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Critical elements for a successful enterprise resource planning implementation in small- and medium-sized enterprises

T. C. LOH and S. C. L. KOH*

The body of research relating to the implementation of enterprise resource planning (ERP) systems in small- and medium-sized enterprises (SMEs) has been increasing rapidly over the last few years. It is important, particularly for SMEs, to recognize the elements for a successful ERP implementation in their environments. This research aims to examine the critical elements that constitute a successful ERP implementation in SMEs. The objective is to identify the constituents within the critical elements. A comprehensive literature review and interviews with eight SMEs in the UK were carried out. The results serve as the basic input into the formation of the critical elements and their constituents. Three main critical elements are formed: critical success factors, critical people and critical uncertainties. Within each critical element, the related constituents are identified. Using the process theory approach, the constituents within each critical element are linked to their specific phase(s) of ERP implementation. Ten constituents for critical success factors were found, nine constituents for critical people and 21 constituents for critical uncertainties. The research suggests that a successful ERP implementation often requires the identification and management of the critical elements and their constituents at each phase of implementation. The results are constructed as a reference framework that aims to provide researchers and practitioners with indicators and guidelines to improve the success rate of ERP implementation in SMEs.

1. Overview of enterprise resource planning (ERP) implementation in small- and medium-sized enterprises (SMEs)

In recent years, many enterprises world-wide have been focusing on their core business, downsizing and outsourcing, due to adverse global economic conditions. However, their approaches to improve performance essentially have been inward-looking and there is a developing consensus that this tactic might have run its course. Enterprises, in particular SMEs within a supply chain that involves larger enterprises, must now turn to more outward-looking approaches such as providing higher added value to customers and developing better working relationships and ultimately partnerships if they are ready to improve their performance and competitiveness.

The supply chain competitiveness between supplier and customer partly relies on how effective and efficient the order and information are being handled between the parties in the supply chain. This can be assisted by the use of an integrated, enterprise-wide information system such as an ERP system. Being an SME in a supply chain that deals with a larger enterprise, having an information system like

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this will provide better performance in manufacturing and logistics (Mabert *et al.* 2003).

At the strategic level, the ERP system is defined as an integrated application programme for enterprise business organization, management and supervision (Davenport 1998). ERP collects all the functionalities of stand-alone applications and gathers inside a standard software, making it compatible with different business processes. At the operational level, ERP is a game plan for planning and monitoring the resources of a manufacturing enterprise, including the functions of manufacturing, marketing, finance and engineering (Wight 1993). ERP represents the application of the latest information technology (IT) to manufacturing resource planning (MRPII) systems and it is related to the fundamental techniques of material requirements planning (MRP) in that if they are used as a production planning and control tool, they follow the same MRP release logic (Enns 2001, Miltenburg 2001, Koh and Saad 2002, 2003). Hence, the outputs (i.e. planned order release, schedules) generated from such a tool are identical. Within an ERP system, this will be generated from the production-planning module. Their planning capability could offer substantial gains in productivity, dramatic increases in customer service, much higher inventory turns and a greater reduction in material costs if they are used efficiently and facilitated by necessary support.

Within an enterprise, each individual department typically has its own computer system optimized for the particular ways that the department does its work. Nevertheless, ERP gathers them all together into a single, integrated software program that runs off a single database so that a number of departments can easily share information and communicate with each other. Figures 1 and 2 underline the logical differences between a stand-alone and an integrated architecture for enterprise business management.

This integrated approach can have a remarkable payback if enterprises implement the software correctly because these features bring about a general reduction of error occurrence due, for instance, to non-up-to-date data or manual data transfer operations between applications. The effect of such an integrated approach would mean that higher levels of efficiency in the processes could be achieved, as the system provides better information that enables better decision-making.

Such an integrated approach is supported by some technological innovations, which include relational database management systems, graphical user interface, open systems and client/server architecture (Robert 1996). Today, web-enabled ERP systems facilitated by online analytical processing capability (Chen *et al.* 2003)

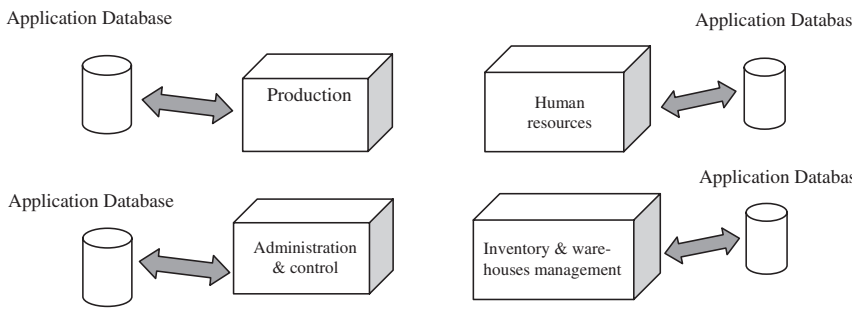


Figure 1. Stand-alone applications' architecture.

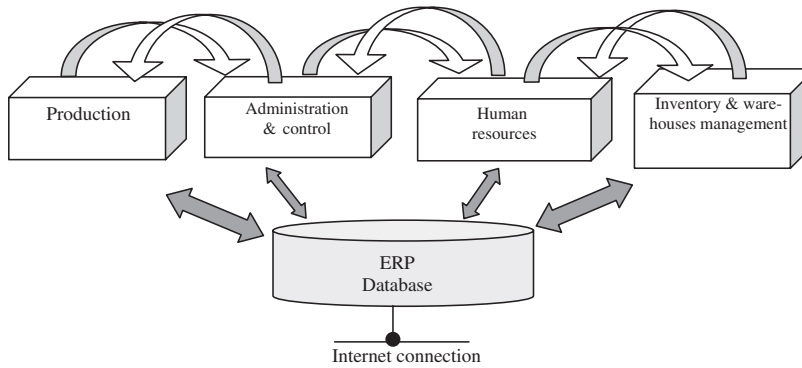


Figure 2. ERP-integrated architecture.

and a total e-business solution approach (also known as extended enterprise or ERPII) via integration with supply chain management software and customer relationship management software (Tarn and Razi 2002) are the key technological developments by many ERP vendors.

2. ERP market and research need

The ERP software market has been growing rapidly between 1993 and 1997, and it has been predicted that the current growth rates of 35–40% will be sustained in the long term (Bingi *et al*. 1999). Many large enterprises have already used ERP systems to support their business-to-business and business-to-consumer activities. The big ERP system vendors are SAP (http://www.sap.com), BaaN, ORACLE and PeopleSoft, and the overall market for ERP was predicted to reach US$66.6 billion by 2003 (AMR Research 1999, http://www.amrresearch.com, accessed 21 October 2003). In parallel to using ERP, some enterprises have also used other and more advanced scheduling tools to support their planning activities, e.g. Advanced Production Scheduling (Tinham 2002, Wiers 2002); and added decision support systems to ease reuse of standard software components (Worley *et al*. 2002).

