

# ENTERPRISE RESOURCE PLANNING IN CONSTRUCTION: AN EVALUATION OF RECENT IMPLEMENTATIONS

Arjen van Leuven<sup>1</sup> and Hans Voordijk<sup>2</sup>

<sup>1</sup> *Balance & Result, Dept. of Construction, P.O. Box 2382, 7500 CJ Enschede, The Netherlands*

<sup>2</sup> *University of Twente, Technology and Management, Dept. of Construction Process Management, P.O. Box 217, 7500 AE Enschede, The Netherlands*

In a large number of construction firms, Enterprise Resource Planning (ERP) systems have replaced non-integrated information systems by integrated and maintainable software. The implementation of ERP systems in the construction industry is a difficult task. So far, ERP implementations have yielded more failures than successes in this industry. Our study tries to understand the underlying factors that cause success or failure of ERP in construction by analysing how ERP fits into the IT and business strategy of a firm. Empirical research was conducted by a multiple case study of three ERP-implementations in different business environments. Based on the results of this study, propositions are developed that relate factors for the success of ERP in construction to concepts of the existing literature on IT and strategy. These propositions are indicative, but present nevertheless a clear overall trend.

Keywords: business strategy, enterprise resource planning, information technology, success factors.

## INTRODUCTION

In recent years, a large number of construction firms have implemented an ERP system. It is striking that generally these implementations are focused on the back office functions inside the single construction firm. ERP systems have replaced intra-organizational non-integrated information systems by integrated and maintainable software. These systems provide construction firms with two different types of new functionality: a transaction processing function, allowing for the integrated management of data throughout the entire company and a workflow management function controlling the numerous process flows that exist in the company. ERP systems can also be an instrument in transforming functional organizations into process oriented ones. The implemented ERP systems generally do not support the front office organization of the construction firm.

This can be explained by looking at the characteristics of construction industry. Production in the construction industry is characterized by a variation of location, changing teams of many diverse actors with each new project and the one-off nature of the work. Designing, constructing, and supplying parties all speak their own languages and all have their own information systems. Often there is no structured communication between them that transcends project level. Lack of continuous relationships between firms and the fragmented organization of the construction process impede the use of inter-organizational information technology (IT). The industry structure is another important obstacle to the application of inter-

organizational information technology. The industry structure is dominated by a great number of small firms: fragmentation is the key characteristic. There is no clear market leader that can impose one technology or standard on the construction industry as a whole. Because hardly any firm starts to apply inter-organizational IT on its own, current IT efforts of construction firms are directed towards more efficiency and standardization of the back-office functions inside these firms.

The implementation of Enterprise Resource Planning (ERP) systems in the construction industry is a difficult task. Recently, several practitioners have stated that ERP implementations so far have yielded more failures than successes in this industry. At the same time, a typical ERP implementation takes between one and three years and tens to hundreds of thousands of Euros.

For these reasons, there is an urgent need to for understanding the underlying factors that cause success or failure of an ERP implementation. In this study, we assume that these factors can be divided into three categories. Our study tries to understand the underlying factors by analysing these three dimensions of ERP-implementations. In the theoretical framework, it will first be argued that the match between business and IT strategy is an important condition for the success of ERP. Secondly, the Nolan model of computing evolution in organizations is used to indicate the level of IT-maturity of a construction firm before and after ERP-implementation. With a successful ERP-implementation, this level has increased after implementing ERP. Third, attention is devoted to implementation strategies used for ERP.

Empirical research was conducted by a multiple case study of three ERP-implementations in three different business environments. The data collection methods of our case study research included both desk and field research (Yin, 1994). Based on the results of this study, propositions are developed which indicate factors for the success or failure of ERP in construction. The paper is structured as follows. The theoretical framework used is presented in the first part. After this section, attention is devoted to the case study research design. In the next sections, the cases are presented and analysed. Finally, insights from the case study are combined with the theoretical framework in order build propositions for further research.

