Determinants of ERPS-Fit and Impact on Firm Performance

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Abstract

Despite the large number of publications addressing 'critical success factors' of ERP software implementations, very little is actually known about the impact of organizational fit of ERP systems on ERP implementation success (in terms of increased organizational performance). Our objective is to investigate the role of ERP fit in the implementation and operation of ERPS; we do so by developing and testing a model which (a) identifies the determinants of ERP fit and (b) links ERP fit to organizational performance. Our research builds on data which was collected through a large-scale mail survey and telephone interviews in an earlier research project in 2001. Our key findings suggest that the adoption and use of ERPS does lead to firm performance increases already within one year after the go-live date, and is then sustained over a period of at least another two years. One of the key determinants of sustained performance increases is the organizational fit of the ERPS, which is again driven by software quality and the quality of the integration (adaptation) mechanisms.

Keywords: Enterprise resource planning systems, ERP, firm performance, ERPS fit, software quality, IS performance measurement.

1 Introduction

1.1 Background and Motivation

Despite the well-documented limitations of enterprise resource planning systems (ERPS), in particular the enormous challenges and cost involved with the implementation (and often also upgrade) of those systems, their global presence is impressive and even further increasing. In 2006, ERPS consumed 32% of the global corporate IT budget of USD 2.02 trillion (Bartels *et al.*, 2006) and it is expected that ERPS budgets will grow by 12.3% in 2007, with one third of ERP users expecting to spend more than USD 10 million on ERPS related activities (Shepherd and Klein, 2006). Further to that, recent consolidation in the ERPS market has created a situation in which most of the ERPS related license revenue goes to two now absolutely dominating players: SAP and ORACLE.

Considering the enormous cost associated with the implementation of ERPS, it is little surprising that both ERPS adopters but also researchers want to see – and ideally quantify – the benefits. ERP software vendors of course provide many examples of how organizations can benefit from the adoption of their 'solutions', e.g. by achieving process improvements, and a reduction in total cost of ownership (TCO).[1]

In academic literature, attempts to that end have been made for several years now, e.g. by Beretta (2002) or Irani (2002), who both used non-financial performance measures as proxies of ERPS implementation success. At about the same time, the accounting discipline came up with the first studies which provided evidence of the economic impacts of ERPS, however with very mixed results (Hunton *et al.*, 2003; Matolcsy *et al.*, 2005; Nicolaou, 2004; Poston and Grabski, 2001). Other attempts towards ERPS performance measurement focused either on certain aspects of ERPS adoption or on outcomes below the firm level, e.g. the operations level (examples of research to that end include Al-Mashari *et al.*, 2003; Fang and Lin, 2006; Hsu and Chen, 2004; Mabert *et al.*, 2001; Palaniswamy and Frank, 2000; Sedera *et al.*, 2004; Vemuri and Palvia, 2006; Walter and Michael, 2002; Wieder *et al.*, 2006; Yang *et al.*, 2006).

At the same time, many organizations started to blend their ERPS with other 'enterprise systems' such as customer relationship management systems (CRMS) or supply chain management systems (SCMS), creating one meta-enterprise system with increased Internet connectivity and functionality. These developments are yet another evidence of the fact that every practical manifestation of an ERPS is different (Wieder *et al.*, 2006) and that there is no 'one solution fits all' approach. ERPS are much more than just software; they are the *manifestation* of the technical and organizational processes of software implementation, which include the configuration of the software, adoption and implementation of policies with regards to use of the system, user training and support, etc. This practical manifestation of software in organizations (rather than the software itself) is the core object of our study.

Whether the system eventually 'fits' depends an a variety of factors, ranging from features of the software to the quality of training and change management. Information systems (IS) literature provides several approaches to tackle the question of fit, the most well-known of which is the task-technology fit model (Goodhue and Thompson, 1995), which, however, applies only to the individual, but not organizational level. More recently, researchers have started to explicitly address the question of fit and misfit in the ERP context (Gattiker and Goodhue, 2005; Hong and Kim, 2002; Soh *et al.*, 2000; Swan *et al.*, 1999), but it is still a long way towards a consistent and robust framework of ERPS fit. The research presented in this paper attempts to make a small contribution on that way. The first step into that direction is clarifying the meaning of key terms for this research.

1.2 Enterprise Systems (Software) and ERP Defined

Over the past two decades, various types of business information systems have emerged, such as management information systems, decision support systems/expert systems, executive information systems, ERP systems, customer relationship

1 SAP (2006), "mySAP™ ERP Drives Lower TCO and Empowers Corporate Governance", http://www.sap.com/company/press/press.epx?pressid=2291 (accessed on 12 Oct 2006)

management (CRM) systems, and supply chain management (SCM) systems. More recently, it has become popular to use the collective term 'enterprise systems' (ES) when referring to (some of) these systems, although it is not always clear precisely what distinguishes ES from other types of business information systems. Our research is guided by the definition provided by Shang and Seddon (2002), who identify several distinctive features of ES and also make a very important distinction between *system* and *software*:

> "Enterprise systems (ES) are large-scale organizational systems built around packaged enterprise system software. Enterprise system software (ESS)
>
> - is a set of packaged application software modules with an integrated architecture, which can be used by organizations as their primary engine for integrating data, processes and information technology, in real time, across internal and external value chains;
> - contains deep knowledge of business practices accumulated from vendor implementations in a wide range of client organizations;
> - is a generic 'semi-finished' product with tables and parameters that user organizations and their implementation partners must configure, customize and integrate with other computer-based information systems to meet their business needs.
>
> ESS includes enterprise resource planning (ERP), customer relationship management (CRM), supply chain management (SCM), product life cycle management (PLM) and eProcurement software."

Shang and Seddon (2002) also specify the unique features of ERP software (as opposed to other ES):

> "ERP software integrates management information and processes, such as financial, manufacturing, distribution and human resources, for the purpose of enabling enterprise-wide management of resources".

It is important to note that ES are *ESS applied* in the *organizational context,* i.e. they are the *manifestation* of the technical and organizational processes of software implementation, which include the configuration of the software, adoption and implementation of policies with regards to use of the system, user training and support, etc. Therefore, the practical representations of a particular standard ERP software package vary substantially from organization to organization (i.e. every ES is unique), even if the organizations use the same ESS product (e.g. SAP R/3), release, etc. This distinction is very important for the development of our model and for research in ES in general.

ERP package implementations are complex projects with several phases each of which requires critical decisions to be made. Some of these decisions relate to the choice of modules[2] and sub-modules, some relate to the (technical) systems context

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2 The classic ERP-term 'module' is increasingly replaced by 'component'.

