Expert Systems with Applications 38 (2011) 3267–3279

Contents lists available at ScienceDirect

Expert Systems with Applications

journal homepage: www.elsevier.com/locate/eswa

Service improvement by business process management using customer complaints in financial service industry

Chong Un Pyon [a,1], Ji Young Woo [b,*], Sang Chan Park [c,2]

[a] Department of Industrial and Systems Engineering, KAIST, 373-1 Kusung-Dong, Yusong-Gu, Daejeon 305-701, South Korea
[b] Eller College of Management, The University of Arizona, 1130 E. Helen Street, Tucson, AZ 85721, United States
[c] College of Business Administration, Kyung Hee University, 1 Hoegi-dong, Dongdaemun-gu, Seoul 130-701, South Korea

ARTICLE INFO

Keywords:
Business process management (BPM)
Customer complaints management system (CCMS)
Voice of the Customer (VOC)
Call centers
Financial service industry

ABSTRACT

In financial service industry, service improvement should be considered from process viewpoint and customer viewpoint because the value creation is ultimately linked with internal business processes on the back office and customers are involved as a co-producer of value. In this perspective, customer complaints through call centers are adequate to support the analysis for service improvement in financial service industry. In this study, we propose a web-based decision support system for business process management employing customer complaints, namely Voice of the Customer (VOC), and its handling data for service improvement. It involves VOC conversion for data enrichment and includes analysis of summarization, exception and comparison. The proposed system is evaluated on a major credit card company in South Korea.

© 2010 Elsevier Ltd. All rights reserved.

1. Introduction

As a labor force of service industry has grown significantly and a portion of service industry in GDP has increased, services are increasingly important to the economy. With this shift to focusing on services, the studies for service improvement are increasing. However, the difference of characteristics between products and services makes it difficult to improve service quality as follows:

- *Intangibility and simultaneity of services*: For the service improvement, it is required to monitor and measure results of service. Results of service are expressed as customer satisfaction or dissatisfaction, which is hard to get information about.
- *Customer involvement in services*: The role of customers as co-producer of service values has been highlighted (IBM Almaden Services Research Reports, 2006). Customers are both the inputs and the source of innovation to the service process. Service quality should be addressed from the customer-oriented viewpoint. Customers' collaboration is required for service improvement.

In addition to these general differences, there exists a problem for service improvement in financial service industry. Service is claimed to be a process that creates benefits by facilitating a change in customers, their physical possessions, or their intangible assets (Wikipedia, 2009). In case of financial service industry such as a credit card service, the service is a series of activities of enabling customers to carry on credit card transactions. These companies create values by supporting customers to manage their financial assets. In this case, the value creation is ultimately linked with internal business process on the back office.

- *Close relation with business process management*: When the state of an internal business process is not normal or when it is not the same with a customer's awareness, a negative value gap arises, which means the difference between service providers' intention and service recipients' expectation. In financial service industry, the negative value gap is related with inadequate states of internal business processes rather than the transaction itself.

Beyond supporting transactions, internal business processes on the back office should be managed to provide all-inclusive services and optimized to make a positive value gap as much as possible. This is can be why business process management (BPM) is issued in service science, management, and engineering (SSME), which is the study of service systems aimed at improving them (Hidaka, 2006; IBM Almaden Services Research Reports, 2006).

However, most of BPM pakages do not support sufficiently diagnoses (Weske, van der Aalst, & Verbeek, 2004). So far, they focus mainly on process design, configuration of a process aware information system such as a workflow management system, and

* Corresponding author. Tel.: +1 520 370 3309.
E-mail addresses: pcu@kaist.ac.kr (C.U. Pyon), jywoo@kaist.ac.kr (J.Y. Woo), sangchan@khu.ac.kr (S.C. Park).
[1] Tel./fax: +82 42 350 5920.
[2] Tel.: +82 2 961 0494; fax: +82 2 961 0515.

