Integrating ERP using EAI: A Model for Post-hoc Evaluation

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Abstract

In recent years there has been an increased focus on improving the capability and flexibility of organisational information systems through improving, and where necessary, re-engineering inter and intra-organisational information flows. In doing so, many firms have realised that the cornerstone of their information systems capability is dependent upon core systems such as Enterprise Resource Planning (ERP). In realising this, it has forced businesses to acknowledge the need to integrate ERP systems with existing disparate legacy systems. Technology solutions such as Enterprise Application Integration (EAI) have been seen as a panacea to facilitate integration through the use of technologies that allow corporate IS subsystems to communicate with one another. In the context of using enterprise technologies to integrate ERP with other organisational business systems, this paper analyses and extends previously published work through presenting the *failure* of an industrial automation business to integrate its ERP system with legacy processes when using an EAI approach. In doing so, the authors present a post-hoc evaluation model that can be used by others as a frame of reference; a tool for reflection. The presented model seeks to provide further insight to the *failed* approach to ERP integration, within the given case study organisation. This proposed model, is constructed in terms of Technical, Organisational and Tailorability components. It is anticipated that this will be a useful tool for both practitioners and academics, who wish to gain a deeper understanding of ERP / EAI implementation approaches, as well as providing insights into *how* the componentization and extension of ERP functionalities can be achieved, towards so-called ERPII.

Keywords: ERP, ERPII, EAI, Evaluation, Tailorability, Post-hoc model

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1 INTRODUCTION

Enterprise Resource Planning (ERP) systems have emerged as a result of developments in organisational resource planning, to address the implementation of automated business processes. Such systems allow organizations to manage their core business process data and information across the enterprise, and can best be described as a collection of business software modules that attempt to automate core business process competencies in areas such as finance, HR, procurement, manufacturing and logistics, in a structured manner. Furthermore, ERP technologies have been designed to address the fragmentation of information across an organisation's business, to integrate intra-and inter-organizational information. As such, ERP systems offer strategic, tactical and operational value-adding dimensions to decision-making. ERP has traditionally been seen as being the backbone of an automated and efficient organization, bringing together enterprise data and information from a multitude of business process sources, overcoming limitations inherent in legacy information systems (Parr and Shanks, 2002).

Although conceived as a panacea with respect to solving inherent legacy application integration issues (Linthicum, 1999; Irani *et al.,* 2003), the implementation of ERP has brought problems for many organisations. In implementing ERP, it is accepted that a significant level of re-engineering is required to streamline 'as-is' processes, to fit the given implementation software architecture. Whilst this approach has indeed proved to be successful in terms of execution, companies have tended to incur increased costs (direct and indirect), as well as a degree of organizational pain (Irani and Love, 2001), particularly in terms of resource allocation and personnel restructuring (Al-Mudhimighi *et al.*, 2000). This is often due to organisations viewing ERP implementation programmes as IT, as opposed to business-led, projects (Larsen and Myers, 1999). As a result, there is often a time lag before the benefits or dis-benefits of an ERP system are realised or can be determined when set against a backdrop of justification criteria (Ash and Burn, 2003, Irani and Love 2001). Zrimsek and Brant (2000) report that the implementation and adoption of ERP can be a time consuming and costly exercise, requiring a significant change in working practices, policies and systems. There is no doubt that ERP can, and will, continue to play a vital role in improving organizational performance but only if core business processes are linked to ERP functionalities, and aligned with internal and external supply-chains. Sprott (2000) suggests that in order to realise this requires continuous improvement of the ERP product by software vendors, and an understanding of the implementation effort required by the consumer.

In exploring the inter-relationship that exists between ERP and enterprise technologies such as Enterprise Application Integration (EAI), this paper investigates and describes key issues associated with an ERP-led EAI initiative. When set against a case study research strategy, an approach to analyse ERP/EAI implementation is explored resulting in a post-hoc evaluative model for ERP/EAI implementation (in terms of IT, Organisational and Tailorability factors). Through analysing the causes and learning lessons from the given case study, it is expected that the model presented will be a useful tool for both practitioners and academics in understanding the intricacies of combined ERP and EAI technologies to support information system integration.

2 THE EVOLUTION OF ERP: ERPII

It is widely recognised that businesses can no longer effectively compete in isolation to their suppliers and customers, and as a result are beginning to improve their supply chains to achieve competitive advantage. The concept of extending the functionality and visibility of the supply chain based upon core ERP and web portal platforms, has long been seen as the precursor to enabling the so-called digital enterprise, and extending the reach of a IT/IS-centric organisation (Tapscott *et al.*, 2000). The multitude of failed ERP implementations and inherent risks involved (McVittie, 2001), has resulted in the emergence of integration approaches such as Enterprise Application Integration (EAI), which seek to integrate information across diverse IS sources (Sharif *et al*, 2004a). For ERP to provide the core functionality for interconnected business systems, such as those electronically connected digital networks or "webs" of business processes, requires that organisational IS should become more extendable, flexible and interconnected (Lee *et al.,* 2003). Li (1999) notes that there needs to be a step change in the role that ERP plays, in managing and optimizing internal enterprise information, to one that can include information and collaboration not only internally within an organization, but also outwards to the external business community via digital business architectures and technology solutions (i.e. via Business to Business, B2B; Business to Consumer, B2C; Customer Relationship Management, CRM; and Supply Chain Management, SCM). Hence, the ultimate aim for the development of ERP systems, is to define and automate those collaborative business processes that reach across and outside a given organization, to encompass the overall business and trading environment that it exists in.

Thus this next stage of ERP, known as ERPII (as defined by market analyst company Gartner Group), is considered to be the expansion of "enterprise-centric ERP", which seeks to externalize and share business processes across trading communities via an adaptable, collaborative IS infrastructure (Bond *et al.*, 2000; Ericson, 2001). In essence, ERPII seeks to provide better integration with customer or client-facing solutions such as CRM / B2C with back office transactional services such as SCM. As Bakht states, ERPII is the summation of three key enterprise technologies: SCM, CRM and ERP (Bakht, 2003). This can be achieved by componentising, or de-coupling, traditional ERP functionalities through an open-architecture approach. Traditional ERP components such as HR, logistics and financials, can therefore be made more accessible and tailorable to suit industry vertical needs, and can facilitate the communication of information amongst all enterprise stakeholders (Bakht, 2003; Ericson, 2001; Zrimsek, 2003). The progression from ERP to ERPII systems is based upon the demand of organisations to build and sustain collaborative business models (Geishecker, 1999). However, this approach to enterprise integration poses newer and some would say greater risks. Web-enabled ERP functionality, faces competition from many existing eCommerce technology providers– many of whom provide robust collaborative solutions already (Blincoe, 2001). Secondly, although providing an open architecture for ERP is a vast improvement on existing ERP infrastructures, there is still a significant amount of effort required to carry out the integration amongst different IS (Ericson, 2001). ERPII significantly increases the complexity of managing an inter and intra-enterprise portfolio of systems, processes and tools (Bakht, 2003). As this relies upon an externalisation of an organisation's internal business processes and information.

