A FRAMEWORK FOR EVALUATING IT BENEFITS IN CONSTRUCTION COMPANIES

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SUMMARY

Information Technology (IT) is seen as an enabling mechanism to allow radical change to be effected in construction industry. However, firms in the construction industry are slowly responding and adapting to developments in information and communication technologies (Love, et al., 2000). A key barrier to the more effective exploitation and application of IT in the construction sector has been the lack of investment on a scale comparable with other sectors. A primary reason cited for the low level of investment is the low level of perceived benefits from IT investments amongst construction business managers (Andresen, et al., 2000). Based on literature review and a survey in the local construction companies, this paper presents a "5Cs" evaluation framework to assist construction companies to predict, measure and evaluate the potential benefits that can or should be achieved by the introduction of IT. The proposed framework answers questions concerning about all factors that need to be considered in the evaluation, such as why, what, when, who and how to perform the evaluation. It is not only presented as a research result but also can be used as a guideline in practice.

INTRODUCTION

Information Technology (IT) is now considered to be a large capital investment (Love, et al., 2000). At the same time, there have long existed uncertainties about benefits that can be derived from IT since they are deeper and wider than the concept of financial benefits. The integration of construction processes using IT offers considerable potential for construction firms (Griffith et al., 2000) and will help the industry to achieve a quantum leap in its future performance. However, the construction sector falls short of having fully arrived in the IT era (Betts and Clark, 1999). A primary barrier to the adoption of the new technologies is the low level of perceived benefits from IT investments amongst construction business managers. Construction is a traditional industry and it is conservative to adopt new technology unless it is clear of the contributions of the technology.

Many construction companies make investments in IT for competitive reasons. But both contractors and consultants found it a problem to quantify the benefits from such investment. Improved quality, increased variety, improved timeliness of delivery and personalized customer service are all aspects that are likely to be enhanced by IT but they are poorly represented in productivity or financial statistics. It is important for a company to know how to measure the right things in the right way.

RESEARCH SCOPE, OBJECTIVES AND METHODOLOGY

This research is conducted at the company level from a managerial point. Instead of IT system or IT project itself, a company as a whole serves as the research object. Efforts will be given to find out the positive impact of IT on a company's performance. Although much literature has been given seeking to demonstrate positive relationships between IT investment and organizational performance (Floyd and Wooldridge, 1990; Mahmood and Mann, 1993, 2000; Sircar, et al., 2000; Bharadwaj, 2000), IT benefits evaluation has received limited attention in the construction literature.

The ultimate objective of this research is to develop an effective IT benefits evaluation framework for construction companies in Singapore. Additionally, efforts will be given to map out relationships between business strategy and IT, and to explore wide spectrum of measures, which cover comprehensive categories of IT benefits, to complement existing conventional ones. This research stresses the alignment of IT with business strategy since strategic alignment has a key role to play in the determination of IT payoffs (Tallon et al., 2000). It seems to be an assumption implicit that

desirable outcomes would be achieved if only alignment could be achieved (Mckay and Marshall, 2001).

Methodology adopted for this research involves a review of literature and a survey in construction organizations addressing IT benefits evaluation issues. A conceptual framework is proposed at first based on literature review and discussion among the authors and some faculty members in the authors' affiliation. The data obtained from survey is used for further formulation and consolidation of the framework.

PAST RESEARCH

Evaluating IT benefits cannot be considered as a new idea or trend since it has existed as long as IT investments have. Current literature on IT benefits evaluation is concerned mainly with the classification of types of benefits (Remenyi et al., 1995; Murphy and Simon, 2001; Irani and Love, 2001), exploration of the essential evaluation measures (Remenyi, et al., 1995; Pitt, et al., 1995; Hitt and Brynjolfsson, 1996; Chan, 2000) and justification of techniques for identifying and evaluation potential benefits (Butterfield and Pendegraft, 2001; Ballantine and Stray, 1998; Andresen, et al., 2000; Andresen, 2001; Money, et al., 1988; Wegen and Hoog, 1996; Tallon, et al., 2000; Chandler, 1982).

Some literature has indicated the importance and immaturity of IT benefits evaluation (Willcocks and Lester, 1997). Evaluation methods are found to be even inadequate for IT benefits evaluation in construction as a result of the industry's structure, fragmentation and under capitalization. Managers do not see the whole picture of IT benefits for their companies. Only tangible benefits are put into consideration while some significant intangible benefits are underestimated. There are limited measures for evaluation. Traditional productivity or financial measures do not encompass all the benefits that IT spawns. There is no systematic way to guide the evaluation and it is very difficult to draw overall conclusions about the evaluation. All those problems highlight the need of an evaluation framework that help to make IT investments more certain and effective.