0957-4174/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.eswa.2010.08.112

process enactment based on ICT infrastructures. They build up the environment where internal processes are automatically monitored about the delivery time and the cost. For the service improvement, it should be considered not only performance data for each business process but also non-measurable contents such as customer responses. To produce reasonable and valuable analysis results for service improvement, companies require a conceptual model that describes the substance of problem from process side and customer side.

Therefore, we propose a business process management framework that employs customer complaints through call centers for business process analysis. The customer complaints are called Voice of the Customer (VOC). As VOC tells what customers think about companies' current offerings and VOC is highly related to internal business processes, it is adequate to support the analysis for service improvement in financial service industry. Because VOC itself is expressed by customers' words, transforming the VOC for analytic usefulness is a prerequisite for analysis. And then, a practical methodology for analysis is presented for managerial implications. In this VOC conversion and analysis, we employ traditional concepts of quality management. To demonstrate results, we introduce a case of a credit card service company in South Korea and build a web-based system embedding the proposed methodology.

2. Literature review

2.1. Business process management (BPM)

Many business excellence models, such as European Foundation for Quality Management (EFQM) and Malcolm Baldrige National Quality Award (MBNQA), and international standards such as the ISO 9001 emphasize the importance of process orientation. There have been many terms used for process-oriented concepts including "process improvement", "process-reengineering", "process redesign" and so on. Although business process re-engineering (BPR) has been highly focused until recently, it has failed to deliver the expect results (Harrington, 1998; Huffman, 1997). In this situation, business process management (BPM) is introduced as the approach to "avoid the tendency to fall prey to the hype of a new management fad" (DeToro & McCabe, 1997). Elzinga et al. define BPM as a systematic, structured approach to analyze, improve, control and manage processes with the aim of improving the quality of products and services (Elzinga, Horak, Lee, & Bruner, 1995). Zairi describes BPM as "a structured approach to analyze and continually improve fundamental activities such as manufacturing, marketing, communications and other major elements of a company's operations" (Zairi, 1997). In his attempt to explain BPM, BPM has to be governed by the following rules; activities mapping and documentation, a focus on customers, measurement activities to assess the performance of each process, a continuous approach to optimization, inspiration by best practices for superior competitiveness, and an approach for culture change.

While many people consider BPM to be the 'next step' after the workflow wave of 1990s, BPM is above workflow management. It supports business processes using methods, techniques, and software to design, enact, control and analyze operational processes involving humans, organization, applications, documents and other sources of information. Weske et al. describe the relationship between workflow management and BPM using the BPM life cycle as shown in Fig. 1 (Weske et al., 2004); processes designs, implementation by configuring a process aware information system (e.g., a workflow management system), execution of operational business processes using the configured system in enactment phase and analysis of operational processes to identify problems and find possible improvement in diagnosis phase. The traditional workflow management system focuses the lower half of the BPM life cycle. As results, there is a little support for the diagnosis phase. Few systems support the collection and interpretation of real-time data (Weske et al., 2004).

2.2. Voice of the Customer (VOC)

According to both academic and practitioner's literature, research methodologies used for analyzing and utilizing VOC vary with application domains. Until now, a great deal of research on the VOC analysis deployed VOC in understanding customer requirements for new product developments from conceptual designs through to manufacturing. These applications use VOC as inputs to Quality Function Deployment (QFD) for formalizing processes of listening to customers. Griffin and Hauser explained that industry practices have used 'Voice of the Customer' as customer input for strategic and operational decisions (Griffin & Hauser, 1993). From a viewpoint of total quality management and Baldrige Award criteria, the use of VOC with each priority helps to identify customer needs and ultimately accomplishes the quality based on customers. Haar et al. developed an approach to fine-tune the product or service offering through incorporating VOC into the design of new products or services in a technology-based multinational company (Haar, Kemp, & Omta, 2001).

