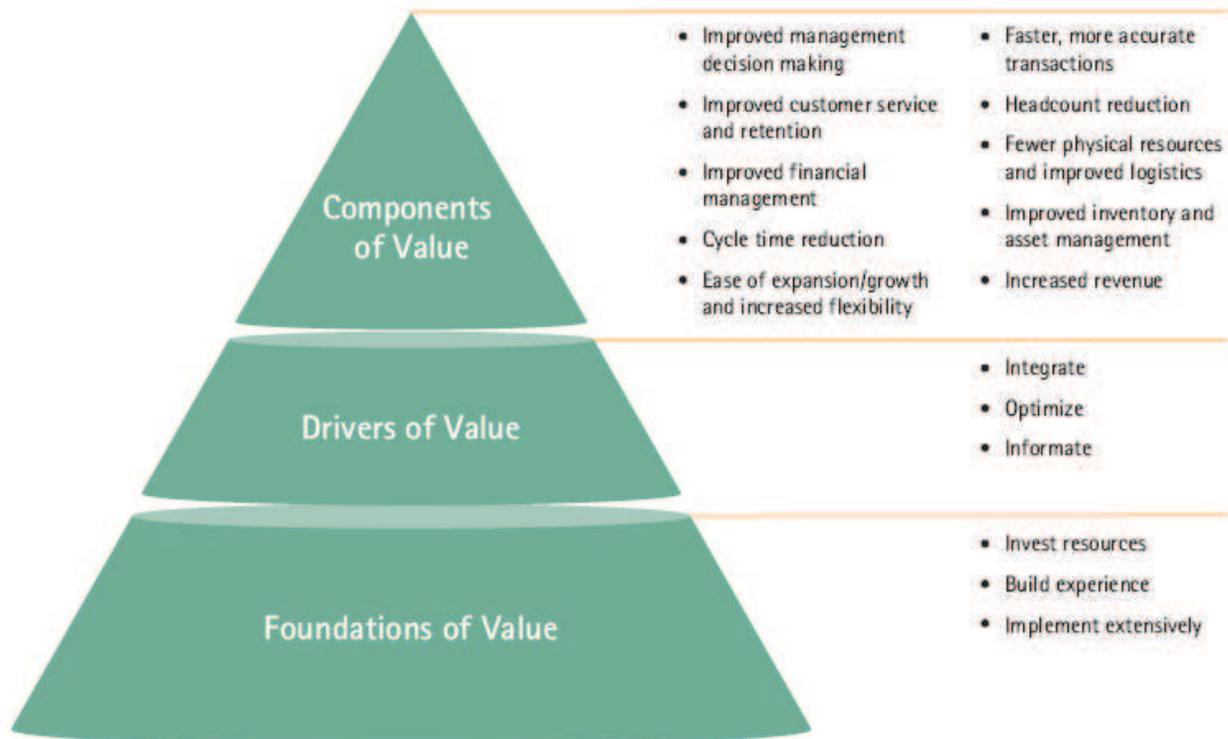


Figure 1: Value of enterprise solutions, adapted from Davenport, et al. (2002)

The benefits of ERP systems are realized, in other words, the value is achieved, by the following three means: integration of information system, data, and processes among different

organizational units and with existing organizational environment or external stakeholders; optimization of business processes using best practices or fitting the business needs; and transforming data into context-rich information and knowledge that support business analysis and decision making (termed “informaté”) (Davenport et al. 2002). There have also been attempts to systematically identify the benefits of ERP systems. Fig 1 lists 10 types of benefits as components of value. Shang & Seddon (2000) presents a comprehensive framework for classifying ERP benefits; according to the framework, 5 dimensions of benefits are proposed, which could be further classified into 25 sub-dimensions. This framework provides a basis for analyzing ERP benefits in project-based organizations.

Cost and cycle time reduction are the basic operational benefits of ERP systems. There are numerous studies stating that investment in information systems to automate transactions can speed up processes, substitute labor, and increase operation volume (Brynjolfsson & Hitt 1996, Shang & Seddon 2000). Unlike retailing companies that sell a wide variety of identical products to a large base of customers, project-based firms operate by providing specific services, products or other results, which are highly customized and seldom duplicable; and their customer base is usually much smaller. Thus it is very important for them to ensure the quality of every product or service and retain customers or clients. The capabilities of ERP systems to reduce duplicates and errors and enhance responsiveness to customer needs can help project-based firms to improve productivity and quality and retain customers. Besides, risk reduction is regarded as an additional benefit of ERP (SAP 2010). By providing real-time information as well as analysis and reporting tools, ERP systems can serve to reduce the business risks that might otherwise be difficult to forecast beforehand and resolve in time.