PROPOSED IT BENEFITS EVALUATION FRAMEWORK

Farbey and Targett (1993) put forward an IT evaluation framework, which expands the traditional narrow approach of the identification and quantification of the tangible costs and benefits of an IT investment. The framework is known as the three rings of the evaluation "onion" as shown in Figure 1.
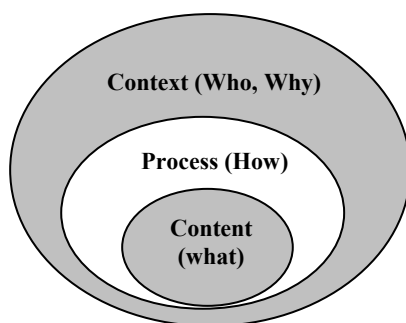

Figure 1 IT evaluation framework - three rings of the evaluation "onion" (Farbey and Targett, 1993)
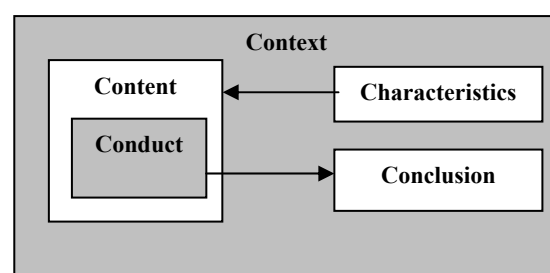
Figure 2 The Proposed "5Cs" IT Benefits Evaluation Framework

Based on the above concept, a new framework has been proposed that completes the "onion" as a "5Cs" evaluation framework (Figure 2).

The outmost layer of the framework is Context, which is defined as the overall business environment in which the IT is conceived and then implemented. Any other component in the evaluation framework is, directly or indirectly, affected by the Context. Most important issue in the Context is business strategy. Demonstrably close alignment between business strategy and IT initiatives is likely to

enhance perceptions of potential benefits from IT investment (Mckay and Marshall, 2001) and therefore help managers make more accurate estimation of expected benefits.

Characteristics in the proposed framework focus on IT itself, such as IT function and IT goal, which reflect the IT strategy of a company. To measure IT benefits, the manager must firstly understand what he is trying to achieve through the use of IT, and then try to find out whether the goals have been achieved. The alignment of IT goal with business strategy is the starting point of understanding what is going to be measured.

Both Context and Characteristics affect Content. Content in the framework refers to IT benefits categorization and evaluation measures selection. In the proposed framework, IT benefits are categorized into operational, tactical and strategic benefits, according to the practice of IT application in construction companies. In order to cover all kinds of IT benefits effectively, wide spectrum of measures should be adopted. Based on the concept of Balanced Scorecard (BSC, initially developed by Kaplan and Norton, 1992), the measures in the proposed framework are derived from four perspectives. Besides the traditional financial measures, the framework accounts for a wider range of IT effects by consisting of measures for customer support (customer focus), internal efficiency and effectiveness (process focus), and innovative culture. Those four kinds of measures are developed accordingly under the four kinds of IT goals.

Conduct as the core element of the framework refers to the way in which evaluation is carried out. This issue will be touched in detail in the later part of this paper. The last component is Conclusion, which is the result of Conduct combined with the interpretation under Contingencies. Evaluation Conclusion provides necessary information for managers to take appropriate actions to ensure the IT benefits realization.

THE SURVEY

Data Collection

A mail survey was conducted from September 2002 to November 2002. There are two main purposes for the survey: to map out the primary relationships among components (Context and Characteristics) in the proposed framework and to validate the measures (Content) identified from literature review. The questionnaire was sent by mail to a randomly selected statistical sample of 134 construction companies across Singapore. The mailing list was assembled with registers obtained from Singapore's Building and Construction Authority (BCA). Data gathered from the survey was analyzed using SPSS, a statistical package. The findings presented here are based on an effective 24.6% return rate (33 out of 134).

