Performance Evaluation of Construction Business Process Reengineering

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ABSTRACT: This study endeavors to focus on developing an evaluation method for comparative analysis of process performance before and after reengineering. Business Process Reengineering (BPR) is a relatively recent concept that has stemmed from management and computer science roots. Process performance evaluations are crucial to managers in identifying the benefit of new process after reengineering. Currently, BPR lacks an effective method of measuring performance. The primary objective of this study is to define a structured process to evaluate the process performance based on the Process Value (PV). The PV, consisting of two major factors, namely process time and customer satisfaction, is developed to evaluate the procedural performance. Process time is an index used to measure the process efficiency, while customer satisfaction is applied for evaluating process effectiveness. Concept derived from the Queueing Theory is used to analyze the time performance of BPR, and Target Attainability Matrix is applied to quantify the customer satisfaction. Dividing process effectiveness with process efficiency, the PV is obtained to assess the reengineering results. The evaluation method has been successfully implemented to real operations in construction industry. It is used as a basis from which business managers can clearly understand the process performance difference before and after reengineering. In addition, the results provide a good reference for those interested in adopting BPR in the industry.

KEYWORDS: Business Process Reengineering, Performance Evaluation, Queueing Theory, Process Value

1. INTRODUCTION

Ever since Hammer elevated BPR in 1990s[Hammer & Champy 1993], most of the articles discussing BPR are only about statements of its steps, design methods, procedures, and prospects after application. They hardly touch upon BPR's performance evaluation methods and standards, leaving businesses unable to figure out the differences before, during and after the application of BPR. A set of proper mechanism of BPR performance evaluation can help businesses understand the differences between before and after reengineering, employ efficient resources on right processing, and build a continuous improvement sequence to deal with any business competition.

Therefore, the primary purpose of this study is to use the idea of "BPR, Queueing Theory, and Process Value (PV)" to develop a "Construction Management Process Performance Evaluation (CMPPE)" model shown in Fig. 1. Using CMPPE, construction company can systematically identify and define the major procedural categories of construction management. Further aims are as follows: Concept derived from the Queueing Theory is used to analyze the time performance of BPR; Target Attainability Matrix [Cheng, 2003] is applied to quantify the customer satisfaction; and Dividing process effectiveness with process efficiency, the PV is obtained to assess the reengineering results. Finally, precise calculation on the performance value difference after reengineering can assure that the success of reengineering may prevent construction companies from applying new processing without a thorough performance evaluation. This study can serve as a basis from which to execute process reengineering and process performance evaluation.

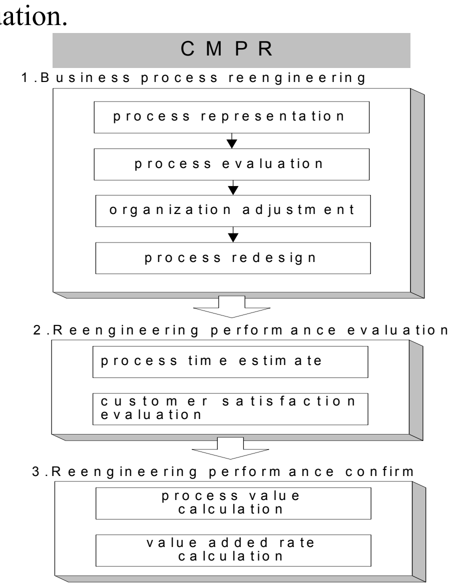

Figure 1. Structure of "Construction Management Process Performance Evaluation (CMPPE)" model

2. BUSINESS PROCESS REENGINEERING

Using Construction Company A as an example, this study is aimed on construction management process performance evaluation that includes Bidding/Contract, Cost estimate/Construction Plan and Procurement/Subcontracting process. Within the Procurement/Subcontracting process, Based on four steps of work in the BPR analysis procedure. The study suggests implementation of Information Technology (IT) and the Internet and Intranet techniques to develop a management information system. Also the study creates case committee with content experience engineers and staff to execute each project for curtail processing time and reduce cross department activity. Furthermore, the study creates decision-making center to support the General Manager for authorizes commitment, recourse distribution and to negotiate with deferent department, reducing obstacle in process operation. Finally, the development of the IDEF0 diagram for Procurement/Subcontracting process is shown in Fig. 2.