There also exist several applications other than new product design and development in manufacturing. Radharamanan and Godoy used QFD to deploy VOC in understanding customer requirements and to include them in continuous improvement of service quality in a health care system (Radharamanan & Godoy, 1996). Johnston claimed that complaint management should result in not only customer satisfaction but also operational improvement and better financial performance (Johnston, 2001). Bosch and Enríquez explained that companies can design a process and continuously improve toward service excellence by successfully implemented CCMS (customer complaints management systems) that extracts knowledge from the customer complaints (Bosch & Enríquez, 2005).

3. Methodology

3.1. The present status of VOC management

VOC over diverse receipt channels including automatic response service (ARS), and Internet homepages are put together to customer support representatives (CSRs) on call centers. VOC are directly handled by CSRs on contact points or transferred to the internal department in charge if the VOC handling requires approvals of the other departments or inquiries to the other institutions. On the back office, the transferred VOC is not monitored or tracked about the handling. Therefore, we suggest the framework of VOC-handling as depicted in Fig. 2. It has following features:

(1) According to the type of VOC, required posterior processes should be mapped to the persons in charge.
(2) Customer information, received VOC details, and handling information are recorded in a data warehouse and shared for the status of transferred VOC.
(3) From the initial transfer to the end of the VOC-handling, every intermediate processes should be managed. Companies should take measurements such as duration times, costs, and amounts of resources, and so on. We record these business performance measurements on family of measures (FOM) database.
(4) Companies analyze the data in VOC data warehouse and FOM database, and derive information about the bottleneck and value-added processes.

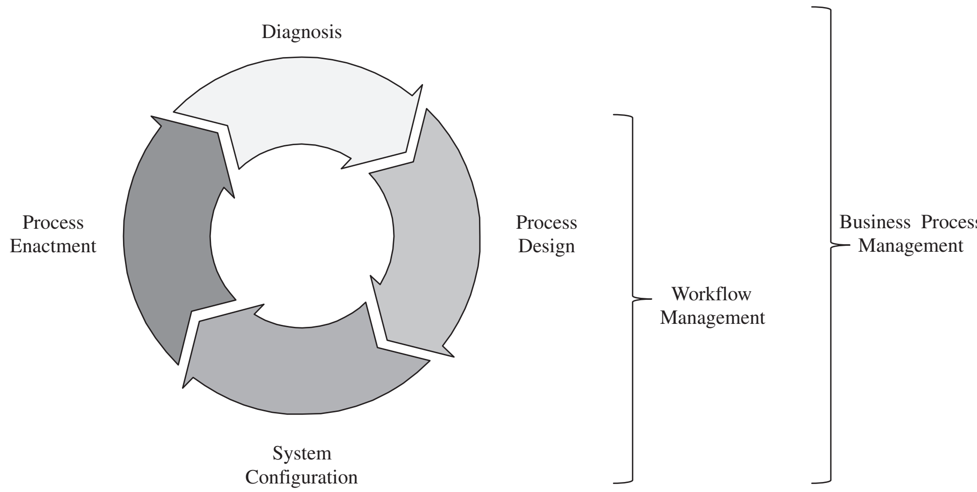


Fig. 1. The relationship between workflow management and business process management.