To cater for the needs of SMEs, many midrange and less complex ERP systems have been developed, e.g. Alliance Manufacturing (Exact Software), MFG/PRO (QAD), WinMan (TTW) and Fourth Shift (http://www.fs.com). In conjunction with using such systems as a planning and control tool, many SMEs combine this with other execution concepts, such as just-in-time and optimized production technology. In SMEs, the combination with just-in-time is the most common practice (Chin and Rafuse 1993).

Ever since the first stories about enterprises implementing ERP systems began to emerge in the mid-1990s, there has been an increasing demand for research into this area. Despite the extensive research on improving the success rate of ERP implementation, Buckhout *et al*. (1999) found that 70% of ERP implementation projects fail to achieve their corporate goals. The high failure rate of ERP implementation calls for a better understanding of its critical elements (CEs) that constitute a successful ERP implementation. Most past research was conducted in the context of larger enterprises, but Chalmers (1999) and Mabert *et al*. (2003) found that enterprises of different sizes approach ERP implementation differently across a range of issues. This research will look at the problem from the perspectives of

SMEs. The amount of research relating to the implementation of ERP systems in SMEs has been increasing rapidly over the last few years (Tinham 1999, Rao 2000, Chung and Wong 2002, Muscatello *et al*. 2003). Therefore, it is important, particularly for SMEs, to recognize the elements for a successful ERP implementation in their environments, which are usually restricted by knowledge and resources constraints.

This research aims to examine the CEs that constitute a successful ERP implementation in SMEs. The objective of this research is to identify the constituents within the CEs. The following sections discuss the research methodology applied, the review of the literature, the results, analysis and discussions for the CEs and their constituents, and the construction of a reference framework. The literature review forms the major part of this paper, which is then further supported by interview results with SMEs in the UK.

3. Research methodology

A multimethods approach was used to enable triangulation of results (Saunders *et al*. 2003). The multimethods in this research consisted of literature review and personal interviews.

A computer search of databases of the published literature and conference proceedings in the University Learning Resources area was carried out to find previous research in the study of ERP. This was based on the searching of results on factors affecting its implementation. The articles were searched by the title based on the criteria that it must contain the term 'ERP implementation' or its equivalent, such as MRPII and 'SMEs'. Given that ERP evolved from MRPII, the findings in this context would be equally applied for their implementations.

Due to the various ways of referring to the same factor used by different researchers, the factors were deduced (Loh *et al*. 2003) in order to filter repetition and highlight key factors. The criteria used for this deduction were also based on the premise that the factors had to be claimed by a minimum of five references to show criticality. The omission of other factors at this threshold was that the factors might not be as critical as compared with the results from such a deduction. This deduction method was applied to identify the CEs and its constituents for ERP implementation in SMEs. It must be noted that this deduction method is not the deduction method usually applied in database and artificial intelligence research, but the same concept was used.

A process theory approach (Markus *et al*. 2000) was then applied to link the constituents to appropriate phases of ERP implementation. The rationale of providing such a link was that different factors are critical at different stages in the ERP implementation process, and hence such a linkage would show academics and practitioners which factors will come into play at particular times during the actual practice and process, and this needs to be made clear.

Personal interviews with eight SMEs in the UK that either had completed or were currently undergoing their ERP implementations were conducted to verify and validate the findings in the literature. These interviews were also used to investigate the types of uncertainty and problems that they perceived and faced during ERP implementation. Using the process theory approach, the results for interviews for this aspect were then linked specifically to particular phases of ERP implementation. Similar rationale as discussed above was applied for this linkage.

4. Overview of literature review

Despite the rapid development of various mid-range ERP systems for SMEs and the technological advancement in ERP systems, many failures of ERP implementation were still reported (Somers *et al.* 2000). This section shows some past research in this area and highlights the research gaps to be addressed.

The benefits of a properly implemented ERP system are significant, but the price of a poorly implemented system is great especially for SMEs. The price refers to both tangible and intangible losses due to failed implementations, such as the tangible cost of hardware and software, and the less tangible cost of customer dissatisfaction. Likewise, many implementations take more time and are more costly than necessary to achieve a given success level (Cantu 1999, Zhao *et al.* 2002). Implementation cost and schedule data readily exist, but success data do not. To this end, a large number of researches in this area examined the critical success factors (CSFs) of ERP implementation. This review highlights the CSFs of ERP implementation in SMEs.

Among the articles identified, Duchessi *et al.* (1988) was the earliest published work that studied CSFs in MRPII implementations. The suggested CSFs include a project champion; project management; business plan and vision; top management support; effective communication and change management program and culture. It is envisaged that the CSFs of MRP and MRPII implementations will also be relevant in the context of ERP implementation because they are both sophisticated and based on centralized information systems used by enterprises for production and manufacturing planning, and their implementations would require similar resources. Petroni (2002) had carried out examination on the CSFs of MRP implementation in SMEs, and their CSFs of MRP implementation were not directly used in this study so that an up-to-date comparison of these results could be made.

Bingi *et al.* (1999) suggested that top management support; strong ERP teamwork and composition; effective business process re-engineering (BPR) and minimum customization; efficient change management program and culture and efficient software development, testing and troubleshooting are the factors affecting ERP implementation. However, Brown (1994) merely emphasized effective project management and an efficient change management program and culture, which could significantly affect the success of such an implementation. Buckhout *et al.* (1999) disagreed with Brown's findings, and instead suggested that a clear business plan and vision; top management support and strong ERP teamwork and composition are the key factors for a successful implementation. However, Mainthou *et al.*'s (1996) findings were consistent with Brown's, but they also found that continuous monitoring and evaluation of performance is critical.

Roberts and Barrar (1992) found that a clear business plan and vision; top management support; effective BPR and minimum customization; efficient change management program and culture and continuous monitoring and evaluation of performance are amongst the CSFs of such an implementation. Nevertheless, Scheer and Habermann (2000) concluded that a successful ERP implementation is mainly dependent on efficient software development, testing and troubleshooting. Stefanou (1999) contradicted Scheer and Habermann's finding, and instead suggested that such an implementation relies on good project championship and strong ERP teamwork and composition. Although project championship seems to be one of the CSFs, which were strongly supported by many authors including Sum *et al.* (1997), they also thought that a successful implementation could not be

achieved unless effective communication, continuous monitoring and evaluation of performance are in place.

Falkowski *et al*. (1998) was one of the researchers who supported the presence of a good project champion being one of the CSFs. They have added that a successful ERP implementation should also depend on effective project management; a clear business plan and vision; effective communication; strong ERP teamwork and composition; efficient change management program and culture and continuous monitoring and evaluation of performance. Sumner (1999) reinforced many of the CSFs suggested by Falkowski *et al*. (1998), but with the exception that they found top management support; effective BPR and minimum customization are more critical than having a clear business plan and vision.

