

Achieving Business Benefits from a Global ERP Implementation

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ABSTRACT

This paper provides an understanding of the implementation, use and business benefits achieved from a global ERP system by an Australian manufacturing organisation. Using an interpretive case study approach ERP implementation and use were examined retrospectively as processes within context over time. The business benefits achieved were assessed using Shang & Seddon's (2000) ERP business benefits framework. The business benefits achieved are explained in terms of the ERP implementation success factor literature, and themes relating to the use of the ERP system that were identified from the empirical findings.

INTRODUCTION

For more than ten years there has been an increasing industry trend to buy off-the-shelf software rather than custom build software to provide an integrated solution for the business transaction processing requirements of organizations. These Enterprise Resource Planning (ERP) systems are large, complex software packages that provide an integrated real-time environment based on an enterprise wide data model with a set of software applications which allow processing of all the data of the organization (Bancroft, Seip and Sprengel, 1998). Collective investment by organizations worldwide in 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.

To date most ERP research has concentrated on the implementation project itself. However the primary focus of this research was on the post-implementation period i.e. the use of the ERP system. The implementation and use of an ERP system was viewed in this research from the perspective of organizational change (Davenport, 2000). The specific research question addressed was:

How and why do business benefits evolve during ERP system use?

The rest of paper begins by placing the study within the existing ERP literature. A brief outline of the research design follows, including details of the characteristics of the case study organization. The results are presented and discussed, followed by concluding remarks.

BACKGROUND

Four strands of the existing ERP literature provide the background to this research. The first is the literature that has proposed ERP life cycles (e.g. Markus and Tanis 2000, Parr and Shanks 2000, Ross and Vitale 2000). Markus and Tanis (2000) propose four phases in the ERP life cycle: "Chartering", "Project", "Shakedown" and "Onward and Upward". The Chartering phase is an initial planning phase however there is some evidence to suggest that in practice some organizations omit the activities in this phase (Markus, Axline, Petrie and Tanis 2000). The Project phase involves getting the system up and running in one or more business units in the organization. The extent of planning undertaken for the ERP system by the organization, and any effects of the Project phase, for example, time relative to schedule, cost relative to budget and functionality relative to original proposed scope (Markus et al. 2000) influences the business benefits gained. The Shakedown phase starts when the system goes "live" and finishes when normal operations are achieved. The final phase, Onward and Upward, starts when normal operations are achieved and lasts until the system is replaced. The research described in this paper, although focussed on the Shakedown and Onward and Upward phases which

together make up the post implementation period, examines the influence of the previous phases on the business benefits achieved by the organisation.

The second group of ERP literature has concentrated primarily on the Project phase of ERP systems and proposed critical success factors (e.g. Holland and Light 1999, Parr, Shanks and Darke 1999) or "recipes" for success with ERP implementation (e.g. Markus and Tanis 2000). Some of these studies have included issues or problems and/or business benefits achieved in the Shakedown and Onward and Upward phases (e.g. Markus et al. 2000, Chang and Gable 2002). And a third strand of the literature has developed models for assessing the business benefits achieved with ERP systems. There are two viable measurement models for assessing the business benefits of ERP systems in use. Compared with the Gable, Sedera and Chan (2003) model, the Shang and Seddon (2000) business benefits framework was developed using data from a much larger number of organizations (233) from different industry sectors. Shang and Seddon's (2000) framework for assessing the business benefits of ERP systems includes five dimensions of benefits: operational, managerial, strategic, IT infrastructure, and organizational, with multiple possible benefits within each dimension. It also has the advantage of assessing business benefits from a single perspective i.e. that of the business managers. This benefits framework was used to assess the business benefits achieved during the post-implementation period in the manufacturing company studied in this research.