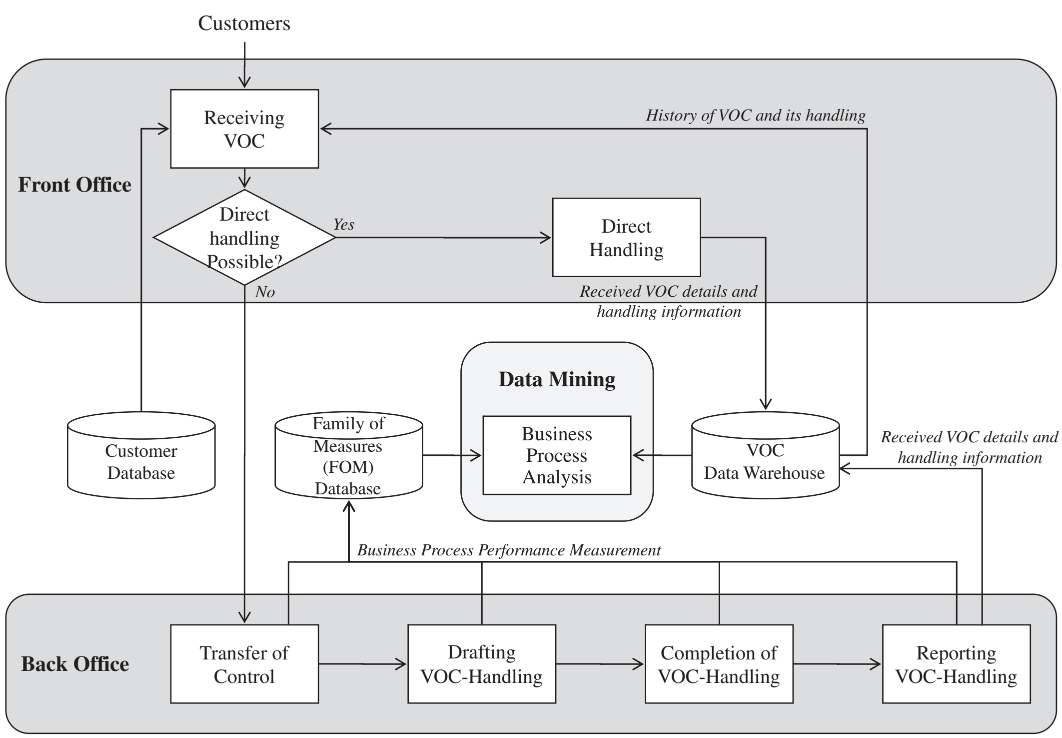


Fig. 2. Framework of VOC management.

3.2. VOC conversion for data enrichment

For each incoming VOC, a company applies a code structure for registration. The code structure usually takes a form of tree structure to hierarchically classify the details of VOC. The company categorizes VOC into several classes and gives a number for each class, which is subdivided into the lower classes. The number of levels depends on the variety of VOC. Each VOC is recorded by a combination of several digits that represents the class number per each level.

As the circumstances of service industries endlessly change, the VOC code structure is periodically updated. However, when a new type of VOC is occurred, the new code is usually added to the most related class for managerial usefulness and the intuitive understanding of CSRs. When the existing type of VOC is exterminated, code overlapping or code splits are occasionally occurred. It is easy for the VOC code structure to be event-oriented and lose the consistency per hierarchy level.

So, the analysis for VOC occurrence per code without any code transformation is not enough for the business process improvement. For the in-depth analysis to identify the reality of problem, time analysis for VOC occurrence should be statistically summarized with code conversion. However, because the VOC code structure should be easy for CSRs to understand, it has to have dual modes with the transaction-oriented structure for CSRs and the analysis-oriented structure.

The analysis-oriented structure should be a data model that describes the substance and characteristics of problems and can help to prioritize emergency of problem-solving for business process improvement. In order to produce practically effective analysis results for decision making of BPM, we suggest a multi-dimensional VOC code structure with data cube.

3.2.1. VOC data cube

For analysis of multi-dimensional data, on-line analytical processing (OLAP) is a method to support decision making where raw data needs to be analyzed at different levels of statistical aggregation (Codd et al., 1993). Gray et al. define the ‘‘data cube’’ operator by extending SQL to include new types of aggregation operators (Gray, Bosworth, Layman, & Pirahesh, 1995). In OLAP, the data cube has been widely accepted as the underlying logical construct of data warehouses.