Effective project management; a clear business plan and vision; top management support; effective communication; strong ERP teamwork and composition; effective BPR and minimum customization; efficient change management program and culture and efficient software development, testing and troubleshooting were amongst the CSFs found by Wee (2000). These CSFs were closely matched with Holland and Light's (1999) findings, with a difference in that Holland and Light also found that continuous monitoring and evaluation of performance being critical for a successful ERP implementation. In addition, they have also identified another factor, i.e. appropriate business and legacy systems, which could affect the success of an ERP implementation. Roberts and Barrar (1992) also found that this particular factor is critical. Rosario (2000) reinforced the CSFs identified by Holland and Light but with two mismatches. Rosario did not highlight that top management support is critical, but disagreed with Holland and Light's finding that a good project champion is not critical.

Extensive research also showed that people are a major factor in detecting the performance of an ERP implementation project in an enterprise. Turnipseed *et al*. (1992) found that people involvement in implementation, support for the system and the level of usage are highly correlated to satisfaction with such a system. However, it was found that prior experience with complex information systems and the level of education and training are not important factors in perceptions of satisfaction with this system. In contrast, Mainwaring (1999) proposed that users' training is the key to ERP implementation. It was suggested that nurturing clients' trust to encourage a successful customization is a key factor for a successful ERP implementation (Gefen 2002).

Issues of uncertainty were also being identified as one of the key factors, which will affect the performance of an ERP implementation (Kochhar and McGarrie 1992, Kochhar *et al*. 1995). However, little research can be found for this factor on ERP implementation. Data quality issues in implementing an ERP system were also being debated (Xu *et al*. 2002).

Little research can be found in examining the CEs and their constituents for a successful ERP implementation in SMEs. The overview of this literature review showed that the majority of the past research in this area concern the factors that would critically affect ERP implementations. Nevertheless, researchers perceived different factors being critical in different ways. Such differences will create difficulties for future researchers and practitioners who would like to use the findings for references. In addition, they were mainly being examined discretely, rather than being linked to the process of implementation. It is clear that the issues of uncertainty during ERP implementation were being overlooked. Some contradictions on

the findings were also identified. To this end, we proposed a conceptual reference framework to show the factors that are critical for a successful ERP implementation in SMEs, by addressing the research gaps identified from this review.

5. Results, analysis and discussions

It was found that the past research on ERP implementation in SMEs could be generally categorized into three CEs, namely CSFs, critical people (CP) and critical uncertainties (CUs). Their constituents were identified and a conceptual reference framework of CEs for a successful ERP implementation in SMEs was developed.

This section discusses the results of the deduction method on the CSFs and their linkage to the appropriate phase of ERP implementation using the process theory approach. The interview results on the CP and CUs of ERP implementation, and their linkage at each phase of ERP implementation will also be explained. Finally, a conceptual reference framework of the CEs for a successful ERP implementation in SMEs will be presented.

5.1. *Critical success factors and critical people*

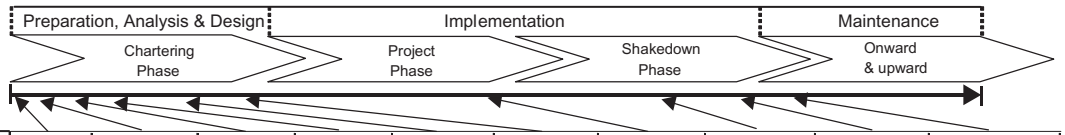
Initially, 21 CSFs were found. They were then deduced to 11 CSFs based on the grouping of similar factors together. These were then deduced to 10 CSFs based on the set threshold that such factors need for referral by at least five references. See Appendix 1 for the complete listing and their relationships with the 10 CSFs. Figure 3 shows a matrix of the 10 CSFs of ERP implementation in SMEs, which were linked to particular phases of ERP implementation using the process theory approach.

During the deduction process, for example, 'appropriate business and legacy systems' were only claimed by Roberts and Barrar (1992) and Holland and Light (1999). This dissatisfied the threshold set and thus the factor was excluded. An alternative instance was that education and training could be approximated as the subsets within a factor, i.e. change management program and culture, in the context of ERP implementation in SMEs. Careful analysis and grouping of the related subfactors were carried out to ensure the 10 CSFs were appropriately represented. In the case of referencing, for those authors who published more than one article in the related area, only the latest publication was shown.

The 10 CSFs were then linked to their particular phase of ERP implementation adapted from the established phases and definitions from Markus and Tanis (2000). They suggested that the phases in the ERP life cycle model were in line with the stages of the traditional systems development life cycle, and there were four phases in a typical ERP life cycle:

- Chartering: decisions defining the business care and solution constraints.
- Project: getting system and end users up and running.
- Shakedown: stabilizing, eliminating 'bugs', getting to normal operations.
- Onward and upward: maintaining systems, supporting users, getting results, upgrading and system extensions.

As certain CSFs are more likely to affect specific phases of the ERP implementation process, it is important to link the 10 CSFs identified to the relevant four phases of ERP implementation. Past research in this area did not particularly link the factors to specific phases. Therefore, this link has provided some references for researchers and practitioners to emphasize their management effort for the CSFs at certain phases of ERP implementation. The linkage focused on the sequence of events



CSFs / Authors	Project champion	Project management	Business plan and vision	Top management support	Effective communication	ERP teamwork and composition	BPR and minimum customisation	Change management program and culture	Software development, testing and troubleshooting	Monitoring and evaluation of performance
Bingi *et al.* (1999)				●		●	●	●	●	
Brown (1994)		●						●		
Buckhout *et al.* (1999)			●	●		●				
Duchessi *et al.* (1988)	●	●	●	●	●			●		
Falkowski *et al.* (1988)	●	●	●		●	●		●		●
Holland and Light. (1999)		●	●	●	●	●	●	●	●	●
Manthou *et al.* (1996)		●						●		●
Roberts and Barrar (1992)			●	●			●	●		●
Rosario (2000)	●	●	●		●	●	●	●	●	●
Scheer and Habermann (2000)									●	
Stefanou (1999)	●					●				
Sum *et al.* (1997)	●				●					●
Sumner (1999)	●	●		●	●	●	●	●		●
Wee (2000)		●	●	●	●	●	●	●	●	

Figure 3. Matrix of the 10 critical success factors in ERP implementation in relation to each phase of implementation.

leading up to ERP implementation completion. The key figures identified for ERP implementation were also highlighted in order to show the input and involvement of various people at each phase of implementation. The views of ERP users (not vendors) were taken in the present study to show their preferred requirements of involvement of various people at each phase of implementation owing to their better understanding of their own business processes and environments.