(such as choice and configuration of hardware and operating system, choice of data base product, setup of interfaces, etc.), but the majority relates to the ongoing[3] process of fine-tuning of the software, learning, upgrading, etc. This ongoing quest for (strategic) alignment (Henderson and Venkatraman, 1993) and fit comprises the iterative process prototyping and configuration of the system (software adaptation), and the organizational aspects of incorporating the system (organizational adaptation) (Somers and Nelson, 2003).

Effectiveness in terms of achieving those objectives is obviously only to some extent contingent upon the 'feature and quality of the software package' as such; the of 'success' of an ERP implementation is eventually determined by the quality of the actions taken throughout the systems development life-cycle in general and the core implementation phase in particular.

1.3 Objectives

Despite the large number of publications addressing 'critical success factors' of ERP software implementations, very little is actually known about the impact of organizational fit of ERP on ERP implementation success (in terms of increased organizational performance). Our objective is to investigate the role of ERP fit in the implementation and operation of ERPS; we do so by *developing and testing a model which (a) identifies the determinants of ERP fit and (b) links ERP fit to organizational performance.*

2 Theory Development

2.1 ERPS Fit

The majority of traditional IS literature investigating the outcomes of IS implementations/use relates the performance (impacts) of IS to 'fit among contingency variables' such as characteristics of structure, size, environment, technology etc. (Weill and Olson, 1989). More recently, IS research has also started to also explore the strategic dimensions of organizational fit, predominately under the heading 'strategic alignment' (Henderson and Venkatraman, 1993).

At the individual (rather than the organizational) level, the most widely used concept of IS fit is the task-technology fit model as suggested by Goodhue and Thompson (1995); but despite the fact that this model has latter been extended to the group level (Zigurs and Buckland, 1998), it does not suit the large variety of tasks supported by ERP software and therefore does not qualify for the analysis of *organizational* fit. The second widely used model which also partly relates to the question of fit at the individual level is the technology acceptance model, which explains the relationship between user satisfaction and information use (Davis, 1989), but does not go beyond this relationship.

3 Davenport *et al.* (2004) emphasise that he has not come across a single company which has ever finished the process of implementation.

Interestingly, the large body of traditional literature on aspects of IS effectiveness and IS quality (systems, information and service quality)[4] does not explicitly investigate issues directly related to organizational fit. One of the possible explanations for this is that organizational fit or misfit of IS was not a major concern in times when most computerized information systems were developed for the specific environment. The emergence and now widespread use of ERP-standard software has shifted the main challenges in IS from development to implementation and has therefore eventually brought the question of fit into the centre of the debate. While initially the main recommended approach to achieve fit was to change (re-engineer) the organization to fit the system (e.g. Davenport, 1998), more recent studies take a more critical perspective and tend to challenge ERP software vendors by emphasizing short-comings of their products in terms of enabling fit.

The first study explicitly highlighting the problem of organization misfit of *ERP* was provided by Swan *et al.* (1999), who analyzed the adoption of ERP in 4 European manufacturing companies and came to the conclusion that the conflicts of interests[5] of ERP vendors and customers is the main reason for misfits in terms of "differences between technology supplier prescription of best practice and user adoption of IS". In essentially all 4 cases, the companies heavily customized[6] the systems in order to overcome those misfits.

Soh *et al.* (2000) pioneered research in cultural reasons for ERP misfits, and Gattiker and Goodhue (2005) analyzed ERPS fit in the context of variations in the level of differentiation and use of ERP in sub-units of an international organization.

Nicolaou (*et al.*) has (have) presented several studies in which he examines moderating factors on ERPS implementations and how their fit impacts firm performance. One of the recent examples is a study which "examines the extent to which discrete changes to ERP systems over a post-implementation time-frame impact on firms' ability to deliver long-run financial performance" (Nicolaou and Bhattacharya, 2006).

The most explicit empirical study on organizational fit of ERP so far (and therefore most relevant study for this paper) is provided by Hong and Kim (2002). In their model, ERPS fit – moderated by ERP adaptation, business process adaptation and organizational resistance – is positioned as the key driver of implementation success. In line with Markus and Robey's (1983) generic concept of organizational fit of IS, they define organizational fit of ERP as "congruence between the original artifact of ERP and its organizational context" (Hong and Kim, 2002) and refine the concept by distinguishing between data fit, process fit and user interface fit. Their key findings suggest a strong association of organizational fit of ERP and implementation

4 For an overview of the main literature in those fields visit the Information Systems Effectiveness research group site at: http://business.clemson.edu/ISE/

5 Everdingen *et al.* (2000) provide further evidence of these conflicts of interests.

6 In this paper (and in most of the IS literature), 'customising' stands for 'program code modification', whereas 'configuration' denotes the process of changing the program parameter (e.g. business process controls). SAP's use of the term customising to describe the configuration process often creates confusion in literature and practise.

success, and some negative moderating effect of process adaptation and ERP adaptation.

Hong and Kim (2002) concede that there are some limitations to their study in terms of the metrics applied. Further to the problems raised by the authors themselves, we argue that there are some other important short-comings:

(1) In their research model, 'organizational fit of ERP' is considered to be independent of ERP and process adaptation, which clearly suggests that their interpretation of the 'original artifact' (object of fit or misfit) is the ERP *software* (and not the ERP *system*, which is the *outcome* of the implementation/adaptation). Their survey questions on aspects of fit, however, address the companies' experience with their post-implementation ERP *system*, i.e. with the result of the adaptation. The 'organizational fit of ERP' is therefore implicitly influenced by the level of process/ERP adaptation, and what is reported as a moderation effect in their study, is more likely to be a determinant of fit in itself.

(2) The rationale for using data fit, process fit and user interface fit – which are obviously derived from Soh *et al.* (2000) – as dimensions of ERPS fit remains unexplained, and neither the reader nor the interviewees are informed about the precise meaning of the constructs.[7] The implicit reference to Soh *et al.* (2000) as such is not convincing either as the latter study focuses on *cultural* reasons for misfits.

(3) Implementation success is measured in terms of plan-actual variances in project budget, project length, system performance and benefits of ERP. The first two variables are without question interdependent, and probably more likely to measure the 'quality of project planning/management' rather than ERP implementation success. Furthermore, those two variables are implementation *process* indicators, whereas the other two vaguely capture implementation *outcomes* (at least the last one does). While it seems reasonable to relate software features to aspects of the implementation *process*, the *outcomes* of an ERP implementation are clearly the result of *both* the software and the quality of the implementation.[8]

Our research approach to organizational fit ERP and organizational performance differs in two main ways from the one discussed above: (a) Firstly, we measure performance implications of an ERP adoption only in terms of outcomes. While we agree that features of the software as such have to be considered in the analysis of fit, we argue that *when it comes to analyzing the <u>outcomes</u> of an ERP implementation*, the question of ERPS fit cannot be isolated from the implementation process and therefore fit has to be analyzed at the ERP *systems* level rather than at

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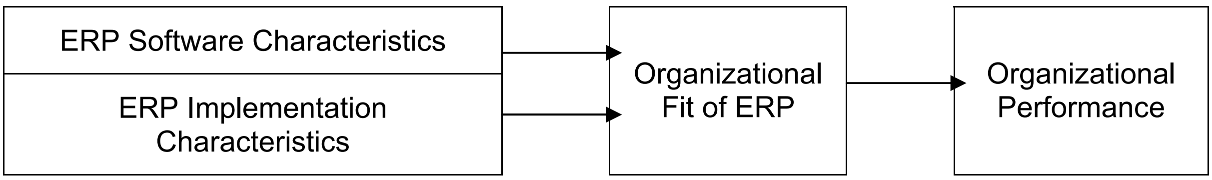
7 The intended meaning can be partly 'reconstructed' from the interview questions, although the latter themselves are partly confusing (e.g. what is actually meant by "The output data items of the ERP correspond to those of the documents used in your company"?)