The data cube contains *dimensions* and *measures*. Fig. 3 shows the basic data cube with three dimensions i_0, i_1, and i_2 and its aggregated views over all combinations of dimensions. The 0-dimensional data cube is a point. The one-dimensional data cube is a line with a point. The two-dimensional data cube is a cross tabulation, a plane, two lines, and a point. The three-dimensional data cube is a cube with three intersecting 2D cross tabs. The dimension serves an axis to form a data cube. The set of attributes form a dimension schema. Points or cells of data cube contain measures or numeric attributes based on a set of dimensions. As dimensions often form a hierarchy, it is allowed to have different levels of granularity in the data warehouse.

The 1st dimension of proposed VOC data cube is the business process. As internal business processes may not be the same with customer-perceived external processes, the actual business process and their flows should be identified and mapped with VOC. Companies should understand what to do, not where to do.

The 2nd dimension is the primary cause of VOC. To find the remedies for problematic processes, companies should understand what makes problems in the process. To discover the causes, we adapt the concept of the Cause and Effect Diagram (known as fishbone diagram or Ishikawa diagram) from total quality management (TQM). It is used to explore all the potential or real causes (or inputs) that results in a single effect (or outputs). It helps to search for areas where there may be problems and compare the relative importance of different causes (King, 1989). Causes are arranged into four major categories. While these categories can be anything, 4 M of manpower, methods, materials, and machinery is often used. We modify 4 M into 5 M in Table 1. It is useful to prioritize the resources for process improvement.

The 3rd dimension is the characteristics of VOC. To differentiate the necessity or urgency of process improvement, we identify the characteristics of VOC by applying Failure Modes and Effect Analysis (FMEA). FMEA is a series of systematic activities intended to recognize and evaluate the potential failure modes of goods or services and their effects. Because FMEA classifies the types of failure modes, which is the reason of VOC occurrence, companies could reduce the chance of potential failure modes occurring (King, 1989; Garvin, 1988). Table 2 shows the types of failure mode error and the examples. For example, inquiries about new goods cannot be the same with complaints caused by the transaction delay.

The set of measures of VOC data cube are about VOC handling and process performance to apply VOC analysis results into BPM. We design the family of measures (FOM) as shown in Table 3.

Table 1
Modified 5 M.

5 M	Description
Man-customer	The VOC just originated from customers' peculiarity. It is a situation of incapable of improvement
Man-employee	The employees' mistakes or errors cause the VOC. The employee training or education is required
Materials	The characteristics of goods or services cause the VOC. The examination for initial design or adjustment is required
Methods	The processes themselves cause the VOC. So the process improvement or process innovation is required
Machinery	Machinery means the affiliated corporations or support agencies. Companies should clear up their authorities and responsibilities

Table 2
Types of failure mode error and the examples.

Type of error	Description	Example
Information validation omission	There are no checks to catch incorrect or incomplete information items	– Inquiries – Confirmations
Process validation omission	There is no mechanism for catching or correcting an incorrectly applied process	– Erroneous notices – Insufficient notices
Reception omission	There is no mechanism for checking that an information item is received by a process after being sent by another process	– Application errors – Application omissions
Transmission omission	There is no mechanism for checking that an information item required by a process has been sent by another process	– Transaction delay
Process exception	A process is not designed to handle a possible situation within its scope	– Discontents