5.1.1. *CSFs and CP at chartering phase*

The chartering phase comprises decisions leading to financial aids so that a secure funding is allocated to the ERP implementation project. Key players in this phase include vendors, consultants, company executives and IT specialists. Key activities include the initiation of the idea to adopt ERP, developing a business case, a decision on whether or not to proceed with ERP, the initiation of a search for project leader/champion, the selection of ERP software and its implementation partner, and project planning and scheduling.

5.1.1.1. *Project champion*. A project champion's commitment is critical to drive consensus and oversee the complete life cycle of ERP implementation (Rosario 2000). Someone should be placed in charge and the project leader should 'champion' the project throughout the organization. A leader should be in charge so there is a business perspective, and the leader must continually strive to resolve conflicts and manage resistance towards positive change in the old system.

5.1.1.2. *Project management*. Good project management is vital. An individual or group of people should be given responsibility to drive a certain aspect of success in project management (Rosario 2000). First, the scope of the ERP implementation project should be established and controlled. The scope must be clearly defined and be limited. This includes the number of systems implemented, the involvement of business units and the amount of business process reengineering needed. Any proposed changes should be evaluated against business benefits and, as far as possible, implemented at a later phase (Wee 2000). Delivering early measures of success is important. Quick, successive and contained deliverables are also critical. A focus on results and constant tracking of schedules and budget against targets should not be overlooked.

5.1.1.3. *Business plan and vision*. Additionally, a clear business plan and vision to steer the direction of the project is needed throughout the ERP life cycle (Buckhout *et al*. 1999). A good business plan that outlines proposed strategic and tangible benefits, resources, costs, risk and timeline is critical (Wee 2000). This will help maintain focus on business benefits.

5.1.1.4. *Top management support*. Top management support is required throughout the ERP implementation. The project must receive approval from top management. Bingi *et al*. (1999) and Buckhout *et al*. (1999) suggested a selection of business strategic goals to attain top management support. This can be achieved by tying management bonuses to project success. Top management needs publicly and expressly to identify the project as a top priority (Wee 2000). Senior management must be fully committed with its own involvement and have a willingness to allocate

valuable resources to the implementation effort (Holland and Light 1999). This includes provision of required resources for the implementation and giving an appropriate amount of time to get the job done (Roberts and Barrar 1992).

5.1.1.5. *Effective communication*. Effective communication is critical to the success of ERP implementation. Expectations at every level need to be communicated. Management of communication, education and expectations are critical throughout the organization (Wee 2000). User input should be managed in acquiring their requirements, comments, reactions and approval (Rosario 2000).

5.1.1.6. *ERP teamwork and composition*. ERP teamwork and composition are another CSF of ERP implementation. The ERP team should consist of the best people in the organization (Bingi *et al*. 1999, Buckhout *et al*. 1999, Wee 2000). Furthermore, building a cross-functional team is also vital. The team should have a mix of consultants and internal staff so that the internal staff can develop the necessary technical skills for design and implementation (Sumner 1999). In addition, the ERP team's understanding of the organization's business strategy and the ERP system's technical know-how are essential for the success of implementation (Bingi *et al*. 1999).

The ERP project ought to be their top and only priority and their workload composition should be manageable (Wee 2000). Team members need to be assigned full time to the implementation. Moreover, the team should be situated together at an assigned location to facilitate working together. Partnerships should be managed with meetings scheduled regularly.

The appropriate compensation and incentives should be given to the team for successfully implementing the system on time and within the assigned budget (Wee 2000). Incentives and risk-sharing agreements will aid in working together to achieve a similar goal. The team should be familiar with the business functions and products so that they know what needs to be improved to the current system and thus, support major business process (Rosario 2000).

5.1.2. *CSFs and CP at project phase*

The project phase consists of system configuration and rollout. Key players include the project manager, project team members (mainly from business units and functional areas), internal IT experts, vendors and consultants. These groups of people are known as the implementation partners. Main activities cover the software configuration, system integration, testing, data conversion and training. In this phase, the implementation partners must not only be knowledgeable in their respective areas of expertise, but also they must work closely and get along well to achieve the organizational goal of ERP implementation.

5.1.2.1. *Business process reengineering (BPR) and minimum customization*. Due to the distinguished nature of discrete manufacturing and process industries, a third-party software development, BPR, software configuration and customization might be required to fit the system to the business process or vice versa. BPR and minimum customization is a CSF that is related to the second phase — project phase. It is inevitable that business processes are moulded to fit the new system (Bingi *et al*. 1999). Organizations should be willing to change the business to fit the software with minimal customization (Roberts and Barrar 1992). Software should not be modified,

as far as possible to reduce errors and take advantage of newer versions and releases (Rosario 2000). It would mean that it would be difficult to upgrade if an enterprise has previously requested a major change in their ERP modules or custom-made modules to fit its business. Therefore, an enterprise's management team should decide to what extent the enterprise should change their business processes to suit the ERP system. Quality of business process review and redesign is important (Rosario 2000). Therefore, the number of previous successful implementations should be taken into account when choosing the right package (Roberts and Barrar 1992).

5.1.3. *CSFs and CP at shakedown phase*

The shakedown phase refers to the period from 'going live' to 'normal operation' or 'routine use' has been achieved. Main activities include bug fixing and rework, system performance tuning, retraining, and staffing up to deal with temporary inefficiencies. In this phase, the errors of prior causes can be felt, typically in the form of reduced productivity or business disruption (Markus and Tanis 2000). Therefore, it is important to monitor closely and to make adjustments constantly to the system until the 'bugs' are eliminated and the system is stabilized.

5.1.3.1. *Change management program and culture.* Change management is important, and this starts at the shakedown phase and continues throughout the entire ERP implementation life cycle. Enterprise-wide culture and structure change should be managed, which includes people, organization and culture (Rosario 2000). An emphasis on quality, a strong computing ability, and a strong willingness to accept new technology would aid in implementation efforts. Management should also have a strong commitment to use the system for achieving business aims (Roberts and Barrar 1992). Users must also be educated and trained, and concerns must be addressed through regular communication, working with change agents, leveraging corporate culture and identifying job aids for different users (Rosario 2000).

During this period of change, users should be involved in designing and implementing the business processes and the ERP system, and formal education and training should be provided to help them do so (Bingi *et al.* 1999). Roberts and Barrar (1992) pointed out that education should be a priority from the beginning of the project, and money and time should be spent on various forms of education and training. Employees need training to understand how the system will change business processes. There should be extra training and on-site support for staff as well as managers during the cycle of ERP implementation. A support team, e.g. help desk or online user manual, is also important to meet users' needs after implementation.

5.1.3.2. *Software development, testing and troubleshooting.* Software development, testing and troubleshooting is essential, and it starts at the shakedown phase. The overall ERP architecture should be established before deployment, taking into account the most important requirements of the implementation. This prevents reconfiguration at every stage of implementation (Wee 2000).

