Beyond critical success factors: 
A dynamic model of enterprise system innovation

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Abstract

Enterprise systems (often referred to as enterprise resource planning (ERP) systems) can help organisations manage their key resources: money, staff, products, customers and suppliers, more effectively. Like many new technologies, ERP has been accompanied by vendor hype and stories of implementation failure. Work on critical success factors (CSFs) should encourage more appropriate implementation practice; however many CSF studies conclude with a list of factors but provide little further guidance. This paper presents a new model of ERP CSFs which draws upon existing work in IS innovation and on simulation ideas in order to better understand the relationships between CSFs and to encourage exploration of more appropriate implementation strategies.

Keywords: Enterprise systems; Enterprise resource planning, ERP; Critical success factors, CSFs

1. Introduction

The work presented here arose from concerns that the large and growing literature on critical success factors (CSFs) was not providing practitioners with the tools to enable more effective interventions in major systems implementations such as enterprise resource planning (ERP) and customer relationship management (CRM). Large-scale integrated systems are by definition complex and difficult to implement. The systems have the potential to “join-up” organisations both internally and externally (with suppliers, partners and customers) with the promise of more efficient communications and transactions. But many implementations of ERP and CRM have been criticised regarding the time, cost and disruption caused by implementation and the sometimes limited benefits once the systems become operational. In response to this, a number of studies have proposed CSFs, largely for the longer-established ERP technology, but latterly for the newer CRM too. Whilst such studies are welcome, providing a list of CSFs is only a partial aid to the practitioner struggling to understand the implications of their actions.

The work described in this paper addresses the next stage in improving understanding of large-scale information systems implementation in general, and ERP implementations in particular. Drawing on the long-established field of simulation, a new model for ERP innovation is presented and its implications discussed.

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2. Enterprise resource planning

Heizer and Render (2003) define an ERP system as: “an information system for identifying and planning the enterprise-wide resources needed to take, make, ship and account for customer orders” (p. 540). A complimentary definition is provided by Aladwani (2001): “… an integrated set of programs that provides support for core organizational activities such as manufacturing and logistics, finance and accounting, sales and marketing, and human resources”. Heizer and Render identified three major advantages of ERP systems: firstly, that business processes are integrated and automated; secondly, that common data and business practices are shared throughout the organisation; thirdly, that information is generated in real time. Enterprise systems are designed to tackle the fragmentation of information in large organisations, acting as an integrative mechanism connecting diverse organisational units by shared data and software modules (Davenport, 1998; Hammer & Stanton, 1999). The ERP software market is led by the German software vendor SAP AG, with its flagship product R/3 supported by an increasing range of additional modules and functionality including CRM, business intelligence, advanced supply chain planning and industry-specific solutions. The implementation of ERP systems involves a significant commitment of time and money. Heizer and Render (2003) reported costs ranging from $300,000 to several hundred million dollars, depending on the size of the organisation. According to some software vendors, implementing organisations spend three to seven times the licence fee on implementation and related expenses (Heizer & Render, 2003; Scheer & Habermann, 2000). A survey by Forrester Research revealed that 54% of responding organisations took more than 2 years to implement ERP (Worthen, 2002). The often-reported problems during or after ERP implementation are easily blamed on complex technology. However, this is generally not the case, and a range of organisational and management issues have been identified as standing in the way of the “dream” of enterprise integration (Davenport, 1998). ERP implementation should be viewed as organisational transformation, not as a large IT project (Edmonson, Baker, & Cortese, 1997; Wood & Caldas, 2001) with a need to devote significant resources and energy to change management (Al-Mashari & Zairi, 2000; Bancroft, Seip, & Sprengel, 1998; Hilson, 2001).