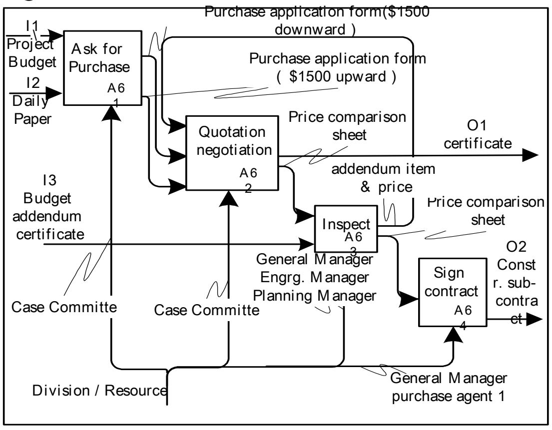

Figure 2. IDEF0 Diagram of Procurement /Subcontracting Process

3. REASSURING PROCESS REENGINEERING PERFORMANCE EVALUATION FACTORS

By interview with top executive and employees, this research defines performance evaluation factors as follows,

Efficiency of process reengineering: difference of operation time length before and after process reengineering

Effectiveness of process reengineering: difference of customer satisfaction before and after process reengineering

The research uses both 'time' and 'customer satisfaction' as indexes of process reengineering performance evaluation, whose framework and steps of evaluation are to be discussed below.

4. PROCESS REENGINEERING TIME FACTOR PERFORMANCE EVALUATION

The entire process, to a business, is like a gigantic queueing system. The followings are steps for process reengineering time factor performance evaluation.

Step 1 Collecting information

Investigate "The interval time between two bidding", " The interval time between two award of contract" and "The interval time between two subcontracting".

Take into account of every activity's operation time and human resource needed in the process, then calculating every activity's operation time per person of former process, define as "Service rate in activity ". Then survey and calculating "Service rate in activity" of each new process.

Step 2 Information analysis

This step is used to check the above information in the goodness-of-fit to insure the information is available to applying in queueing theory model, and to calculate expected value and variance of collected information, see Table 1 and 2.

Step 3 Selecting queueing theory model

Based on the result of the statistical test, the research has found that each arrival rate of bidding and service rate in activities does not show any possible distribution. With arrival rate of GI/G/1, queueing theory model's arrival rate and service rate distribution can be of random of distribution, thus the research adopts GI/G/1 queueing theory model. The arrival rate and service rate of GI/G/1 model can be regarded as independent identical distribution and general distribution.

Step4 Establish queueing theory model

The queueing theory model adopted by this research is a mathematic one emphasized by [Buzacott 1993]。The mathematic model has two major parts, First is the overall operational time(including waiting)in each activity (the summation of both time that project pending for implementation and being implementated) as shown in equation (1). The accumulation of each operational time thus lead to average overall processing time. Second is the operation departure rate (shown as squared coefficient of variation) shown in equation (2). Because operation departure rate is often the arrival rate of the next activity, squared coefficient of variation in interarrival stages is need to be calculated.

$$E[T] \le \frac{\rho(2-\rho)C_a^2 + \rho^2 C_s^2}{2\lambda(1-\rho)} + E[S] \ldots\ldots\ldots\ldots..(1)$$

$$C_d^2 \ge (1-\rho\ )^2 C_a^2 + \rho^2 C_s^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

where E[T] : Expected value of overall processing time in a activity per project; ρ : (Expected value of processing time in a activity per project)/ (Expected value of interval time between two project); C_a^2 : Squared coefficient of variance of interval time between two project (arrival rate; equal to previous activity's departure rate); C_s^2 : Squared coefficient of variance of each operational time in a operation; λ : 1 / (Expected value of interval time between two project); E[S] : Expected value of processing time in a activity per project; C_d^2 : Squared coefficient of variance of interval time between two project (departure rate).

Step5 Calculate overall processing time of both new and old process.

Coding the queueing theory model program then input data of both new and old processes into the program, and calculate the overall processing time of each process. Procurement/Subcontracting process is taken as an example in the research to explain the following steps.

a. Establish operational process model based on represented process.
b. Input "Expected value and Variance value of the interval working hours between two award of contract" as shown in table 1 and "Expected value and Variance value of Service rate in activity" into program.
c. Output average time of each process : the program calculated the overall processing time in first activity by Eq.1 and departure rate of first activity(Squared coefficient of variance of interval time between two project) by Eq.2. Assume the departure rate of first activity is equal to next activity's arrival rate. The program can calculate the overall processing time of next activity by Eq.1. By this procedure, the overall processing time of each activity in the process can be estimated.

The overall processing time of both new and old processes can be known by cumulating all activities' overall processing time in the process.