There is a choice to be made on the level of functionality and approach to link the ERP system to the legacy systems. Enterprises may also integrate other specialized software products to the ERP suite to best meet the business needs. Bingi *et al.* (1999) indicated that the interfaces for commercial software applications may need to be developed in-house if they are not available in the market.

The organization that implements an ERP system should work well with vendors and consultants to resolve software problems. Quick response, patience, perseverance and problem solving capabilities are important. It has been found that vigorous and sophisticated software testing would ease ERP implementation (Rosario 2000). A requirements definition can be created and system requirement definition can be documented. There should also be a plan for migrating and cleaning up data and proper tools and techniques and skills to use those tools will aid in ERP implementation success.

5.1.4. *CSFs and CP at onward and upward phase*

The last phase refers to ongoing maintenance and enhancement of the ERP system and the relevant business processes to fit the evolving business needs of the organization. It continues from normal operation until the system is replaced with an upgrade or a different system. Main players include operations managers, end users and IT supports personnel (internal and external).

Vendor and consultants may be involved when upgrades are concerned. Main activities include continuous business improvement, additional user skill building, upgrading to new software releases and post-implementation benefit assessment.

5.1.4.1. *Monitoring and evaluation of performance.* Monitoring and performance evaluation come into action at the shakedown phase. Milestones and targets are important to keep track of progress. Achievement should be measured against project goals. The progress of the project should be monitored actively through set milestones and targets.

Two criteria may be used as indicated by Roberts and Barrar (1992). Project management-based criteria should be used to measure against completion dates, costs and quality, whilst operational criteria should be used to measure against the production system. Monitoring and feedback include the exchange of information between the project team members and analysis of user feedback.

Rosario (2000) pointed out that there should be an early evidence of success to manage scepticism. Reporting should be highlighted with custom report development, report generator use and user training in reporting applications (Sumner 1999). Management should obtain information on the effect of the ERP system on business performance. Reports or processes for assessing data need to be designed. These reports should be produced based on established matrices. The inclusion of a set of effective and measurable project goals to monitor and evaluate the performance of ERP implementation against business needs should also be thought through.

5.2. *Critical uncertainties (CUs)*

The results of the interviews with eight SMEs in the UK showed various types of uncertainty that could affect the process of ERP implementation. Uncertainty in this case was referred to any unexpected event during the phases of ERP implementation. It would be an ideal ERP implementation for an enterprise if everything works out according to plan. Then, the 10 CSFs and the CP would be a good control/measurement system to handle the implementation from the chartering phase to the onward and upward phase, if uncertainty does not occur during the implementation process.

It has been identified that due to both unpredictable and unexpected events, a plan generated yesterday might not be executable today because the conditions

might have changed (Koh *et al.* 2002, Koh and Saad 2002). An example of this uncertainty is late delivery of the required necessary supporting hardware, software and implementation expertise from the respective ERP vendor and implementer. In this case, the chain reaction would properly be a delay in the software set-up and hence affect all the later operations, e.g. data transfer and module integration. This kind of uncertainty is difficult to quantify because the ERP implementation project is a cross-functional project and it involves human resources in different departments, which could range from production, warehouse, to administration. Subsequently, other planned work may be displaced to accommodate for the delay, if an alternative schedule for that delay cannot be found. Therefore, acknowledgement of the CUs at each phase of ERP implementation is equally important in conjunction with knowing the CSFs and CP.

The interviews found several uncertainties that the SMEs would consider during the ERP implementation, and they were linked to a specific phase of ERP implementation. The following subsections discuss these uncertainties.

5.2.1. *CUs at chartering phase*

5.2.1.1. *Insecure funding*. Insecure funding was more likely to occur at this phase because the management not only needs to consider which ERP software provides the best real profits to their enterprise at this stage, but also the amount of money it needs to spend before it obtains the output and profit after implementing that particular ERP software. Not knowing whether the required fund/budget is secured will prevent the progress and full completion of an ERP implementation. Hence, it is important to ensure secure funding at the chartering phase so that the implementation of the project is not affected.

5.2.1.2. *Inappropriate software selection and evaluation*. Most enterprises choose the easier option of purchasing ready-made software without taking into account the risks involved. If given a large amount of money, then it is not a problem to have the most expensive ERP software implementation. Nevertheless, whether or not the expensive ERP software will really help the overall process compared with the old and traditional method of doing things also needs to be considered. It may be very good in providing many specific details and information for a business. However, such details may not be useful for SMEs because the transactions are meant to be as simple as possible rather than the complicated ERP software procedures. This would hinder the fast response in terms of speed and decrease the efficiency at work. Therefore, brainstorming among the operations experts is needed before selecting and evaluating the ERP software at the chartering phase.

5.2.1.3. *Inexperienced project leaders*. During the chartering phase, a project leader is the head of the core committee. It is a big problem if the project leaders do not know what to do when it comes to a certain decision-making point. This is something that cannot be taught, but comes with experience. Therefore, it is advisable to hire an external consultant to oversee the ERP implementation project.

5.2.1.4. *Non-committed project partners*. The project partners could range from personnel, internal and external to the implementation project. Internal partners cover the co-members in the committee and the shop floor members. External partners would include all those who are not directly employed by the enterprise, i.e.

short-term wiring workers, independent consultants and also the suppliers for all the parts or hardware needed for ERP implementation. It was found from this study that this uncertainty would mostly affect the ERP implementation at the chartering phase owing to the need to identify suitable project partners at this stage.

5.2.1.5. *Poor project planning*. Poor project planning could trigger delay for the planned activities. Planning relies on accurate and up-to-date information. Therefore, it is important to ensure that the project is planned with realistic input to avoid any unnecessary delay to the project phase of the ERP implementation. It is advisable to have visual aids to help the committee monitor the actual situation and progress of activities. Microsoft Project® could be used as a tool to do such planning and monitoring with regards to time, resources and due date.

5.2.1.6. *Ineffective communication*. This is not a scientific matter, but it is an important factor in every aspect irrespective of the project being dealt with. Communication breakdown is sometimes unavoidable due to different languages or technical jargon used. To avoid this type of uncertainty, one should always give clear instructions and messages to avoid confusion. Educational workshop and training could be arranged for all users involved and affected by ERP implementation to enhance their knowledge and to disseminate any new policy and work procedure, and hence to be able to eliminate or minimize unnecessary communication breakdown. It was identified from this study that this uncertainty would not only affect ERP implementation at the chartering phase, but also at the project phase.

5.2.1.7. *Poor teamwork*. Poor teamwork will slow the speed and reduce the efficiency while working with each other. This uncertainty was found to be affecting the ERP implementation at the chartering phase, because it is at this stage that appropriate teams are formed. Therefore, it is important to ensure that a means to promote good teamwork is designed for example, setting common goals and providing a good reward scheme.

