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Modelling the factors that influence the achievement of business benefits from ERP systems

Lorraine J. Staehr
La Trobe University, l.staehr@latrobe.edu.au

Graeme J. Byrne
La Trobe University, g.byrne@latrobe.edu.au

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Lorraine J. Staehr
Graeme J. Byrne
School of Engineering and Mathematical Sciences
La Trobe University
Bendigo, Australia
Email: l.staehr@latrobe.edu.au
Email: g.byrne@latrobe.edu.au

Abstract

Enterprise Resource Planning (ERP) systems are large, complex software packages with the potential to provide many business benefits. However, the billions of dollars invested by organizations worldwide in ERP systems have resulted in varying outcomes. This research will identify the significant factors contributing to the achievement of business benefits from ERP systems, and develop a structural model to gain an understanding of the nature of these effects and how they interact with each other. The research findings will contribute to an under researched area in information systems and be of practical value to organizations that are considering implementing, or already have implemented ERP systems.

Keywords

ERP systems, post-implementation, business benefits, structural equation modelling.

INTRODUCTION

Collective investment by organisations worldwide in enterprise resource planning (ERP) systems since the early 1990s has been in the order of many billions of dollars. However there have been widely varying outcomes from ERP system implementations with a high degree of risk associated with implementation and use. Despite a large body of ERP research literature few studies have focused on the ERP system in use and for those that have (e.g. Davenport et al. 2004; Gattiker and Goodhue 2005; Mabert et al. 2000; Swanson 2003), there are mixed results as to the business impact of these systems. One of the major questions still not adequately answered is what factors are important in assisting organisations to achieve business benefits from ERP systems during the post--implementation period.

Enterprise system tracks continue to appear in national and international information systems (IS) conferences around the world underscoring the importance of these systems to business organisations. In a review of the information technology (IT) value literature, Chan (2000) called for more studies that answer *why, where, when, how* and *whom* questions as opposed to *what* value is provided by IT investments. In addition, the financial press continues to feature articles on ERP systems (e.g. Brickley, 2008; Worthen, 2007), and have linked ERP system implementation success or failure to the overall economic health of an organisation (Bulkeley, 1996). This study aims to address the practical and research concerns described above.

There has been much work done on information systems success in general (e.g. DeLone and McLean 1992; Sabberwal et al. 2006; Seddon 1997). Building on this work Sedera and Gable (2004) developed an enterprise systems success measurement model which is not specific to ERP systems. Their model was developed and tested using public sector organisations, whereas the proposal in this paper is specific to ERP systems in the private sector.

The proposed research builds on completed qualitative research (Staehr 2006) and integrates qualitative and quantitative approaches as suggested by Lee (1991). The qualitative findings provided a deep understanding of how and why business benefits were achieved from ERP systems in four Australian manufacturing organisations. This information is used to define factors that potentially influence the business benefits of ERP systems and build a theoretical model linking them to each other and eventually to measures of the business benefits. The model is amenable to calibration using structural equation modelling (SEM) which provides a framework for testing the validity of the model and its components. If successful, the resulting quantitative model will extend knowledge of the factors that influence the achievement of business benefits from ERP systems.

This research will contribute to both research and practice. It will add to the body of knowledge on a central issue in the IS discipline, that is, obtaining business value from IT investments (Kohli and Grover, 2008). The use of ERP systems provide organizations with enhanced IT infrastructure and large volumes of transactional data that can be used to provide wide ranging business benefits e.g. increased productivity, improved managerial decision making, new strategic directions. However, prior research in Australia and overseas has shown that organizations are not taking full advantage of these ERP system capabilities (e.g. Davenport et al. 2004; Staehr 2010). The proposed research will identify the significant factors that contribute to the maximum use of the capabilities of ERP systems in order to achieve business benefits for organizations. The research findings will contribute to an under researched area, will be of practical value to organizations using ERP systems, and have the potential to provide economic benefits through enhanced organizational performance.

The remainder of this paper discusses the background to this research, outlines the research design and provides concluding remarks.

BACKGROUND

The background to this research is provided in this section and covers three separate topics. The first is the prior relevant ERP literature, the second is the theoretical basis of the proposed theoretical model, and third, some background on structural equation modelling.