Step6 Time performance evaluation before and after reengineering.

Make a comparison in processing time between before and after reengineering. The shrinkage of overall processing time of the new process is obvious shown by Table 3.

5. PERFORMANCE EVALUATION OF PROCESS REENGINEERING WITH CUSTOMERS SATISFACTION FACTOR

Using the concept of Quality Function Deployment (QFD) method, this study transforms company policy and customer concerns into targets of process. This study is applying the method of "Target Attainability Matrix" in examining the attainability of target as an important source for measuring the effectiveness of process. The main steps of the evaluation process are described as follows.

Step1 Definition of the Operational Strategy and Policy of Company

A company's operation can be viewed as a serial composition of processes. Each process has targets to achieve. In this framework, it is essential to combine company policy with targets of each process in order to accomplish company policy. Before analyzing process, a company's operation policy must first be defined. Inclusion of policy demands when setting process targets is also essential to the realization of a company's operation policy and its customer needs.

Step2 Identification of the Internal and External Customers of the Process

In the process operation, the output of the previous process is the input for the next. This means that the follow-up process will check the result of the preceding process. Based on this condition, the followings are the definitions of internal and external customers. Internal customers are those who actually participate in the process. External customer are the consumers who accept the final products of the process. The objective of this step is to identify the executor of each operation from the process diagram. The executor is the internal customer of the previous operation. Taking the example of procurement/subcontracting process, the internal and external customers of each process are identified and listed in the 2nd and 3rd columns of Table 4.

Step3. Surveying of Customers' Requirements of Process

Customer's requirements have to be considered when setting process targets. Based on the internal and external customers identified above, the demands of each customer are established and shown in the 4th column of Table 4. Expert's interviews are used to collect customer's requirements in the case of company A for the procurement/subcontracting process.

Step4 Determination of Process Targets

The process must satisfy customer's demands. To satiate customer's demands, the process must have the capability to assign human resource and other related resources to accomplish the necessary tasks. Hence, this step treats customer's demands as input information to determine the targets of process. The identification of process targets are described as follows:

a. Determination of the process targets according to customer demand. Process Targets Deployment (PTD) method developed in this study is used to transform the customer demands into process target. Taking the example of procurement /subcontracting process, the targets of the process as shown on the top of Table 4, are determined based on the PTD analysis.

b. Analysis of the relative importance of process targets. The relative importance of process targets is identified using Relative Importance Weight Evaluation Matrix (as shown in Table 4). In the matrix, customer's demands are listed vertically in the left-hand side and process targets are listed at the top. Based on the relationship between the two, the corresponding number rij (rij: 1, 3, 5) is determined. The higher the value of rij, the more the target elicits customer's demands. Then, considering the emphasis customers place on each demand, represent it as pj (pj: 1~5 points) and fill it in on the right-hand side of the matrix. The degree of emphasis is assessed by questionnaires and interviews. Finally, use equation (3) to calculate the score of relative importance (Wi) of each process target:

$$W_i = \frac{\sum_{j=1}^{m} r_{ij} \times p_j}{\sum_{i=1}^{n} \sum_{j=1}^{m} r_{ij} \times p_j} \quad \text{………..………(3)}$$

where Wi :relative importance weight for process target i; m :the number of customer's demands; n :the number of process targets; i :the ith item of process targets; j :the jth item of customer's demands; rij :the corresponding rating between the ith process target and the jth customer demand, rij =1, 3, 5; pj :the emphasis degree of the jth customer demand; pj =1~5.

The score of process target (Wi) represents the degree of demand satisfaction that the process target delivers to the customer - the higher the score, the higher the satisfaction. Using the case of procurement/subcontracting process as an example, this study conducts interviews with senior managers to complete the Relative Importance Weight Evaluation Matrix for the company. The score of relative importance (Wi) of each process target is calculated as shown in Table 4.