8 Following Hong and Kim's (2002) definition of ERPS fit and relating it to implementation process indicators could be modelled as follows: ERP software fit → adaptation requirements and resistance (or better: level of acceptance) → success of implementation project (in terms of process indicators).

the ERP *software* level. As mentioned in the introduction, the software as such is only a semi-finished product which develops its potential value in the enterprise systems context, which includes the implementation process. Apart from that, proper systems analysis should ideally[9] prevent organizations from selecting software which does not fit an organization. Analyzing ERPS fit at the systems rather than software level also avoids measurement problems as those outlined in item (1) above and emphasizes that the efforts undertaken during the implementation are essentially *integration mechanisms aiming to achieve maximum fit*. (b) As in our model ERPS fit is not considered to be an endogenous variable, we investigate what contributes to ERP system fit.

We can summaries that for the purpose of this study we conceptualize organizational fit of ERP as a *result* of the interplay of *characteristics of the ERP software* and *characteristics of the implementation process*. Only the combination of the two dimensions determines whether an ERP system is eventually broadly *accepted by the users* (subjective fit indicator), is *aligned/compatible with an organization's business processes* after going live (objective fit indicator) and eventually supports the objectives of an organization effectively (performance implications). Accordingly, we propose the following basic research model:

Figure 1: Basic Research Model



2.2 Firm Performance

It follows from above that high levels of fit mean that the ERP system is actually used to do what it is designed for: Effective processing of information along efficient integrated business processes. Hence it is reasonable to expect that *the level of ERPS fit* eventually manifests itself in the *financial performance of an organization*. The term 'eventually' accounts for results of prior research (e.g. Hunton *et al.*, 2003; Matolcsy *et al.*, 2005; Nicolaou, 2004) which indicate that the realization of benefits from ERP systems is subject to a time lag of one to two years from the go-live date and resulting positive impacts on *firm* performance. The time lag can be explained with a combination of the 'aftershock of an ERP implementation'[10] and an often strong initial learning curve effect.

The potentially positive impact of high levels of ERPS fit on firm performance, however, cannot be isolated from the cost implications associated with ERPS. As we investigate the implications on firm performance *after* the go-live date, implementation costs are not relevant for our study. We rather focus on the cost

9 We acknowledge that parent companies often impose ERP software on their subsidiaries.

10 RFP Wizard (1997), "Dealing with the aftershock of a new SAP implementation", *Datamation.*

implications of operating the ERP system (as opposed to running other systems). The most holistic approach towards capturing these costs is the total cost of ownership (TCO) approach, which considers all direct and indirect costs associate with IT as a function or certain systems in isolation. If the claim of major ERP vendors holds, viz. that the adoption of their software package has a positive medium/long term impact on TCO, then we would expect to see this reflected in medium to long term firm performance. Accordingly, we expect stronger positive impacts on TCO to have a very similar (time-lagged) impact on firm performance as higher levels of ERPS fit.

The following hypotheses summarize our discussion of the relationship of ERPS fit, TCO and organizational performance impacts.

Hypothesis 1: ERP adopters experience a reduction in total cost of ownership (TCO).

Hypothesis 2: Reductions in TCO are positively associated with medium-term increases in firm performance.

Hypothesis 3: ERPS fit is positively associated with medium-term increases in firm performance.

Hypothesis 4: Over the first few post-implementation years, ERPS develop an increasingly positive impact on firm performance.

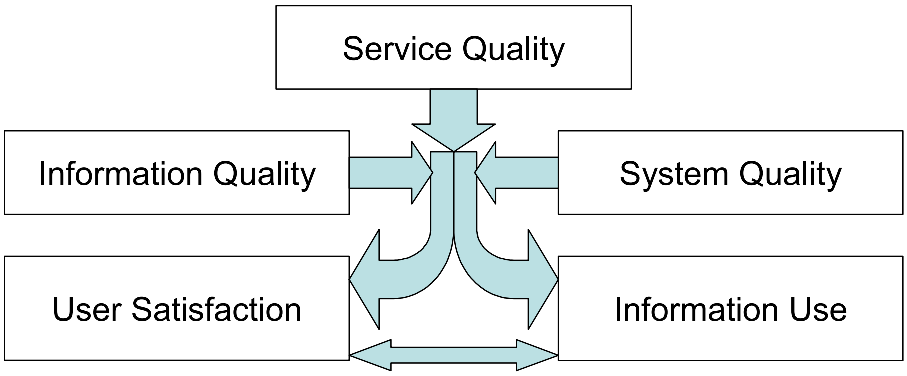
2.3 Determinants of ERPS Fit in Detail

Despite the fact that the ERP-software product as such is only a 'semi-finished product' (Shang and Seddon, 2002), many features of the product are already predetermined (hard-coded) and cannot be changed (or are hard to change) during implementation. Significant misfits at this level are ideally identified at the systems analysis stage and should lead to a rejection of the product. Examples of these features include business (process) functionality, general user-interface design features are a large range of technical aspects (e.g. stability, capacity, etc.). All these features except for the first one have been extensively discussed in the IS quality literature.

2.3.1 System vs. Software Quality

The construct of system quality has a long tradition in information systems research.[11] System quality is usually discussed in the context of information systems effectiveness. This stream of literature usually distinguishes between information quality, service quality and systems quality and investigates how theses three constructs are related to user satisfaction, information use, individual impact on information and ultimately organizational impact. The relationship between user satisfaction and information use is further investigated in models such as the technology acceptance model (Davis, 1989).

Figure 2: IS Quality and Acceptance Model[11]



As far as system quality is concerned, the concept is operationalized in a variety of ways. Kriebel and Raviv (1980) for example take an economics approach and define systems quality in terms of resource utilization and investment utilization. For the purpose of this study, approaches to systems quality which incorporate (economic) *outcomes* are certainly too broad, as we relate outcomes to fit.