Finally, some studies have looked at the ERP system in use in order to explain the business benefits achieved from ERP systems. Markus and Tanis (2000) and Markus et al. (2000) related the business consequences to events in the earlier ERP life cycle phases and to external influences due to changing business conditions. However, there is little information provided on the internal organizational influences on the business benefits, such as changes to organizational structure and culture. Neither is there any attempt to assess the "success" of the individual organizations studied.

In a study of manufacturing organizations Ross and Vitale (2000) identified four obstacles to achieving business benefits from ERP systems. They were failure to plan and implement performance metrics for the new system, inadequately resourcing the Shakedown and Onward and Upward phases, no improved management decision making and inadequately addressing resistance to change. Two studies have looked at the business benefits from ERP systems and the factors that contribute to them. The first study (Davenport, Harris and Cantrell 2004) developed a statistical model that identified three main factors (integrate, optimize and informate) that predict perceived business value to the organization as a whole. In contrast Gattiker and Goodhue (2005) focused on benefits from ERP systems at an individual manufacturing plant rather than the organization as a whole. The Gattiker and Goodhue (2005) model identified four factors contributing to plant level benefits in manufacturing organizations: interdependence (between plants), differentiation (i.e. between plant differences), time elapsed since implementation and customization. Both the Davenport et al. (2004) and Gattiker and Goodhue (2005) models are predictive rather than explanatory. This study differs by aiming to understand and explain how and why the case study organization achieved business benefits from its ERP system.

RESEARCH DESIGN

An interpretive case study method was used to answer the research question. The case study organization (ManB) had begun implementation more than four years prior to data collection. Since business benefits take time to accrue it was expected that with this time frame business benefits from the ERP system would be clearly evident.

Table 1. Background data for the ManB ERP implementation

Motivation for Implementing SAP	Strategic business reasons
Cost of Implementation	~AUD\$25 million
Sites	Multiple (65 sites in 5 countries)
Modules	FI, CO, MM, PP, SD, AM
Version of SAP implemented	3.0F, then upgrade to 4.6B
Implementation Strategy	Small Bang (all modules at one site, or small group of sites, at a time)
Implementation Approach	System replacement
Implementation Partner	Yes
Business process reengineering	No
Customisation?	Yes, but minimal
Business Restructuring	Accounts payable and accounts receivable shared services after go-live
Was project completed on time, within budget and within original scope?	Yes
Number of users	~1000
When were the business benefits assessed?	Four years after the first site went live. One and a half years after last site went live i.e. full implementation.

An overview of the ManB ERP implementation is shown in Table 1.

The theoretical framework that underpinned data collection was adapted from Orlikowski (1993). The Shang and Seddon (2000) ERP benefits framework was used to assess the business benefits achieved. The adapted Orlikowski framework and the Shang and Seddon (2000) framework provided the main basis for the semi-structured interview protocol.

The primary source of data was from in-depth interviews with key informants chosen because of their position within the organization. The interviewees included a senior manager (General Manager IT and Business Solutions), the Group Business Solutions Manager (Finance), the Group Business Solutions Manager (Manufacturing), the Group Project Manager and the SAP Applications Manager. Interviews were tape recorded to ensure accuracy and were returned to interviewees for verification. To provide triangulation other sources of data collected were company documentary evidence and archival data such as post implementation reviews etc.

The case study research design conformed to the principles for conducting interpretive field studies in IS developed by Klein and Myers (1999). Full details of the research design can be found in Staehr, Shanks and Seddon (2002).

RESULTS AND DISCUSSION

ManB achieved extensive business benefits from its ERP implementation. The business benefits achieved at ManB are shown in Figure 1 using the Shang and Seddon (2000) benefits framework. Some additional business benefits not in the original Shang and Seddon benefits framework were achieved at ManB and these are shown in bold italic in Figure 1. The business benefits at ManB were not uniform across all sites. This variation in business benefits also occurred within a particular functional area. The fact that different business benefits were realized not only in different functional areas but also at different sites within the same organization highlights the difficulty in assessing the business benefits overall that an organization achieves with its ERP system.