3 MODEL FORMULATION: CONCEPTUALISED GROUNDING

To develop a model for understanding those facets of the ERP/EAI implementation approach, the authors have sought to build upon previously published work in this area; in doing so, exploring an established void. Through highlighting those factors within the taxonomy that are relevant to ERP/EAI integration, the authors recognised that any suitably robust EAI analysis model would need to include a post-hoc analysis phase, to capture and reflect the impact of the adopted EAI approach. Such a model is presented in Figure 1.

Insert Figure 1 here

In this model, the strategic component is based upon the recent work of Markus (2004), where Techno-change as organisational change is driven purely by the capabilities and realisable benefits of an IT/IS solution. The tactical value chain component seeks to establish *what is or could be the impact of the given integration approach if the project is to succeed within the organisational context.* This provides, at a glance, a summary of all of the key aspects of the change required and the resulting impact upon the supply chain. The operational aspect of the model includes a method to assess and analyse the extent of an integration project within an organisation, through the application of the EAI adoption framework as defined by Themistocleous (2004). Within this adoption framework, risks, benefits, costs as well as operational, tactical, strategic, technical and organisational aspects are taken into account, as grounded in the work of Irani and Love (2001).

The authors therefore seek to update and reframe the post-hoc EAI analysis model as proposed by Sharif et al., (2004b) to include those ERP-dependent factors which can inhibit or accelerate ERP/EAI implementations.

4 RESEARCH METHODOLOGY

To investigate and describe the core issues associated with the failed ERP-led EAI initiative, the methodological approach used is now presented. This encompassed the selection and design of an appropriate methodological stance in the form of case study-based research; methods for data collection; and the formulation of an appropriate and relevant post-hoc evaluation model to assess the effect of the case study organisation's approach taken in the context of identifying key factors, which impinge upon IS integration efforts (Sharif *et al*., 2004a). The extrapolated data were then classified and coded, which lead to the authors crafting a talk-through story that ultimately lead to a number of lessons learnt.

Research approach

The normative information systems evaluation literature suggests that the primary reason why organisations fail to operate a robust evaluation process lies with a lack of understanding and agreement on what constitutes meaningful evaluation from a human, organisational, management and process perspective (Pouloudi and Serafeimidis 1999; Serafeimidis and Smithson 2000; Irani et al., 2001; Irani and Love, 2001; Stefanou, 2001; Irani *et al.,* 2003).

To acquire an understanding of the significance of human and organizational issues involved with IS evaluation, the development of a research methodology that involves and enfranchises organizations and their staff is needed. Considering the originality and contextual surroundings of this research, a case study research strategy was followed as advocated by interpretivist researchers such as Bonoma (1985); Hakim (1987) and Yin, (1994). The case used for the research was not systematically sampled, and as a result, it is not possible to generalize the findings to a wider population. However, the findings are considered appropriate to provide others with a frame of reference when seeking to use enterprise application integration technologies to compliment existing ERP infrastructures.

Data collection

The data collection procedure has followed the major prescriptions of the normative literature for doing fieldwork research (e.g. Fielder, 1978; Yin, 1994). A variety of secondary data sources were also used to collect data, such as internal reports, budget reports, and filed accounts that were later transcribed. Additional data were used to derive the findings presented in this paper, which included interviews, observations, illustrative materials (e.g., newsletters and other publications that form part of the case study organization's history), and archived documentation. The authors have extensive industrial experience in the carrying out research of this nature and have used this experience, together with a predefined interview protocol to determine the data necessary to explore post implementation evaluation of enterprise technologies.

Interviews

One-on-one interviews of approximately forty minutes were conducted with the Chief Executive Officer (CEO), Chief Operating Officer (COO), Chief Technology Officer (CTO) and Chief Financial Officer (CFO), as well as two managers from the technologies department. The interviewer carefully ensured that the interviewees were fully informed about the purpose of the interviews, and took steps to put the interviewees at ease so that a two-way, open communications climate existed. Shaughnessy and Zechmeister (1994) suggest that interviewer bias needs to be addressed, which often results from the use of probes. These are follow-up questions that are typically used by interviewers to get respondents to elaborate on ambiguous or incomplete answers. Care was taken to reduce bias to a minimum through refraining, as much as possible from asking leading questions. In trying to clarify the respondent's answers, the interviewer was careful not to introduce any ideas that may form part of the respondent's subsequent answer. Furthermore, the interviewer was also mindful of the feedback respondents gained from their verbal and non-verbal responses. The interviewer therefore avoided giving overt signals such as smiling and nodding approvingly. After every interview that was undertaken, notes were given to each person to check to resolve any discrepancies that may have arisen and eliminate any interviewer bias. This approach to interviewing has proved successful in similar type research as reported by Irani et al., (2001; 2005).

5 CASE STUDY ANALYSIS

The case study company is an internationally renowned Global industrial products company (herein known as Company X). Company X boasts a large portfolio of supply chain, process monitoring and quality control software. Company X is unusual in that it not only sells a range of products for the manufacturing sector, but also heavily utilises some of its own products itself in running the business, much akin to the philosophy adopted by Oracle Corporation (Stone, 2002) and Cisco (Bunnell, 2000) in using their own systems in-house. The primary business lines of expertise that Company X focusses on are Enterprise Information (scorecard and business performance metrics); Automation and Control (numeric control of flexible manufacturing cells); Manufacturing Execution (automated assembly and production monitoring systems); and Safety (hazard detection, evacuation alert and environment monitoring systems).

Company X foresaw that the market for automation software was a growth area, for which it was well positioned. The organisation proceeded to purchase companies that were producing similar/complementary software products. By bringing newsystems into their product line, Company X immediately gained market share advantage over its competitors in the area of process and machine interface control. Coupled with their market leading position in enterprise management and safety-critical systems also, this cemented their position within the industry. Since there was a direct need to support the underlying ERP requirement of those packages (namely Baan ERP), Company X would be able to provide an integrated information system right across its industrial automation software product line. During this time, the organisation was faced with the prospect of upgrading and maintaining its current SAP R/3 product internally, which seemed to be a significant cost outlay. One of the main reasons for the purchase of the ManuWare and SuperPak vendors was that, of all of the ERP vendors Baan was seen to have had the most modern and flexible architecture for these products. This was in terms of interface support for manufacturing and production control legacy systems, as well as interfacing with other competitor products and complementary software packages.

Given these issues and also a better fit with Baan ERP within a process and discrete manufacturing environments, the board of Company X, decided to adopt Baan not only as their own internal core ERP. Senior management instigated an Enterprise Application Integration (EAI) programme to enhance the integration between the organisation's order entry, planning, production and order tracking and logistics technologies. Management went so far as to suggest that a new software and services division should be set up to address this programme (led by a selection of the product business lines, e.g. Manuware, SuperPak, Simpak). To maintain and grow the profitability of Company X, management also planned to implement a rigorous restructuring and cost management program under which costs were forecasted to be cut by half over a 12 month period. In the auspices of the CEO and board, the project would involve the delivery of an internal 'B2B portal' concept, using Baan as the core manufacturing process ERP system to aggregate core planning and fulfilment information for customer orders: embracing both partners and customers similar to that explained by Davis (1995). At the time of conducting the research, Company X had approximately 15 such systems, which fed into both the production planning and fulfilment processes, which is shown in Figure 2. The tight integration between these systems and their core ERP that was required, was thus the basis of the ensuing ERP/EAI initiative to be undertaken (as such, this does not highlight the necessary EAI linkages for this to be achieved).