Step5 Analysis of Process Target Achievement

A quantitative method is used to calculate the achievement of each process target that the operational functions complete. Table 5, the Process Target Achievement Matrix (PTAM), illustrates this concept. Taking the case of after reengineering "Procurement/Subcontracting " process as an example, the operation items in process diagram are placed on the left of the table and the process targets and scores of relative importance weight (W_i) are listed at the top of the table. Based on each process target, the attainability of each operation for each process target A_{ik} (A_{ik}: 0~10/10) is evaluated by the senior managers. After completing the A_{ik} evaluation, the Operation Target Attainability, OA_i (OA_i: 0~W_i), obtained from the process activities can then be calculated. The Total Process Attainability (TA) of the targets and the degree of Contribution (C_k) endowed by each operation are also identified. The equations for calculating OA_i, TA and C_k are demonstrated as follows:

$$OA_i = \sum_{k=1}^{g} W_i \times A_{ik} \quad \text{……………..…………(4)}$$

$$TA = \sum_{i=1}^{n} OA_i \quad \text{……………………………....(5)}$$

$$C_k = \sum_{i=1}^{n} W_i \times A_{ik} \quad \text{………………………… (6)}$$

where g: number of process operations; n: number of process targets; OAi: the attainability of ith process target achieved by the process operations; Aik: operation k's attainability of the ith process target; TA: total attainability of process to the targets, TA=0~100; Ck: contribution of operation k.

OAi, TA, and Ck can be used as indices for process evaluation. OAi represents the process attainability of a certain process target - the higher the number the more probable the attainability. TA represents the process' total attainability - the higher the value, the more suitable the operational function related to the process targets. Ck represents the contribution of a certain operation to all process targets - the higher the number, the greater the contribution, which also means the function is more likely to satisfy customer demand.

Step7 Use Customer Satisfaction Comparison Before and After Reengineering

Using the total attainability of process to the targets (TA) to evaluation the customer satisfaction. The TA of the process before and after reengineering are shown in Table 6

6. REENGINEERING PERFORMANCE CONFIRM

Performance is evaluated by "Process Value"[4], which is customer satisfaction achieved with time as unit, as shown in equation (7). Time unit is used to evaluate the speed to achieve customer satisfaction, as business seeks for more efficient way to reach expected goal after reengineering. Therefore, the sooner a goal is reached, the more value a process is added.

According to an investigation in 1993 and 1994, conducted by Gateway Management Consultant Company surveying CEOs, 90% of the recipients believe that when value added rate is over 25%, such performance can be seen as a breakthrough. This research also uses the "Value added rate" as a standard for evaluation value added rate of the process, Table 7 shows the application of equation (8) on processes before and after reengineering. Increase rate of three operational process after reengineering are over 25%; therefore, the performance of BPR in construction company A can be considered as a breakthrough.

Processing value

$$(PV) = \frac{CustomerDemand}{OperationTime} = \frac{\text{Processs Total Attainability(TA)}}{\text{Overall Processing Time of Process}} \quad \ldots\ldots\ldots(7)$$

Value Added Rate=

$$\frac{\text{PV After reengineering - PV Before reengineering}}{\text{PV Before reengineering}} \quad \ldots\ldots(8)$$

7. CONCLUSION

This research can be concluded as follows:

a. Queueing theory is used to evaluate performance of time factor. With statistical calculation, one can explain differences before and after process time for objective analysis.

b. This research uses Process Target Attainability Matrix to analyze performance of customer satisfaction factors, regarding company's expectations and customer's needs as process elements, quantifying the attainability of each operation for each process target and identifying the Total Process Attainability (TF), which provide for the reengineering team to exam customer satisfactions of the new process.

c. The concept of process value can be used specifically to evaluate time efficiency and customer satisfaction achievement. It also serves to evaluate efficiency and effectiveness as reference for further research.

d. This research employes process time factor and customer satisfaction factor as performance evaluation on management process reengineering. It can also be applied to other management processes in construction companies for further research , such as the engineering operational process, the financial and accounting process, as well as the management operational process

e. The established reengineering performance evaluation model of the research is to evaluate reengineering performance of management process in construction companies. It can also be used in future construction engineering life-cycle teams, such as architecture, consulting companies, professional construction management team to implement the process reengineering performance evaluation model.

8. REFERENCES

[Hammer & Champy 1993] Hammer, M. & Champy, J., 1993,"Reengineering the Corporation–A Manifesto for Business Revolution",Harper Business.

[Cheng, 2003]Cheng M. Y. & Tsai M. H., 2003 "Reengineering of construction management process" *J. of Constr. Eng. and Manage.*, 129(3), 105-114.

[Buzacott 1993]Buzacott, J.A. & Shanthikumar, J.G., 1993. "*Stochastic Models of Manufacturing Systems*" Englewood Cliffs, NJ: Prentice-Hall.

Table 1. Expectated value and variace of Construction company A project arrival interarrival working hours.