Table 2 below shows the major situations and/or actions that influenced the eventual achievement of extensive business benefits at ManB. The first column in Table 2 lists the contextual influences, both internal and external to the company, followed by the phases of the ERP lifecycle. Column 2 specifies the situation/action at ManB that influenced the achievement of business benefits, while column 3 explains the influence and indicates in parentheses the subsequent phases of the

ERP lifecycle affected. Column 4 shows whether the situation/action resulted in a positive or negative influence.

The results in Table 2 provide a process oriented view of the ERP implementation at ManB. The two contexts, external and internal to the organization, had the potential to influence the achievement of business benefits right across the ERP lifecycle. Each phase of the ERP lifecycle had the potential to influence the current and subsequent phases of the ERP lifecycle. Examination of the influences of situations/actions contributes to understanding how and why ManB achieved extensive business benefits from its ERP implementation. The external and internal contexts provided mainly positive contextual influences across the entire ERP lifecycle.

During the Chartering and Project phases of the ERP lifecycle critical success factors (CSF) reported in prior ERP research were identified at ManB. Examples of each of these CSFs at ManB appear matched by number in Table 2 below:

1. Top management support (e.g. Holland and Light, 1999; Parr et al., 1999; Brown and Vessey, 2003)
2. Project champion (e.g. Parr et al., 1999; Sumner, 2000; Somers and Nelson, 2001)
3. Project management (e.g. Holland and Light, 1999; Parr et al., 1999; Duplaga and Astani, 2003)
4. Change management (e.g. Markus and Tanis, 2000; Aladwani, 2001; Brown and Vessey, 2003; Markus, 2004)
5. Minimal customization (e.g. Holland and Light, 1999; Parr et al., 1999; Brehm, Heinzl and Markus, 2001; Somers and Nelson, 2001; Soh and Sia, 2005)
6. Project team characteristics (e.g. Parr et al., 1999; Ross and Vitale, 2000; Robey, Ross and Boudreau, 2002)
7. Implementation strategy (e.g. Holland and Light, 1999; Duplaga and Astani, 2003)
8. Education and training (e.g. Somers and Nelson, 2001; Robey et al., 2002; Sumner, 2000)

However, despite the presence of these CSFs at ManB, and no major issues due to the contexts and earlier phases that needed resolving during the Shakedown

Figure 1. Business benefits achieved at ManB (adapted from Shang and Seddon (2000))

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 alliances 3.3 Supports business innovation 3.4 Supports cost leadership 3.5 Supports product and service differentiation 3.6 Supports external linkages 3.7 Enables world wide expansion 3.8 Enables ebusiness
4. IT INFRASTRUCTURE	4.1 Increased business flexibility 1.2 IT cost reduction 4.3 Increased IT infrastructure capability
5. ORGANIZATIONAL	5.1 Supports business organizational changes 5.2 Facilitate business learning and broaden employee skills 5.3 Empowerment 5.4 Changed culture with a common vision 5.5 Changed employee behaviour with a shifted focus 5.6 Better employee morale and satisfaction 5.7 Standardization

KEY: **Benefit category = business benefit achieved**
Benefit category = new business benefit

Table 2. Overview of ManB ERP implementation and use (KEY: “+ve” and “-ve” indicates positive or negative influence, C = Chartering, P = Project, S = Shakedown, OU = Onward and Upward)