ERP Literature

Some studies have identified individual "conditions" that lead to organisations achieving business benefits from ERP systems. (Note that some literature on material resource planning (MRP) systems, the precursors to ERP systems is included in this group). Seven "conditions" can be distilled from the literature. They are

- The influence of early phases in the ERP life cycle on subsequent phases (Markus et al. 2000)
- *Resources* (Chang and Gable 2002; Davenport et al. 2004; Deloitte Consulting 1998; Markus and Tanis 2000; Ross and Vitale 2000; Somers and Nelson 2004; Wagner and Newell 2007; Wilson et al. 1994)
- *Establish metrics* (Deloitte Consulting 1998; Markus and Tanis 2000; Ross and Vitale 2000;)
- *Change management* (Davenport et al. 2004; Deloitte Consulting 1998; Markus 2004; Ross and Vitale 2000; Shang 2001; Somers and Nelson 2004)
- *Education and training* (Baskerville et al. 2000; Boudreau 2003; Boudreau and Robey 2005; Chang and Gable 2002; Deloitte Consulting 1998; Duplaga and Astani 2003; Koh et al. 2000; Leonard-Barton 1988; Lorenzo 2001; Markus and Tanis 2000; Nah et al. 2004; Ross and Vitale 2000; Somers and Nelson 2004; Wilson et al. 1994)
- *Software fit to business* (Chang and Gable 2002; Gattiker and Goodhue 2005; Markus and Tanis 2000; Nah et al. 2004; Shang 2001; Soh et al. 2000; Wilson et al. 1994)
- *People* (Deloitte Consulting 1998; Koh et al. 2000; Kraemmergaard and Rose 2002; Rikhardsson and Kraemmergaard 2006; Walsham 1992)

The "condition" studies listed above are the type of studies that were being referred to by this well known IS scholar:

"In sum, studies of ERP's critical success factors offer few insights beyond conventional wisdom. Most studies lack a theoretical framework that adequately explains why the investigated project and business outcomes occur. Thus, their contribution to understanding ERP implementation is limited." Robey et al. (2002 p. 20)

Four models have been developed for predicting business benefits from ERP systems (Davenport et al. 2004; Gattiker and Goodhue 2005; Seddon et al. 2010; Zhu et al. 2010). Of these four models three have been calibrated with some success (Davenport et al. 2004; Gattiker and Goodhue 2005; Zhu et al. 2010), while the fourth (Seddon et al. 2010) is yet to be quantitatively confirmed or calibrated. Of the three models that have been calibrated only the Gattiker and Goodhue (2005) and Zhu et al. (2010) models give any details of the measurement models associated with the factors. In the following paragraphs each of the four models are discussed in turn.

Davenport et al. (2004) looked at the overall business benefits to organisations from enterprise systems (ES), and the factors that contribute to them. They developed a causal model that identified three main factors (integrate, optimize and informate) that predict perceived business value. The model incorporates time, acknowledged in other studies as an important influence on the achievement of business benefits from ERP systems, but ignores contextual factors. There are three main limitations to this study. The first is that it involved some organisations that had implemented more than an ERP system. That is, Davenport et al.'s (2004) use of the term "enterprise systems" includes for example, customer relationship management (CRM) systems and supply chain management (SCM) systems. It is not known whether the same factors are involved in creating business

value from the entire range of enterprise systems. The second is that the causal model has an R-squared value of 0.13. This means that the model accounts for only 13% of the variation in the data. And finally, the study was done by a consulting company (Accenture) and could be construed as a means to encourage the use of their services.

The model of Davenport et al. (2004) described above focuses on business benefits to the organisation as a whole. In response to Barua et al.'s (1995) contention that understanding how IT creates value requires a finer level of analysis, the second study by Gattiker and Goodhue (2005) focused on benefits from ERP systems at an individual manufacturing plant. The results showed that interdependence (between plants) is associated with increased benefits from ERP systems and differentiation (i.e. between plant differences) is associated with the converse. Three intermediate variables, coordination improvements, task efficiency and data quality explained 71% of the variance in the benefits at plant level (R-squared value of 0.71). In addition, both customization and the amount of time elapsed since implementation had positive effects on the benefits at plant level. The Gattiker & Goodhue (2005) model identifies factors contributing to plant level benefits in manufacturing organisations. It also goes some way towards explaining how these benefits are achieved i.e. through coordination improvements, task efficiency and data quality. It includes context in a limited sense i.e. the interdependence and differentiation between plants. However the model is limited by its focus on operational level benefits and by doing so ignores potential managerial and IT infrastructure benefits that might be expected to be observed at the plant level. The focus at the plant level also means that organisational and strategic benefits of ERP were not considered.

