MEASURING THE ADDED VALUE OF IT IN CONSTRUCTION FIRMS

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The added value of information technology (IT) varies widely along firms. The objective of this paper is to analyse the underlying factors that enlarge or reduce the added value of information systems and IT-applications in construction firms. By applying the process-oriented approach of Tallon *et al.*. (2000) the value of these information systems on the process-level is assessed. Information systems and IT-applications create value for an organization by improving individual business processes, or linkages between processes, or both in terms of Porters' value chain (Porter and Millar, 1985). Determining the IT-value in a structured and meaningful way requires an operational description of what IT is in those critical value activities. For this analysis, the concept of the IT-based infrastructure of Renkema (2000) is used. By applying the IS Assessment and Contingency Theory of Myers *et al.*. (1998) critical success factors for the alignment of IT and business processes are shown. In order to verify our expectations, an empirical research was conducted by a multiple case study of five firms in civil engineering and housing and real estate.

Keywords: alignment, IT business value, information technology.

INTRODUCTION

In recent years, construction firms have implemented (integrated) information technologies (IT) enabling companies to manage the efficient and effective use of resources (materials, human resources, finance, etc.) by providing an integrated solution for the organization's information processing needs (Al-Mashari and Zairi, 2000; Fui-Hoon Nah *et al.*., 2001). Although firms invest hundred of thousands of Euros in IT, the contribution to the business performance - in terms of added value - is often unknown (Henderson and Venkatraman, 1999; Voordijk *et al.*., forthcoming).

The objective of this paper is to analyse the underlying factors that enlarge or reduce the added value of information systems and IT-applications in construction firms. This added value of IT systems is assessed on process-level by applying the process-oriented approach of Tallon *et al.*. (2000). This process-oriented assessment of IT value is based on the argument that the first-order impacts of IT investments occur at the process level (Barua *et al.*., 1995). Enterprise systems create value for the organization by improving individual business processes, or linkages between processes, or both in terms of Porters' value chain (Porter and Millar, 1985). Determining the IT-value in a structured and meaningful way requires an operational description of what IT is in those critical value activities. For this analysis, the concept of the IT-based infrastructure of Renkema (2000) is used. Finally, by applying the IS Assessment and Contingency Theory of Myers *et al.*. (1998) critical success factors for the alignment of IT and the business processes are developed.

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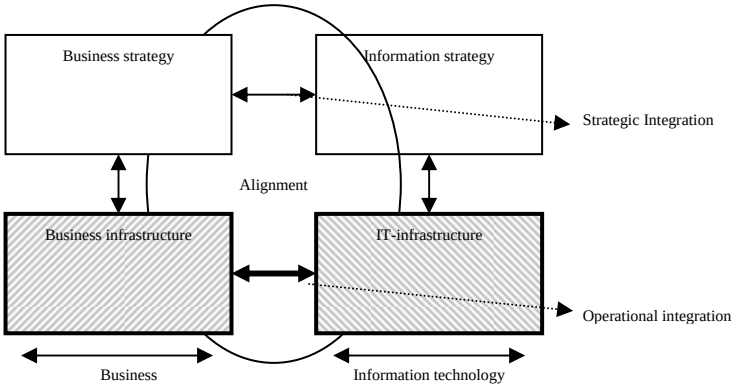

Figure 1: The Strategic Alignment Model (Henderson and Venkatraman, 1999)

In order to verify our expectations, an empirical research was conducted by a multiple case study in civil engineering and housing and real estate. This partition into two market segments is relevant for determining the added value of IT for a construction firm since value depends on the market in which a firm operates. Five companies in the Dutch construction industry were analysed. The data collection methods of our case study research included both desk and field research (Yin, 1994). In the case companies the responsible IT-managers were interviewed using a semi-structured questionnaire.

The outline of this paper is as follows. In the theoretical framework, the fundamental characteristics of the Strategic Alignment Model of Henderson and Venkatraman (1999), the process-level model of IT-value of Tallon *et al.* (2000), the concept of IT-based infrastructure of Renkema (1998) and the IS Assessment and Contingency Theory of Myers *et al.* (1998) are discussed. In the second part, the added value of IT investments in the construction industry is assessed by applying these models in civil engineering and housing and real estate. In the concluding section, the failure to realize benefits from IT investments is explained by discussing misalignments in construction firms.