Since project-based firms are composed of dispersedly located teams undertaking different projects that have loose coupling with each other, these project teams normally enjoy considerable autonomy (Bresnen et al. 2004). This makes lots of firms essentially decentralized. Indeed, conflict and abrasion frequently occurs among different projects in a firm (Kodama 2007). By storing and managing all the data in a centralized database and providing built-in data analysis capabilities, ERP systems can enable both project managers and senior executives to better manage the resources (asset, inventory, workforce, etc.) within a project team and also among different teams, measure and control individual and team performance, and make better informed decisions. In addition, project cost management applications that are widely in use today may be confined to a single project or a number of them; they cannot provide a holistic view of corporate financial status or effectively manage all the financial assets and liabilities of the firm. In contrast, ERP systems have been proven able to effectively and efficiently manage the finance of a whole organization (Davenport et al. 2002). Therefore improved financial management is considered as a separate benefit.

Rackoff et al. (1985) proposed five strategic thrust areas where a company could make a major offensive or defensive move: differentiation, cost leadership, innovation, growth, and alliance. As stated by Shang & Seddon (2000), ERP could assist in achieving these strategic benefits, although the benefit of product differentiation is questionable as the products of project-based firms are always differentiated. Powered by the up-to-date information of ERP systems and the increased processing capacity, it is possible for project-based firms to respond quickly and competitively to new opportunities leading to business growth, such as bidding on new projects.

Such growth can lead to worldwide expansion, as ERP systems are capable of supporting global operations. The need to achieve project objectives that fully address key stakeholder expectations throughout the project lifecycle has been stressed in previous studies (Bourne & Walker 2005, Cleland & Ireland 2006). Thus the benefit of ERP to build external linkage is of significance to project-based firms. Also, ERP systems can help align business strategies with daily operations of an organization (SAP 2010). Another benefit is that, as Internet becomes indispensable and ubiquitous today, web-enabled ERP systems can integrate or support e-Business.

ERP systems, with integrated and standardized application architecture, provide an infrastructure that could support 1) business flexibility for current or future changes, 2) reduced IT costs and marginal cost of business units' IT because with the high integration cost eliminated and the need to purchase third-party software diminished, and 3) increased capability for quick and economic implementation of new applications (Shang & Seddon 2000). With organizational structure adjusted and business process reengineered according to the best practices embodied in the system, ERP implementation can support organizational changes and enhance corporate governance. Other organizational benefits include facilitating learning, empowering employees, building a culture with common visions, and improve employee morale and retention (SAP 2010, Shang & Seddon 2000).

Based on the above analysis and adapted from the framework developed by Shang & Seddon (2000), Table 1 lists 28 types of ERP benefits categorized into 5 dimensions. While the majority of these benefits are put forward from generic organizational environment, they could be evaluated in the context of project-based firms. Davenport et al. (2002) argue that increased revenue is a component of ERP value. Integrated business processes can enable an organization to provide new offerings of products or services or exploit new channels, thus generate extra revenue. Nonetheless, this is covered by other benefit sub-dimensions such as business growth and productivity improvement. There are also studies that support positive connections between ERP and improved liquidity (Matolcsy et al. 2005), and ERP and increased profitability (Hendricks et al. 2007, Matolcsy, et al. 2005). Similarly, they are considered as the results of benefit realization rather than benefit themselves in this study.

Table 1

Taxonomy of ERP Benefits, adapted from Shang & Seddon (2000)

Dimensions	Sub dimensions
1. Operational	1.1 Cost reduction <ul style="list-style-type: none"> • Labor cost (headcount) reduction • Inventory cost reduction • Administrative cost reduction (e.g. printing, office supplies, travel) 1.2 Cycle time reduction: faster project delivery <ul style="list-style-type: none"> • Cycle time reduction in customer support activities • Cycle time reduction in employee support activities • Cycle time reduction in supplier support activities • Cycle time reduction in support activities with other external partners or stakeholders 1.3 Productivity improvement
2. Managerial	1.4 Quality improvement <ul style="list-style-type: none"> • Error reduction • Duplicates reduction • Accuracy or reliability rate improvement 1.5 Improve customer services and retention <ul style="list-style-type: none"> • Ease of customer data access and inquiries • Improved ability to retain customers 1.6 Reduce business risks <ul style="list-style-type: none"> • Better risk forecasting • Improved response and responsiveness to risk occurrence 2.1 Better resource management <ul style="list-style-type: none"> • Better asset management • Better inventory management • Better production management for optimized supply chain and production schedules • Better workforce management • Few physical resources/better logistics 2.2 Improved planning and decision making <ul style="list-style-type: none"> • Improved strategic planning and decisions • Improved operational decisions • Improved customer decisions 2.3 Better performance measurement and control
3. Strategic	2.4 Improved financial management <ul style="list-style-type: none"> • Improved financial budgeting and analysis • Better management of financial assets and liabilities • Centralized and real-time financial reporting and performance evaluation 3.1 Improve alignment of strategies and operations
	3.2 Support business growth
	3.3 Support business alliance <ul style="list-style-type: none"> • Consolidate newly acquired companies into standard business practice • Collaborate with external parties for joint projects 3.4 Build business innovations <ul style="list-style-type: none"> • Enable new market strategy • Build new process chain • Create new business 3.5 Build cost leadership <ul style="list-style-type: none"> • Achieve economies of scale