5.2.1.8. *Unclear role and responsibility (vendor and internal staff)*. An unclear role and responsibility of the vendor and internal staff were found to affect the ERP implementation at the chartering phase. This will induce ineffective communication and will eventually delay the whole implementation if conflicting tasks are allocated. The project leader should have a list of tasks to follow up and distribute to all the committee so that they are aware of their responsibilities.

5.2.2. *CUs at project phase*

5.2.2.1. *False software configuration and system integration*. After implementing the standard package, software customization might be required to fit the system to the business processes. This should be carried out in the project phase. Such software customization includes reconfiguration and modules integration. These tasks are found to be uncertain due to the changing requirements as the implementation progresses. This implies that these tasks might take longer or shorter than expected. To avoid this uncertainty, such software customization and modules integration

should be performed after the project phase, i.e. in shakedown phase. This will ensure that the standard modules are implemented and all activities are carried out according to plan.

5.2.2.2. *Communication breakdown*. This was discussed in section 5.2.1.

5.2.2.3. *Conflict between business objectives and ERP system objectives*. The results of interviews show that this conflict could exist at the project phase if the objectives are not properly defined before the chartering phase. One possible way to avoid this conflict is to set subgoals and link these to the overall goal of the business.

5.2.2.4. *Labour shortage*. ERP implementation usually needs more manpower and resources for test run, analysis and evaluation of the possible effect on the production plans and business goals, than those previously expected. Therefore, it is wise to plan for slack or build in contingency and have the test run when there is slack between the processes. Usually, this should not be done at the busiest time.

5.2.2.5. *Unskilled personnel*. Even skilled personnel will require some forms of training due to the changes in the procedures and new way of inputting the data and retrieving the useful information for evaluation from the ERP system. Therefore, a brief meeting of introduction to all users of the systems in an enterprise would be very useful to explain the changes and the new procedures.

5.2.2.6. *Poor data collection*. Data such as from the bill of materials (BOM), lead-time, routing, capacity, resources, and inventory need to be collected and to be inputted into the new ERP system. Due to the amount of data required, the accuracy of the data collected is often being traded off against the quantity. This uncertainty was found to be occurring at the project phase and thus, it is very likely to affect the ERP implementation project. Therefore, it may be useful to have all the machines, tools and equipment calibrated, all engineering drawings updated and all suppliers data verified before data collection.

5.2.3. *CUs at shakedown phase*

5.2.3.1. *Employees' resistance to change from traditional process to ERP process culture*. This uncertainty was found more likely to affect the shakedown phase of the ERP implementation project. At this phase, the employees and users of the system need to be educated and thus the normal or old way of production planning needs to be forgotten. SMEs may lack the organizational culture and top management commitment required to absorb the short-term discretions and uncertainties associated with adopting the new ERP system. In such organizations, there is a risk that the SMEs' employees or managers may quickly abandon the ERP system when there are short-term failures or that they will avoid major changes by simply automating the SMEs' old, inefficient process and therefore not obtain the benefits of the new ERP system (Chase 1998). This was also found to be true through the interview with the SMEs where getting the users or employees to use the systems through their competitive use of IT skills is limited. This could involve a cultural change progression, which will take time to complete.

5.2.3.2. *Difficulty in defining the business aspect within the SMEs that needs to be changed (with respect to software customization).* This might be the common problem faced by the SMEs because the procedures needed for SMEs are more flexible i.e. paper work in their daily job to prepare the invoice and receipt. Thus, for an ERP system to have an impact in SMEs, the procedures need to be fine-tuned and they might need some changes as compared with the traditional procedures. This would eventually affect the old customers and suppliers in handling the daily procedures. The SMEs need to find the compromise point for dealing with internal as well as external business partners.

5.2.3.3. *Difficulty in evaluating the performance during the transition period.* Due to the dynamic characteristic of the shakedown phase, difficulties were encountered in evaluating the performance of the systems during this transition period. This uncertainty could be dealt with by having a clear performance indicator of 'what we are' and 'where we want to be'. Examples of these performance indicators include paperwork reduction, improved data accuracy, reduced delivery lead-time, etc.

5.2.4. *CUs at onward and upward phase*

5.2.4.1. *Problems in authorizing access to the relevant data in the ERP system.* After setting up the fundamental procedures and making the necessary customization and changes to the systems and the business processes, it is now the time to allocate the responsibilities of using and authorizing access to the systems according to the department and job function. Sometimes it is difficult to have a precise area of responsibility on certain ERP modules. Data retrieving could be accessed by for example, manufacturing, purchasing and finance departments, but who is going to authorize and make changes to the system? If a clear policy of access authorization is not drawn, then the data integrity will be questionable. It could be argued that a department can only change data relevant to itself, for example, a production manager will have full authorization to change the manufacturing routing data but not the finance manager. However, this will limit the flexibility and the usefulness of the 'what if' feature in the system. One way to solve this problem is to have a 'training' or 'shadow' system run off line to the one on-line so that simulation or experimentation can be carried out. Therefore, a clear policy of access authorization needs to be set-up at different levels to different departments.

5.2.4.2. *Unclear system maintenance discipline.* System maintenance is crucial in any information and communication technology areas. It is a good practice to have system maintenance and update the software with new releases. Unclear system maintenance discipline was found to affect the onward and upward phase owing to its feasible time scale of occurrence at this stage of ERP implementation. If the system was being updated without the users' knowledge, they would have major difficulty in adapting to and learning the new system. Therefore, any major update should have the approval from the systems director or equivalent and a memo should be sent to all the related personnel from the ERP specialists who maintain the system in house.

5.2.4.3. *Unclear procedure to operate and fully use the ERP system.* It would be a waste if one does not know how to use the ERP system to their advantage in the enterprise. Despite the ongoing education and training for the users, a working

manual will be very useful to address how the system works and from which module (and how) the required information could be retrieved. On-the-job training, where a standardized training course for every user in the enterprise and a break down of the tasks learnt to a series of checklists, would also be useful. This will usually take about two weeks to a maximum of three months depending on the job function and responsibility.

5.2.4.2. *Outdated data.* Outdated data need to be discarded. This is one of the challenges in the onward and upward phase. Most enterprises do this in the yearly shut down week. This is important because arranging, purging and updating the data are fundamental to ensuring the highest level of accuracy possible.

5.3. *Conceptual reference framework for ERP implementation success*

The literature review and interviews' results and findings in this study led to the development of a conceptual reference framework for a successful ERP implementation, particularly for the SMEs. Figure 4 shows the conceptual reference framework for a successful ERP implementation in SMEs. It must be noted that some CEs and their constituents could also be applied in larger enterprises.