Since each of these source systems were the result of previous, historic mergers and acquisition purchases, each software product was essentially run as a separate business unit (with its own unit business manager reporting to the CTO).

Insert Figure 2 here

The integration programme began by first successfully implementing and configuring the packaged ERP within the organisation (in this case, Baan). Ultimately, the information contained in the portal, along with a systematic decommissioning and system rationalisation programme, would be able to lead to a short-term improvement of estimated lead times. Componentisation of ERP modules along the lines of ERP II, would also allow the implementation of the ERP package to be faster, as each ERP component could be isolated in terms of core data dependencies. Following this, existing interfaces from each of the source systems across the product range would be modified to transmit messages to the core ERP system, whenever a business level event (BLE) would occur via a dedicated XML interface. For example, if a build-to-order (i.e. configuration) request would enter a part of the internal B2B 'network' of systems from the B2B integration portal, this request would be routed through the ERP system first of all, and then would be actioned as appropriate by the relevant component package within the organisation (see Figure 3).

Insert Figure 3 here

Essentially, this would be based upon a publish / subscribe (pub/sub) broker architecture (Linthicum, 2000), where requests from the portal would be posted into ERP as appropriate, and then posted to the business specific systems. Senior management realised, that by integrating information across and within their industrial automation software product line, via a core ERP package, potentially both suppliers as well as customers could be able to see the state of build, design, forecast, production and control cycles. As such, this was a business proposition that could ultimately be sold to their customers, to allow them to see the benefits of a fully integrated, interconnected enterprise as presented by Tapscott *et al.*, (2000). In seeking to achieve this solution, Company X faced obstacles and dealt with risk management / mitigation, which ultimately led to the initiative being aborted after 8 months.

First of all, considerable effort had to be expended to integrate and consolidate the core business process applications (not least of which, was replacing their existing ERP package, SAP, with Baan). Although this effort was planned for, there was little or no realisation or understanding of the level of complexity that such a re-engineering process would require. As such, the primary focus of the integration effort was spent on installing and configuring Baan to fit the particular requirements of Company X, which took 6 months. The effort required to setup the EAI pub/sub broker and application-specific applications were also underestimated. The apparent disregard for the inherent risks associated with the vigorous and aggressive timescales suggested by senior management, did not take into account the severe change management issues, which would be encountered. Coupled with this was the amount of time being spent on development; the organisation had to juggle the multiple pressures of keeping the overall business running and attempting to merge the ManuWare and SuperPak products into the overall software product line all within a justification of cost cutting. This was essentially at the expense of an overall reduction in headcount within the firm, which was being carried out to achieve a low cost income ratio thus, providing a 'value for money' investment in its ERP system. The proposed B2B portal concept and EAI

implementation was shelved after a period of 8 months as it became clear, that the successful adoption of Baan internally to achieve 'reference site' status, was not achievable. Product line heads (such as for Enterprise Management and Automation) were also concerned about the extent of effort required to integrate and standardise their product lines with Baan (which had not even been fully implemented as core ERP within the company).

6 CASE STUDY SYNTHESIS

Ultimately, Company X was not able to implement the planned the combined ERP and EAI implementation it anticipated. One reason for this could be that it was too reliant upon its internal capabilities, for which strong integration capability was not a primary strength (industrial automation software and plant-level solutions were, however, its 'bread and butter'). Coupled with this, Company X was a conglomeration of a number of existing companies, the residual people, processes and techniques of each constituent part of the conglomerated organisation may have been at odds with each other. This may also have caused internal tensions and strains that were not directly evident to senior management, and would have undoubtedly have inhibited project success. As noted in the analysis of the given number of connections that would have been written, no fewer than 105 interfaces would have been required for the 15 or so subsystems and software products that Company X had invested. The sheer size and scale of the integration effort that presented itself may have been too great.

Even by a conservative estimate, integrating all these systems together *at the same time* as implementing a core ERP system, would be a significant undertaking for a technologically-competent organisation within the time frame given. There is a risk involved in integrating dissimilar people, processes and technologies together at the same time as being involved in initiating new software developments. Due to the lack of evaluation of the enterprise systems, there could also have been a lack of understanding of the fit of the existing systems and if there was any real requirement to integrate *all* of the products together in the first place. This could also be put down to organisational inertia and lack of mature skills in combined ERP and EAI integration skills. Potentially the short-term cost-based approach to achieving an implementation date within a 12 month timeframe, would have had an inevitable impact on the ability of the organisation to sustain such an effort. In short, the overall approach was completely over-ambitious for the goals set by management.

Although the majority of factors that inhibited or restricted Company X were internal, additional factors may also have come into play at the same time. Although the given ERP system, Baan, was ultimately a very capable and mature resource planning package in its own right, at the time it was not as advanced and extensible (including scaleable) as SAP or PeopleSoft. Additionally, Baan as a company was suffering from declining market share and customer support in the wake of the dot-com boom. Subsequently, many ERP vendors had repositioned their technologies to encompass e-Commerce type functionalities (CRM and SCM for example). In this respect, Baan was not able to execute that combined vision and in that sense was not fully tailorable in an ERPII (supply chain) sense. Company X tried to employ an internal B2B type architecture. It attempted to implement a combined approach to extend and integrate a base-level ERP system to encompass CRM and SCM functionalities, through an application integration approach (i.e. ERPII). Within the context of the case study, Linthicum (2001) states that it is important to understand the different enterprise integration architecture choices (hub and spoke; federated static; federated dynamic; transactional; peer-to-peer; hybrid) before embarking upon any such front-to-back enterprise integration. Indeed, the vague and wanton usage of the term B2B by Company X as relates to this

specific integration programme, was something of a misnomer as there was no external integration carried out during this phase.

This was purely an internal EAI scheme (i.e. intra-enterprise application integration), but couched in terms and the language of contemporary business information systems. This may also have confused the technical issues around the exact needs and requirements of the integration to be achieved. Company X was trying to extend the capabilities of the underlying Baan ERP, Company X was unwittingly involved in attempting to carry out an ERPII-type implementation: but using traditional ERP and EAI techniques to do so. As such, and based upon the analysis given in this paper, it can be said that Company X encountered and experienced a *failed attempt* at an ERPII implementation, which is widely accepted within the company. Integrating its separate enterprise systems in a piecewise fashion was not considered at all by Company X. This could have involved a phased implementation of Baan alongside SAP, whereby data and enterprise information could well have been migrated between both systems over a period of time, using application integration technologies and data transformation engines. In this way, Company X may well have been able to achieve their goal using a best-of-breed ERP approach.