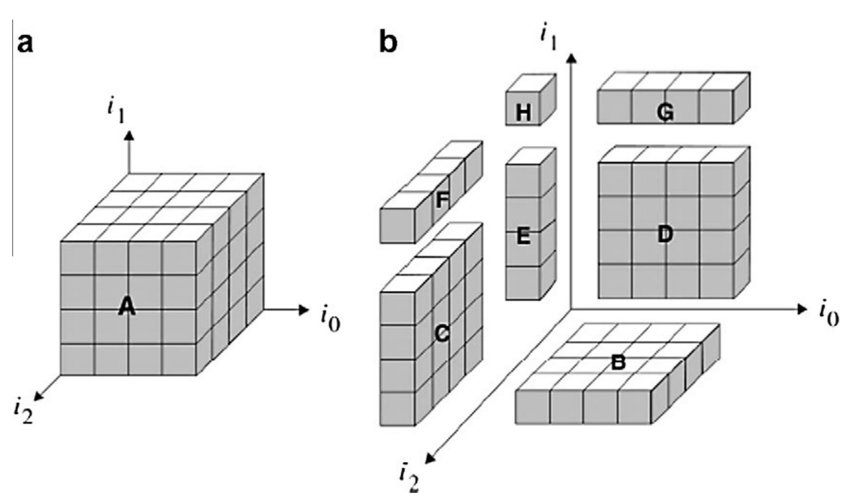


Fig. 3. Basic data cube. Example 3D data cube A showing: (a) base data cube A with three dimensions i_0, i_1, and i_2 and (b) aggregated views (B–H) computed over all combinations of dimensions of A.

Table 3
Family of measures (FOM).

Measure	Description
Quantity	The number of the VOC occurrence: Both the absolute quantity and the relative quantity should be considered. The relative quantity is estimated by normalization. According to the managerial analysis purpose, companies can select the various bases for normalization, for example, the number of subscribers per product, the number of subscribers per district
Cost	The amount of money to handle the VOC: Because some of VOC arouses the loss such as the compensation payment, companies should reduce the occurrence of VOC with heavy cost
Delivery	The speed of the VOC handling: Usually companies measure only the duration time from the VOC receiving to the VOC handling completion. However, the intermediary processes should be measured; receiving, notification of transfer-of-control (if the VOC is transferred), drafting VOC-Handling, completion of VOC - handling

VOC handling data reflect whether the received VOC is directly handled or transferred, or when the transferred VOC is completely handled, and so on. It informs the output or performance of business processes.

3.3. Framework of VOC analysis

We propose a framework of VOC analysis for business process improvements as shown in Fig. 4. VOC conversion module performs a sort of feature construction from a knowledge discovery in database (KDD) viewpoint. There exist too many processes to be monitored and eventually too many combinations of VOC data cube dimensions. To standardize and automate the detection of problematic processes, we propose three kinds of modules; summarization, exception, and comparison (SEC) module. It is revised from the concept of description tasks of Shaw et al.; summarization, discrimination, and comparison (SDC) (Shaw, Subramaniam, Tan, & Welge, 2001). On the summarization module, various VOC data cubes are generated by the combination of VOC dimensions and measures. Among these cubes we select distinct performance of business process and entitle distinctive patterns (DPs) in consideration of the unstableness that is derived on the exception module. On the comparison module, the relations between VOC data cubes are examined for prediction of VOC occurrence.

3.3.1. Summarization module

In the summarization module, the measures of VOC data cube are aggregated and summarized. The Fig. 5 shows the feasible combinations of dimensions and measures. For time series analysis, the temporal dimension such as day, week, month, and quarter are additionally included. VOC data cubes are generated for processes at all levels by the repetition of drill down. We use descriptive statistics such as the frequency, the mean, the variance, the maximum and so on for summaries per period.

The results are shown as the form of Pareto chart in respect to various measures. We will illustrate with the data listed in Table 4. The summarization results, which are one-dimensional cubes, are displayed with respect to each measure in Fig. 6. As we consider the total number of VOC occurrence (quantity) and the cost, we select the process 2, 4, 5 and 6 as the objects of drill-down analysis. We can register these processes as DP.

Among these processes we give an example of drill down analysis with process 6. We construct two-dimensional data cubes for the VOC primary causes of process 6 as shown in Fig. 7.