Findings

The alignment of IT goal with business strategy

Relationships between Context and Characteristics reflect the alignment of IT goal with business strategy. From literature review, it is summarized that there are 8 kinds of business strategies and 4 kinds of IT goals for a company (Table 1). Respondents were asked to assess the importance on a Likert scale from 1 to 5 for each of the specific strategies and IT goals, where 1 represents "not important at all" and 5 represents "very important". Table 1 shows also the survey analysis results on the correlation between the IT goals and the business strategies.

Business Strategies		IT goals			
		Enable new ways of management and improve productivity and quality	Improve company's economic performance	Improve company's market performance	Improve the innovative culture in the company
Improving internal efficiency and effectiveness	Pearson Correlation	0.547**	0.523**	0.488**	0.473**
	Sig. (2-tailed)	0.001	0.002	0.004	0.005
Gain low cost leadership	Pearson Correlation	0.439*	0.336	0.451**	0.227

	Sig. (2-tailed)	0.011	0.056	0.008	0.205
Product differentiation	Pearson Correlation	0.167	0.227	0.393*	0.326
	Sig. (2-tailed)	0.353	0.205	0.024	0.064
Human resource differentiation	Pearson Correlation	0.065	0.175	0.139	0.107
	Sig. (2-tailed)	0.718	0.331	0.44	0.552
Technology leadership	Pearson Correlation	0.486**	0.13	0.303	0.406*
	Sig. (2-tailed)	0.004	0.471	0.087	0.019
Segmentation and product breadth	Pearson Correlation	0.102	0.086	0.192	-0.163
	Sig. (2-tailed)	0.571	0.634	0.285	0.364
Market share orientation	Pearson Correlation	0.368*	0.326	0.475**	0.314
	Sig. (2-tailed)	0.035	0.065	0.005	0.075
Improve strategy links with customers to gain customer satisfaction	Pearson Correlation	0.500**	0.507**	0.529**	0.254
	Sig. (2-tailed)	0.003	0.003	0.002	0.153

* Correlation is significant at the 0.05 level (2-tailed), ** Correlation is significant at the 0.01 level (2-tailed)

Table 1 Correlation between business strategy and IT goal

The correlation between each business strategy and each IT goal provides information on specific strategy-IT relationship, from which seven conclusions are derived:

- Strategy one (improving internal efficiency and effectiveness) has significant relationship with all four IT goals;
- Strategy two (gain low cost leadership) has significant relationship with IT goal one (enable new ways of management and improve productivity and quality) and goal three (improve company's market performance);
- Strategy three (product differentiation) only has significant relationship with IT goal three (improve company's market performance);
- Strategy four (human resource differentiation) and strategy six (segmentation and product breadth) are not significantly related to any IT goal. Therefore it is not indicated to be useful to investigate the possible weights of IT goals for these two strategies.
- Strategy five (technology leadership) has significant relationship with IT goal one (enable new ways of management and improve productivity and quality) and goal four (improve the innovative culture in the company);
- Strategy seven (market share orientation) has significant relationship with IT goal one (enable new ways of management and improve productivity and quality) and goal three (improve company's market performance);
- Strategy eight (improve strategy links with customers to gain customer satisfaction) has significant relationship with IT goal one (enable new ways of management and improve productivity and quality), goal two (improve company's economic performance) and goal three (improve company's market performance).

The statistic results provide useful information to weight IT goals for a company under different business strategy. However, it would be too naïve to suggest the quantitative relationship between a certain IT goal and a certain business strategy. After all the analysis is intended to present statistically certain theoretical relationships, rather than provide normative guidelines for specific strategy-IT choices.

Validity of measures chosen for IT benefits evaluation

There are 20 measures for IT benefits evaluation derived from literature review, which fall into four categories, aligning with four kinds of IT goals. The questionnaire asks about the respondents' attitude toward the degree of impact that IT has on each proposed measure, using the five-point Likert scale (1 to 5), where 1 represents "no impact at all" and 5 represents "significant impact". This is to assess how important is the impact of IT on these measures. Only those measures that are perceivably impacted by the introduction of IT will be included in the framework.

Statistical tests of the mean were carried out to check whether those measures are considered to be perceivably impacted by IT or not. For each measure, the null hypothesis is that the measure is not perceivably impacted (H$_0$: $\mu \leq \mu_0$) and the alternative hypothesis is that the measure is perceivably impacted (H$_1$: $\mu > \mu_0$). Here μ is the population mean and μ_0 is fixed at 3 because in this survey by definition given in the rating scale, ratings above 3 (i.e. 4 and 5) represented 'high impact' and 'significant impact'.