Company X also did not take professional advice and research implications of ERP implementation into consideration, during and *after* the project was started. Indeed, if research such as Themistocleous *et al*. (2001) were taken into account, it would have found that 82% of such implementation project issues were due to technical problems; 58% due to project delays and barriers; 42% due to resistance to change within the organisation; and 46% due to problems associated with integrating disparate applications together. Furthermore, if the level and type of tailorability required was taken into account (in the sense of specific interface development), Company X may have gleaned some understanding by the successful and unsuccessful multiple integration implementations of Siemens Power Corporation (Hirt and Swanson, 1999) and Hershey Food Corporation (Nelson and Ramstad, 1999). Of the two, the Siemens case study would have been invaluable to Company X, as this occurred largely in the same business sector.

7 PROPOSED POST-HOC MODEL FOR ERP/EAI INTEGRATION

The evolution of ERP systems via concepts such as CRM-focused ERP (as discussed in section 2), and componentization of enterprise systems, the focus of the development of ERP systems should be to align supply chain processes with associated emerging architectures across functional and process lines. For ERP systems to provide a high impact business benefit to supply chain and extended enterprise concepts, there needs to be a step change in minimizing ERP limitations, and leveraging ERP benefits. This was the key driver for Company X in this initiative. As such, the authors suggest that the level of tailorability of such IS (in terms of the degree to which they are adaptable to the organisational specifics), is an inherent part of understanding the level of impact (Patel and Irani, 1999; Patel and Paul, 1998). This is separate and distinct from the definition of tailorability of ERP systems, in the sense of customisation to the base system which is always required in order to get the system running in the first place (as highlighted by Brehm *et al.*, 2001).

Tailorability of ERP systems

Any assessment of such IS, should attempt to evaluate existing and proposed processes, and the extent of business impact during and after implementation. The authors suggest that

ERP system tailorability, with respect to the evolution of ERP towards ERPII, encompasses a number of characteristics, which are in the sense of the impact of the integration approach utilized. This occurs across four facets of *Influencers*, *Organizational Processes Impact, Technology* and *Perception.*

Influencers play a large but indirect role in the adoption and development of ERP, as they are often used to benchmark investment evaluation ex-post decisions. A key aspect of the definition and applicability of ERP systems in this context, lies with ERP market analysts and implementers. As such, they are not necessarily grounded in any specific, IS evaluation framework, as they are primarily concerned with assessing and defining technology trend and financial (usually earnings) data, relative to the market as a whole. In assessing the extent of *Organizational Process Impact*, there needs to be an understanding of the role that each core IS plays within the delivery of the organizations' business. For the purposes of brevity, the authors have limited these core systems to supply chain, customer and e-Business centric systems. To realize the benefits of adopting an EAI approach to this internal supply chain enablement, the authors suggest that there needs to be an implicit level or reasoning and understanding of the technology factors involved.

It is considered that the *Technology* component composed in terms of Capability (the performance and functionality of a particular technology delivery platform); Integration (in terms of data, information and knowledge level deployment of business-process critical factors)*;* Componentisation (technology to be made accessible / available in constituent parts); Organisational Fit (relevancy of a particular technology platform to business). Obtaining an outcome in terms of success or failure for an IS, is a key *Perception* in the adoption of such enterprise approaches. To address how ERP can be made more tailorable, the authors suggest that there are a number of factors that can determine its outcome, which the following (extrapolated from the literature and Company X analysis) include:

- *Vertical Specialisation* (Harnessing niche market solutions): assessment of whether ERP vendors offer solutions to targeted industry verticals (e.g. such as the retail food and apparel industries, and also rapidly developing markets such as agrochemicals), and also provide flexible architectures to link into IS infrastructures, standards and architectures, such as portals, e-marketplaces and exchanges relevant to the sector.
- *Horizontal Specialisation* (Becoming a constituent part of end-to-end eBusiness offerings): Integration with best-of-breed platforms and packages that leverage eBusiness concepts is critical in the continual development and deployment of ERP packages, as a vital component of implementing a virtual supply chain (fulfilment, procurement, logistics and multi-channel sales management). ERP systems, must be seen to extend the supply chain, through allowing IS and the underlying business model to gain visibility into stakeholder roles, responsibilities and data flow dependencies. This can be achieved through componentization of ERP.
- *Optimisation of business models*: Adaptive and flexible business models have driven the growth of the internet economy. Organisations who espouse and implement digitally connected supply chains, will continue to be differentiated from their competitors by optimizing their operating models via addressing: channels to market; new product development cycles; sourcing and procurement processes; collaboration and partnering relationships; distribution and fulfilment tasks; and most importantly, internal technology integration efforts (in order to facilitate more effective business processes).
- *Extending ERP functionality* (ERP componentisation / modularisation): As ERP vendors continue to evolve existing ERP products to be more supply chain and digital

marketplace-aware, a core feature of developing ERP competencies relies upon the componentization of modules that visibly and demonstrably touch more than 10% of the end user population (Economist, 1999). ERP suites and associated integration technologies should be amenable to a greater degree of customization and tailorability to an individual organisation's IS needs.

- *Effect of Influencers:* The effects of influences from external sources (partners, vendors, market analysts, organizational stakeholders, and professional service organizations), as well as internal stakeholders (management, IS organization, HR, Finance departments), have an indirect impact upon the choice and implementation of ERP, in terms of functional requirements and preferences, all of which need to be balanced.
- *Acceptability of Success:* Where and when should ERP be judged as being a success, and how this can be measured remains a key challenge for the future. Industry and academe need to explore the notion of success and failure within strategic (people), tactical (process) and operational (technology) dimensions.
- *Scope of technical effort involved*: As discussed in the analysis of Company X, the impact and depth of effort involved in implementing ERP solutions should never be underestimated. Adequate and effective planning, audit and control of not only ERP implementations, but associated EAI integration efforts need to be carried out in order to ensure successful implementation outcomes.
- *Level of change required in the organisation*: The change required in order to evolve an organisation's business towards a technologically integrated entity, requires careful management, communication and collaboration of all members of that company. The business as well as IT effects of any integration efforts (ERP as well as EAI) need to be agreed and understood by internal and external stakeholders.

In the case of Company X, whilst the remit of the ERP-led EAI programme was wholly technical in nature, the indirect (and some would say direct), effect of their proposed approach was to change the way in which the company was to operate. Company X were inadvertently satisfying another of Markus' criteria : that of aligning new business processes with new technology in order to engender change. So whilst in principle the B2B EAI initiative was in the spirit of a techno-change programme, the lack of realisation of any of the benefits, supported the fact that the initiative was poorly constructed and ill-conceived, in terms of underestimating the extent of change relating to replacing SAP with Baan ERP. Likewise, a set of internal and external factors impinged upon the core business value chain of Company X: corporate strategy, leadership of the organisation, market differentiation technology, customer value. It was found that people-related integration issues were simply not included in the scope of the project (effect of change, skills and training required). In addition, costs relating to adopting this approach largely centred around the licensing of the core ERP product and associated training (as would be expected). Table 1 presents tailorable aspects with respect to Company X.