In the third study Seddon et al. (2010) proposed a causal model of factors believed to affect organizational benefits from enterprise systems (OBES). The OBES model was developed from the ES, ERP and IS literature. Preliminary qualitative assessment of the model was done by analyzing customer presentations by senior managers from one ERP vendor at two of the vendor's conferences. This model, like the Davenport et al. (2004) model, is not ERP specific but includes all enterprise systems and therefore has similar shortcomings in this respect.

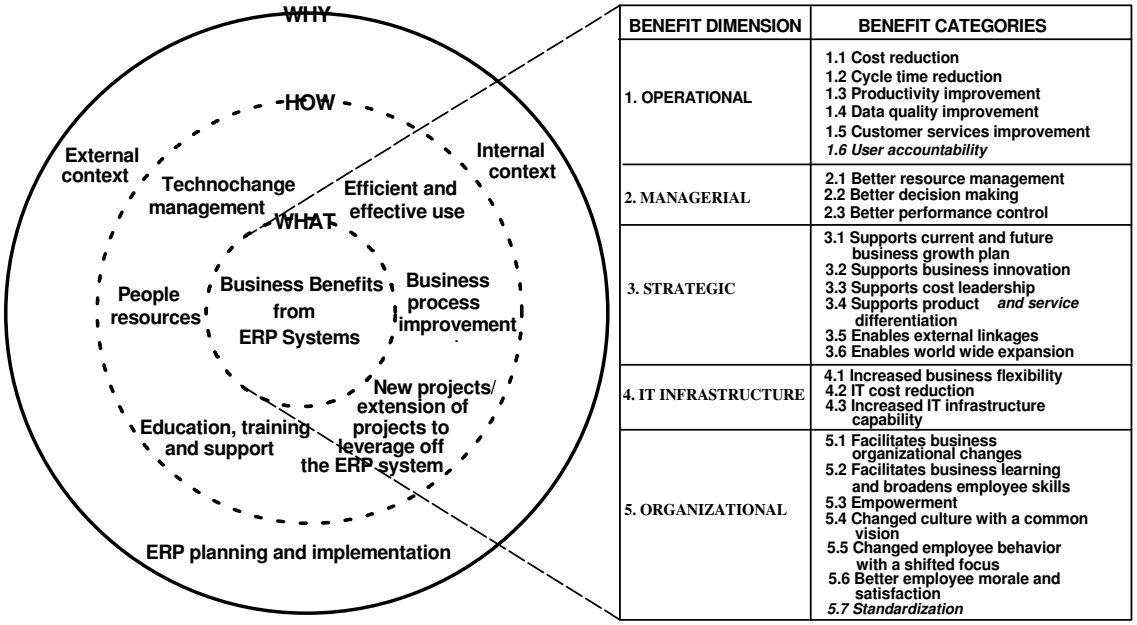
The model of Zhu et al. (2010) was based on Technology-Organization-Environment (TOE) theory and proposed that ERP implementation quality, organisational readiness and external support will affect the operational and managerial benefits achieved post-implementation. The results showed that ERP implementation quality and organizational readiness positively affected post-implementation success. However, although this study was ERP specific, it only included organizations from the Chinese retail sector and was limited to operational and managerial benefits as measures of post-implementation success.

The ERP literature reviewed above provides an incomplete picture on how and why business benefits are achieved from ERP systems. Although the models reviewed achieve some success in explaining why business benefits are realised, their low explanatory power indicates that a more general approach is required. In this paper a framework based on extensive qualitative research (Staehr 2006) is used to identify a wider range of factors than contained in any of the four models discussed above. The intended outcome is a model where all relevant factors and business benefits are included, resulting in a quantitative tool with high predictive power.

