Implementing enterprise resource planning systems with total quality control and business process reengineering

Survey results

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Abstract *The primary objective of an enterprise resource planning (ERP) system is to help integrate an organization's business operations and processes effectively and efficiently. Not all firms have been successful in their ERP implementations and to that end research has helped to identify many factors that might be critical to a successful implementation. Such factors as the use of business process reengineering (BPR), and establishing a total quality management (TQM) culture have all shown to play important roles in ERP implementation. The focus of this survey research on US electronic manufacturing firms is to identify successful integration sequences of TQM and BPR with ERP. The findings reveal that both the sequence of implementation and the strategies selected to initiate ERP systems can significantly impact business performance successfulness.*

Introduction

A family of software packages used to integrate business organizations with one another is called enterprise resource planning (ERP) (Chase *et al*., 2001, pp. 420-30; Wallace, 2001). ERP has had a positive impact on the ability of businesses to improve working capital, implement a total quality management (TQM) culture, lower inventory levels, optimize raw materials and sell and deliver products to the customers (Shtub, 1999). ERP has helped alleviate the arduous job of supporting inflexible systems that in most cases result in cost increases, data redundancy and inaccuracy, and above all, various inefficiencies (O'Leary, 2000). Ideally, ERP is a computer system that keeps managers informed about what is happening in real-time throughout a corporation and its global connections (Jacobs and Whybark, 2000).

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Unfortunately corporations have complained of excessive costs in deployment and maintenance of their ERP systems (Stevens, 1996). Besides being expensive, ERP systems can be difficult to implement (Davenport, 1998). According to Davenport (1998) most ERP system projects fail during the implementation stage.

What are major reasons for ERP failure?

One reason for ERP failure is not implementing a paradigm shift in operation areas before ERP implementation (Shtub, 1999). The proper implementation procedure requires a "sequence" of careful planning and implementation in conjunction with organization catalysts for change like TQM. An organization needs to assess the corporate culture and restructure it to TQM culture if it is needed (Braithwaite, 1994; Clark, 1999; Rampersad, 2000). For example, "teamwork" concept of the TQM such as problem-solving teams, quality improvement teams, or cross-functional teams need to be implemented throughout the organization to solve problems or improve problem solving inside and outside of the organization for purposes of change (Pike and Barnes, 1998; Rothwell and Kazanas, 2000). Although the TQM results in small improvements, the TQM approach has been a powerful catalyst for change on productivity improvements of the organization (Torok and Cordon, 2002).

The implementation of a TQM culture can, and usually should, impact the entire organization, as well as its supply-chain partners. The most common procedure to accomplish this type of change is through a more drastic change management approach called, business process reengineering (BPR). According to Ansari (2000), Elzinga *et al.* (1999) and Sethi and King (1998), BPR provides a guide for diagnosing possible problem areas and a tool for restructuring within and outside an organization. BPR is defined by Andersen (1999) as a radical redesign of business processes to achieve dramatic improvements in critical areas of performance, such as cost, quality, delivery and flexibility. This definition treats the TQM and the BPR concepts separately since BPR's focus is on large-scale "radical redesign" or "dramatic improvements" whereas the TQM focus on small incremental "continuous improvement." Although some proponents of BPR consider BPR as superseding TQM, some researchers set BPR as a pre-planning phase of the ERP and set TQM as pre-execution phase of ERP (Braithwaite, 1994; Sohmen 1998). Braithwaite (1994) suggested that BPR and TQM where partners that work together to achieve necessary organizational changes.

According to Rockefeller and Rockefeller (1998) BPR, a key concept in the ERP implementation, reviews business practices and procedures in a kind of "mapping" investigation. This "mapping", a kind of sub-text that becomes the foundation for the entire ERP system, can be done by ERP software vendors, consultants or a firm's own in-house team (Keller and Teufel, 1998). The more thoroughly this mapping is done, the better the BPR implementation will be. However, it has been estimated that about two-thirds of BPR projects either fail

completely or fall significantly short of hoped-for outcomes (Plenert 1994; Sheridan, 1994; Schumacher, 2002). The most common barriers and errors to the success of BPR attempts observed are: resistance to change; limitations of existing systems; lack of a senior-executive support; a lack of cross-functional project teams and staff; neglecting employee's values and beliefs; trying to make reengineering happen from the bottom up; and lack of education and training (Greenberg, 2002).