3. Success and failure

ERP represents a major investment. But the failure rates are high, with Griffith, Zammuto, and Aiman-Smith (1999) reporting that three quarters of ERP projects were judged as unsuccessful by the implementing firms. Success and failure are well-established areas of study in the information systems literature. A number of generic IS success models have been developed and tested in recent years (Davis, 1989; DeLone & McLean, 1992; Rai, Lang, & Welker, 2002; Seddon, 1997). More specifically, ERP implementations have been the subject of a number of studies aiming to identify CSFs (Akkermans & van Helden, 2002; Holland & Light, 1999; Hong & Kim, 2002; Somers & Nelson, 2001). Somers and Nelson (2001) asked US executives to rank the ERP CSFs—producing the following “top 10” in terms of the mean score (from 1 = low to 5 = critical):

- Top management support 4.29
- Project team competence 4.20
- Interdepartmental co-operation 4.19
- Clear goals and objectives 4.15
- Project management 4.13
- Interdepartmental communication 4.09
- Management of expectations 4.06
- Project champion 4.03
- Vendor support 4.03
- Careful package selection 3.89

Alongside, and complementing the work on success factors, is the body of work on IS failure (Irani, Sharif, & Love, 2001; Keil, 1995; Lemon, Liebowitz, Burn, & Hackney, 2002; Lyytinen & Mathiassen, 1998; Lyytinen...
Sauer (1993) developed a model of information system innovation which emphasises the importance of the organisational context into which the system is being introduced and the need to manage expectations and system evaluations to ensure support is maintained (Fig. 1).

Sauer’s model can be used to structure the list of 10 ERP CSFs presented above as follows:

- **Context**: interdepartmental co-operation, interdepartmental communication.
- **Supporters**: top management support, project champion, vendor support.
- **Project organisation**: project team competence, clear goals and objectives, project management, management of expectations, careful package selection.

Sauer’s constructs: context, supporters and project organisation serve to connect Somers and Nelson’s work to the extant body of knowledge on IS success/failure and to provide a higher level of abstraction to the CSF list. They also suggest a set of high-level relationships between the CSFs. Finally, Sauer’s model amplifies the CSF work by making explicit a key element of any work on CSFs—outcomes (or “solutions” in Sauer’s model)—and suggests that further work may be required to identify the outcomes and to show how they relate to the CSFs in order to build up a fuller model of the ERP implementation process. Although not shown in Fig. 1, Sauer also provides a useful definition of IS failure as a process whereby support is withdrawn over a period of time and eventually reaches a point where the project organisation can no longer sustain development. This moves the definition of failure away from the commonly used concepts of time and budget overruns and defects, and suggests failure has a strong social dimension.

### 4. Modelling and simulation

Akkermans and van Helden (2002) have moved the ERP CSF debate on from simply listing factors to trying to understand the interrelationships between factors. They also use Somers and Nelson’s ten CSFs with the aim of developing a causal model that can be used to explain ERP project success (or failure)—see Fig. 2.

Building on the discussion of the previous section, where Sauer’s model adds a macro-level structure to the CSFs, Akkermans and van Helden provide a micro-level structure by showing the relationships between individual CSFs. They argue that a ripple effect occurs which leads to the creations of either virtuous or vicious cycles and, eventually, to ERP success or failure, respectively. For example, an increase in top management support could lead to the appointment of a dynamic project champion who, in turn, encourages the project manager to introduce regular cross-departmental process redesign workshops involving a wide range of
stakeholders. These workshops lead to greater interdepartmental communication and, consequently, to greater collaboration. This is a virtuous cycle. In contrast, a vicious cycle could be where a poorly constituted project team lacks the competence to engage departmental stakeholders fully. This leads to limited interdepartmental communication and co-operation with the result that expectations are unrealistic and inappropriate goals and objectives are set for the project. Combining the models of Sauer and Akkermans and van Helden produces Fig. 3, which depicts the “virtuous” cycle described above.

Whilst improving understanding of the interrelationships between CSFs is undoubtedly a step forward, more can be done. Sauer’s model and Akkermans and van Helden’s model are valuable conceptual tools. But the causal relationships contained within them have not been validated: “The correctness of the causal loop diagram built up [in Fig. 2] … cannot be ‘proven’, since it was an intuitive effort … It should therefore be seen as exploratory theory building and as a possible starting point for follow-up research” (Akkermans & van Helden, 2002, p. 44).