The framework shows the three main CEs that consisted of 10 CSFs, nine CP and 21 CUs identified to be significant on the success of an ERP implementation in SMEs, which were linked to particular phases of ERP implementation. This framework collated such knowledge to provide SMEs with indicators and guidance on their ERP implementation project especially for those who are planning to implement such a system. It shows the elements they need to be aware of and also the constituents at each phase of ERP implementation. This useful indication was expected to enable SMEs to look out for the critical issues before and during implementation. Such framework will also be useful for researchers in this field in order to focus on the study of the CEs and particular constituents that affects ERP implementation.

The results showed that most of the CSFs were significant at the chartering phase and the majority of the CUs occur at the chartering phase and project phase. Therefore, it was clear that meeting and managing the CSFs, CP and CUs at the chartering phase is the key start-up stage towards a successful ERP implementation. The particular linkage of the CSFs, CP and the CUs in the framework represented the first effort or momentum required at that specific phase on that particular factors in order to ensure a successful ERP implementation.

The involvement of ERP vendors, consultants, company executives and IT specialists were found to be apparent at chartering phase, project phase and shakedown phase. This finding showed that these CP appeared to be the initiators and decision-makers for an ERP implementation in an enterprise. However, the results also indicated that operations manager, end users and IT support personnel within the enterprise do contribute to these phases in ensuring a successful ERP implementation. However, their main roles were more critical at the onward and upward phase. Project managers and project team members were the CP at the project and shakedown phases, and this finding was expected.

The AMR Research (available at http://www.amrresearch.com/Content/viewpress.asp?id=13280&docid=947, accessed 21 October 2003) released results of a new study (29 March 2002) that evaluated the costs, challenges and added benefits of ERP system upgrades, and it concluded that enterprises that plan for ERP upgrades must document complex cost factors to justify their project.

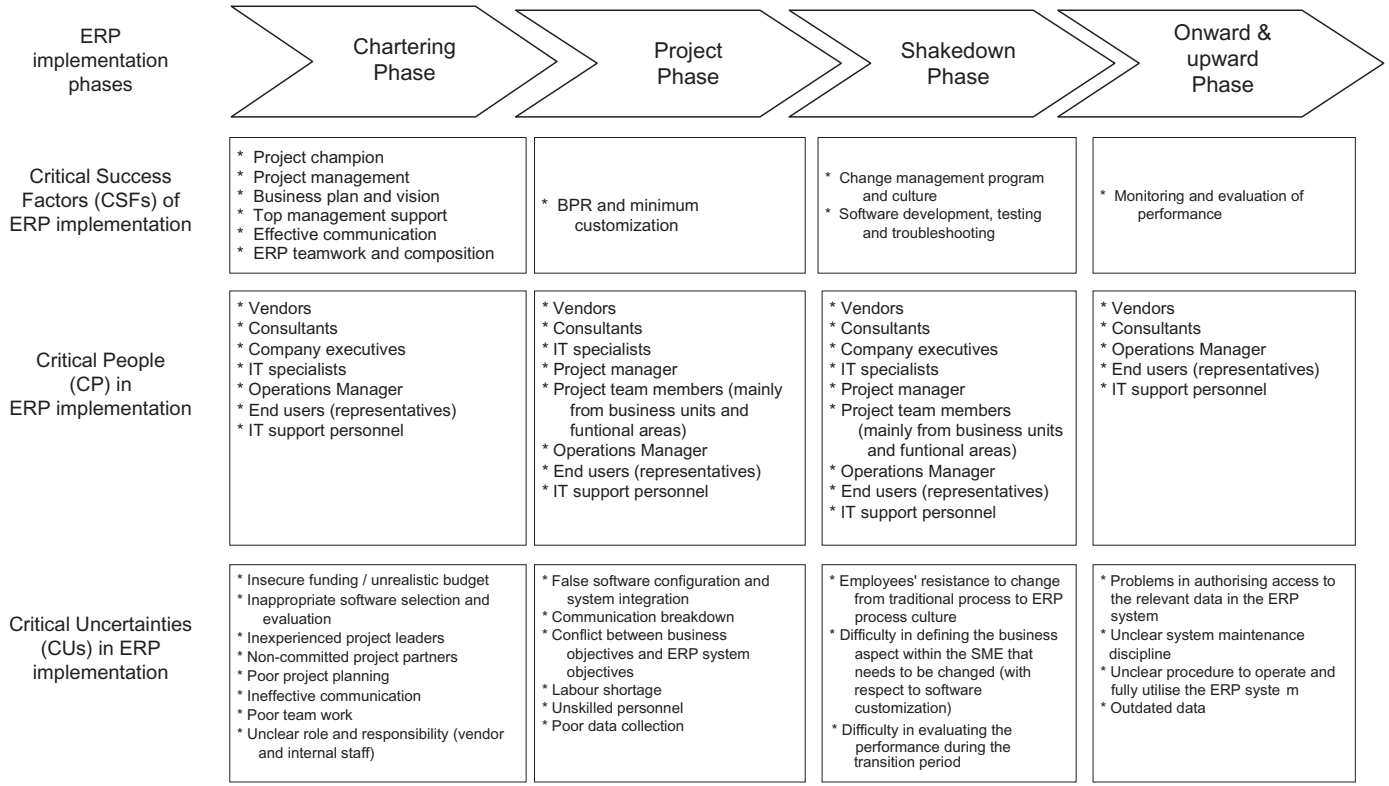


Figure 4. Conceptual reference framework for a successful ERP implementation in SMEs.

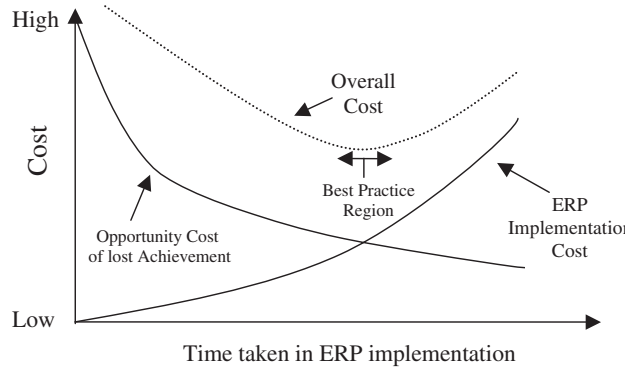


Figure 5. Cost–benefit curve for a time relationship between cost and achievement.

Therefore, justifications for this investment for the SMEs are particularly important and difficult. In order to reflect a realistic ERP implementation, the relevance of the CEs assumed the following:

- SMEs would accept the CEs and its constituents, i.e. CSFs, CP and CUs of ERP implementation and their constraints were budget and time.
- SMEs were fully prepared for ERP implementation before starting the actual implementation phase.

The cost–benefit curve (figure 5) could be adapted to ERP implementation, such that as the implementation schedule lengthened, the cost increased dramatically, while the success achieved increased to some point, beyond which there was no significant achievement in benefit.