With regard to the total number of VOC occurrence (quantity) and the total cost, the major problem of VOC of process 6 can be seen as the man-customer. However, if the primary cause of VOC

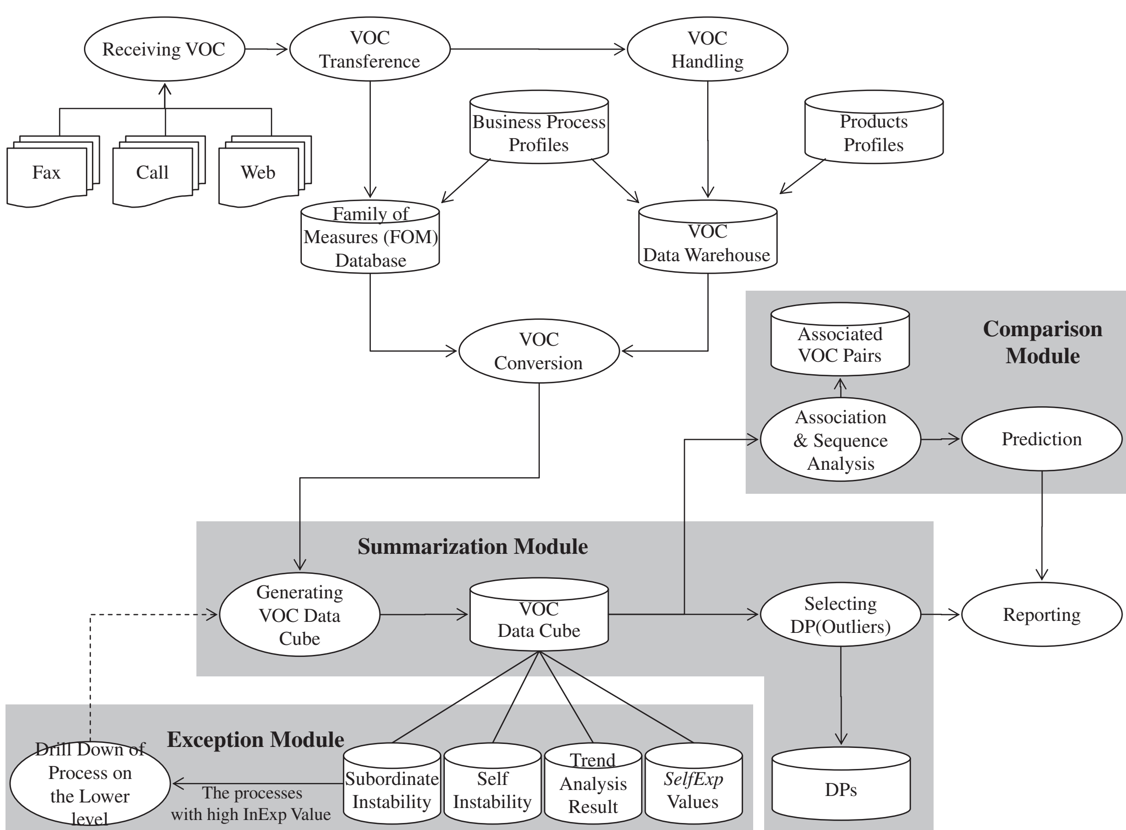


Fig. 4. A framework of VOC analysis.