Insert Table 1 here

An additional organisational cost not typically taken into account until after ERP has been adopted (Larsen and Myers, 1999), is that of headcount adjustment. Such an *internal* integration project had never been carried out before. This barrier is essentially a risk in that Company X had little or no realisation of the extent to which it had the sufficient and

necessary in-house skills to manage and execute the programme. The internal pressures present within the organisation ultimately tempered the potential benefits also. For example, in order for Company X to be more customer-centric, it would eventually have to reorganise its product lines and integrate with Baan and so forth. Hence, the key to adopting the ERP-led EAI solution within Company X, involved a juxtaposition of implicit organisational change factors (aligning product lines, restructuring and running the business). These factors were almost subsumed within purely IT/IS considerations about how to enable the organisation through ERP-based integration. Thus, Company X was unable to even begin the programme of change due to this lack of organisational inertia. The revised EAI impact framework of Figure 1 is expanded and updated once more to include the case study and analysis findings and is shown in Figure 4. As such, the IT basis naturally relates to those technology factors of capability, integration, componentisation and organisational fit. The remaining organisational aspects are likewise mapped to their respective components of the underlying EAI framework too: innovation against Influences; modelling of the IS enterprise and Organisational impact against Organisational Process Impact; and project communication and collaboration against Perceptions of success and failure.

Insert Figure 4 here

Given that the authors have analysed the case company's integration approach in detail and have presented factors that may assist in the tailorability of ERP systems, the development of a holistic post-hoc model for ERP/EAI evaluation is now offered. To develop and conglomerate all the preceding concepts and results together, the authors included those aspects of extensibility and componentisation that the case study organisation was trying to achieve in their implementation, by introducing aspects of ERPII tailorability. This then provides the basis for generating a post-hoc ERP/EAI evaluation model and is detailed in Table 2.

Insert Table 2 here

This post-hoc model encapsulates all of those aspects of IT, organisational and ERPII tailorability factors, which have so far been discussed and analysed in terms of Company X. It has been shown that the given evaluative ERP, EAI and organisational evaluative models provide a useful insight into the given case organisation's implementation experiences. As such, and noting the overlap with those aspects of ERPII tailorability presented earlier, the resulting post-hoc evaluation model provides a multi-level view of how ERP/EAI implementation can be analysed, after such efforts have been completed. Through highlighting each particular component of such integration projects, it is hoped that a deeper understanding of the reasons for the success and / or failure of such programmes can be realised.

8 LESSONS LEARNT

Hence, from analysing the case study data the authors highlight and suggest the following lessons that can be learned from the experiences of Company X, in terms of Technical (IT) and Business (Organisational) factors:

Technical:

- *Doing both a combined ERP and EAI effort at once is a very risky approach*: the success / failure of one part of this joint approach has a direct and inevitable impact on the other;
- *Technical capability is different to technical ability in order to carry out enterprise systems integration*: the maturity, skills, knowledge and experience within an organisation is fundamental to achieving successful EAI. Thus, *EAI capability* (the quality of being capable, or having the potential to carry out integration), must be differentiated from *EAI ability* (the quality of being able to perform / facilitate achievement, or possessing the qualities required to get something done);
- *Technical ability taken for granted*: in the context of the previous lesson learned, merely having the capacity to achieve a given goal does not necessarily mean that it can be achieved successfully. As Linthicum (2001) notes, EAI is a continual test of ingenuity, skill and character as the basis of any integration is a requirement to understand the diverse characteristics of an organisation (which is itself, perpetually under flux and change).

Organisational:

- *Assistance and advice not sought*: although Company X had previous relationships and had engaged with professional services organisations (consultants and paralegals) before, there was a distinct lack of advice sought from outside the company, to "sanity-check" the approach being taken.
- *Strong communication warranted strong collaboration* (in the guise of Akkerman and Van Helden, 2001): although there was a very lucid and strong level of communication about what the ERP-led EAI initiative was hoping to achieve from senior management, there was no supporting collaborative effort to get cross-divisional software teams and groups to actively approach the integration effort together. The emergence of internal resistance to the project was therefore directly as a result of this lack of collaboration combined with ERP project overrun.
- *"Keep the eye on the ball"*: keeping the operational business running smoothly alongside a major effort such as this, is always a risk. Although senior management mandated and initiated the programme, and was the steering committee, there was no apparent governance structure to control the initiative. In effect, the programme was left very much to its own devices.
- *Micro-management in the technicalities of the project*: although on the one hand there was a lack of command and control on the part of senior management in Company X, there was perhaps an overly zealous level of interference in the technicalities of the integration required. This was in the sense of increasing the verbosity and vagueness of what was meant by integration – for example the term "B2B portal" was widely used by the CEO of Company X when he in fact meant internal IS integration, i.e. EAI.

- *Silo mentality of software product businesses*: as Company X historically consisted of a series of mergers of several industrial automation and software companies, many of the acquired companies (hence software product lines), were never fully integrated into the overall Company X group structure. As such, products such as ManuWare, SuperPak and SimPack (separate software divisions) were still very much run as separate companies, and resisted being included as part of an overall integrated software division as mandated by management for this project.

Thus, given these continuum of factors which were not realised, the authors agree with the experience and findings of Connor (2001), who outlines three key decision points when considering realising the benefits to be had from enterprise technologies:

- *Assess and evaluate how technologies change how people work*: recognise that most organisations lack true process owners who know and understand how technologies impact day to day work (organisations with disparate process-centric leadership styles can be very difficult to co-ordinate, as managerial power, politics and social networks can implicitly affect decision making capabilities);
- *Utilise the commitment of Management and Leadership within the organisation in order to help adopt change*: however, transforming a functional organisation into a process organisation is more complex and takes longer than anticipated;
- *Learn from and follow examples of successful process-driven enterprises*: understand and realise inherent explicit and tacit risks associated with enterprise-level IS implementation and adoption from others ("look before you leap").

8 CONCLUSIONS

This paper has attempted to highlight those factors and issues that were experienced by a case study organisation, in attempting to carry out an ERP-led EAI initiative. By including reflexive feedback within a previously published EAI analysis model, the authors highlighted the need to place the success/failure of enterprise implementations in terms of an overall information systems evaluation (ISE) approach. In doing so, the case study organisation's experiences were set against a backdrop of those aspects of extensibility / componentisation involved in integrating and tailoring ERP across an organisation using EAI. As such, through combining concepts of an internalised ERPII, in terms of a revised impact framework alongside the results of these applied evaluative models, a suitable arrangement of IT, organisational and ERPII tailorability factors allowed a holistic ERP/EAI evaluation model to be formed. As such the post-hoc model developed by the authors, upholds and confirms those critical aspects of ERP and EAI implementation which define success and failure: clarification of business goals and objectives; support of management; effective BPR/BPM with minimum customisation changes; systems integration ability; effective interdepartmental collaboration and communication; adherence to an integration lifecycle approach; and effective modelling of the IS enterprise. The authors believe the issues raised warrant further investigation and research, beyond the scope of this paper. In particular those aspects of ERP tailorability identified: extension of ERP functionalities (i.e. ERPII); effect of influencers; acceptability of success; and scope of technical effort involved. As such it would be useful to

develop further and gather any detail from case or other data, on these points in order to corroborate the concerns raised.