	<p>3.6 Generate or enhance product differentiation</p> <p>3.7 Build external linkage (with customers, suppliers, contractors, collaborators, etc.)</p> <p>3.8 Enable worldwide expansion and operations</p> <p>3.9 Enable e-Business</p>
4. IT Infrastructure	<p>4.1 Increased business flexibility</p> <p>4.2 Reduce or optimize IT spending</p> <p>4.3 Increase IT infrastructure capability and adaptability for implementation of new applications</p>
5. Organizational	<p>5.1 Support organizational changes and corporate governance</p> <p>5.2 Facilitate business learning and broaden employees' skills</p> <p>5.3 Empowerment</p> <p>5.4 Changed culture with common visions</p> <p>5.5 Changed employee behavior with shifted focus</p> <p>5.6 Better employee morale and satisfaction with improved retention of top performers</p>

Costs of ERP Systems

Compared with typical software licensing and installation, ERP systems are much more expensive to acquire and deploy. The total cost of ERP project varies in a wide range, from hundreds of thousands of US dollars for a single ERP module implementation in small firms, to the magnitude of over one billion dollars for complicated global ERP roll-outs in multinational corporations. ERP cost depends on many variables, such as the ambition of the project, the number of the organization units the system will serve, the number of modules installed, the amount of integration required with legacy systems, the readiness and extent of organizational changes in terms of structure and business processes, the scope of software modification and customization, etc. This makes it hard to precisely estimate or predict the expenses.

In general, the cost of ERP system implementation can be classified into two categories: direct costs and indirect costs. Direct costs, or tangible costs, are those costs explicitly related to ERP implementation that the hosting organization has to pay and thus can be reflected on the corporate income statements. Normally, direct costs include expenses incurred due to software purchase or licensing, hardware acquisition and installment, procurement of external professional services, addition of headcount, staff training, and so forth. According to a survey on ERP implementations in Swedish manufacturing companies, the average shares of the proposed six components of ERP direct costs are: software, 24.2%; hardware, 18.5%; consulting, 30.1%; training, 13.8%; implementation team, 12.0%; and others, 1.4%, respectively (Olhager & Selldin 2003). Software and hardware costs basically depend on the selection of ERP packages and hardware upgrades, existing IT infrastructure, and IT planning. The use of ERP consultants, usually external consultants from professional service firms, is common in ERP projects and regarded as a success factor (Somers & Nelson 2001). Because lots of project-based firms have fragmented processes and differentiated business needs, customization, system integration and data conversion are critical, thus using consultants' expertise could play a major role in diminishing ERP risks. As a result, choosing the right consultants with sufficient application knowledge and industry experience and making full use of consulting services have the potential to control or lower the direct cost of ERP implementation in project-based firms.

Indirect costs, or intangible costs, are elusive to define, identify and control. They are "off-the-books" expenses, damages, or losses generated mainly by human or organizational factors (Irani

& Love 2001). Organizations implementing an ERP system often have to be prepared to see the organization reengineered, its staff disrupted, and its productivity drop before the payoff is realized (Umble & Umble 2002). Indeed, ERP system implementation may turn out to be a distraction or disruption, at least temporarily, to the firm's ongoing projects and operations. This include shifted management focus, using employees' time for extensive training, lowered employee morale and work efficiency because of possible job role redesign or headcount reduction, conflicts and frictions between organizational units, and so on. Indirect costs in generic IT investment (Irani et al. 1998, Love & Irani 2001, Marsh & Flanagan 2000) are also likely to occur in the ERP projects.

Table 2 provides a taxonomy of ERP costs, categorized into the two dimensions. It is noteworthy that while ERP maintenance cost in the post-implementation stages must be taken into account, the cost of optional ERP system upgrades and introduction of additional functionalities are considered separate projects. Besides, although indirect costs are difficult to fully enumerate and quantify, total cost of ownership (TCO) has been advocated by some as an effective method to measure the cost of ERP systems and support ERP strategies and decisions (Aberdeen Group 2006, West & Daigle 2004), which may partially incorporate the estimation of indirect costs.