If the concept of TQM holds, most of barriers or errors of BPR implementation listed above can be removed (Braithwaite, 1994; McDonald, 1995). Almost without exception the successful exponents of BPR have been and continue to be committed to the TQM process. TQM puts a heavy emphasis on the need to change people's behavior, attitude and philosophy of doing business. In other words, TQM provides the essential cultural framework and foundation to enable BPR to be successful.

Problem statement

If an organizations' core business systems have an infrastructure that is ill prepared for the ERP changes necessary for system success, an integration project will fail no matter what types of ERP software packages an organization decides to implement. The success of the integration project does not depend on the speed of the implementation or the amount of the capital investment. The previous literature suggests the success of the integration depends on how an organization prepares itself for the quest of an integration program. Change methods, such as BPR and catalyst for change methods like TQM, must be aligned to support the implementation of ERP. For those firms that use TQM and BPR for change preparation of an ERP system, a fundamental question for integration is how to formulate or manage the integration sequence of the TQM, BPR and ERP. Specifically, what order should these three critical components of business operations be aligned to achieve business performance success?

Research questions

The primary purpose of this research is to find the proper ordering of an implementation strategy for the TQM and BPR with ERP for manufacturing industries in the USA. By identifying the proper integration sequence and proper implementation strategy, the contribution this research hopes to achieve is in helping organizations to improve the successful implementation chances of an ERP integration project. Specifically, this research study will answer the following four questions:

(1) What is the current relationship between a TQM program's implemented results and an ERP program's implemented results?

(2) What is the current relationship between a BPR program's implemented results and an ERP program's implemented results?

(3) What is the proper integration sequence (or ordering) of TQM and BPR with ERP programs to achieve business performance success?

(4) What is the best implementation strategy for TQM, BPR, and ERP programs that results in business performance success?

Research methodology

An e-mail questionnaire survey was used to gain data on the current and future plans for the TQM, BPR and ERP among manufacturing organizations. The targeted survey subjects were managers and engineers in the field of manufacturing and information technology industries who are responsible for or involved with the implementation of TQM, BPR and ERP programs. Several on-site interviews were conducted with selected managers of Honeywell (of Illinois) to validate the survey questions. The survey was designed in an e-mail format and was sent to 250 subjects, which were randomly selected from a group of electrical parts and products manufacturers and assembly organizations from memberships in American Production and Inventory Control Society (APICS), the Product Development and Management Association (PDMA), and the Institute of Electrical and Electronics Engineers (IEEE). All subjects were manufacturers of electronic components or finished products. No two individuals where selected from the same company. Their companies sell products both retail and industrially, and are equally dispersed over the USA. Telephone calls were made to selected participants to encourage participation and to ask if the survey questions were understandable in the way they were intended. The response rate of this approach was 46 percent (i.e. 115 out of 250). It was observed that some of the respondents were unable to participate in this research due to lack of time and company confidentiality issues. No non-response bias was observed or reported by subjects in the telephoned participation inquiries. Several questions were used to measure constancy in answering questions used in scaling variables in the study. Based on a split-haves test ($r = 0.951$, $p < 0.001$), it could be concluded that survey subjects use of a rating scale in answering questions where highly reliable.

Survey results

As can be seen in Table I, the majority of the respondents come from electronic manufacturing industries such as non-computer, cable or telecommunication products (58.3 percent). About one-third of the respondents (33 percent, Table I) hold the position of plant or operations manager and approximately 44 percent of the respondents employ 5,000 to 10,000 employees. About 35 percent of the respondents reported their firms' revenue ranged from $251 to $750 million (Table I) at the time of the survey.

	Frequency	Percent
What is your company's primary business?		
Electronics manufacturing (non-computer, cable or telecom)	*67*	*58.3*
Electronics manufacturing (computer, cable or telecom)	48	41.7
Total	115	100.0
What is your position in the company?		
Executive – OM	33	28.7
Executive – information systems	2	1.7
Plant/operations manager	*38*	*33.0*
Materials/supply manager	33	28.7
Production/inventory control manager	9	7.8
Total	115	100.0
What is the number of employees in your company?		
Below 500	3	2.6
500-1,000	22	19.1
1,000-5,000	22	19.1
5,000-10,000	*51*	*44.3*
10,000-50,000	17	14.8
Total	115	100.0
What is your firm's revenue in $ millions?		
51-250	16	13.9
251-750	*41*	*35.7*
751-1,500	27	23.5
1,501-5,000	30	26.1
5,001 and more	1	0.9
Total	115	100.0