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References

Ash C.G, Burn J.M. 2003. Assessing the benefits from e-business transformation through effective enterprise management, *European Journal of Information Systems*, **12**(6)297-308.

Akkermans, h. and K. van Helden. (2002). Vicious and Virtuous Cycles in ERP Implementation: A Case Study of Interrelations Between Critical Success Factors, *European Journal of Operational Research*, **11**, pp 35-46.

Al-Mudimigh, A., Zairi, M., Al-Mashari, M. (2000). ERP software implementation: an integrative framework, *European Journal of Information Systems*, **10** (4) : 216 - 226.

Bakht, A. (2003) *Get ready for ERP, Part II*. Available. [on-line]. http://www.tribuneindia.com/2003/20031201/login/guest.htm. December 1st, 2003.

Blincoe, A.J. (2001) *The CRM vs ERP Showdown*. CompterWeekly.Com. Available [on-line]. http://www.computerweekly.co.uk/Article12728.htm January 5th, 2001

Bond, B., Genovese, Y., Miklovic, D., Zrimsek, B., and Rayner, N. (2000). ERP is dead – Long live ERP II. *Gartner Group Research Note, Strategic Planning Assumption SPA-12-0420*, 4th October 2000, Gartner Group, Inc.

Bonoma, T.V. (1985). Case research in marketing: Opportunities, problems, and a process. *Journal of Marketing Research*, **12**:199 - 208.

Brehm, L. Heinzl, A. and Markus, M.L. (2001). Tailoring ERP Systems: a spectrum of choices and their implications. In. *Proceedings of the 34th Annual Hawaii International Conference on Information Systems*, Hawaii, Jan 2001.

Bunnell, D. (2000). *Making the Cisco Connection : The Story Behind the Real Internet Superpower*. John Wiley and Sons.

Connor, M. (2001). Can you get more from your Enterprise Technologies?. *e-Business Advisor*, October / November 2001, pp.16 – 19.

Stefanou C.J. 2001. A framework for the ex-ante evaluation of ERP software, *European Journal of Information Systems* **10**(6): 204-215.

Davis, D. (1995). State of a new art: Manufacturing and trading partners learn as they go. *Manufacturing Systems*, **13** (8): 2-10.

Economist. (1999). ERP RIP ?. *Economist Survey Ltd, The Economist*(U.S. Edition), 26th June 1999.

Ericson, J. (2001). *What the heck is ERPII?* Available. [on-line]. http://www.line56.com/articles/default.asp?ArticleID=2851 August 16th, 2001.

Fiedler, J. (1978). *Field Research: A Manual for Logistics and Management of Scientific Studies in Natural Settings*. Jossey-Bass, San Francisco, USA.

Geishecker, L. (1999) ERP vs. Best-of-Breed, *Strategic Finance*, 80, 62 - 67.

Hakim, C. (1987). *Research Design: Strategies and Choice in the Design of Social Research*. Allen and Unwin, London, UK.

Hirt, S.G., and Swanson, E.B. (1999). Adopting SAP at Siemens Corporation. *Journal of Information Technology,* **14** : 243 – 251/

Irani Z, Jones S. Love P.E.D, Elliman T and Themistocleous M. (2005). 'Evaluating Information System Investments in Local Government: Drawing Lessons from Two Welsh Cases' *Information Systems Journal,* 15(1): 61-82.

Irani Z, Themistocleous M and Love P.E.D. (2003). 'The impact of enterprise application integration on information system lifecycles'. *Information and Management,* 41(2): 177-188.

Irani, Z**,** Sharif, A.M and Love P.E.D. 2001. Transforming failure into success through organizational learning: An analysis of a Manufacturing Information System. *European Journal of Information Systems,* **10**(1): 55-66.

Irani, Z., and Love, P.E.D. (2001). The propagation of technology management taxonomies for evaluating information systems. *Journal of Management Information Systems* **17**(3) : 161-177.

Larsen, M.A., and Myers, M.D. (1999). When success turns into failure: a package-driven business process re-engineering project in the financial services industry. *Journal of Strategic Information Systems,* **8** : 395 - 417.

Lee, J., Siau, K., and Hong, S. (2003) Enterprise Integration with ERP and EAI, *Communications of the ACM,* 46, 2, 54 - 60

Li, C. (1999) *ERP Packages: What's Next?* [Electronic version] *Information Systems Management*, 16, 3, 31 - 36.

Linthicum, D. (1999). *Enterprise Application Integration*. Addison-Wesley, Massachusetts : MA, USA.

Linthicum, D. (2001). Solve the integration puzzle: Choose the right architecture. *e-Business Advisor*, October / November 2001, pp.24 – 27.

Markus, M. L. (2004). Technochange management : using IT to drive organizational change. *Journal of Information Technology*. **19** : 3 - 19.

McVittie, L. (2001) *Buckle up: implementing ERP takes time and patience*. Network Computing. Available. [on-line]. http://www.networkcomputing.com/shared/printArticle?article=nc/1206/1206ws2full.html&pub=nwc

Nelson, E., and Ramstad, E. (1999). Trick or Treat: Hershey's Biggest Dud Has Turned Out to be New Computer System, *Wall Street Journal*, October 291999, p.1.

Parr, A. N. and Shanks, G. (2002). A Taxonomy of ERP implementation approaches., In *Proceedings of 33rd Hawaii International Conference on Systems Sciences* (HICSS), 2002

Patel, N.V., and Irani, Z. (1999). Evaluating information technology in dynamic environments: a focus on tailorable information systems. *Logistics Information Management*, **12** (1/2) : 32-40.

Patel, N.V., and Paul, R.J. (1998). Towards systems tailorability: a comparative analysis of business change and systems flexibility. *Proc. Assoc. Information Systems, Americas Conference,* 14-16 August 1998, Baltimore, USA.

Pouloudi, A and Serafeimidis, V. (1999). Stakeholders in information systems evaluation:experience from a case study. In *Proceedings of the 6th European IT Evaluation Conference*, November 4-5th, London, UK, pp. 90-98.

Serafeimidis, V and Smithson, S. (2000). Information Systems Evaluation in Practice: a case study of organisational change. *Journal of Information Technology,* **15**(2): 93-106.

Sharif, A.M., Elliman, T., and Badii, A. (2004a). Integrating the IS with the Enterprise: key EAI research challenges. *Journal of Enterprise Information Management*, **17** (1 / 2) : 164 – 170.

Sharif, A.M., Irani, Z. and Themistocleous, M. (2004b). Using ERP as a basis for Enterprise Application Integration. In (Ed. Z. Irani). *Proc. European and Mediterranean Conference on Information Systems 2004 (EMCIS 04)*, June 2004, Tunis, Tunisia.

Shaughnessy, J.J. and Zechmeister, E.B. (1994). *Research methods in Psychology. 3rd edition*. New York. McGraw Hill.