H$_0$ will be rejected when the calculated t value was greater than t$_{(n-1, \alpha)}$ as shown below

$$\frac{\overline{X} - \mu_0}{S_x / \sqrt{n}} > t_{(n-1, \alpha)}$$

where the random variable t$_{(n-1)}$ follows a student's t-distribution with n-1 degrees of freedom and in this study t$_{(32, 0.05)}$=1.6955; $\overline{X}$ is the sample mean; S_x is the sample standard deviation; and n is the sample size, which is 33 in this study.

Table 2 shows the survey result on the IT benefits measures.

IT benefits measures		Test value = 3			
		N	Mean	Standard Deviation	t
Internal efficiency and effectiveness measures (process focus)	Cost	33	3.818	0.683	6.886
	Productivity	33	4.000	0.707	8.124
	Product quality and service quality	33	3.97	0.810	6.881
Financial measures (economic focus)	Value added	33	4.000	0.661	8.685
	Gross profit	33	3.727	0.761	5.488
	Net profit	33	3.576	0.792	4.177
	Construction turnover	33	3.364	0.859	2.431
	Growth in revenue	33	3.515	1.004	2.948
	Return on assets	33	3.424	0.867	2.811
	Return on investment	33	3.424	0.867	2.811
Customer measures (market focus)	Market share	33	3.818	0.808	5.815
	Customer retention	33	3.848	0.755	6.456
	Customer acquisition	33	3.727	0.719	5.810
	Customer satisfaction	33	4.121	0.650	9.911
	Customer profitability	33	3.667	0.816	4.690
Innovative culture measures	Employee capabilities	33	4.061	0.659	9.251
	Information systems capabilities	33	4.152	0.566	11.692
	Employee motivation	33	3.848	0.619	7.880
	Employee empower	33	3.818	0.683	6.886
	Employee alignment	33	3.727	0.674	6.197

Table 2 t-test of means of IT benefits measures

The t-test of the means showed that all the 20 measures are deemed as perceivably impacted by the introduction of IT. It is therefore concluded that when evaluating IT benefits, it is important to consider its impact on those measures. It is worth mentioning here that in the survey no respondent provide additional measures for IT benefits evaluation. Even that, it is still too risky saying that those measures

in the proposed framework are comprehensive enough. Future research can go on to explore more measures for IT benefits evaluation purpose.

PROCEDURE OF APPLYINGTHE PROPOSED FRAMEWORK

When performing IT benefits evaluation, it is important to keep in mind that one should measure the right things in the right way. In the proposed framework, Context, Characteristics and Content will help to find out the "right things" and Conduct will guide evaluator to perform the evaluation in the "right way". There are six steps, each of which will be described below in details, to perform the IT benefits evaluation using the proposed framework:

Step 1: Determine weight for each IT goal and hence for each benefit measure (Appendix A);
Step 2: Set specific IT goals for the company in terms of IT benefits score (ITBS) for each measure (Appendix B);
Step 3: Calculate expected IT benefits in terms of ITBS;
Step 4: Input perceived ITBS for each measure;
Step 5: Calculate perceived IT benefits in terms of ITBS;
Step 6: Compare the perceived IT benefits with the expected IT benefits and draw IT benefits evaluation conclusion.

Step 1 is to define weight for each IT goal and hence for each measure. Weights for measures are determined directly by IT goals and weights for IT goals are determined under the consideration of weights for business strategies. Evaluators must come to a consensus on company's current business strategy. Referring to the relationship between each business strategy and IT goal, evaluators can score the importance of each IT goal under a business strategy so as to determine a proper weight for each IT goal, using the following formula:

$$\beta_j = \frac{\overline{N}_j}{\sum_{i=1}^{4} \overline{N}_i}$$

where β_j: Weight for jth IT goal (j = 1, 2, 3, 4);

$\overline{N}_j$: Average importance score of the jth IT goal given by different evaluators, where 1 represents "not important at all" and 5 represents "very important".

Weight for each specific measure is calculated under each IT goal.

$$\beta_{jk} = \beta_j * \frac{\overline{N}_k}{\sum_{i=1}^{m} \overline{N}_i} \qquad k = (1,2,\cdots m)$$

where β_{jk}: Weight for the kth measure under the jth IT goal;

β_j: Weight for the jth IT goal (j = 1, 2, 3, 4);

$\overline{N}_k$: Average importance score of the kth IT measure given by evaluators, where 1 represents "not important at all" and 5 represents "very important";
m: Number of measures under jth IT goal.