## **THEORETICAL FRAMEWORK**

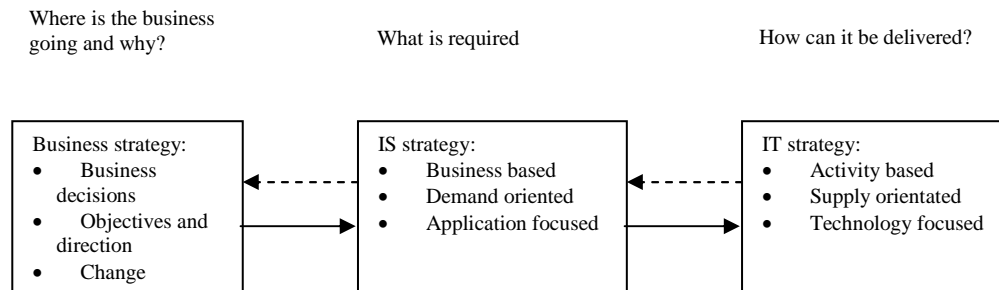
### **IT and business strategy**

In order to analyse the underlying factors for success or failure of ERP, the implementation of this technology has to be placed in the overall strategy of a construction firm. The methodology of Earl (1993) relates information systems (IS) in general with information technology (IT) and business strategy (see Figure 1). In this methodology, ERP is a success when following targets are achieved (Betts, 1999):

- aligning investments in ERP with business goals;
- exploiting ERP for competitive advantage;
- directing efficient and effective management of ERP resources.

In this section, we will focus on business and IT strategies by discussing the concepts of Porter (1985) en Parson (1987).

ERP implementations may contribute to the three generic competitive strategies of Porter (1985): cost leadership, differentiation or focus. ERP as part of a cost leadership strategy aims to achieve the lowest cost of producing. In a differentiation strategy, ERP contributes to the development of a unique product or service and long-term customer relationships. In a focus strategy, the contribution of ERP is limited to certain segments (in products, in clients or in geographic markets).



**Figure 1:** The IS/IT/business strategies and relationships (Betts, 1999)

The generic IT-strategies identified by Parson (1987) represent different approaches to managing IT-resources. These strategies can also be used to analyse different ERP-implementations. The six IT-strategies identified are:

- Centrally planned: a central decision-making unit integrates business needs with IT capabilities by understanding the competitive opportunities and requirements of the firm and the potential of IT for creating or increasing competitive advantage.
- Leading edge: state of the art IT is developed to create business opportunities.
- Free market: users determine their own needs and how to satisfy them; IT specialists compete against outside vendors for users' customers.
- Monopoly: an internal IT group is set up as the sole source to meet IS/IT demand within reasonable costs.
- Scarce resource: IT resources and expenditure are constrained and their use determined by resource allocation procedures, such as ROI criteria.
- Necessary evil: IT is not used unless there is no alternative.

Porters' competitive strategies and Parsons' IT strategies can be combined into one matrix (see Table 1). In our study, it is assumed that the match between business and IT strategy is an important condition for the success of ERP. In free market, scarce resource, and necessary evil strategies the dominant focus is on IT as a cost saving tool. In a free market strategy, a firm buys its IT against the lowest possible costs on the market for software products. If the organization uses a scarce resource strategy, any IT proposal must clearly define expected costs savings. In a necessary evil strategy, IT is not used unless there is no alternative. In centrally planned, leading edge, and monopoly strategies IT contributes to the differentiation strategy of a firm. IT is developed and implemented to increase competitive advantage and to create new business opportunities.

Depending on the existing and future strategic roles of IT inside construction firms before and after implementing ERP, these roles can be categorized by using the framework of McFarlan and McKenney (1983) (see Table 2).

### The Nolan growth curve

The growth curve of Gibson and Nolan (1974) has become a standard and widely known model of computing evolution in organizations. In our study, we use this model to analyse the level of IT-maturity before and after the implementation of ERP. The Nolan model offers a framework in which different stages of information systems growth are discussed. Each stage has its own distinct characteristics, opportunities and problems.