Table I.
Description of survey subject's business organizations

Question 1: the relationship between TQM and ERP

To research the implementation status of the TQM, a Pearson correlation and *t*-test were conducted to determine the strength of the relationships between an "implementation dimension" (i.e. the degree to which TQM programs are being used) and the "implementation results" for a TQM program. The implementation dimension included categories where survey subjects could indicate the degree of TQM use in their organization from programs that ranged from only "being developed", to the programs being used in "some areas", and finally to programs begin used in "most areas". A Pearson correlation coefficient, comparing the TQM implementation dimensions and implementation results of only 0.051 ($p < 0.591$), showed a less than significant *t*-test result (see Lee *et al.*, 1998, pp. 530-33). Despite this lack of significance an examination of the cross-tabulation of the TQM implementation dimensions and their implementation results in Table II does show for the majority of the organizations that success with TQM programs is increased if the firm uses TQM in most of the areas of the firm (28.1 percent of the time). A further cross-tabulation of the TQM implementation results with those of the ERP

implementation results in Table III, reveals that their relationship together is predominately successful (i.e. sharing a successful implementation 34.2 percent of the time).

Question 2: the relationship between BPR and ERP

To research the implementation status of BPR, a Pearson correlation test was conducted to again determine the strength of the relationships between the "implementation dimension" (i.e. the degree to which BPR programs are being used) and the "implementation results" for a BPR program. The implementation dimension included the categories where subjects could indicate the degree of use of BPR in the organization along a range from programs that were just in the "planning" stage, to programs "being developed", to the programs being used in "some areas", and finally to programs begin used in "most areas". A Pearson correlation coefficient of 0.535 and subsequent *t*-test ($p < 0.001$) comparing the BPR implementation dimensions and implementation results was statistically significant. The significance of this correlation was also examined in a cross-tabulation of the BPR implementation dimensions and their implementation results as presented in Table IV. Similarly to TQM, BPR implementation is most likely to achieve business success if it is used in most areas of the organization (26.1 percent of the time, Table IV). A further cross-tabulation of the BPR implementation results with those of the ERP implementation results in Table V, reveals that their relationship together is predominately successful. Note that the 41.7

	Being developed		Some areas		Most areas		Don't know		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Success	10	8.8	13	11.4	*32*	*28.1*			57	49.1
Mediocrity	7	6.1	16	14.0	6	5.3			29	25.4
Failure	4	3.5	10	8.8	16	13.2	1	0.9	29	25.4
Total	21	18.4	39	34.2	54	46.5	1	0.9	115	100.0

Table II. TQM results vs degree of TQM implementation

	ERP							
	Success		Mediocrity		Failure		Total	
TQM	*n*	%	*n*	%	*n*	%	*n*	%
Success	*39*	*34.2*	11	9.6	6	5.3	57	49.1
Mediocrity	2	1.8	9	7.9	18	15.8	29	25.4
Failure	8	7.0	19	16.7	2	1.8	29	25.4
Total	50	43.0	39	34.2	26	22.8	115	100.0

Table III. Implementation results comparison between TQM and ERP

percentage in the success-to-success cell in Table V is even greater than the 34.2 percentage observed of TQM.

Question 3: the proper implementation sequence

To research the implementation status of EPR in the surveyed organizations, a Pearson correlation and *t*-test were conducted to determine the strength of the relationships between the "implementation dimension" (i.e. the degree to which EPR systems are being used) and their "implementation results". The implementation dimension included the same categories as were used for BPR programs. A Pearson correlation coefficient of 0.306 and subsequent *t*-test ($p < 0.001$) comparing the EPR implementation dimensions and implementation results were statistically significant. The significance of this correlation was also examined in a cross-tabulation of the EPR implementation dimensions and its implementation results as presented in Table VI. Similarly to both TQM and BPR implementations, businesses are most likely to achieve

Table IV.
BPR results vs degree of BPR implementation

	Planning		Being developed		Some areas		Most areas		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Success			4	3.5	21	18.3	*30*	*26.1*	55	47.8
Mediocrity	2	1.7	5	4.3	30	26.1	8	7.0	45	39.1
Failure			11	9.6	4	3.5			15	13.0
Total	2	1.7	20	17.4	55	47.8	38	33.0	115	100.0