Step 2 is to set specific IT goal for a company in terms of ITBS for each measure. ITBS of 1 to 5, where 1 represents "no benefits" and 5 represents "great benefits", are adopted in the proposed framework as perceived value for each IT benefits. ITBS for each measure is the average score from all the evaluators. For most tactical and strategic benefits, it is hard or even impossible to attach them with monetary value. Their value highly depends on the subjective perception of the evaluators and can only be measured in terms of ITBS. For operational benefits and some tactical and strategic benefits, they have objective values that can be measured directly in terms of percentage of improvement. In order to unify value of different kinds of benefits, it is necessary to define relationship between objective benefits and ITBS before performing the evaluation. For example, if "cost reduction is up to 50%" is defined as a great benefit, an ITBS of 5 is given to represent the great benefit achieved when cost reduction is 50% or even more while an ITBS of 1 is given to represent the nil

benefit when there is no cost reduction. Using this method, each percentage of cost reduction can have a corresponding ITBS.

Step 3 is to calculate expected IT benefits in terms of ITBS using the following formula:

$$Y_0 = \sum_{j=1}^{4} \beta_j \overline{N}_j = \sum_{j=1}^{4} \begin{bmatrix} \beta_{j1} & \beta_{j2} & \cdots & \beta_{jm} \end{bmatrix} \begin{bmatrix} \overline{N}_1 \\ \overline{N}_2 \\ \vdots \\ \overline{N}_m \end{bmatrix}$$

where Y_0: Total expected ITBS;

$\overline{N}_j$: Matrix of expected ITBS for each measure under the jth IT goal (j = 1, 2, 3, 4);

β_j : Matrix of weights for each measure under the jth IT goal;

m: Number of measures under the jth IT goal.

Step 4 is to input the realized IT benefits in terms of ITBS after the IT implementation, using the pre-defined relationship between objective benefits and ITBS. The purpose of this step is to monitor the IT implementation and its benefits realization.

Step 5 is to calculate the realized IT benefits in terms of ITBS, using the same formula for calculation of the expected IT benefits. The procedure is similar to in step 3 with the only difference of using Y_i to represent the realized benefits at time i.

Step 6 is to compare the realized ITBS with the expected ITBS and get the evaluation conclusion. Based on the results, proper actions may be taken to ensure or maximize the IT benefits.

It is worth mentioning that each time before conducting an evaluation, the evaluation involvement (Appendix A) and evaluation purpose (Appendix A) should be defined.

CONCLUSIONS

IT benefits evaluation has long been deemed as important and, however, immature, especially in the construction industry. Building on Farbey and Targett's (1993) three rings of the evaluation "onion", a "5Cs" IT benefits evaluation framework has been proposed, especially for measuring the IT benefits from the managerial point for construction companies in Singapore. It is a useful tool for dynamic evaluation at the company level during the life time cycle of the IT as it can be applied for pre-investment appraisal, regular reviews after implementation and post implementation evaluation. Since the proposed framework is to make managerial domain assessment of IT benefits rather than technical or social domain, the alignment of IT with business strategy is an important focus. Relationships between each specific business strategy and each IT goal have been explored by survey in the local construction companies. The information can help to orient IT benefits evaluation under certain business strategies. Additionally wide spectrum of measures that derived from literature review was further validated by the survey. Those measures can cover IT benefits (tangible and intangible) comprehensively from different perspectives, such as financial impacts, product and service quality impacts and customer relationship impacts.

The proposed evaluation framework has the main advantage of its operability and practicality. It can help the evaluator or manager answer questions concerning about all factors that need to be considered in the evaluation, such as why (Context: evaluation purpose), what (Characteristic and Content: IT goals and identified benefits), which aspects (Content: criteria/measures), when (Conduct: evaluation stage), who (Context: evaluation involvement) and how (Conduct: evaluation process).