**Table 1:** Relationship between generic competitive strategies and generic IT-strategies

	Possible competitive strategies		
	Cost leadership	Differentiation	Focus
Possible IT-strategies	Free market	Centrally planned	Depends on the chosen
	Scarce resource	Leading edge	lower strategy
	Necessary evil	Monopoly	

**Table 2:** Existing and future roles of IT systems (McFarlan and McKenney, 1983)

		Future strategic role of IT	
		Low	High
Existing strategic role of IT	Low	Support	Turnaround
	High	Factory	Strategic

These stages correspond to major changes in the way information systems resources are managed. Nolan characterizes each stage in terms of slack and control. The four stages are (Nolan, 1979; Reynolds, 1992):

1. **Initiation:** the computer is placed into the organization. Applications are replacements of existing manual systems (low slack) and are paid out of discretionary budget (low control). In this stage the focus is on functional cost-reduction applications.
2. **Contagion:** a period of rapid and controlled growth in the number and kinds of information system applications developed. In order to nurture widespread use of computer applications in the firm slack is high. Control remains low in order to promote extensive experimentation with applications in multiple functional areas.
3. **Control:** top management gains control over information system resources by implementing formal control processes and standards that stifle almost all new information system projects. Management actions aim to control and reduce slack.
4. **Integration:** the use of information resources increases rapidly, providing new benefits and supporting the overall business strategy. The responsibility for operating of the systems is transferred to the users. Conventional data processing activities are highly controlled.

Nolan changed the curve several times, due to technical development and a better insight in computer budgeting. Later the two following stages were added:

- **Data administration:** data are recognized as an important resource to the company. Efforts are made to manage data.
- **Maturity:** information systems, people, and business managers are jointly held accountable for identifying and capitalizing on opportunities to use information systems technology.

Each stage is characterized by certain benchmarks relating to information processing technology, data processing organization, user awareness, and the portfolio of applications (Wiseman, 1985). By determining where an organization fits on the various benchmarks, Nolan's approach can be used to indicate the transition from one stage to the other. After implementing ERP, the level of IT-maturity is expected to increase.

### **Implementation strategies**

The main differences between IT-implementation strategies are their revolutionary or evolutionary nature and the risk and time needed for implementing a system. Using these criteria, the following strategies used for ERP-implementations can be identified:

- **Business Process Redesign (BPR).** Parallel with the ERP-implementation, business processes are redesigned. The throughput time and the risk of failure (the results desired are not realized) of this revolutionary implementation method are quite high.
- **AS-IS.** The existing situation of the firm is starting point for implementation. After implementing ERP, business processes are improved step-by-step. Important difference with BPR is the evolutionary nature of this method and the lower risk.
- **ASAP (As Soon As Possible).** The implementation time needed is the critical factor of this method. A standard model is the starting point for implementation. The ERP-system is adapted to this model. When processes differ from this standard, they are redesigned. From this perspective, it is a revolutionary implementation strategy.

The implementation process may have a linear or an iterative character. In a linear method, the implementation process is composed of a series of different steps in one sequence. Using an iterative method, the same steps are repeated several times till the optimal solution is found. When the strategic interest of an ERP-implementation increases, a more iterative implementation model is preferred. In this method, all possibilities of an ERP system are thoroughly checked on their contribution to the business strategy.

## **RESEARCH METHOD**

ERP is a relatively new re topic for research and most of its implications have hardly been researched at all. Therefore, an exploratory research approach is appropriate, such as the multiple case study approach described here (Yin, 1994). In this multiple case study, three business units of a Dutch-based construction firm were investigated. These business units implemented ERP in very different business environments. The authors collected recent data on IT and business strategies, the level of IT-maturity before and after implementing ERP and implementation methodologies used by the business units. Findings were triangulated by using data from multiple sources and of both quantitative and qualitative nature.

The construction firm appears under the fictitious name of VL Construction Group. This company is one of the leading construction firms in the Netherlands. The activities of VL Construction Group are divided into ten operating companies and four clusters: infrastructure, construction, consultancy and engineering and trade and industry. Our case study focuses on the infrastructure cluster. This part of the firm called VL Infrastructure is a major player in the Dutch market in the field of

infrastructure. VL Infrastructure is an integrated provider of civil engineering works, maintenance and services and is on the basis of this experience also active in other transport systems. Over 2100 employees work on projects that cover all aspects of a project, from involvement in the design phase to implementation, plus subsequent maintenance. The turnover of VL Infrastructure is €250 Million (£ 150 Million).

VL Infrastructure is divided into seven autonomous business units that work closely together. The multiple case study focuses on the following three business units: Projects, Services and Equipment. Projects focuses on construction projects in infrastructure. This business unit has 400 employees and a turnover of €90 Million (£ 55 Million). The business unit Services has 1200 employees and a turnover is about € 100 Million (£ 60 Million). Major service product is the maintenance of infrastructure. Equipment has 200 employees and a turnover of €23 Million (£ 14 Million). Equipment is responsible for the supply of equipment to the other business units inside VL Infrastructure. This business unit supplies also equipment to Dutch competitors of VL Infrastructure.