	Situation/Action	Influence (Phase affected)	
External context	Demand for SAP experts in the Australian IT industry	ManB did not lose IT staff. The policy of training existing IT staff to support SAP after implementation, the excellent communication between the existing ManB staff and the implementation partner consultants during the project, and the payment of bonuses to the ManB staff at the completion of the project all contributed. (C, P, S and OU) Changes/enhancements to the software to fit existing business processes not easy to obtain. (C and P)	+ve
	Dependence on software vendor		-ve
Internal context	ManB's motivation for the SAP implementation involved strategic business reasons including risk reduction. Although SAP software used by another part of the parent organization there was no compulsion to choose SAP. Restructure to shared services after go-live.	The SAP implementation proceeded despite a forecast negative return on investment. (C, P, S and OU) Software chosen was capable of meeting the requirements of the business. (S and OU)	+ve
		Managers/users already had some working knowledge of the software when shared services were implemented. (OU)	+ve
Chartering and Project phases (C and P)	¹ Management understood the scale of the project and the need for comprehensive planning process.	(C, P, S and OU)	+ve
	² Experienced project manager and champion.		
	³ Project completed on time, within budget and with original scope.	(P, S and OU)	+ve
	⁴ Comprehensive and well thought out change management plan.	(S and OU)	+ve
	⁵ Minimal customization of the SAP software.	(P, S and OU)	+ve
	⁶ Used several different templates across the sites i.e. did not use a “one template fits all” approach	(P, S and OU)	+ve
	⁷ Excellent working relationship with implementation partner. Best business people on the implementation team.	(S and OU)	+ve
	⁸ Small bang implementation strategy.	Facilitated a quality configuration (P, S and OU)	+ve
	⁹ Used learning from early implementations to improve subsequent implementations.	Low risk implementation strategy (S and OU)	+ve
	¹⁰ Existing IT staff trained to support SAP post go-live. Few issues remaining from these phases to be solved in subsequent phases.	Some training deferred until after go-live when users could learn using “real” data. (P and S)	+ve
Shakedown (S)	Some issues with user education and training.	(S and OU)	-ve
	Issues with poor management control practices	Users did not understand the increased need for data quality (S and OU)	-ve
	Phone support inadequate	Results didn't look as good after go-live as they did before (S)	-ve
	Businesses had to pay for extra training	Users “didn't know what they didn't know” (S and OU)	-ve
	IT staff involved in other site implementations/new project work	A disincentive to having properly trained staff (S and OU)	-ve
		Limited availability of IT staff for training and support (P, S and OU)	-ve
Onward and Upward (OU)	Use of key users and professionals (e.g. accountants, engineers) for support services		+ve
	Sweeps of sites for training		+ve
	Issues with shared services		-ve
	Some productivity issues with poorly trained staff		-ve
	Business suggesting improvements to existing processes		+ve
	Business suggesting new projects to leverage off the SAP system		+ve
	Business has a common language for strategic planning		+ve

phase, other issues surfaced during the Shakedown phase that provided negative influences affecting the achievement of business benefits (see Table 2). This should not be considered unusual, since, consistent with the effect of organizational change (Eason, 1988), in this phase the process of adapting to the new system

typically results in a performance dip (Markus and Tanis 2000; Ross and Vitale 2000) which may last up to 12 months or more. However, at ManB most sites were back to normal operations within 6 months.

A number of themes emerged in the Shakedown phase that highlighted areas for improvement. There were ongoing issues with education, training and support and change management. The deficiencies in education and training in the Project phase meant that users were not sufficiently aware of the integrated nature of the software and the increased need for data quality. The telephone support provided once the implementation team left the site was a problem for users who “didn’t know what they didn’t know”. Additional training and support was required at some sites but the resources were often not available since the same team was used for ongoing implementations and for training. Also the business unit requesting additional training had to pay for it, surely a disincentive.

Change management was required to deal with issues of poor management practice:

“Basically, it hit the fan, where there were poor management practices. They were flushed out in the early days. SAP was accused of actually having wrong numbers. We went through, did a whole lot of work as to whether the configuration was right, whether the reporting was right, all those sorts of things. Time and time again it was proven that the system was doing what the system should do and that the poor practices were very much made visible and led to improved practices over time.” (General Manager Information Technology & Business Solutions)

In the Onward and Upward phase there were sweeps of all sites to ascertain training needs. Key users and professionals who moved from site to site were used to provide more support opportunities:

“I spend a lot of my day just connecting people between plants and saying, well this plant does it this way, why don’t you talk to this person. They might be completely different business units, but they can share information and they can talk the same language.” (Group Business Solutions Manager - Manufacturing)

This reduced the load on the centralized support facility.