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Appendix A:

Evaluation date: _____

Evaluation involvement (tick applicable):

Parties	Conduct the evaluation	Responsible for the evaluation
IT manager		
Internal audit		
User department		
Financial officers		
Board/executive/business manager		
External partners		
Others (please specify):		

Evaluation purpose (tick applicable):

Choosing between alternative proposals/systems; Making a "Go or no Go" decision	
Correct IT system design and performance	
Regular reviews to monitor the progress of a system	
Get a conclusion of whether the original goals has been achieved or whether the investment is worthwhile	

Define weight for business strategy

What is the importance of the following business strategy for your company currently? (Please use scale: 1 - not important at all; 2 - not important; 3 - neutral; 4 - important; 5 - very important)

	Business strategy	Score of importance (N)
Internal	Improve operational efficiency and effectiveness	1　2　3　4　5
External	Gain low cost leadership	1　2　3　4　5
	Product differentiation	1　2　3　4　5
	Technology leadership	1　2　3　4　5
	Market share orientation	1　2　3　4　5
	Improve strategy links with customers to gain customer satisfaction	1　2　3　4　5

Define weight for IT goals

Business strategy	Correlated IT goal
Improving internal efficiency and effectiveness	• Enable new ways of management and improve productivity and quality • Improve company's economic performance • Improve company's market performance • Improve the innovative culture in the company
Gain low cost leadership	• Enable new ways of management and improve productivity and quality • Improve company's market performance
Product differentiation	• Improve company's market performance
Technology leadership	• Enable new ways of management and improve productivity and quality • Improve the innovative culture in the company
Market share orientation	• Enable new ways of management and improve productivity and quality • Improve company's market performance
Improve strategy links with customers to gain customer satisfaction	• Enable new ways of management and improve productivity and quality • Improve company's economic performance • Improve company's market performance

Referring to the above relationships between business strategies and IT goals, score the importance of each IT goal for your company under your current business strategy (Please use scale: 1 - not important at all; 2 - not important; 3 - neutral; 4 - important; 5 - very important).

IT goals	Score of importance (N)
Enable new ways of management and improve productivity and quality	1 2 3 4 5
Improve company's economic performance	1 2 3 4 5
Improve company's market performance	1 2 3 4 5
Improve the innovative culture in the company	1 2 3 4 5

Define weight for IT benefits measure under each IT goal:

IT goals	IT measures	Score of importance (N)
Enable new ways of management and improve productivity and quality	Cost reduction	1 2 3 4 5
	Productivity improvement	1 2 3 4 5
	Product quality improvement	1 2 3 4 5
	Service quality improvement	1 2 3 4 5
Improve company's economic performance (financial perspective)	Value added	1 2 3 4 5
	Gross profit	1 2 3 4 5
	Net profit	1 2 3 4 5
	Construction turnover	1 2 3 4 5
	Growth in revenue	1 2 3 4 5
	Return on assets	1 2 3 4 5
	Return on investment	1 2 3 4 5
Improve company's market performance (customer perspective)	Market share	1 2 3 4 5
	Customer retention	1 2 3 4 5
	Customer acquisition	1 2 3 4 5
	Customer satisfaction	1 2 3 4 5
	Customer profitability	1 2 3 4 5
Improve the innovative culture in the company	Employee capabilities	1 2 3 4 5
	Information systems capabilities	1 2 3 4 5
	Employee motivation	1 2 3 4 5
	Employee empower	1 2 3 4 5
	Employee alignment	1 2 3 4 5

Appendix B:

Set specific IT goals of your company for each measure in terms of IT benefits score (ITBS)

IT benefits score (ITBS), from 1 to 5, represents perceived benefits of IT, where 1 represents no benefits and 5 represents great benefits.

Set relationship between real benefits and ITBS

- How much cost reduction for your company can be deemed as great benefits of IT?

  Cost reduction (%): _____

- How much productivity improvement for your company can be deemed as great benefits of IT?

  Productivity improvement (%): _____

- How much improvement of the following financial indicators can be deemed as great benefits of IT for your company?

	Value added	Gross profit	Net profit	Construction turnover	Growth in revenue	Return on assets	Return on investment
Improvement (%)							

Referring to the above defined relationship between real benefits and ITBS, give each measure an ITBS that can reflect your expectation of IT benefits:

IT goals in terms of benefits score

Enable new ways of management and improve productivity and quality	Improve company's economic performance (financial perspective)	Improve company's market performance (customer perspective)	Improve the innovative culture in the company
cost reduction % _____	Value added _____	Market share _____	Employee capabilities _____
productivity improvement % _____	Gross profit _____	Customer retention _____	Information systems capabilities _____
product quality improvement _____	Net profit _____	Customer acquisition _____	Employee motivation _____
service quality improvement _____	Construction turnover _____	Customer satisfaction _____	Employee empower _____
	Growth in revenue _____	Customer profitability _____	Employee alignment _____
	Return on assets _____		
	Return on investment _____		