Alloway (1980) uses hardware utilization efficiency as synonym for system quality where as Swanson (1974) defines it in terms of reliability, response time and ease of terminal use. Hamilton and Chervany (1981) list a system quality measures is probably the most well known: data currency, response time, turnaround time, data accuracy, reliability, completeness, system flexibility and ease of use. More recently, Seddon (1997) came up with a similar definition: system reliability, user interface consistency, ease of use, document quality and quality and maintainability of the program code.

None of the above-mentioned definitions can be applied to this study without modification for two reasons: First they mix system aspects with software aspects, and second they do not consider the specifics of ERP software. Data/information

11 An overview of this research is provided by the IS-Effectiveness group of the Association of IS: http://business.clemson.edu/ISE/

quality,[12] for example, has to be excluded, because they are not referring to features of the software product as such, but rather to the quality of the implementation process and the ongoing data maintenance, i.e. they are endogenous rather then exogenous factors.

The first problem can be overcome by referring to the ISO/IEC Software Quality Standards 9126,[13] which specifies the following categories of software quality characteristics (and sub-groups thereof): Functionality, reliability, usability, efficiency, maintainability and portability. Basically, these dimensions of software quality also apply to ERP software, but with some limitations:

a) Especially in the case of the leading ERP software products, no organization uses the full functionality of the software, but rather implements functionality very selectively. Furthermore, this base functionality requires configuration to operate properly. Accordingly, we suggest analyzing functionality at the ERP systems and not at the ERP software level.

b) Maintainability primarily refers to the flexibility of program code changes; as this is not a recommended activity in ERP systems, we omit this criterion.

c) Portability includes adaptability, installability, replaceability, etc.; as mentioned before, program adaptation is not recommended, whereas configuration adaptation is a key activity of the implementation process. Technical installability is not considered to be a challenge with ERP software, whereas replaceability is far from being a main consideration in system analysis (considering that hardly any company will consider adopting an ERP product with the option of abandoning it in the near future). In the context of ERP software, *flexibility* seems to be a more appropriate concept than *portability* (similar: Hamilton and Chervany, 1981).

From our preliminary list of dimensions of ERP software quality (reliability, usability, efficiency and flexibility) one stands out insofar as it is the only one that directly relates to the *end-user experience* with ERP: usability. As claimed by the

12 *Data quality* research addresses the identification and measurements of data quality characteristics and their representation, the management of data quality and the analysis of business impacts of data quality (Parssian *et al.,* 1999). Research initially focused on the identification of the important characteristics that define quality (Redman, 1997, Wang and Strong, 1996), and later on the management of data quality and the quality of associated data management processes (Ballou et al., 1998). Data quality is generally understood as a multidimensional concept. Huh et al. (1990) and also Fox et al. (1994) define four dimensions of data quality: accuracy, completeness, consistency, and currency. Wang and Strong (1996) present a framework for measuring data quality which comprises fifteen dimensions. Further taxonomies of data quality were developed by e.g. Zmud (1978). In more recent literature, the term 'data quality' is often replaced by 'information quality', usually without mentioning reasons for this metamorphose. The most worrying example of this silent transition is presented by Klein (1999) and Klein (2000): The first few paragraphs of both publications are almost identical except for one major difference: In the 2000 paper, the term 'data quality' is simply replaced by 'information quality' – the only explanation we have is that the search-and-replace function has been used efficiently …

13 Joint Technical Committee 1 of the International Organization for Standardization (ISO) and International Electrotechnical Commission (IEC) (Jung *et al*., 2004).

protagonists of the Technology Acceptance Model (TAM), perceived ease of use of an IS is one of the drivers of the perceived usefulness and eventually the actual use of the system (Davis, 1989). Amoako-Gyampah and Salam (2004), who applied the TAM in the context of ERP, found that perceived usefulness and ease of use do indeed contribute to the intention to use ERP systems, and that interventions in form of training etc. have a positive impact on the acceptance of ERP amongst end-users. Accordingly, we include the aspect 'perceived ease of use' in our model; however, we use the more common terms 'user friendliness'.

We have identified a second aspect of usability which is not as common in general IS literature as it relates very specifically to ERPS: making business processes transparent to the end user. We know from previous research (Wieder, 2003) that one of the keys to understanding transactions in ERPS is to understand the whole the business process stretching across various functions. Making those business processes transparent to the end user assists his/her understanding of the system and its usefulness for an organization. Therefore we assume that higher transparency of business processes contributes to the end-user acceptance of the system (which is part of our definition of ERP fit).

In summary, we distinguish two aspects of software quality:

1. Predominately technical aspects of quality which refer to the quality of software as installed on the server, prior to organizational configuration: Reliability, efficiency (in terms of speed and capacity) and flexibility.

2. Aspects of quality which relate to the 'human-machine' interface (interaction quality) and are supposed to play a key role in user acceptance and therefore fit; we further distinguish two dimension of interaction quality: 'user friendliness' and 'transparency/quality of visualization of business processes'.

The abovementioned discussion can now be summarized in the following 2 hypotheses.

Hypothesis 5: Technical aspects of ERP software quality are positively associated with ERPS fit.

Hypothesis 6: The interaction quality of ERP software is positively associated with ERPS fit.

2.3.2 Integration Mechanisms for ERPS Fit

ERP *implementation characteristics* are the second set of drivers in our ERPS fit model. In the large body of literature on ERP implementations there is widespread agreement that the success of an ERP project is contingent upon many factors other than the software quality.[14] Following a long tradition of critical success factor (CSF)

[14] In practice many implementation methodologies have been developed aiming to guide and facilitate the overall implementation project. The probably best known methodology in practice is the one developed by SAP and referred to as *Accelerated SAP* implementation methodology (now part of the SAP Business Solution Manager), which slices the implementation project into five main phases: project preparation, business blue print, realization, final preparation and go live and ongoing

research for IS in general, more recently a whole stream of literature has emerged which tries to identify these CSFs of ERP implementations (Akkermans and van Helden, 2002; Al-Mashari *et al.*, 2003; Gargeya and Brady, 2005; Grabski *et al.*, 2000; Holland and Light, 1999; Hong and Kim, 2002; King, 2005; Nah and Delgado, 2006; Somers and Nelson, 2001; Sun *et al.*, 2005; Tsai *et al.*, 2005; Umble *et al.*, 2003). In essence, ERP-CSF literature attempts to identify and often 'recommend' factors which contribute to either 'success' or 'failure' of ERP implementations. However, it is not always clear what *success* or *failure* means in the context of ERP implementations.[15] One of the few exceptions to this limitation is a study provided by Al-Mashari *et al. (2003),* who provide a clear taxonomy of CSFs, ERP benefits and ERP success (however, they fail to test it empirically). In most other cases, CSFs are – usually implicitly – put forward as factors contributing to either a positive or negative *outcome* of an ERP implementation, but fail to operationalize outcome.