Theoretical Basis for the Proposed Model

The theoretical basis for the proposed model in this study is drawn from completed qualitative research (Staehr 2006) on how and why business benefits are achieved from ERP systems in the post-implementation period. This completed research involved in-depth case studies of four Australian manufacturing organisations that had implemented ERP systems. It provided a rich understanding and explanation of how and why business benefits occurred in the years immediately following ERP system implementation. There were three main outcomes of this prior research. The first was a tested and extended version of Shang and Seddon's (2000) ERP business benefits framework (Staehr 2007), shown on the right hand side of Figure 1. The second was a detailed explanation of each individual case using concepts from structuration theory (Staehr 2006). And the third was a framework (Staehr, Shanks and Seddon 2006) that showed the contexts and themes that influenced how and why some organisations achieve more business benefits than others from their ERP systems (see left hand side of Figure 1).

The theoretical framework in Figure 1 will be used as a basis to develop a model that can be used by organisations to maximize business benefits from ERP systems during the post-implementation period. The theoretical model consists of the contexts and themes from the left hand side of Figure 1 combined with the business benefits from the tested and extended Shang and Seddon (2000) ERP benefits framework on the right hand side of Figure 1. A preliminary theoretical model is shown in Figure 2. The relationships between the constructs in Figure 2 are based on the qualitative research findings. They are labelled P1 through P16 and are explained in Table 1.



BENEFIT DIMENSION	BENEFIT CATEGORIES
1. OPERATIONAL	1.1 Cost reduction 1.2 Cycle time reduction 1.3 Productivity improvement 1.4 Data quality improvement 1.5 Customer services improvement *1.6 User accountability*
2. MANAGERIAL	2.1 Better resource management 2.2 Better decision making 2.3 Better performance control
3. STRATEGIC	3.1 Supports current and future business growth plan 3.2 Supports business innovation 3.3 Supports cost leadership 3.4 Supports product *and service* differentiation 3.5 Enables external linkages 3.6 Enables world wide expansion
4. IT INFRASTRUCTURE	4.1 Increased business flexibility 4.2 IT cost reduction 4.3 Increased IT infrastructure capability
5. ORGANIZATIONAL	5.1 Facilitates business organizational changes 5.2 Facilitates business learning and broadens employee skills 5.3 Empowerment 5.4 Changed culture with a common vision 5.5 Changed employee behavior with a shifted focus 5.6 Better employee morale and satisfaction *5.7 Standardization*

Figure 1: What, how and why business benefits are achieved from ERP systems (Staehr 2006)