Sprott, D. (2000). Componentizing the Enterprise Application packages. *Communications of the ACM*, **43**(4): 63-69.

Stone, F.M. (2002). *The Oracle of Oracle: The Story of Volatile CEO Larry Ellison and the Strategies Behind His Company's Phenomenal Success* . Amacom, NY, New York, USA.

Tapscott, D., Ticoll, G., and Lowy, F. (2000). *Digital Capital*. McGraw-Hill.

Themistocleous, M. (2004). Justifying the decisions for EAI implementations. *Journal of Enterprise Information Management*. **17** (2) : 85 – 104.

Themistocleous, M., and Irani, Z. (2000). Taxonomy of factors for information system application integration. In *Proceedings of the AIS Americas Conference on Information Systems (AMCIS2000)*, University of California Long Beach, August 2000, pp 955-959.

Yin, R.K. (1994). *Case study research: Design and Methods – 2nd Ed*. Sage Publications : Thousand Oaks, CA, USA.

Zrimsek, B. (2003). Client issues for ERPII, Supply Chain and Manufacturing. *Gartner Group Article Top View, AV-20-9598*. Gartner Group Inc., Stamford, CT, USA.

Zrimsek, B., and Brant, K. (2000). ERP adjustments – Short-term friend, long-term foe. *Gartner Group Commentary, COM-11-8900*, 20th September 2000, Gartner Group, Inc., Stamford, CT, USA.

Table 1. ERPII tailorability aspects with respect to Company X

Aspect of ERP II Tailorability	*Company X finding*
Vertical Specialisation	Weak
Horizontal Specialisation	Weak
Optimisation of business models	Not found
Extending ERP functionality	Weak
Effect of Influencers	Weak
Acceptability of Success	Cost reduction; integrated system within 12 months
Scope of technical effort involved	Large / Complex
Level of change required in the organisation	High

Table 2. Post-hoc ERP/EAI evaluation model

TECHNOLOGY			ORGANISATIONAL	
Evaluation Model		Results	Evaluation Model	Results
EAI	Process	…	IS Architecture model	…
	Infrastructure	…		…
	Adoption	…	Organisational impact (change, adoption, leadership)	…
	Lifecycle evaluation	…		…
ERP	Implementation Strategy	…	Project Communication and Collaboration	…
	Level of Integration	…		…
	Tailorability	…	Market and product Innovation	…

ERPII TAILORABILITY				
ERPII Aspect	Strong	Average	Weak	Not Found
Vertical Specialisation	…	…	…	…
Horizontal Specialisation	…	…	…	…
Optimisation of business models	…	…	…	…
Extending ERP functionality	…	…	…	…
Effect of Influencers	…	…	…	…
Acceptability of Success	…	…	…	…
Scope of technical effort involved	…	…	…	…