## **PROJECTS**

### **ERP and business strategy**

The ERP-implementation was the result of the need to replace the existing IT system. Examined more closely, this ERP implementation is in fact an upgrade of the outdated information system used and not the result of a strategic choice of the management. External factors (no support of the outdated system by the software supplier, market demand, and millennium bugs in the old software) compelled this business unit to search for a new system. The IT-strategy used can be characterized as a “necessary evil”-strategy. Management reacted on external factors and has no strategic focus on state-of-the-art IT-solutions. Managerial attention is primarily focused on cost control. In terms of McFarlan and McKenney, IT has still a support function. Before implementation of ERP, IT was not of strategic importance to the organization. This situation is continued after implementing ERP. According to the management, high dependence on IT was not desirable.

### **IT-maturity**

Before implementation of the ERP system, the IT-maturity of Projects was in stage 2 of the Nolan model. Each department used a number of isolated computer applications. The level of IT-maturity did not change after ERP implementation; the firm stays in stage 2. The ERP-system implemented links only the departments Calculation and Finance. Purchasing (40% of the turnover of this business unit) and the overall project planning are not linked with each other by the ERP-system. This means that delivery schedules will not be adapted in case of changes in the project planning. Because only Calculation and Finance are now linked with each other, this ERP implementation is the start of the transition from stage 2 to 3. This transition demands, however, for further integration and standardization of IT-applications.

### **Implementation**

As just mentioned, this ERP implementation was in fact the replacement of the existing IT system. This replacement was a typical example of an AS-IS implementation methodology. In an evolutionary approach that took for about two years the ERP system had to be adapted to existing processes. The implementation focused on processes of the departments Calculation and Finance. These departments

were using the old application that was to be replaced. Logically, these two departments started to use the new system first. Purchasing was planned to be the next department using ERP. Projects wanted to develop the system itself. Hardly any external advisors were hired in. Management feared high consultancy costs and the leaking away of sensitive information. This led to a strong intra-company focus for the ERP-implementation and was also the reason that a supply chain context for the ERP-implementation was not developed. Such an implementation would require co-ordination with suppliers and customers. The implementation started as a very structured process with regular meetings between the management, an internal project leader and a small group of core users (representatives of the different departments). During implementation this structured approach lost its strength, due to time constraints and business schedules.

## **SERVICES**

### **ERP and business strategy**

In the interviews managers stated that ERP was needed to increase control and transparency of the processes of Services. By more control and transparency Services could react faster on changing market demands. Because the market for infrastructure maintenance services has been liberalized, foreign firms entered the Dutch market. The ERP-implementation was part of the strategic answer on this increasing competition. The IT-strategy of this business unit can be characterized as a “free market”-strategy. Services tried to integrate different business functions into one ERP-system. The management, however, gave the different departments freedom to use tools other than provided by the ERP system. The resulting system consists of different IT-tools bilaterally linked with the ERP system. The role of IT changed from support to factory. IT has become much more important for the daily operations of the firm. On the long term, IT can achieve a strategic position.

### **IT-maturity**

Some years ago, Services could be placed in stage 2 of the Nolan’s growth curve. Since then, the implementation of ERP has led to substantial integration of localized IT functions. Currently, the company is redesigning its work processes to enable further integration and standardization. As just mentioned, the ERP-system is still supported by a number of other software tools caused by the missing functionality in the ERP-system, which has led to the use of other IT-tools. Strict labour regulations and irregular working hours demand for planning applications that are not supported by the ERP system. Logistics (inventory control, purchasing) and Product Quality (measurements of the services delivered) still demand non-ERP software. The widespread use of IT-tools is an aspect of stage 2 of the Nolan model. Implementing an ERP philosophy integrating these tools into one system shows that the organization is in the transition from stage 2 to 3.

### **Implementation**

According to the vision of the management, the ERP implementation had to be part of a BPR methodology. Restructuring business processes was one the targets of this implementation. For implementing ERP, several activities had to be standardized. As just mentioned, several aspects of existing processes are difficult to change (strict labour regulations and irregular working hours). By using the IT-strategy of “free market” the external and internal project managers of this implementation gave much freedom to the core users involved. In particular the controllers saw many problems

with the ERP system. In the end, the implementation methodology used became a typical example of AS-IS. Software tools were adapted to existing processes.