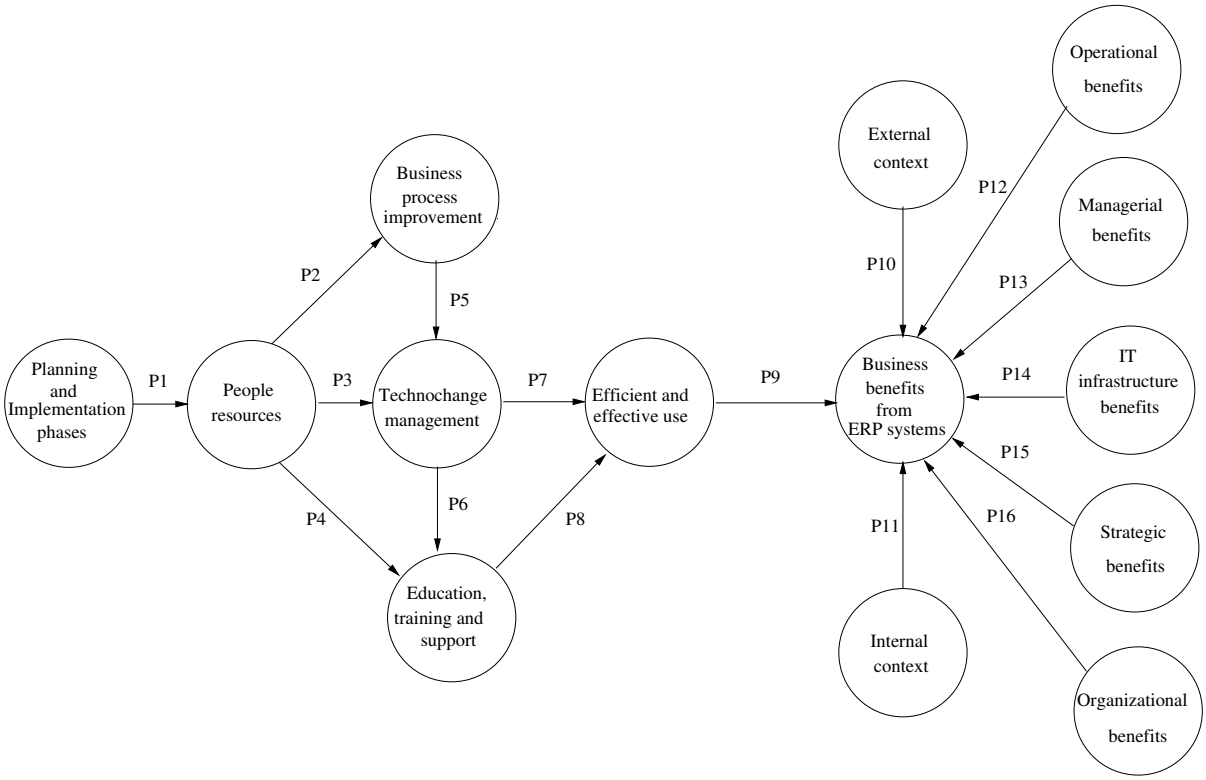


Figure 2: Preliminary model concept with paths labelled

Table 1: Rationale for the relationships between the constructs (based on Staehr (2006))

Path	Relationships Between the Constructs
P1	*Having issues to resolve from the **planning and implementation phases** influenced **people resources** available in the post implementation period i.e. ERP experts and key business users worked on problems from earlier phases and were unavailable for other tasks.*
P2	***People resources** (ERP experts and key business users) were needed during the post-implementation period to work with business managers and users to **improve business processes**. Without business expertise combined with ERP expertise (i.e. without appropriate **people resources**), **business process improvement** did not occur.*
P3	***People resources** (ERP experts and key business users) were needed to drive **technochange management** during the post-implementation period.*
P4	*Different skills and abilities of users meant that there were widely varying needs for **education, training and support** across functional areas requiring **people resources** (ERP experts and key business users) during the post-implementation period.*
P5	*Ongoing **business process improvement** during the post-implementation period required ongoing **technochange management** as changes to business processes were implemented.*
P6	*Ongoing **technochange management** during post-implementation identified where **education, training and support** was needed.*
P7	***Technochange management** during post-implementation identified where job roles had changed, or process controls were not in place, which when addressed resulted in **efficient and effective use** of the ERP system. Incentives provided through **technochange management** encouraged business managers to make more **efficient and effective use** of the ERP system, e.g., for decision making.*
P8	***Education, training and support** during post-implementation resulted in **efficient and effective use** of the ERP system by business managers and users.*
P9	***Efficient and effective use** of the ERP system resulted in, for example, increased data quality, better decision making, better management control that led to **business benefits** for the organization.*
P10	*The **external context**, for example, Government legislation, the state of the Australian IT industry, impacted on the **business benefits** achieved **from the ERP system**.*
P11	*Acquisitions, divestments, change of ownership and requirements from headquarters i.e. the **internal context** of the organisation, all provided additional activities that distracted from achieving **business benefits from the ERP system**.*
P12-P16	*When combined these represent the overall **business benefits from ERP systems**.*

Structural Equation Modelling (SEM)

SEM provides the statistical machinery required to assess the model described in Figure 2. Each component in the model will be measured by a set of reflective indicators and the validity of these measurement models will be assessed through SEM. Once measurement validity is established, the paths P1 to P16 forming the structural part of the model can be assessed. These paths present a set of hypotheses to be tested within the SEM framework.

For complex phenomena such as the one being studied, SEM is one of the few tools that allows complete and simultaneous tests of all the relationships involved (Ullman 2001). The principal goals of SEM are to a) identify correlations and direct relationships between latent or observed sets of variables, and to b) develop a parsimonious model that provides good predictive ability (Kline 1998).