Whilst the factors identified in these articles do overlap substantially, the research approaches and rigor vary significantly. In terms of methodology, CSF literature comprises examples of the survey approach, secondary data/content analysis (Gargeya and Brady, 2005; Somers and Nelson, 2001), the (multiple) case study approach (Akkermans and van Helden, 2002; Nah and Delgado, 2006) or simply literature reviews coupled with 'own experiences' (Al-Mashari *et al.*, 2003; King, 2005). Furthermore, some of the authors distinguish between different phases of the ERP life-cycle (Akkermans and van Helden, Al-Mashari *et al.*, 2003; Nah and Delgado, 2006; Somers and Nelson, 2001), whereas most others do not.

As far as the overall themes in the various lists of CSFs are concerned, three aspects dominate the discussion and are present in all the literature:[16] *(1) Quality of project*

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support. In the case of SAP (solution manager) there are software tools, which documents each stage of the process, assist in the creation of own documentation and guide the implementers to transactions in the system which are used for configuration.

15 One possible interpretation of *failure* is that the implementation is abandoned before or some time after going life. But that raise the question: Are all other outcomes (e.g. 'muddling through') 'successes'?

16 - Akkermanns and van Helden (2002) - following Somers and Nelson (2001) - (ranked by importance): Top management support, project team competence, interdepartmental cooperation, clear goals and objectives, project management, interdepartmental communication, management of expectations, project champion, vendor support, careful package selection, data analysis & conversion, dedicated resources, use of steering committee, user training on software, etc.
- Al-Mashari et al. (2003): Management and leadership, visioning and planning, ERP package selection, communication, process management, training and education, project management, legacy systems management, system integration, system testing, cultural and structural changes, and performance evaluation and management
- Gargeya and Brady (2005): Worked with SAP functionality/maintained scope, project team/management support/consultants, internal readiness/training, deal with organizational diversity, planning/development/budgeting and adequate testing
- Sun et al. (2005) (ranked by importance): People, technology, data, process and management/organization.
- Nah and Delgado (2006): Business plan and vision, change management, communication, ERP team composition, skills and compensation, management support and championship, project management, system analysis, selection and technical implementation.
- Etc.

team/project planning/management, (2) top business management vision and support, and (3) change management, learning and education.

These three themes also guide our research, although some minor changes are required, because we do not relate CSFs of ERP implementations directly related to 'success/failure' of 'performance', but rather to *ERPS fit* (see above). The first theme can be adopted as it does relate to ERPS fit. The quality of project management plays a key role in the success of any business or IT project. High quality project management facilitates many other CSFs such as interdepartmental communication and cooperation, expectation fit, project team motivation, effective change management, etc. and is therefore expected to result in higher levels of ERPS fit. Considering the scope, length and complexity of most ERP implementation projects and the impact of ERP on organizations, the quality of PM is deemed to play an even more important role in ERP projects than most other IT projects. Furthermore, ERP projects require special skills which relate to the organizational, human and political dimensions of those projects (Ryan, 1999). Gefen and Ridings (2002), for example, demonstrate that implementation team responsiveness leads to better cooperation, better quality of configuration and better user acceptance (fit).

Hypothesis 7: Project management skills are positively associated with ERPS fit.

The second theme, top business management support and vision, is of key importance in terms of engaging managers at lower levels, ensuring adequate funding and highlighting the priority of the project, but as far as achieving ERPS fit is concerned, a direct link is as obvious. A related but more immediate factor addressing a similar concept is one which is missing in much of the ERP CSF literature: *business ownership* of the project (as opposed to IT-ownership). Gibson *et al.* (1999), for example, make it very clear in their analysis that ERP projects benefit substantially if they are "business driven as opposed to IT driven", and industry journals are frequently pointing at the risks of being "misled into thinking of it [an ERP project] as a technology project" (Bartholomew, 2004). Despite the apparently unanimous agreement on the view that ERP projects are by far likely to be successful if they are championed by business rather than IT, in practice there are reportedly still many cases in which ERP implementations are 'run' by IT-departments which are clearly not in a position to understand business processes and requirements at the same level of detail as business managers do. Accordingly, we expect lower levels of ERPS fit in implementations led by IT management than those headed by business management.

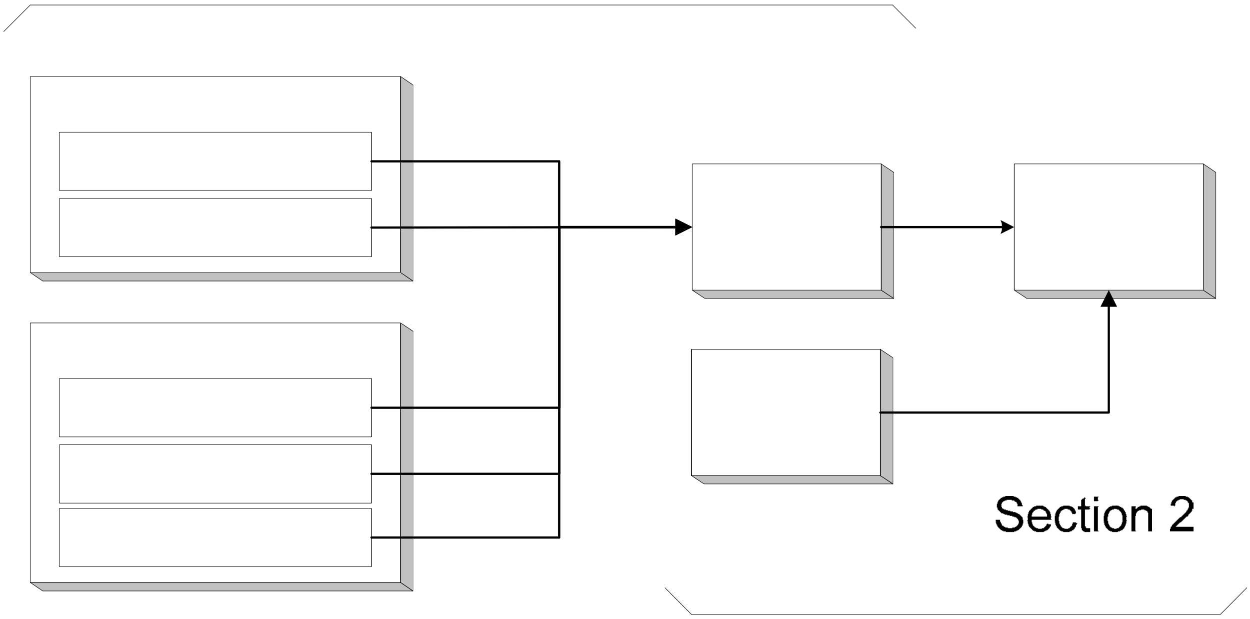
Hypothesis 8: ERP implementation projects led by business managers result in higher ERPS fit than projects led by IT managers.