During the Onward and Upward phase process improvements and new projects to leverage off the ERP system were suggested by the business rather than being initiated from the IT staff. This occurred as business users came to better understand the capabilities of the ERP system.

Although not entirely free of problems the ERP implementation at ManB did achieve extensive business benefits. Two major contributing influences emerged from analysis of the empirical data and the ERP research literature. The first was that the approach ManB adopted towards its ERP implementation indicated a strategic business motivation which has been linked by Markus (2000) to achieving more business benefits from ERP systems. The second influence involved the individual manufacturing plant level. ManB showed a variation in business benefits from site to site. In their study of local plant level benefits from ERP systems Gattiker and Goodhue (2005) found that interdependence between plants increases the business benefits achieved through the integration provided by the ERP system. There was substantial interplant trading at ManB. However, Gattiker and Goodhue (2005) also found that differences between plants decreased benefits. They suggested that customization is one way to alleviate this although they could not provide supporting evidence. ManB was able to accommodate the differences between plants by using several different templates, and in the case of one plant, letting it keep its legacy system (see number 5 in Table 2). Therefore the interdependence between plants and the accommodation of variation between plants contributed to the extensive business benefits achieved.

CONCLUSION

ManB achieved extensive business benefits from its ERP implementation (see Figure 1). At ManB the possible negative consequences due to external and internal contextual influences on the organization did not eventuate due to management’s strategic business motivation, planning and foresight during the Chartering and Project phases. The successful Chartering and Project phases set the scene for the achievement of business benefits during ERP system use. During the Project phase the accommodation of differences between manufacturing plants contributed to the business benefits achieved. Although there were some issues that arose during Shakedown these were overcome in readiness for the Onward and Upward

phase. During the Shakedown and Onward and Upward phases some themes that influenced the achievement of business benefits at ManB emerged. They were *education, training and support, change management*, and the need for adequate *people resources*. Once the business users fully understood the capabilities of the ERP system business benefits were achieved through *business process improvement* and *new projects that leveraged off the ERP system*. These results are of interest not only to IS researchers and IS practitioners but to senior management in organizations. They contribute to our understanding of how and why some organizations gain more business benefits from their ERP systems than others.