Bidding project name	Interarrival working hours from previous project
A Parking Lot	--
B Parking Lot	161
C Plant	94.5
D Building	546
E Building	780.5
F Building	322
G Building	791
H Building	507.5
Expectated value(hours)	457.5
Variance(hours)	77320.83

Table 2: "Service rate in activity"for Procurement/Subcontracting process（unit：hr/person）

Name of Activities	Expectated value	Variance
Collect/Delete Namelist	1.63	0.34
Fill purchase form	220.76	1449.08
Apply for permission	100.75	353.07
Search Subcontractors	124.13	171.84
Collect/Delete Namelist	0.01	0.00
Evaluate Subcontractors	0.01	0.00
Request Quotation	45.75	119.36
Quotation negotiation	25.25	15.36
Quotation negotiation (trivial jobs)	24.38	29.98
Apply for permission (trivial jobs)	18.75	56.21
Inspected by Planning Manager.	103.75	341.07
Inspected by Engr. Manager.	0.01	0.00
Inspected by G.M.	39.38	54.27
Sign contract	23.00	25.43

Table3、Average overall operational time of process

Processing time / process	Old process (hours)	New process (hours)
Bidding/Contract	332.13	214.10
Cost estimate/Constr.Plan	724.45	201.38
Procurement/Subcontracting	71.74	33.65

Table 6 TA of the process before and after reengineering

TA / Process	TA before BPR	TA after BPR
Bidding/Contract	62.1	89.3
Cost estimate/Constr.Plan	63.9	87.6
Procurement/Subcontracting	57.2	94.1

Table 7 PV of the process before and after reengineering

Process Value / Process	PV before BPR	PV after BPR	Value Added Rate
Bidding/Contract	1	2.66	1.66
Cost estimate/Constr.Plan	1	4.27	3.27
Procurement/Subcontracting	1	2.55	1.55

Table 4. Relative Importance Weight Matrix for Procurement/Subcontracting Process

Customer Demands / Target components			Planning			Bidding		Awarding				
			Accurate takeoff quantity	Reasonable purchase schedule	Forecast possible outburst situation	Vendors evaluation standards	Thoroughness/ completeness of bidding content	Perceive market price	Price negotiation skill	establish faultless contract	well controlling of purchase budget	Emphasis degree(p)
External	Owner	Purchase quality matching requirements		3		5	3			3		5
	Subcontractors	Accurate subcontracting data	3				5					4
		Reasonable profit						5	3		3	3
Internal	Purchase unit	Definite purchase schedule	3	5	3							5
		Accurate vendor information				5		1				4
		Clear price quote	3		1		5				5	3
	Financial unit	Low purchase cost	3					5	5		5	5
		Vendor with sound financial condition				5					3	3
	Engineering unit	Purchase matches time effectiveness		5	5					1		5
		Vendor's willingness to cooperate				5	3					4
		Correct quantity of purchase	5	3	3						1	5
		Purchase quality matching requirements				5	3			3		4
		Competent and skillful vendors				5	3			3		4
		Clear purchase contracts								5		3
			76	80	58	120	86	44	34	59	63	620
			12.3	12.9	9.4	19.4	13.9	7.1	5.5	9.5	4.1	

r_{ij} W_i P_j

Table 5. Process Target Achievement Matrix for Procurement/Subcontracting Process

Operation node	Name of Operation	Target components: Planning			Bidding		Awarding				contribution of operation(C)
		Accurate takeoff quantity	Reasonable purchase schedule	Forecast possible outburst situation	Vendors evaluation standards	Thoroughness/completeness of bidding content	Perceive market price	Price negotiation skill	establish faultless contract	well controlling of purchase budget	
	Wi	12.3	12.9	9.4	19.4	13.9	7.1	5.5	9.5	10.2	
A611	Purchase Planning	9/10	9/10								22.6
A612	Fill purchase form		1/10								1.3
A613	Apply for permission										0.0
A6211	Search Subcontractors					1					13.9
A6212	Collect/Delete Namelist				3/10						5.8
A6213	Evaluate Subcontractors				7/10						13.5
A6214	Request Quotation						8/10				5.7
A6215	Quotation negotiation						2/10	5/10		2/10	6.2
A6221	Quotation negotiation (trivial jobs)							5/10		2/10	4.8
A6222	Apply for permission (trivial jobs)			1							9.4
A6223	Inspected by Planning Div.										0.0
A6224	Inspected by Engr. Div.	1/10									1.2
A63	Inspected by G.M.										0.0
A64	Sign contract								1		9.5
	Target attainability(OA)	12.3	12.9	9.4	19.4	13.9	7.1	5.5	9.5	4.1	94.1

A_{ik} C_k OA_i TA