## EQUIPMENT

### ERP and business strategy

The IT strategy of Equipment can be characterized as “scarce resource”. According to the management, ERP is a tool that has no direct relation with the business strategy. The focus was on increasing the efficiency of the planning. The management forced the employees to work only with the new system. Importing data from the old IT-systems (systems used before the ERP-implementation) into the new one was not permitted. Before implementation, Equipment used three systems that could not exchange information with each other. The role of IT changed from support to factory. The importance of IT after implementation increased for daily operations but will hardly have any impact on the future business strategy. ERP is used as an internal tool to increase productivity by improving the planning process.

### IT-maturity

Different isolated applications have been replaced by one ERP-system. In order to *get all* IT-applications in one ERP-system, there have been tough discussions with the software firm developing the system. A tailor-made ERP-system resulted. Main objective was an improvement of the planning, the planning process and the link between planning and finance. In terms of Nolan, Equipment transformed itself very clearly from stage 2 to 3. IT is very much centralized and current ERP implementation efforts have been focused on even stronger integration and standardization. In the new system, efforts are made to manage data instead of managing the system.

### Implementation methodology

The implementation methodology used can be characterized as AS-IS. An iterative implementation method was used. From the start of the implementation of ERP, core users were involved in the process. Core users were the intermediaries between the departments and software supplier. These users commented on the system prototype on behalf of the department the system prototypes. Because the old system functioned well, there was a lot of resistance. High user participation tried to decrease this resistance.

## DISCUSSION

In this section, we will combine the insights from the case studies in order build propositions that relate the success of ERP to concepts of the existing literature on IT and strategy. These propositions are indicative, but present nevertheless a clear overall trend.

In all cases analysed, IT has not a strategic focus. Before implementation of ERP, IT was not of strategic importance for Projects. This situation is continued after implementing ERP but is gradually changing. Recently, optimization projects are started and business processes are being examined. For Services and Equipment, IT has become much more important for the daily operations of the firm after implementing ERP. The position of IT changed from support to factory. For Services, IT may even achieve a strategic position in the long term. For Equipment, IT will have hardly any impact on the future business strategy. Using an ERP philosophy integrating different IT-applications into one system shows that all business units are



in the transition from stage 2 to 3. Equipment transformed itself most clearly from stage 2 to 3. The implementation methodologies used at all business units can be characterized as AS-IS. Software tools are adapted to the existing processes. Based on the results of this multiple case study, the following propositions can be formulated.

*Proposition 1: There will be no relation between IT and business strategy as long as IT efforts are directed to the standardization of back-office functions inside construction firms.*

In all cases, the ERP-implementation focused on the back-office processes of the construction company. The functionalities provided by the ERP-system are supporting and integrating traditional back-office functions like cost control, equipment planning and calculation. These functions are recurrent and stable and can therefore be standardized. They are not frustrated by industry characteristics as the temporary coalitions realizing construction projects, location bound production and the one-off nature of the work. Back-office functions do, however, not have the primary attention of the management. This explains why there is no explicit relation between the business strategy and ERP in the three cases analysed. It also explains why AS-IS implementations occur in all cases and why the investment in IT is considered high in relation to the results.

*Proposition 2: IT becomes part of the business strategy of construction firms when it provides the tools for inter-organizational standardization of primary processes (the front office activities of construction firms).*

The cases showed that ERP is applied as an intra-company tool, while primary processes in the construction industry are characterized by inter-company relations. Future ERP-systems that provide tools to manage or simulate these inter-company processes will give IT the link with the business strategy that is missed in the ERP-implementations studied.

*Proposition 3: Large construction companies appear to be in the transition from stage 2 to 3. These companies have to invest a lot to bring their IT-maturity level at the level of stage 4, a major precondition for implementing inter-organizational ERP-systems.*

*Proposition 4: From an inter-organizational perspective, most construction firms still have to enter the first stage of the Nolan curve.*

From the Nolan perspective, intra-organizational IT efforts transform IT-maturity level from stage 2 to 3. The fragmented organization of the construction process and industry structure impede the use of inter-organizational IT. In an inter-company Nolan curve most construction firms still have to enter the first stage.

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