In particular there is a body of knowledge in the field of simulation that can be drawn upon in order to develop a more powerful model which can be used to explore the impact of changes to individual CSFs, and to link the CSFs directly to project outcomes. Furthermore, the simulation discipline provides techniques for model validation which could help develop a more rigorous theory of ERP innovation. Abdel-Hamid and Madnick’s (1990) work on software development simulation provides an example of the kind of model that can be developed (Fig. 4).

The model shown in Fig. 4 makes three advances on Akkermans and van Helden’s work (Fig. 2):

1. Individual variables, which in some instances equate to CSFs, are grouped into higher-level constructs such as Software Production, Control and Planning making the model easier to understand.
2. Project outcomes are included in the model, such as Actual Productivity and Error Rate.
3. The model can be used in simulation studies; in this case _Perceived Project Size_ was varied to assess the impact on _Actual Productivity_.

Points 1 and 2 above have already been addressed by combining Figs. 1 and 2 to produce Fig. 3, although in Fig. 3 the precise nature of the project outcomes (or “solutions”) has yet to be defined. Point 3 supports
Akkermans and van Helden’s concept of “vicious” and “virtuous” cycles by suggesting that these cycles can be simulated in a simulation study. To summarise, there are strong parallels between the combined ERP CSF model (Fig. 3) and the simulation model (Fig. 4). This suggests that it will be possible to build a simulation model for ERP innovation and to use that model in a simulation study in order to explore the effects of different project scenarios, such as increased top management support or reduced interdepartmental communication.

5. Social capital and social exchange theory

Fig. 3 depicts the set of social relationships as essentially linear or two-dimensional. Supporters and the project organisation are shown as somehow separate from the “departments”, which are viewed as part of the organisational context. In reality they are likely to be embedded to a greater or lesser extent within the departments. For example, the project champion(s) should be respected members of the departments which are the focus of the enterprise system project. They are tasked by top management with promoting the benefits of ERP to their departmental colleagues and acting as boundary spanners between departments. Similarly, the project organisation is likely to comprise of both technical specialists and departmental user representatives. The web of social relations constitutes a third, hidden, dimension to the model shown in Fig. 3. A deeper understanding of these relations can help explain why top management are supporting the project, why the project champion(s) wish to devote time and energy to promoting ERP and why departmental users might support (or resist) the change. Two theories that encourage a deeper exploration of these drivers are social capital theory and social exchange theory.