As far as theme three is concerned, we consider change management to be part of project management (see above) and therefore focus entirely on the impact of learning/training on ERP fit:

Hypothesis 9: The quality of training is positively associated with ERPS fit.

Figure 3 summarizes our research model as elaborated above; the first 4 hypotheses refer to section one of the model (ERPS fit and performance), and the remaining five to section two (determinants of ERPS fit).

Figure 3: Research Model



3 Research Method

3.1 Research Instrument

3.1.1 Sample

Our research builds on data which was collected through a large-scale mail survey and telephone interviews in an earlier research project in 2001. The initial survey addressed a variety of enterprise systems related topics, and only part of the data had not been analyzed for research purposes before.[17] The data available originates from 67 relevant survey responses and 37 telephone interviews. As some of the research questions of the initial project aimed to compare attributes of ERP users with those of non-adopters, the original data set contained responses from both groups. For the purpose of the research presented in this paper, however, only the 49 responses collected from ERP users are used (48% of all responses).

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17 See Wieder *et al.* (2006) for details on the survey process.

Table 1: Industry Classification of Respondents

	All Respond.		ERP Users		ERP User Rate
Industry Sector	**Abs.**	**%**	**Abs.**	**%**	
Diversified Resources/Mining	16	15.7%	10	20.4%	62.5%
Energy	3	2.9%	2	4.1%	66.7%
Others (Primary Sector)	1	1.0%			
Primary Sector total	***20***	***19.6%***	***12***	***24.5%***	***60.0%***
Batch Production	14	13.7%	9	18.4%	64.3%
Assembly-Line Production	6	5.9%	3	6.1%	50.0%
Process Production	11	10.8%	7	14.3%	63.6%
Project/Unit Production	1	1.0%			
Secondary Sector total	***32***	***31.4%***	***19***	***38.8%***	***59.4%***
Retail/Wholesale and Transport	19	18.6%	8	16.3%	42.1%
Financial Services, Banking/Finance, Insurance	12	11.8%	2	4.1%	16.7%
Healthcare, Tourism and Leisure	7	6.9%	4	8.2%	57.1%
Media, Telecomm., Software, IT-Services	3	2.9%	2	4.1%	66.7%
Property, Infrastructure and Facilities	1	1.0%			
Consulting	2	2.0%			
Others (Services Sector)	6	5.9%	2	4.1%	33.3%
Tertiary Sector total	***50***	***49.0%***	***18***	***36.7%***	***36.0%***
Total	***102***		***49***		***48.0%***

The average operating revenue in the financial year preceding the survey was Mio A$ 11,573 for the group of ERP users, and clearly (Mio A$ 3,252) for the non ERP users. The differences in size are also reflected in the average number of full-time employees (or equivalents), which are 10,542 in the group of ERP users, as opposed to only 2,493 in the other group.

67.3% (91.9% for non ERP) of the respondents indicated that their company was fully or majority Australian owned and the rest were either dominated or fully owned by a foreign entity.

3.1.2 Measurement Details

Perceptions based measures were used to capture the *impact of ERP on organizational performance.* Respondents were asked to rate the impact of their ERPS on their firms' performance (a) at the time of going live, (b) one year after going live and (c) three years after going live, on a 7-point Likert scale (1 = very poor, 4 = neutral, 7 = very good).

A similar approach was used to measure *ERPS fit* except for that we used three variables to compute an aggregate measure of fit (as outlined in section 2.1):

- Compatibility with business processes
- General user acceptance

- Management overall satisfaction with system (expressed by the likelihood of choosing the system again)

For the first two variables respondents were asked to indicate on a 7-point Likert scale whether or not their firm found theses characteristics to be a weakness (1) or a strength (7) of the ERPS, or neither (4). In a similar way, they were asked to indicate whether their company would choose this system again if it had another choice (1 = strongly agree, 4 = indifferent, 7 = strongly agree). The tree variables were factor-tested (principal component analysis) with the result that only one component was extracted and 63.65% of the variance was explained by the three variables. The results demonstrated high convergent validity with factor loadings exceeding 0.5 for each variable.

Both technical aspects of *software quality* and the interaction quality were measured using aggregated (mean) variables derived from questions relating to the quality dimensions discussed in section 2.3.1. Like in the case of ERPS fit, respondents were asked to indicate on a 7-point Likert scale whether or not their firm found theses characteristics to be a weakness (1) or a strength (7) of the ERPS, or neither (4). The technical aspects mentioned were (a) reliability, stability and security, (b) performance, speed and capacity and (c) flexibility/open-system architecture, whereas interaction quality was addressed by asking for (a) transparency/ visualization of the business processes and (b) user friendliness.

The scores relating to aspects of *quality of integration mechanisms* were obtained directly from three specific questions, addressing on the one hand whether a particular issue (training and project management skills) was a *relevant problem* during the implementation (7-point Likert-scale, 1 = *very relevant*, 7 = *not relevant*),[18] and on the other hand inquiring about the leader of the implementation team (0 = business, 1 = IT).

3.2 Descriptive Statistics

The subsequent section provides some descriptive statistics which give the reader some preliminary insights into the nature of the data and the isolated relationship between some of the key variables (correlations). Table 2 shows the number of valid responses for each of the variables, minimum and maximum values, means including standard errors and standard deviations. As mentioned before, the values shown in the table refer to ERP users only.

The mean scores in software quality reflect common knowledge suggesting that the *technical quality* of most ERP software packages is a significantly stronger argument in favor of ERP than their *interaction quality* (paired samples test: t = 4.535, p = 0%).

The table also shows that a relatively large portion of ERP implementation projects is led by IT (32%), despite the fact that both academic and practitioner literatures clearly suggest to put business managers in charge. Project management skills and

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18 This coding implies that the predicted relationship between training/project management skills and ERPS fit is *positive* (e.g. 'the fewer problems with adequate training, the higher ERPS fit').

training overall seemed to be relevant problems – with large variations across the sample as indicated by the standard deviations.

The impact of ERP adoption on TCO was moderately positive, with scores normally distributed around the mean.

The immediate impact of going live with ERP on firm performance was negative. However, the mean score for the performance impacts in t_1 indicates a strong upwards trend already in year one, and the mean score in and t_3 (5.320) suggests that – overall – the ERP implementations in the sample were 'success-stories'.