THEORETICAL FRAMEWORK

Following the Strategic Alignment Model of Henderson and Venkatraman (1999), the basic premise of this study is that the added value of IT can be enlarged by aligning the following ‘domains’ of a firm: business strategy, IT strategy, organizational infrastructure and processes and IT infrastructure and processes. Unfortunately, Henderson and Venkatraman do not give a clear interpretation of these elements. In a recent study of Voordijk *et al.* (forthcoming), the focus is on the *strategic* integration of these elements (the alignment of the business strategy and the IT strategy) - the upper part of the Strategic Alignment Model. In this paper, we focus on the operational integration of the business infrastructure and the IT-infrastructure and so on the lower part of the Strategic Alignment Model (see Figure 1).

The process-level model

Major question is in this paper is how to measure and evaluate the business value of IT systems. In order to deal with this question, the process-level model of IT business value is discussed (Tallon *et al.*, 2000). In assessing the payoffs from IT at the process level, this model focuses on how IT affects critical business activities within the corporation’s value system. These activities include aspects of production, logistics,

Table 1: Dimensions of IT business value (Tallon *et al.*, 2000)

Activities within the value chain
Process planning and support
IT improves planning and decision making by improving organizational communication and co-ordination and by enhancing organizational flexibility
Supplier relations (inbound logistics)
Use of IT to co-ordinate supplier linkages and reduce search costs
Production and operations
Use of IT to deliver enhanced manufacturing techniques through computer-aided design.
The use of advanced manufacturing techniques can enable a greater range of products and services
Product and service enhancement
IT can be used in the development of new products and services
IT can enable products and services to be uniquely differentiated in a variety of ways
Sales and marketing support
IT can be used to track market trends and responses to marketing programs
Customer relations (outbound logistics)
IT can be used to establish, sustain, and improve customer relationships
Improving customer relations can result in improved market share.

sales and marketing, customer service, and administrative support. The process-oriented assessment of IT business value is based on the argument that the first-order impacts of IT investment occur at the process level (Barua *et al.*, 1995). IT creates value for the organization by improving individual business processes, or linkages between processes, or both in terms of Porters' value chain (Porter and Millar, 1985). This value chain divides an organization into a sequence of primary activities (inbound logistics, operations, outbound logistics, marketing and sales, and service) and support activities. Tallon *et al.* (ibid.) present different examples from the literature of ways in which IT impacts different business activities within the value chain (see Table 1). By analysing the impacts of IT on these 'critical value activities', the IT business value can be evaluated.

The IT-based infrastructure

The IT-value can be measured by analysing the impacts of IT on the 'critical value activities' of Porters' value chain. Determining this value in a structured and meaningful way requires an operational description of what IT is in those critical value activities. Therefore, the concept of IT-based infrastructure (Renkema, 2000) is used. The IT-based infrastructure is the shared system of staff/skills, tools and procedures in the field of IT that is used for a longer period of time. Not all IT-based infrastructures have the same impact on the business processes or on the products and services of a business. In order to be able to assess the main differences in business impact, two main types of infrastructure can be discerned: direct and indirect.

The direct infrastructure consists of all shared, relatively permanent capacities and capabilities in the field of IT and to a large extent integrated within business processes. Indirect infrastructure is all shared, relatively permanent capacities and capabilities in the field of IT, which enable the use of IT in business processes. The first type of infrastructure concerns the shared applications of software, databases and knowledge bases of an organization. The second type of infrastructure concerns the 'traditional' infrastructure of shared technical computing facilities. The indirect facilities create the enabling conditions for the well-directed deployment of the direct facilities, while in turn the use of direct infrastructure necessitates the use of indirect infrastructure. Direct infrastructure generally has a much more tangible business