6. Conclusions and further research

This study found three CEs, namely CSFs, CP and CUs, that SMEs must consider to achieve a successful ERP implementation. These CEs were constituted of 10 CSFs, nine CP and 21 CUs. The literature review and results of the interviews showed that specific CSFs, CP and CUs are critical at particular phase of ERP implementation. These results were collated and a conceptual reference framework that shows the CEs and its constituents was developed.

A comprehensive literature review uncovering the CSFs of ERP implementations in SMEs was carried out. A deduction method was used to consolidate those factors, which found 10 CSFs that were most apparent. Since different factors would affect the ERP implementation process at different stages, the 10 CSFs were then linked to a particular phase of ERP implementation using the process theory approach. It was found that a good project champion, effective project management, a clear business plan and vision, top management support, effective communication, and strong ERP teamwork and composition need to be critically taken into account by SMEs at the chartering phase of ERP implementation. Having an effective BPR programme and minimum customization to the software was significant at the project phase of ERP implementation. At the shakedown phase of ERP implementation, it was identified that SMEs should critically consider having an efficient change management programme and culture, and efficient software development, testing and troubleshooting to ensure a successful ERP implementation. Lastly, continuous monitoring and evaluation of performance must be included in the onward and upward phase.

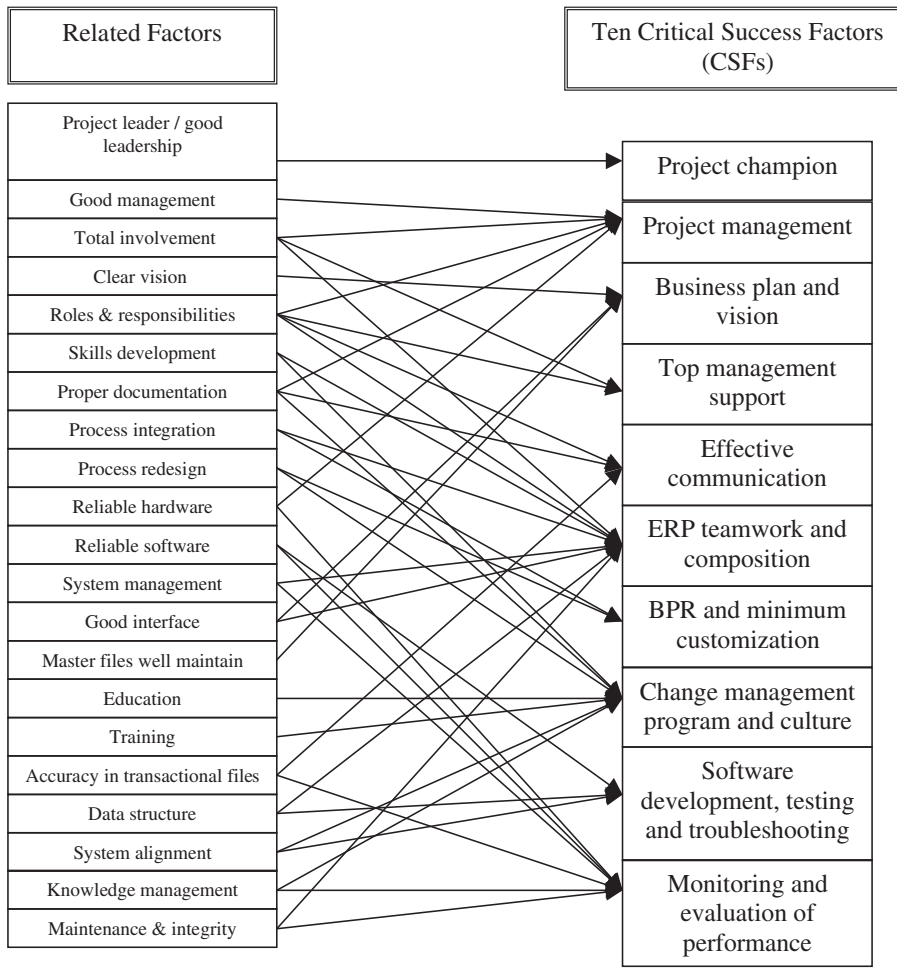
Some overlapping of CP was identified from the results of the interviews with eight SMEs in the UK. The results suggested that ERP vendors, consultants, company executives and IT specialists must be involved at the chartering, project and shakedown phases to ensure a successful ERP implementation. However, the results also indicated that the operations manager, end users and IT support personnel within the enterprise do contribute to these phases in ensuring a successful ERP implementation. However, their main roles were more critical at the onward and upward phase. Project managers and project team members were the CP at project and shakedown phases, and this finding was expected.

In addition, the results of the interviews also suggested that various CUs would affect particular phases of ERP implementation. It was found that insecure funding/unrealistic budget, inappropriate software selection and evaluation, inexperienced project leaders, non-committed project partners, poor project planning, ineffective communication, poor team work, and unclear role and responsibility (vendor and internal staff) appeared to be critical at the chartering phase for SMEs. SMEs were more concerned with the issues of false software configuration and system integration, communication breakdown, conflict between business objectives and ERP system objectives, labour shortage, unskilled personnel, and poor data collection at the project phase. These are the two phases that were significantly affected by a large number of uncertainties. At the shakedown phase, these SMEs were critically experienced with employees' resistance to change from the traditional process of ERP process culture and there was also a difficulty in defining the business aspect that needs to be changed. Moreover, the ERP implementation in SMEs was also critically affected by some uncertainties relating to system access and maintenance, data update and operation procedure. The occurrence of these CUs was likely at the onward and upward phase. The CUs described here could also be related to problems and issues faced by SMEs during ERP implementation. Some CUs could also be related to risk. Since little research could be found studying the types of uncertainty that could affect ERP implementation, the CUs identified in this study provided an initial reference for further study.

These findings led to the conclusion that the CEs, which incorporated the CSFs, CP and CUs identified in this study need to be closely examined by the SMEs at each specific phase of ERP implementation in order to achieve a successful implementation. It was envisaged that the conceptual reference framework for a successful ERP implementation would provide some useful indicators and guidelines for SMEs in ERP implementation, particularly in increasing the awareness of the CEs and the constituents that could affect the implementation process at particular phases. Based on the critical information shown in the framework, researchers and practitioners in this field could also use this framework to prioritize areas for further study.

In this paper, the deduction process was only applied to the literature identified to date. It was not terminating and this will be updated in further research to provide a better fit. The conceptual reference framework will be further verified and validated in order to attempt to include all possible factors and constituents, and various sizes of enterprises. The limitations of the interviews, such as biases and contradicting views, the nature of business, the country and cultural differences, and sample size issues, were acknowledged. Further verification and validation of the findings will be carried out at the later stage of this research through more interviews and case studies.

Appendix 1. Process of factors deduction



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