Table 2

Taxonomy of ERP Costs, adapted from Love & Irani (2001) and Iba (2006)

Dimensions	Sub dimensions
1. Direct costs	1.1 Software purchase or licensing <ul style="list-style-type: none"> • ERP solutions • Database management system • System software • Security software • Additional applications 1.2 Hardware acquisition or upgrade <ul style="list-style-type: none"> • Servers & database machines • PCs, workstations, printers, scanners, and other computer peripherals. • Network equipment • Installation and configuration of hardware • Other facilities 1.3 Professional services by external consultants <ul style="list-style-type: none"> • Customization • Data conversion • Installation and configuration • System integration • Testing and troubleshooting • Other technical support 1.4 Internal staffing <ul style="list-style-type: none"> • Additional permanent hiring • Additional temporary hiring • Staff turnover 1.5 Instruction and training 1.6 Maintenance and mandatory upgrades 1.7 Administrative and miscellaneous costs <ul style="list-style-type: none"> • Overheads

	<ul style="list-style-type: none"> • Travel • Contingency
2. Indirect Costs	2.1 Disruption to ongoing projects (strains on resources, additional change orders, delays, etc.) 2.2 Temporary loss in productivity 2.3 Temporary decline in quality of work 2.4 Business process reengineering 2.5 Organizational restructuring 2.6 Shift of management focus and dedication 2.7 Use of management and employee time 2.8 Job role redesign & reassignment 2.9 Decline in employee engagement and morale 2.10 Culture changes 2.11 Conflicts and frictions among organizational units 2.12 Transition from legacy system to the ERP system 2.13 Impact on relationship with key stakeholders

Implementation Challenges

ERP implementations are exposed to various risks. Previous studies have described a number of risk factors in generic ERP implementations, such as low top management support and involvement, inadequate business process reengineering, inadequate legacy system management, and ineffective project management (Aloini et al. 2007, Umble et al. 2003). In project-based firms, the mission-oriented nature and resource- and time- constrained ways of working, combined with the loose coupling between different projects, usually create highly distributed and fragmented working practices (Bresnen et al. 2004, Lindkvist 2004). As such, implementing ERP systems in such organizations must overcome certain additional challenges.

Project success is critically dependent on the collaboration and support of its stakeholders. Examples of such key stakeholders include major clients of the company, as well as suppliers, regulators, and collaborating partners. Regarding ERP projects, stakeholders not only include those participants in the implementation processes, but also need to involve the stakeholders in the projects carried out by the organization during and after the implementation. It is these projects that bring profits to the firm and make the ERP adoption worthwhile. Ineffective stakeholder relationship management leads to frictions, scope creep, inappropriate measurement, specification changes, delays, and other issues (Hartman & Ashrafi 2002). Therefore, it is very important to maintain good relationships with stakeholders and involve key stakeholders, including but not limited to internal users, into the implementation process.

As a result of the physical dispersion of project teams, ERP systems in project-based firms have to be implemented in a multi-site manner, which brings special concerns (Umble et al. 2003). The conflicts between centralized control and individual site autonomy, and between corporate standardization and localized optimization, increase the complexity of ERP implementation and entail difficult trade-offs. Local legal, regulatory, and environmental issues are also need to be seriously addressed and reflected in the reengineered business processes. Moreover, since project teams are of high mobility, moving from one site to another with reshuffled staff as a project is completed, the temporariness of project team composition and site location makes it difficult to carry out ERP implementation and manage the IT asset effectively. In addition, project-based firms often need third-party specialized applications with functionalities that

current ERP systems are not able to provide. For example, engineering design and construction firms heavily rely upon Computer-Aided Design (CAD) or Building Information Modeling (BIM) solutions to undertake their projects. As a result, achieving integration and interoperability to some extent between ERP system and non-ERP applications is a big challenge during the implementation process.

Conclusion

This study aims to systematically identify and analyze the benefits and costs of ERP systems in the context of project-based firms. A number of challenges to ERP implementations are also discussed that specifically pertain to such kind of organizational environment. The listed costs and benefits constitute a comprehensive taxonomy addressing the impacts of ERP systems on project-based firms, which can be used to conduct cost-benefit analysis and support decision making on ERP system evaluation and investment. While almost all direct costs can be quantified in financial terms, most of the benefits and indirect costs are difficult to measure using a quantitative method, which makes the comparative evaluation of costs and benefits inconclusive for decision making. The effort of developing effective techniques to approximate these intangible costs and benefits quantitatively and building sound cost benefit analysis method for ERP system evaluation will be undertaken in future studies.

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