The model proposed in Figure 2 will be calibrated using data from a representative random sample. Although adjustments to the model can be made at this stage, the revised model remains tentative until it is confirmed in a subsequent analysis based on new data.

RESEARCH DESIGN

This section of the paper presents the research questions, outlines the research method and reports on the current status of the research.

Research questions

The primary research question is: What factors should an organisation concentrate on to maximise business benefits from its ERP system?

This question can be broken down into three sub-questions:

1. Which observed variables are able to adequately measure the constructs in the theoretical model description of the situation?

2.a. Does the proposed theoretical model provide an adequate description of the situation?

2.b. If not, how can the theoretical model be changed to better fit the situation?

3. Do the hypothesized relationships stand up to scrutiny when tested in real world situations?

Method

The method of choice for this type of model is SEM since it allows for relationships between unobserved variables each of which may have underlying measurement models. The SEM analysis will proceed using the following steps (adapted from Suhr (2002)) in a two part process.

1. *Model specification based on prior research.* The qualitative framework in Figure 1 was used to develop the preliminary model shown in Figure 2. For clarity of presentation, variables are shown without their measurement models. A line with one arrow indicates an hypothesised direct regression relationship and the variable at the arrowhead is the dependent variable (all lines in Figure 2 are of this type). A goal of the project is the identification of the measurement models for all these variables based on the qualitative research already completed.

2. *Refine preliminary model.* Calibration and refinement of the structural model shown in Figure 2. Calibration uses techniques such as maximum likelihood to estimate regression and correlation coefficients and associated standard errors along with means and variances of latent variables. The refinement process involves testing overall model fit using a variety of fit indices and testing hypotheses about regression and correlation coefficients to assess the validity or otherwise of model components.

3. *Select measures for the variables represented in the model.* Measurement models for each of these factors will be developed as part of the research. These measurement models will consist of a series of measurement items as shown in Figure 3 below. The survey questions will be developed from the measurement items. How the high level concepts in Figure 1 can translate into measurable variables is explained below. A significant outcome and strength of the qualitative work that the structural model will be based on (Staehr 2006) was the identification of the constructs and outlines of their measurement models. For example, in Figure 3 the metric for "Improved management decision making" can be obtained by putting an appropriate question or questions to the relevant personnel in an organization. The response would take the form of a rating based on the participant's perception of the improvement in management decision making since the implementation of the ERP system. This is not an objective measure as would be the case for an item like "cost reduction", however it is a widely used approach where a direct metric

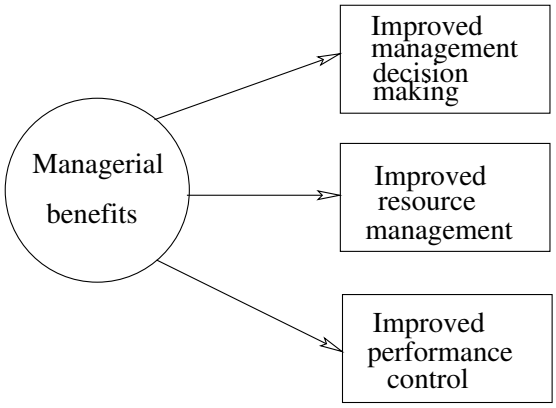


Figure 3: Example measurement items for a variable (factor)

is not available. This approach can be applied to other variables for which direct measures are not available. Results from the previous qualitative research provide much more detail on such high level concepts from which the actual questions will be developed. For each high level concept in Figure 2 there are a minimum of three examples, and in the case of the 5 business benefit dimensions (i.e. operational, managerial, IT infrastructure, strategic, and organizational) there are 25 categories with a total of about 90 examples from which to develop questions.

4. *Design questionnaire* Once the measures have been identified then the questionnaire can be designed and the actual questions developed.