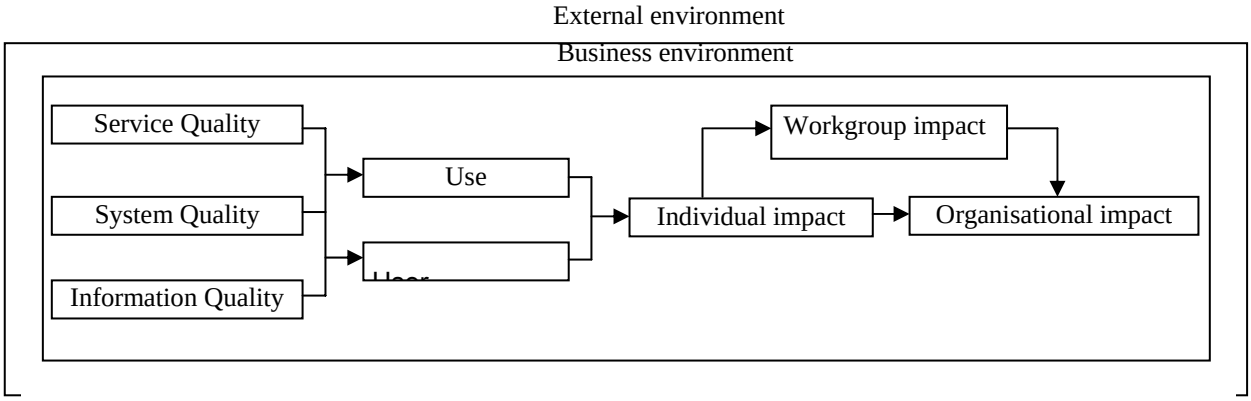

Figure 2: IS Assessment and Contingency Theory of Myers *et al.* (1998)

impact than indirect infrastructure, therefore it is often easier to identify IT business value in the value chain for direct than for indirect infrastructure.

How the IT-based infrastructure precisely looks like in practice depends on the decisions taken by the firm. Therefore a checklist of infrastructure components is used (Renkema, 2000). The components can be divided into the value chain processes (planning and support, inbound logistics, operations, outbound logistics, marketing and sales, and service). To determine the added value of IT the direct infrastructure in the value chain processes is charted first. It is assumed that the percentage of the available direct infrastructure components is an indicator of the relative importance of these processes for the company. This percentage gives the ratio between components that are actually available within the firm and the infrastructure components available from the checklist. After that the contribution of IT to the direct infrastructure in the processes is measured, which is an indicator of the possible value of IT to those processes. This percentage gives the ratio between the amount of IT components in comparison to the infrastructure components that are available in the firm.

Performance the available IT-infrastructure

The possible value of IT only leads to real added value when the IT is functioning properly within the processes. By applying the IS Assessment and Contingency Theory of Myers *et al.* (1998) the functioning of the available IT infrastructure can be measured.

The dimensions critical to the success of the IS function are shown in Figure 2. Service quality (the service function), system quality and information quality (reliability) jointly affect both use (usage) and user satisfaction. Additionally, the amount of use can affect the degree of user satisfaction – positively and negatively – as well as the reverse being true. Use and user satisfaction are direct antecedents of individual impact (performance); the multi-individual impacts lead to workgroup impact (synergy); and lastly, this individual and workgroup impact should have organizational impact (business performance).

IT-ALIGNMENT IN THE DUTCH CONSTRUCTION INDUSTRY

In order to verify our expectations, five companies in the Dutch construction industry were analysed. In the companies the responsible IT-managers and/or CEOs were interviewed using a semi-structured questionnaire. The key figures of the companies are given in Table 2. By applying the models introduced in the theoretical framework, we analysed the underlying factors that enlarge or reduce the added value of

Table 2: Case firms and their critical processes

	Firm D	**Firm T**	**Firm H**	**Firm E**	**Firm R**
Activities	Gardening	Civil Engineering	Housing/ Real estate	*Data will follow*	*Data will follow*
Turnover (million Euros)	60	70	40		
Employees (FTE's)	450	220	450		
Profit 2001 (%) (sector average)	3,6 (unknown)	2,0 (2,7)	2,1 (1,8)		
Critical Processes	Plan. & Sup. Inb. Log. Prod.	Plan & Sup. Inb. Log. Prod.	Plan. & Sup. Inb. Log. Prod. Sal. & Mar. Outb. Log.		

Table 3: Expected IT business value for different activities of the value chain

Activity value chain	**Expected IT business value**	
	Civil engineering	***Housing and real estate***
Process planning & support	High: in particular planning and exploitation of equipment (40% of the total costs)	High: in particular planning and exploitation of personnel (30% of the total costs) Project planning is also critical because of the large number of parties at the construction site.
Inbound logistics	High (40% of the total costs)	High (60% of the total costs)
Production & operations	Moderate	Moderate
Product & service enhancement	Low	Low
Sales & marketing support	Low	Low
Outbound logistics	Low (restricted number of principals)	Reasonable, high in reach-strategy

information systems and IT-applications in construction firms. First, the expected value for the different activities of the value chain was analysed. Second, the contribution of IT to the direct infrastructure was measured. Thirdly, the performance of the available infrastructure was evaluated.