Table V.
Implementation results comparison between BPR and ERP

	ERP							
	Success		Mediocrity		Failure		Total	
BPR	*n*	%	*n*	%	*n*	%	*n*	%
Success	*48*	*41.7*	7	6.1			55	47.8
Mediocrity	1	0.9	31	27.0	13	11.3	45	39.1
Failure	1	0.9	1	0.9	13	11.3	15	13.0
Total	50	43.5	39	33.9	26	22.6	115	100.0

Table VI.
ERP results vs degree of ERP implementation

	Planning		Being developed		Some areas		Most areas		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Success	2	1.7	4	3.5	12	10.4	*32*	*27.8*	50	43.5
Mediocrity	2	1.7	9	7.8	1	0.9	27	23.5	39	33.9
Failure	1	0.9	6	5.2	18	15.7	1	0.9	26	22.6
Total	5	4.3	19	16.5	31	27.0	60	52.2	115	100.0

business success if ERP is used in most areas of the organization (27.8 percent of the time, Table VI).

To answer the proper implementation sequence question of this study, a total of five different types of implementation sequences (i.e. orderings) were suggested to the engineering subjects. They are: TBE, BET, BTE, EBT and ETB, where "T" represents the TQM, "B" represents the BPR and "E" represents the ERP system. The correlations between these five implementation sequences and the three implemented results reported by the subjects are presented in Table VII. While generally significant, suggesting that sequence does matter, these relationships were cross-tabulated in Table VIII. As can been seen in Table VIII, only two implementation sequences dominatingly reported by the engineers as being successful where TBE (22.8 percent) and BET (20.3 percent). Based on these statistics, we conclude that either of the two sequences (TBE or BET) are the best implementation sequences for organizations to follow in future ERP implementations.

Question 4: the proper implementation strategy

Based on the literature there are four following different "implementation strategy" choices that the engineers typically select from (O'Leary, 2000; Rockefeller and Rockefeller, 1998):

(1) *Step-by-step*. Implement one of three programs (T, B and E) based on the project schedule. Measure the implementation result before committing to the implementation of the next program.

(2) *Parallel*. Implement all three programs at the same time and adjust or revise the system during the implementation process.

(3) *Remedy*. There is no specific implementation sequence or strategy. Implement any of three programs as firm finds the necessity.

(4) *Other*. Other strategy than listed above.

Table VII. Correlations between implementation sequence and results

	Pearson correlation	Sig. (two-tailed)
TQM	0.182	*0.053*
BPR	0.536	*0.000*
ERP	0.440	*0.000*

Table VIII. ERP results vs implementation sequence

	TBE		BET		BTE		EBT		ETB		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Success	*26*	*22.8*	*23*	*20.2*							50	43.0
Mediocrity	8	7.0	7	6.1	2	1.8	16	14.0	6	5.3	39	34.2
Failure	1	0.9	13	11.4	12	10.5					26	22.8
Total	35	30.7	43	37.7	14	12.3	16	14.0	6	5.3	115	100.0

To answer the implementation strategy question in this study, the above four different types of implementation strategies were correlated with "implementation results". The correlations between these four implementation strategies and the three implemented results reported by the subjects are presented in Table IX. While all three were significant at a $p < 0.05$, suggesting that strategy and results are related, additional information was sought on the relationships by cross-tabulation in Table X. As can be seen in Table X the "step-by-step" strategy was reported as being the predominate success strategy and the "Parallel" strategy was reported as the predominate failure strategy. From this we concluded that managers should seek to follow the step-by-step strategy, in the implementation of their ERP systems.

The literature suggested that ERP implementation success maybe related to the particular ERP system software package users chose. To support the implementation of the results of this study further a subsequent question sought to examine the successfulness of the "type" of ERP system package that should be used in the implementation process. The subjects in the study were given their choice of the six different types of ERP system packages reported in the literature. These types are:

(1) "Single" software application.

(2) "Best-of-breed" system from those currently available in the organization.

(3) "Single and other" software applications, joining minor applications to one major system.

(4) "Multiple" software application packages with a variety of major applications working together.

(5) An "In-house" evolved software application.