Table 2: Basic Descriptives

	N	**Minimum**	**Maximum**	**Mean**		**Std. Deviation**
Variable	**Stat.**	**Statistic**	**Statistic**	**Stat.**	**Std. Error**	**Statistic**
Software Quality:						
Technical Quality	36	1.00	7.00	5.204	0.214	1.286
Interaction Quality	36	1.00	6.50	4.097	0.238	1.428
ERPS fit	36	1.67	6.33	4.509	0.206	1.233
Quality of Integration Mechanisms:						
Business vs. IT-Leadership	34	0.00	1.00	.320	0.081	0.475
Project management skills	35	1.00	7.00	3.86	0.304	1.801
Adequate training	35	1.00	7.00	3.71	0.300	1.775
TCO	36	1.00	7.00	4.330	0.267	1.604
Performance:						
Performance Impact of ERP – t0	46	1.00	7.00	3.300	0.196	1.331
Performance Impact of ERP – t1	44	1.00	7.00	4.390	0.187	1.243
Performance Impact of ERP – t3	31	2.00	7.00	5.320	0.209	1.166

Pearson's correlations were performed in order to gain initial insights into the drivers of ERPS fit. The interaction quality has the strongest impact, followed by technical quality and adequate training. The other two dependent variables are not significant, at least if analyzed in isolation.

Table 3: *Pearson* Correlations for ERPS Fit

	Predicted Sign	**ERPS fit**
Independent:		
Interaction Quality	**+**	**.820*** **
Technical Quality	**+**	**.539*** **
Business vs. IT-Leadership	**-**	-.126
Adequate training	**+**	**.355** **
Project management skills	**+**	.17
Dependent:		
Performance Impact of ERP – t0	**0**	0.258
Performance Impact of ERP – t1	**+**	**.585*** **
Performance Impact of ERP – t3	**+**	**.731*** **

*** *significant at the .01 level, ** significant at the .05 level, * significant at the .10 level (all two-tailed)*

The preliminary correlation results regarding the relationship of ERPS fit and short/medium-term performance impacts of ERP confirm Hypothesis 3.

4 Results and Analysis

4.1 Total Cost of Ownership, ERPS Fit and Performance Impacts

The first four hypotheses refer to section one in our research model as summarized in Figure 3. Our first hypothesis suggests that ERP adopters experience a reduction in TCO. As we asked respondents directly about their perceptions about the relationship of ERP adoption and *change* in TCO, no benchmarking of TCO in ERP adopter and non-adopter organizations was required. We rather used a One-Sample T Test to compare the mean (4.33) impact with neutral score of 4, just to confirm what was already evident in **Error! Reference source not found.** as well: Hypothesis 1 is rejected (t = 1.247, p = 22%, 2-tailed).

In search for possible explanations we also tested for possible correlations between changes in TCO and functional ERP scope (in terms of the number of ERP modules used) and we did indeed find some indications suggesting that large scale ERP implementations perform better in terms of TCO reductions than smaller scale implementations (*Pearson* correlation: .305, p = 7%, 2-tailed). However, more data would be required to provide more robust evidence of this relationship.

Hypotheses 2 and 3 relate ERPS fit and changes in TCO to medium-term performance increases, and were tested with linear regression models. Table 4 summarizes the results of the tests[19].

19 The results for period t_0 are displayed for reference/control purposes only.

Table 4: OLS Estimation of Determinants of Medium-Term Performance Impacts

			Perf. Impact t_0 (at go-live)		Perf. Impact t_1 (after go-live)		Perf. Impact t_3 (after go-live)	
Variables	**Hypothesis**	**Pred. Sign**	**Std. Coeff.**	**t-stat**	**Std. Coeff.**	**t-stat**	**Std. Coeff.**	**t-stat**
ERP Impact on TCO	Hypothesis 2	+	.285	1.623	**.373**	**2.559****	.237	1.657
ERPS Fit	Hypothesis 3	+	.183	1.042	**.464**	**3.183*****	**.685**	**4.796*****
Constant				1.420		1.055		1.584
R squared			**.142**		**.467**		**.588**	
F Statistic			**2.478**		**12.243**		**14.979**	
Significance			**.101**		**.000**		**.000**	

**** significant at the .01 level, ** significant at the .05 level, * significant at the .10 level (all two-tailed)*[20]

Hypothesis 3 is clearly supported, whereas hypothesis 2 only holds for t_1 but not for t_3. As expected, ERPS fit and changes in TCO cannot be used to explain performance impacts immediately after going live, as many other factors impact on this usually very hectic period. The R-squares for the models t_1 and t_3 demonstrate high goodness of fit, and also the F-statistics are very satisfactory. A possible explanation for the weakening effect of reductions in TCO in t_3 is that those reductions are realized earlier in the post-implementation period, but afterwards, TCO stay more or less constant, thereby no longer contributing to performance increases in later periods.

Hypothesis 4 aims to provide further insights into the level of performance changes within different points of time in the post-implementation phase. Paired-Samples T Tests were used to test for significances of changes of mean performance impacts between t_0 and t_1, t_0 and t_3 and t_1 and t_3. The results as depicted in Table 5 confirm that ERP performance impacts increase significantly within all these segments of the post-implementation period, with the strongest improvement experienced within year 1, but still significant improvements between year one and 3.

20 Tests for multi-collinearity were performed with negative results.

Table 5: Paired-Samples T Test for Performance Differences

ERP Impact on Firm Perform.	Paired Differences							
	Mean	Std. Dev.	Std. Error Mean	95% Confidence Interval Lower	95% Confidence Interval Upper	t	df	Sig. (2-tailed)
t_0 and t_1	-1.098	1.338	.209	-1.520	-.675	-5.252	40	.000
t_0 and t_3	-1.821	1.765	.334	-2.506	-1.137	-5.461	27	.000
t_1 and t_3	-.767	.898	.164	-1.102	-.431	-4.678	29	.000

As the descriptive statistics in Table 2 suggest that the mean impact of ERP adoptions on firms' performance in t_0 is 3.3 and therefore negative (below 4 = 'neutral'), but then turns slightly positive in t_1 (4.390) and clearly positive (5.320) in t_3, we decided to also test these scores for significant deviations from 'neutral', again using One Sample T Tests. The test results indicate that ERP adopters under-perform in t_0 ($t = -3.544$***), achieve above-level performance by the end of t_1 ($t = 2.062$**) and 'excel' by the end of t_3 ($t = 6.316$***). This suggests that the 'performance-dip' after going live with an ERPS might actually be shorter than suggested in previous literature, which identifies performance increases in t_2 at the earliest (Matolcsy *et al.*, 2005), if at all (e.g. Poston and Grabski, 2001).

4.2 Determinants of ERPS Fit

The results of the OLS estimation of determinants of ERPS fit covering hypotheses 5 to 9 are summarized in Table 6.