The expected IT business value in construction

The Dutch construction industry is traditionally divided into two market segments: civil engineering and housing and real estate construction. This partition is relevant for determining the IT business value for a construction firm since value depends on the market in which a firm operates. In both market segments, public tendering dominates: the bidding price of a firm is the major criterion for acquiring a building project. Public tendering results in firm strategies focusing on operations effectiveness and more specific on cost reduction. Therefore, reduction of major cost categories is the major incentive for construction firms to invest in IT.

Table 4: Case study results

	Firm D			**Firm T**			**Firm H**			**Firm E**	**Firm R**
Act. Value Chain Proc.	(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)		
Plan. & Sup.	100%	65%		67%	44%		80%	81%			
Inb. Log.	80%	40%		100%	60%		100%	100%			
Prod.	100%	25%	High	75%	67%	Low	75%	100%	High		
R&D	100%	0%		0%	0%		50%	100%			
Sal. & Mar.	100%	67%		50%	0%		100%	50%			
Outb. Log.	67%	100%		67%	0%		100%	100%			

IT adds value by improving different activities of the value chain and the linkages between these activities. Based on the cost structures showed, we expect business value of IT on activities of the value chain of construction firms as shown in Table 2. The major focus of IT investments is theoretically the improvement of the utilization and productivity of equipment and personnel. Secondly, IT should support the planning and execution of projects and preventing stagnation of building processes, in particular in housing and real estate construction. Thirdly, IT can contribute to improvement of purchasing performance of construction firms.

The contribution of IT to the direct infrastructure

To determine the added value of IT in the case firms, the direct infrastructure in the value chain processes is charted first. It is assumed that the percentage of the available direct infrastructure components is an indicator of the relative importance of these processes for the company (Table 5, columns '(a)'). This percentage gives the ratio between components that are actually available within the firm and the infrastructure components available from the checklist. After that, the contribution of IT to the direct infrastructure in the processes was measured, which is an indicator of the possible value of IT to those processes (Table 4, columns '(b)'). This percentage gives the ratio between the amount of IT components in comparison to the infrastructure components that are available within the firm (Table 4, columns '(a)').

The functioning of the available infrastructure

The possible value of IT only leads to real added value when the IT is functioning properly within the processes. By applying the IS Assessment and Contingency Theory of Myers *et al.* (1998) the functioning of the available IT infrastructure was measured (Table 4, columns '(c)' - overall score). If the IT is functioning properly in the critical value processes and the contribution of IT is high then the IT business value will be high. Finally, the expected business value of IT was compared with the outcomes of the three case studies (Table 5a/b).

Based upon the results in the cases, there is evidence for a lower added value of IT than expected. In case D, the IS performance is good while the contribution to the critical processes is lower than expected. The business strategy is market focused and the IT strategy is operational focused. In case T, the IS performance as well as the contribution to the critical processes is poor. The firm does not maximally exploit the IT-possibilities. In case H the IS performance is good as well as the IT contribution to the critical processes.

Table 5a: Classification of the scores

Low	Moderate	Reasonable	High
< 20%	20-49%	50-80%	> 80%

Table 5b: Comparison of expectations (Table 3) and outcomes (Table 4 column '(b)')

	Expectations	Firm D	Firm T	Firm H	Firm E	Firm R
Plan. & Sup.	High	Reasonable	Low	High		
Inb. Log.	High	Moderate	Moderate	High		
Prod.	Moderate	Moderate	Low	Reasonable		
R&D	Low	Low	Low	Reasonable		
Sal. & Mar.	Low	Reasonable	Low	Reasonable		
Outb. Log	Moderate/ High	Reasonable	Low	High		
IT Bus. Value		Moderate	Low	Reasonable/ High		

CONCLUSION

The objective of this paper is to analyse the underlying factors that enlarge or reduce the added value of information systems and IT-applications in construction firms. The basic premise is that firms with a high level of alignment between the business infrastructure and the IT-infrastructure will also realize high levels of IT business value. Any attempt to increase IT business value must consider the extent to which IT-infrastructure is aligned with the (critical) business processes. The potential value of IT was evaluated by applying the process-oriented approach of Tallon *et al.* (2000). This analysis showed that the expected IT business value is high in process planning and support (planning and exploitation of equipment and personnel) and supplier relations (purchasing). In order to verify these expectations, five companies in the Dutch construction industry were analysed.

First, the expected value for the different activities of the value chain was analysed. Second, the contribution of IT to the direct infrastructure was measured. Thirdly, the performance of the available infrastructure was evaluated. Based upon the results in the cases, there is evidence for a lower added value of IT to the business strategy than expected.

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