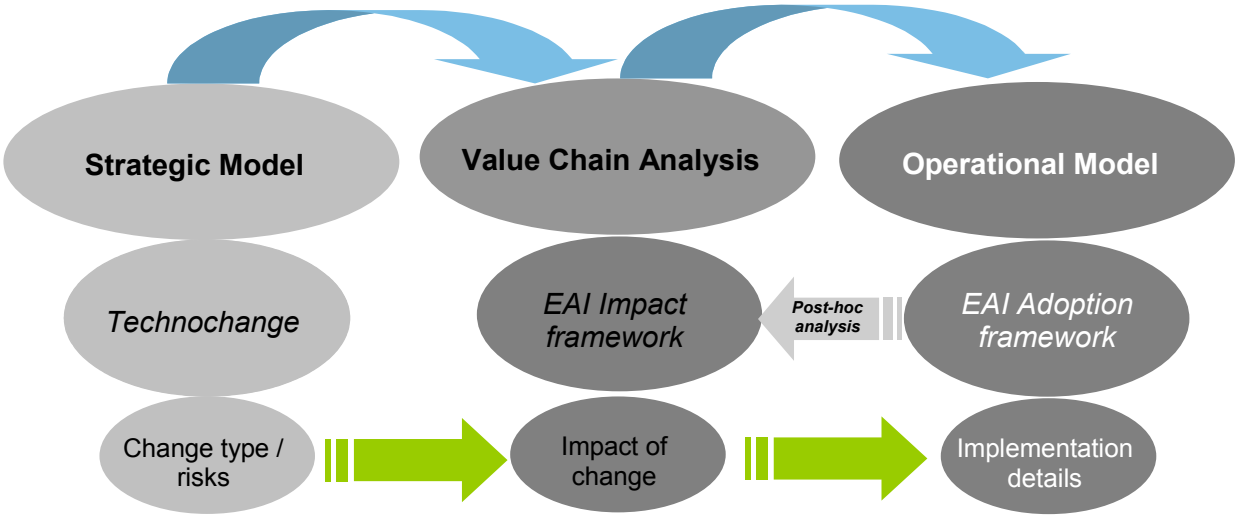

Figure 1. Post-hoc EAI analysis model

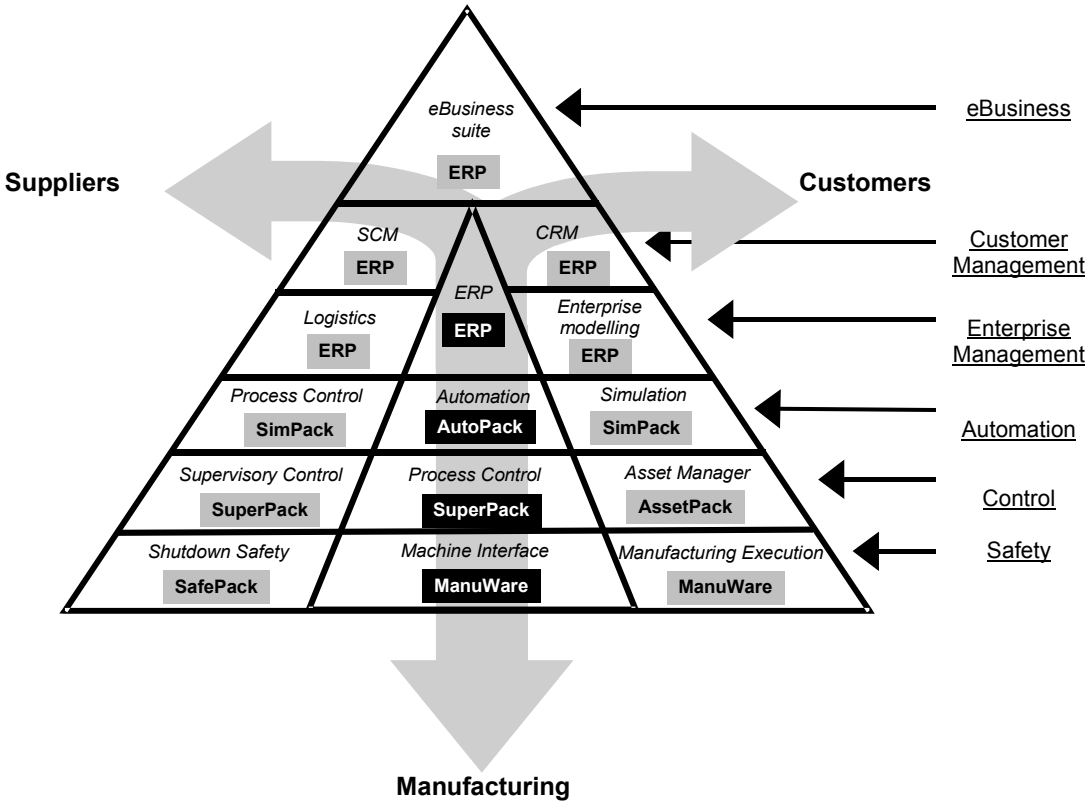

Figure 2. Systems infrastructure and key systems in Company X

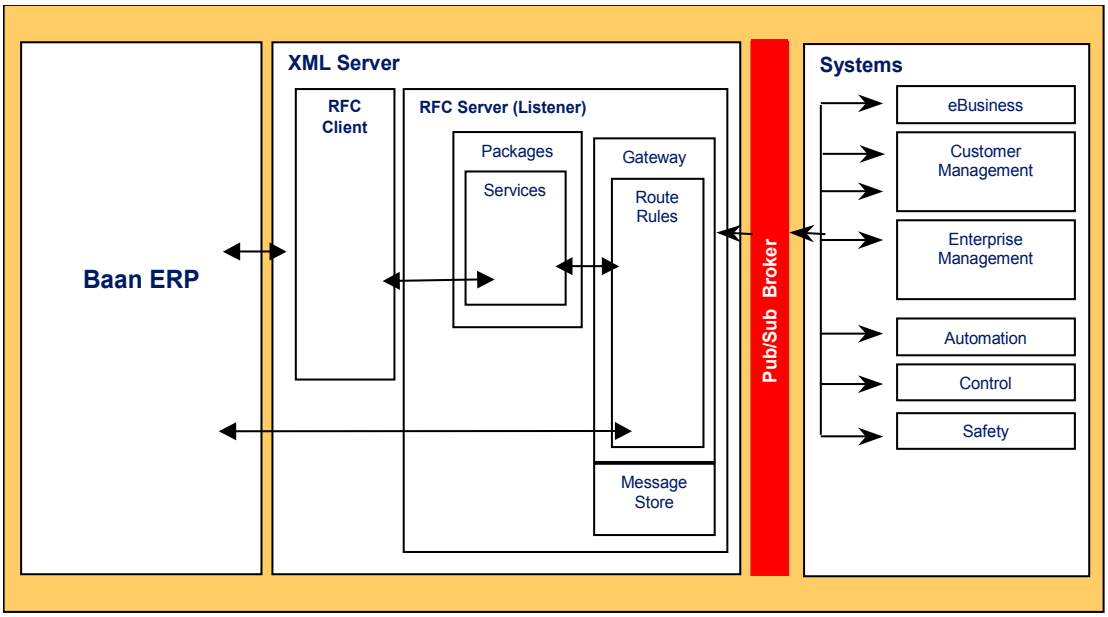

Figure 3. Company X EAI architecture

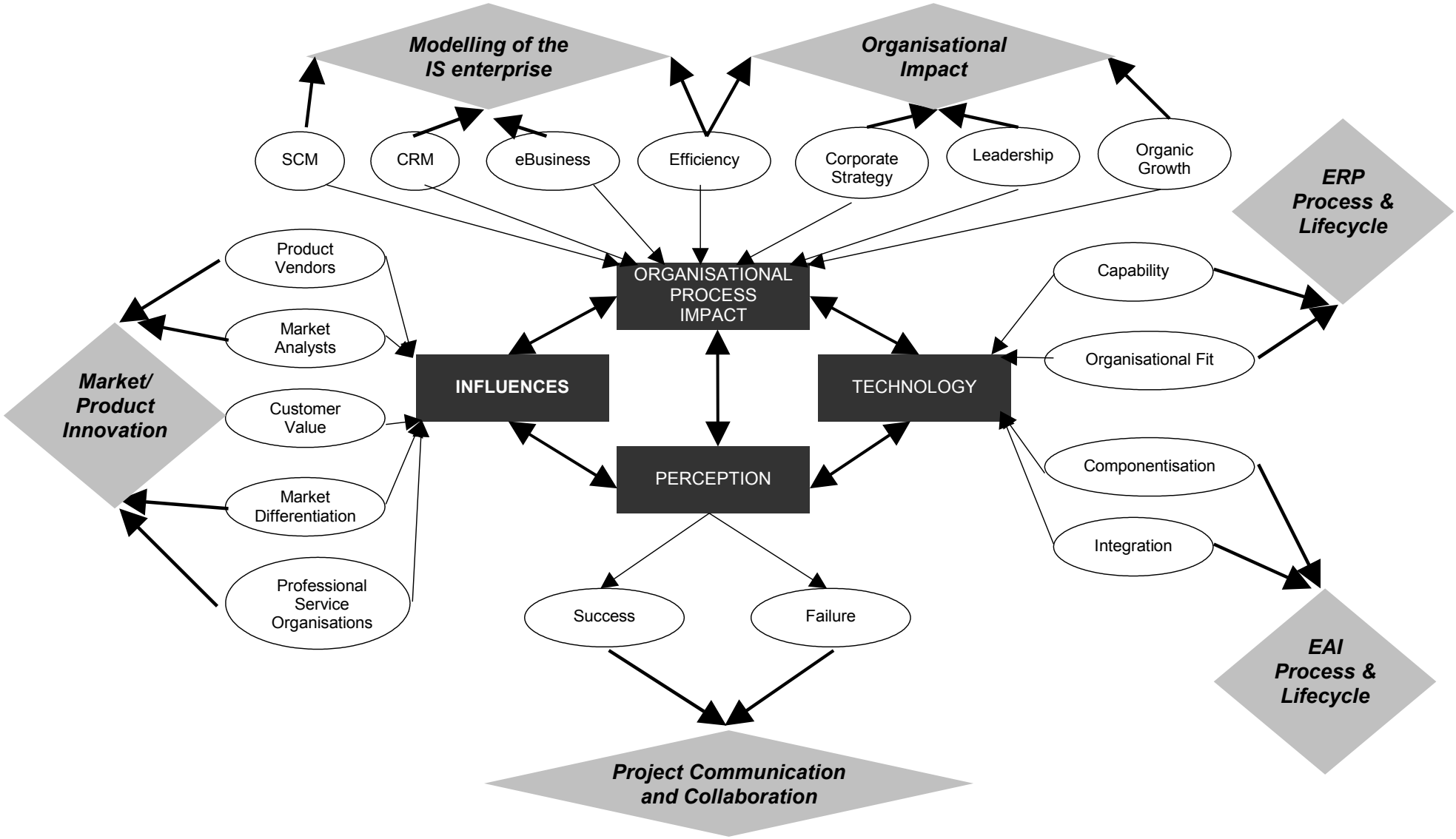

Figure 4. ERP/EAI impact framework in the context of evaluation findings of Company X