REFERENCES

- Aladwani, A. (2001). Change management strategies for successful ERP implementation, *Business Process Management Journal* 7(3): 266-275.
- Bancroft, N., Seip, H. and Sprengel, A. (1998) *Implementing SAP R/3*, 2nd edn, Manning, Greenwich.
- Boudreau, M. (2003). Learning to use ERP technology: A causal model, in R. Sprague (ed.), *Proceedings of the 36th Hawaii International Conference on System Sciences*, IEEE Computer Society, Los Alamitos, CA.
- Brehm, L., Heinzl, A. and Markus, M. L. (2001). Tailoring ERP systems: A spectrum of choices and their implications, in R. Sprague (ed.), *Proceedings of the 34th Annual Hawaii International Conference on Information Systems*, Vol. 9, IEEE Computer Society, Maui, HI. (9 pages).
- Brown, C. V. and Vessey, I. (2003). Managing the next wave of enterprise systems: Leveraging lessons from ERP, *MIS Quarterly Executive* 2(1): 65-77.
- Chang, S. and Gable, G. G. (2002). A comparative analysis of major ERP life cycle implementation, management and support issues in Queensland government, *Journal of Global Information Management* 10(3): 36-54.
- Davenport, T. (2000) *Mission Critical*, Harvard Business School Press, Boston.
- Davenport, T. H., Harris, J. and Cantrell, S. (2004). Enterprise systems and ongoing process change, *Business Process Management Journal* 10(1): 16-26.
- Duplaga, E. and Astani, M. (2003). Implementing ERP in manufacturing, *Information Systems Management* 20(6): 68-75.
- Eason, K. (1988). *Information Technology and Organizational Change*, Taylor Francis, London.
- Gable, G. G., Sedera, D. and Chan, T. (2003). Enterprise system success: A measurement model, in S. March, A. Massey and J. DeGross (eds), *Proceedings of the Twenty-Fourth International Conference on Information Systems, Association for Information Systems*, pp. 576-591.
- Gattiker, T. F. and Goodhue, D. L. (2005). What happens after ERP implementation: Understanding the impact of interdependence and differentiation on plant-level outcomes, *MIS Quarterly* 29(3): 559-585.
- Holland, C. P. and Light, B. (1999). A critical success factors model for ERP implementation, *IEEE Software* 16(3): 30-36.
- Klein, H. and Myers, M. D. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems, *MIS Quarterly* 23(1): 67-93.
- Markus, M. L. (2000). Conceptual challenges in contemporary IS research, *Journal of Global Information Management* 8(3): 42-48.
- Markus, M. L. (2004). Technochange management: Using IT to drive organizational change, *Journal of Information Technology* 19(1): 3-19.
- Markus, M. L. and Tanis, C. (2000). The enterprise systems experience – from adoption to success, in R. Zmud (ed.), *Framing the Domains of IT Research: Projecting the future through the past*, Pinnaflex Educational Resources, Cincinnati, Ohio, chapter 10, pp. 173-207.
- Markus, M. L., Axline, S., Petrie, D. and Tanis, C. (2000). Learning from adopters’ experiences with ERP: Problems encountered and success achieved, *Journal of Information Technology* 15(4): 245-265.
- Orlikowski, W. (1993). CASE Tools as Organizational Change: Investigating Incremental and Radical Changes in Systems Development, *MIS Quarterly*, 17(3): 309-340.
- Parr, A. and Shanks, G. (2000). A model of ERP project implementation, *Journal of Information Technology* 15(4): 289-303.
- Parr, A., Shanks, G. and Darke, P. (1999). Identification of necessary factors for successful implementation of ERP systems, in O. Ngwenyama, L. Introna, M. Myers and J. DeGross (eds), *New Information Technologies in Organisational Processes*, Kluwer Academic Publishers, Boston, pp. 99-119.
- Robey, D., Ross, J. W. and Boudreau, M. (2002). Learning to implement enterprise systems: An exploratory study of the dialectics of learning, *Journal of Management Information Systems* 19(1): 17-46.

- Ross, J. W. and Vitale, M. R. (2000). The ERP revolution: Surviving versus thriving, *Information Systems Frontiers* 2(2): 233-241.
- Shang, S. and Seddon, P. B. (2000). A comprehensive framework for classifying the benefits of ERP systems, in H. Chung (ed.), *Proceedings of the Sixth Americas Conference on Information Systems*, Association for Information Systems, pp. 1005-1014.
- Shanks, G. (1997) The challenges of strategic data planning in practice: an interpretive case study, *The Journal of Strategic Information Systems*, 6(1): 69-90.
- Soh, C. and Sia, S. (2005). The challenges of implementing "vanilla" versions of enterprise systems, *MIS Quarterly Executive* 4(3): 373-384.
- Somers, T. and Nelson, K. (2001). The impact of critical success factors across the stages of enterprise resource planning implementations, in R. Sprague (ed.), *Proceedings of the 34th Annual Hawaii International Conference on Information Systems*, Institute of Electrical and Electronic Engineers, Inc., New Jersey, USA.
- Staehr, L., Shanks, G. and Seddon, P. (2002). Understanding the business benefits of ERP systems, in J. DeGross (ed.), *Proceedings of the 8th Americas Conference on Information Systems*, Association for Information Systems, Dallas, Texas, pp. 899-906.
- Sumner, M. (2000). Risk factors in enterprise-wide/ERP projects, *Journal of Information Technology* 15(4): 317-327.

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