Social capital is defined as “the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit” (Nahapiet & Ghoshal, 1998, p. 243). Social capital theory has been developed to explain the importance of networks of social relationships which are developed over time and provide the context for social interactions within and between organisations and across communities (Jacobs, 1965). It is seen as comprising of three dimensions: a relational dimension (including trust, social norms of behaviour and obligations), a cognitive dimension (including shared representations, language and narratives) and a structural dimension (including formal organisational structures, and informal personal social networks) (Nahapiet & Ghoshal, 1998). Increases in social capital are seen as likely to engender improved social outcomes (such as access to knowledge and expertise and an increased motivation and capacity to collaborate) which, in turn, are likely to lead to improved operational outcomes, such as greater creativity, innovation and collaboration (Cohen & Prusak, 2001; Hatzakis, Lycett, Macredie, & Martin, 2005). Applying a social capital perspective to the dynamics depicted in Fig. 3 encourages further exploration of the underlying relationships between the participants; for example, is there a history of trust between top management and the departmental users? Have top management supported the career aspirations of the project champion(s), thereby creating an obligation on the latter’s behalf to support/champion the new initiative? Similarly, with regard to the cognitive dimension, do the project team members “speak the same language” as the departmental users? Have they perhaps “gone native” and, through close and regular contact with vendor staff, become inculcated with the vendor’s language and beliefs about the inherent superiority of the new system over the existing ways of working? This would have the effect of increasing social capital between the vendor staff and the project organisation, at the cost of decreasing social capital between the project organisation and the departmental users. Thirdly, it is likely that the formal organisational structure discourages interdepartmental communication and collaboration. Departments may not be co-located, and they are likely to be constituted with different objectives, work processes, technologies and clients. These structural differences will amplify the relational and cognitive differences over time, as physical and organisational separation leads to weaker obligations, fewer opportunities to collaborate and thereby build up trust, and separate histories and narratives of sales won, deadlines met (or missed) and (glorious?) failures. The net outcome of the above scenarios could be low levels of social capital residing in the relationships between departments, low levels between top management and the departments, high levels between top management and the project champion(s), increasing levels between the project organisation and the vendor, but reducing levels between the project organisation and departmental staff.
Social exchange theory also seeks to explain what motivates actors to behave as they do (Blau, 1964; Kelley & Thibaut, 1978; Thibaut & Kelley, 1959). Social exchange theory “... views interpersonal interactions from a cost-benefit perspective, much akin to an economic exchange—except that a social exchange deals with the exchange of intangible social costs and benefits (such as respect, honour, friendship, and caring) and is not governed by explicit rules or agreements. Like economic exchange, social exchange assumes that individuals take part in an exchange only when they expect their rewards from it to justify the costs of taking part in it.” (Gefen & Ridings, 2002, p. 50). Gefen and Ridings describe a “quasi-experiment” whereby they contrasted the outcomes of two CRM implementation projects. In one project, the CRM project organisation reacted rapidly and constructively to users’ request for bug fixes and software changes, in the other project the response was slower and less helpful. Their hypothesis was that this “perceived responsiveness” would lead to increased “cooperative intentions” on the part of the users which, in turn, would increase software “configuration correctness” leading to greater “user approval” of the CRM system. The experiment results supported this hypothesis—namely that the social exchanges between the users and the project team were more positive, from a user perspective, in the first project—the project team were seen to “care” more for their users and to be providing them with a better-customised solution than in the second project. The users, in turn, repaid this care by providing greater support (“approval”) to the CRM project. There are many similarities between ERP and CRM systems and projects. Both are typically large-scale, complex systems supplied by external vendors. Both aim to integrate the work of separated departments and work groups and to encourage the sharing of information and knowledge. Social exchange theory suggests that the level of support and co-operation is likely to fluctuate over time as different social exchanges take place. For example, top management will meet with vendor staff and will be seeking assurances that the software will meet their needs at a cost they can afford. They will be judging the vendor staffs’ responsiveness in much the same way as Gefen & Ridings’ users judged the CRM team: do they answer our questions quickly and clearly? Do we believe their responses? Are their staff knowledgeable and credible? Are we important clients to them?

Underlying all social exchanges is a degree of exposure: often one party is more vulnerable than the other, sometimes both are equally vulnerable. Top management may feel vulnerable in their dealings with vendor sales staff. Management are unlikely to be familiar with the software or to have used it before. They will not comprehend fully the degree of organisational change implicit in the adoption of the new system. Similarly, the project champion will be asking of top management: what are the explicit and implicit rewards being promised for my commitment to this (time-consuming) role? Are you genuinely supportive of the project? Will you be actively involved or will you leave all the “fire fighting” to me? And, as Gefen & Ridings showed, the departmental users will be having social exchanges with the project organisation and asking: how responsive are they? Do they really understand our concerns? Do they fulfil their promises to us? Whilst formal contracts can be drawn up to address some of these concerns, the sheer complexity of social relations surrounding an organisational innovation as large and as complex as a new ERP system means that all stakeholders are likely to be exposed at times to unsatisfactory social exchanges and to deficits in social capital.

6. A dynamic model of ERP success factors

In this section a dynamic model for ERP success is proposed (Fig. 5). The model draws upon the preceding discussion and extends Fig. 3. The CSFs in italics are taken from Somers and Nelson (2001). Additional support for these CSFs is as follows: vendor support (Robey, Ross, & Boudreau, 2002; Soh, Kien, & Tay-Yap, 2000; Swan, Newell, & Robertson, 1999), project management (Robey et al., 2002), package selection/customisation (Hong & Kim, 2002; Soh et al., 2000; Swan et al., 1999), project team competence (including education and training) (Gefen & Ridings, 2002; Robey et al., 2002; Soh et al., 2000). Hong and Kim (2002) identified two additional CSFs that did not appear in Somers and Nelson’s top 10: organisational resistance and process adaptation—these are shown in bold in Fig. 5. ERP outcomes are split in two: development outcomes and operational outcomes. The former are drawn from Abdel-Hamid and Madnick’s (1990) work; the latter from Shang and Seddon (2002). Shang and Seddon define five categories of benefits arising from ERP:

1. Operational (cost reduction, cycle time reduction, productivity improvement, quality improvement, customer service improvement).
2. Managerial (better resource management, improved decision making & planning, performance improvement).