Table 6: OLS Estimation of Determinants of ERPS Fit

Variables	Hypothesis	Pred. Sign	Stand. Coeff.	t-stat.	Tolerance	VIF
Quality Aspects:						
Technical Quality	Hypothesis 5	**+**	**.234**	**2.681****	0.803	1.246
Interaction Quality	Hypothesis 6	**+**	**.711**	**7.877*****	0.772	1.296
Integration Mechanisms:						
Business vs. IT-Leadership	Hypothesis 8	**-**	**-.209**	**-2.590****	0.964	1.038
Adequate Training	Hypothesis 9	+	**.234**	**2.523****	0.732	1.366
Project management skills	Hypothesis 7	**+**	.033	.363	0.759	1.317
Constant				1.085		
R squared			**.824**			
F Statistic			**26.196**			
Significance			**.000**			

*** *significant at the .01 level, ** significant at the .05 level, * significant at the .10 level (all two-tailed)*

The overall statistics of the model show high goodness of fit and high explanatory value of the variances, and the collinearity statistics exclude problems with multi-collinearity.

Interaction quality proofs to have the strongest and most significant impact on ERPS fit, followed by the *technical quality* and *adequate training* with almost identical scores. *Business leadership* is also a significant determinant of ERPS fit, whereas project management skills are almost neutral. Sensitivity analysis was performed to test whether the elimination of this variable leads to an improved ex-post model; the results of the modified tests are summarized in Table 7.

Table 7: OLS Estimation of Determinants of ERPS Fit (Revised Model)

Variables	Hypothesis	Pred. Sign	Stand. Coeff.	t-stat	Tolerance	VIF
Quality Aspects:						
Technical Quality	Hypothesis 5	**+**	**.238**	**2.727*** **	0.803	1.245
Interaction Quality	Hypothesis 6	**+**	**.709**	**7.991*** **	0.775	1.290
Integration Mechanisms:						
Business vs. IT-Leadership	Hypothesis 8	**-**	**-.205**	**-2.604** **	0.985	1.015
Adequate Training	Hypothesis 9	+	**.250**	**3.099*** **	0.939	1.064
Constant				1.250		
R squared			**.823**			
F Statistic			**33.722**			
Significance			**.000**			

*** *significant at the .01 level, ** significant at the .05 level, * significant at the .10 level (all two-tailed)*

The exclusion of 'project management skills' has hardly any impact on the R^2, but it improves the F statistic and further strengths the relationship between technical quality/adequate training and ERPS fit.

5 Summary and Conclusion

The objectives of this study were (1) to provide insights into the relationship between organizational fit of ERPS and organizational performance, (2) to provide further insights into the performance implications of ERP adoptions in general, and (3) to explore how aspects of software quality and integration mechanism impact on organizational fit of ERPS. Our results indicate that:

- the adoption and use of ERPS leads to firm performance increases already within one year after the go-live date;
- firm performance increases are sustained over a period of at least three years after the go-live date;
- a key driver of the increases in firm performance is the organizational fit of the ERPS after the go-live date (i.e. after the main phase of organizational and software 'adaptation');
- software quality and the quality of the integration (adaptation) mechanisms co-determine ERPS fit, and that the interaction quality of the software and adequate training have the strongest impact on ERPS fit; and that

- improvements in TCO have a moderate impact on short-term firm performance, but ERP adopters do not achieve significant reductions in TCO.

These results contribute to the existing ERP-performance literature in various ways: First, the findings suggests that the 'performance-dip' after going live with an ERPS might actually be shorter than suggested in previous literature, which identifies performance increases in t_2 at the earliest (Matolcsy *et al.*, 2005), if at all (e.g. Poston and Grabski, 2001). Secondly, the study provides evidence of clearly significant and sustained medium-term performance increases in the aftermath of an ERP implementation (while most of the previous literature found little or no evidence of significant performance increases). Thirdly, our research introduces a new concept of ERPS fit, provides evidence of the determinants of fit and links the concept to firm performance.

There are, however, some limitations to our study which suggest caution when interpreting our results and prompt for further research to strengthen the validity of our results. One of these limitations is that we used perception-based indicators of form performance rather than real financial data. Furthermore, we collected responses from only one person within each organization (CIO or equivalent), without getting at least a second opinion from an employee in a different function. The fact that we asked a senior IT executive/manager might further suggest a positive bias in terms of assessment of the implications of a systems implementation on firm performance. However, we noticed with interest that the IT executives/managers surveyed rated the IT-led ERP implementations clearly lower in terms of outcomes than the business-led implementations – a fact which is at least an indicator of the reliability of the responses.

Another limitation is the small sample size (49), which was eventually further reduced in most of the tests as not all respondents completed all the questions. The small sample size also prevented us from using more advanced testing methods such as Structural Equation Modeling/Path Analysis. Nevertheless, we think we have provided some important insights which might at least provide an incentive for further research.

Appendix: Variables Defined

Name	*Description*	*Notes*
Size (Revenue)	Total Operating Revenue for last Financial Year (Millions)	-
Size (Employees)	Average Number of Employees	-
TCO	Impact of ERP on Total Cost of Ownership (TCO) (negative, neutral or positive).	-
Technical Quality	Technical quality of an ERP system refers to technical component of the software.	Technical quality is calculated as the mean of the quality in terms of reliability, speed/capacity and the flexibility, which have been measured on a 7 step Likert scale (1=very poor, 7 = very good.)
Interaction Quality	Interaction Quality includes quality of interaction of the software.	Interaction Quality is calculated as the mean of the quality of transparency/visualization of the business process and the user friendliness, which have been measured on a 7 step Likert scale (1=very poor, 7 = very good.).
ERPS fit	ERPS fit is the enterprise system (software) in the context of the business environment (company).	ERPS fit is calculated as the means from the score of user acceptance, user satisfaction, and compatibility with business process. All figures have been measured on a 7 step Likert scale (1=very poor, 7 = very good.).
Business vs. IT-Leadership	The implementation project was led by IT people vs. business people.	0=Business leader ship, 1= IT leadership
Implementation Support	The implementation support was given by consulting company versus vendor.	0 vendor support, 1=consulting company support
Adequate Training	Adequate Training	Adequate training was measured in the section "ERP implementation - problems during implementation inadequate training" on a 7 step Likert scale (1=very relevant, 7= not relevant)
Project management skills	Project management skills	Project management skills was measured on a 7 step Likert scale in the part "ERP implementation - problems during implementation inadequate project management skills"(1=very relevant, 7= not relevant)
Performance Impact of ERP – t0	Performance impact of ERP at the time of going live	The impact on your companies performance - at time of going live was measured on a 7 step Likert scale (1=very poor, 7=very good)
Performance Impact of ERP – t1	Performance impact of ERP at the time of one year after going live	The impact on your companies performance –one year after going live was measured on a 7 step Likert scale (1=very poor, 7=very good)
Performance Impact of ERP – t3	Performance impact of ERP at the time of three years after going live	The impact on your companies performance –three years after going live was measured on a 7 step Likert scale (1=very poor, 7=very good)

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