5. *Data collection* has four main aspects:

   - *Identification of companies.* Suitable companies will be identified using the web site IBISWorld.com and their reports, software vendor success stories published on the web, stories of ERP systems from the financial press (both successes and those with problems). The companies selected will have used a variety of software vendors and will have implemented ERP modules across the value chain (minimum four modules).
   - *Obtaining access to organisations* is not a trivial task. Background company information and phone numbers of key personnel will be obtained from purchased IBISWorld company reports. The methods used in the prior qualitative research to obtain information about ERP investments include cold calling (telephone), letters of invitation to participate in the research, through colleagues at other universities with ERP vendor contacts, through La Trobe University alumni and through those organisations that have already participated in the research.
   - *Identification of cases.* Organisations will have been using their ERP system for at least three years, to ensure that business benefits have had sufficient time to accrue (Shang 2001; Staehr 2006) at each organisation. Key participants will be chosen because of their position within the organisation and their experience over time with the planning, implementation and use of the ERP system. As far as possible the participants will be chosen according to their perceived ability to report on the business benefits achieved in particular dimensions of the improved ERP benefits framework (see right hand side of Figure 1). That is, the operational, managerial and organisational business benefits will be obtained from the perspective of business unit managers, strategic benefits from the perspective of a senior manager and IT infrastructure from the perspective of the IT or ERP manager. In addition participants will include business managers from different functional areas/sites within the same organisation since business benefits have been found to vary along these lines (Lorenzo 2002; Shang 2001; Staehr 2007).
   - *Number of cases.* The number of cases required is dependent on the number of parameters in the structural model. At this stage it is anticipated that at least 300 cases will be needed.

6. *Pilot the questionnaire*. The questionnaire will initially be administered face to face in about ten cases.

7. *Modify questionnaire if necessary.*

8. *Data collection.* A commercial entity will be used to collect data since they possess the required infrastructure and trained personnel to conduct computer assisted telephone interviewing (CATI) for this project. The use of research assistants at the university would require their training as well as development of the necessary infrastructure, both expensive and time consuming tasks.

9. *Input data into statistical software (e.g. AMOS)*

10. *Conduct preliminary descriptive statistical analyses.* Determine method for treating missing data, examine the measured variables for outliers (all dependent and independent variables) and test for multivariate normality. Examine linearity through the use of scatter plots. Check for absence of multicollinearity and singularity (Ullman 2001).

11. *Calibrate structural model.* A variety of calibration techniques such as maximum likelihood, non-parametric and Bayesian estimation are available to calibrate the model.

12. *Assess model components.* Initial assessment of the model involves examining global fit indices such as the comparative fit index (CFI) and the root mean square error of approximation (RMSEA). More detailed assessment is carried out using modification indices and testing of individual path coefficients. Bootstrap estimation procedures also play a role in model assessment.

13. *Modify the model if necessary.* If the hypothesised model provides an inadequate fit, diagnostic statistics from the calibration procedure are used to suggest ways in which the model may be improved.

14. *Validate model using bootstrap and other methods.* Proper validation of the model should be carried out on a new data sample or a "hold-out" sample if enough data is available. Bootstrap methods can also be used to assess the distributional properties of parameter estimates and overall model validity.
15. *Present and interpret the model.* Interpretation is done by examining the direct and indirect relationships and providing practical interpretations. This involves relating components of the model to parts of the system and making statements about the effect of changing various components of the model/system on the system outputs.
16. *Prepare and distribute reports.* Prepare non-technical reports for participating organisations. Prepare technical reports for the academic community. Publish findings in the IS academic literature.

RESEARCH OUTCOMES

There are three broad aims of the proposed research. The first is to identify and validate the measurement models associated with the constructs of the theoretical model. The second is to test the validity of the hypothesised paths in the structural model and interpret the significant paths thus providing a deeper understanding of the processes, their interactions and their influence on achieving business benefits from ERP systems. And third, flowing from this will be the ability to provide practical guidelines to organisations on how to maximise business benefits from ERP systems.

CURRENT STATUS OF THE RESEARCH

Currently work is being done on refining the preliminary conceptual model and further refinements will be completed by the time of the conference. Development of the measurement models for the factors will have commenced and this will be reported at the conference.

CONCLUSION

This research will provide an independently developed structural model in contrast to one developed or supported by an ERP software vendor or implementation partner organisation. The research findings will be of interest not only to IS researchers but also to IS practitioners and to senior management of organisations. The findings will be of use not only for organisations that plan to implement ERP systems but for those that have already implemented ERP systems.

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