Table IX.
Correlations between implementation strategy and implementation results

	Pearson correlation	Sig. (two-tailed)
TQM	0.517	*0.000*
BPR	0.378	*0.000*
ERP	0.196	*0.037*

Table X.
ERP results vs implementation strategy

	Step-by-step		Parallel		Remedy		Other		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%
Success	*26*	*21.9*	9	7.9	15	13.2			*50*	*43.0*
Mediocrity	4	3.5	6	5.3	13	11.4	16	14.0	39	34.2
Failure			*25*	*21.9*	1	0.9			26	22.8
Total	30	25.4	40	35.1	29	25.4	16	14.0	115	100.0

(6) An "In-house and other" application using an in-housed developed package with other commercial packages.

The cross-tabulation in Table XI clearly supports the prior research in showing that the possible result of an ERP implementation depends on the choice of the ERP system package. Among the subjects reporting success in their ERP system, the "Single" system package (at 20 percent) was the most dominate system to use. Those subjects reporting a mediocre result predominately reported using a "Multiple" system package, and those reporting failure predominately reported using an "In-house and other" system package. Therefore, these results suggest managers should adopt a Single ERP package to improve the chance of success in their future ERP implementation process.

Conclusion

This research started with four questions to be answered in an effort to find the best sequence and strategy to employ when using TQM and BPR as organization change agents to implement an ERP system. About half of the respondents succeeded in their ERP implementations and half of them are split between a "mediocrity" result and a "failure" result. The firms that succeeded tended to adopt a "Single" ERP package approach in their ERP implementation. The proper integration sequence that most organizations reported (called BET), started with BPR for purposes of making the radical change, followed by the implementation of ERP system, and then followed with a TQM program whose purpose is to slow the change down and record quality improvements. In addition to the ERP sequence, the TBE sequence was about equally reported as a successful sequence. These sequences were further supported by the "step-by-step" strategy selection, which dominated the reported successful strategies for implementing an ERP system that utilizes TQM and BPR.

The selection of the BET and TBE sequences and their logical "step-by-step" strategy for implementation are well supported in the literature of managing planned organizational change. A classic and still popular three-phased organizational change model by Lewin (1952) can be seen as overlaying explanation for the two selected sequences (Schermerhorn, 2001, pp. 385-6). In

	Failure		Mediocrity		Success		Total	
	n	%	*n*	%	*n*	%	*n*	%
Single			3	2.6	*23*	*20.0*	26	22.6
Best bred			1	0.9	9	7.8	10	8.7
Single and other	5	4.3	6	5.2	12	10.4	23	20.0
Multiple	1	0.9	*23*	*20.0*	4	3.5	28	24.3
In-house	4	3.5	6	5.2	2	1.7	12	10.4
In-house and other	*16*	*13.9*					16	13.9
Total	26	22.6	39	33.9	50	43.5	115	100.0

Table XI. ERP results comparison with ERP system type

Lewin's model, the organization must under go three phases: unfreezing, changing and refreezing. Clearly BPR, which precedes ERP in both sequences, is a great "unfreezing" strategy to get the organization ready for ERP. In some organizations, particularly in the larger organizations, the use of TQM to begin the unfreezing and then the use of BPR to accelerate more radically the unfreezing phase can be logically viewed as a more temperate approach to this phase. The second "changing" phase can be viewed as the implementation of the ERP system. In the case of the dominate BET sequence, TQM could be employed to complete the third phase of "refreezing" gradually, since much a TQM program involves recording and documenting quality improvement it naturally will slow the change process down. It should be noted that all of the organizations that chose the TBE sequence indicated that they would continue to use TQM after the implementation as an ongoing continuous improvement program, so they did also have a third "refreezing" phase as well.

Like all surveys, this one has some limitations that should be considered before implementing its results. First, only electronics manufacturers were surveyed, which might not be representative of all ERP applications. While we feel manufacturing applications are well represented in our study, service ERP applications might be substantially different in their use of implementation strategies. Second, only self-reported "success" was used to draw on for conclusions of business implementation success. Although some questions in the survey where used to show a consistency in the scaling measures, the idea of "success" in the minds of the survey subjects may not be viewed as "success" for other people. This shortcoming is of course a bias that all surveys typically face. Finally, the choices for the sequences and programs might have been considered limited (only TQM, BPR and ERP were listed). Also, other non-listed programs might actually factor in a successful ERP implementation. In defense of this study, the dominate responses received and the lack of responses in the open-ended questions provide some confidence that the given sequences or programs listed posed no real limitation on survey subject responses.

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