3. Strategic (support for business growth, support for business alliance, building business innovations, building cost leadership, generating product differentiation, building external linkages).

4. IT infrastructure (building business flexibility for current and future change, IT cost reduction, increased IT infrastructure capability).

5. Organizational (changing work patterns, facilitating organizational learning, empowerment, building common vision).

Fig. 5 suggests a set of high-level dynamics between the key groups: departments, top management, ERP vendor, project champion(s) and project organisation. In order to develop a simulation model, these high-level relationships need to be replaced with low-level relationships between individual variables, of the type shown in Fig. 4. Fig. 6 shows how a subset of the relationships could be modelled using simulation software.

The model depicts the following cycle. Top management set the project goals (target cost and work quality). As the project progresses they monitor project costs. Once the system goes live they also monitor changes in average business work quality (e.g. cost reductions, cycle time reductions, productivity improvements etc. listed by Shang & Seddon). If the costs are as expected and work quality improves as expected top management support is maintained (or increases). In this simple model, support is linked to project workforce hire rate—in other words the project organisation is rewarded for delivering a successful system by being given more staff. The implication here is that more staff will enable the project organisation to complete its work more quickly (whilst acknowledging concerns about linear productivity gains—the “mythical man month” argument). But, as shown in Fig. 6, more staff also means more cost. This may lead eventually to the project exceeding the target cost and result in a fall in top management support. Further scenarios not currently supported by the simulation model are described in the next section.

7. Using the model

The dynamic model shown in Fig. 5 has yet to be converted into a simulation model—Fig. 6 is an initial attempt at converting part of the model. Nonetheless, more extensive scenarios than the one described in the
previous section can be envisaged. For example, a fall in top management support may lead to less experienced staff being seconded to the project team, reducing team competence. This in turn could lead to inappropriate customisation decisions which reduce system quality by limiting functionality. An alternative scenario could be low levels of interdepartmental collaboration leading to limited process adaptation which in turn leads to limited productivity improvements (an operational benefit). These are examples of Akkermans and van Helden’s “vicious” cycles. Similarly, “virtuous” cycles could be explored as discussed earlier in the paper.

The purpose of simulation is to explore possible outcomes using a realistic model of a situation without incurring the cost of “doing it for real”. By exploring different outcomes, the appropriateness of different courses of action can be evaluated and compared, thereby leading to improved practice. But there are also benefits to be gained from the process of constructing the model. The model suggested here encourages participants in ERP innovation to consider the CSFs and how they interrelate. In particular, the examples of vicious cycles highlight some of the negative patterns of behaviour that are often not addressed in the implementation of complex systems but which can have a significant impact on the end result.

8. Conclusion and future work

Organisations face considerable challenges in implementing large-scale integrated systems such as ERP. The promise of internal and external integration is understandably attractive in a world where service excellence, innovation and efficiency are relentless task-masters. There exists a large body of work identifying and describing critical success factors for information systems in general and ERP in particular. The vast majority of this literature focuses on “static” CSFs, often for the development stage of the life-cycle, and generally not explicitly linked to outcomes. The work presented here moves this line of thinking forward by creating a dynamic CSF model wherein individual CSFs are linked in causal chains. Outcomes are explicitly included in the model, particularly operational outcomes such as productivity improvements and improved decision making which, after all, are the reason for the investment in the new technology in the first place. To simplify the model and ease understanding, Sauer’s model of information systems innovation is used to group the factors together and to add a higher-level set of relationships emphasising the role of organisational context, support management and evaluation of outcomes in particular.

The model is currently under development and is to be validated via interviews with key stakeholders in ERP-using organisations. Once the set of CSFs and relationships have been validated, a full simulation model will be developed and further validation of the simulation results undertaken with the supporting organisations. The simulation model will be used for further research into ERP implementation and benefits and for management education, where different scenarios will be posed for groups of managers to explore the consequences of their actions.
References


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