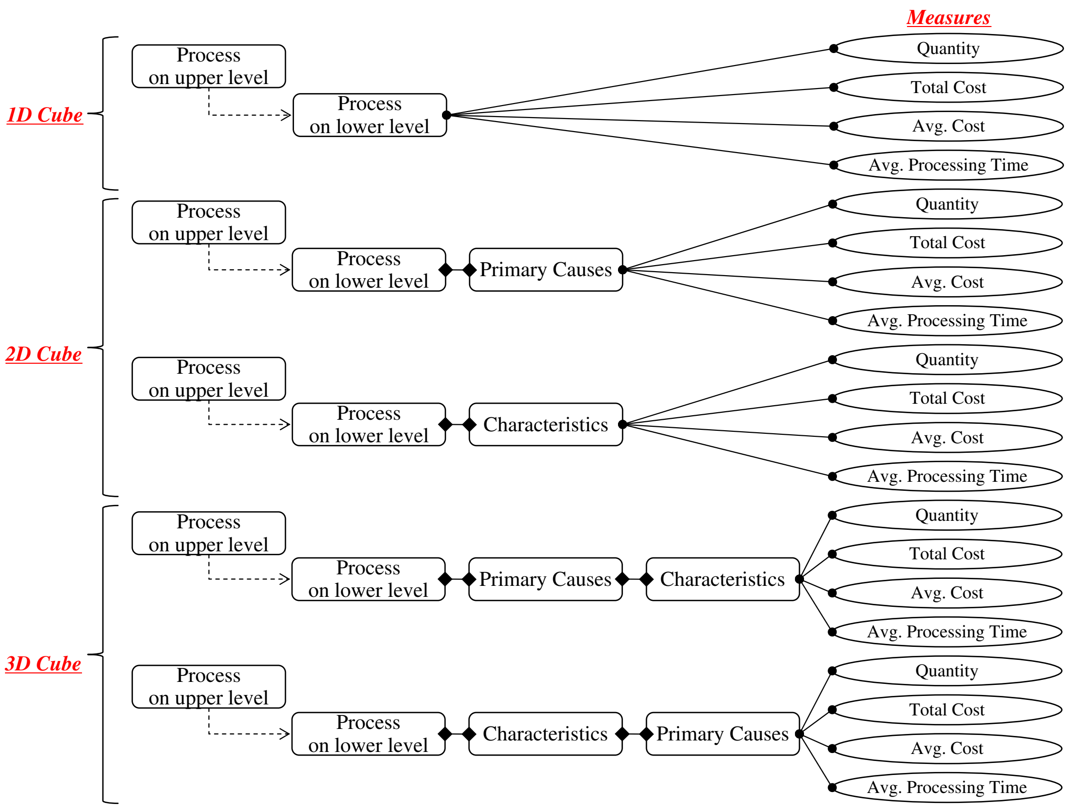


Fig. 5. Combinations of dimensions and measures.

is the man-customer, the VOC are caused by customers' allergies and there is no appropriate solution. On the other hand, it is necessary to improve the method on process 6 with regard to the average cost. Although it is not frequently occurred and the total cost is small, the average cost is relatively high. So we can register this two-dimensional data cube in Fig. 7c as DP. The result of further drill down is displayed in Fig. 8. This three-dimensional data cube can be registered as DP and it can be reported that the process 6 requires the additional activity of information checking.

As the number of processes increases, it is required to automate selection of DP. Usually, the managers consider the scale of entire business processes and then determine the number of automatically filtered DP per each process level. It is supported by the exception module. However, there always exists a manual part of managers who select the urgent DPs, investigate how to improve and make in-depth reports periodically.

3.3.2. Exception module

Although Pareto charts in summarization module are useful to distinguish the "vital few" from the "trivial many" problems, it gives information only about a snapshot of VOC. Information such as VOC fluctuations on a series of snapshot is not gained. Even if a sub-process at very low level shows an unusual behavior, it may not be identified by the cancellation of amount of other processes. Therefore, the exception modules is necessary for two reasons: (1) to identify the unstableness of VOC occurrence patterns for consecutive periods and (2) to identify the abnormal patterns at any level of aggregation. We intend to find exceptional performances with outlier detection method.

While there is no single, generally accepted, formal definition of outlier, Hawkins' definition is well quoted: "an outlier is an observation that deviates so much from other observations as to arouse suspicions that it was generated by a different mechanism" (Hawkins, 1980). We revise a discovery-driven exploration method of OLAP data cubes proposed by Sarawagi et al. which is suitable for large search space (Sarawagi, Agrawal, & Megiddo, 1998). The applied method employs pre-computed indicators of exceptions. The indicators proposed by Sarawagi et al. are the degrees of "surprise" that show how anomalous a quantity in a cell is with respect to other cells. The surprise value of a cell is a composite of three values, which capture surprise values from three viewpoints:

(1) Relative to other cells at the same level of aggregation (*SelfExp*),
(2) The degree of surprise somewhere beneath the cell in case of drill down (*InExp*), and
(3) The degree of surprise for each drill down path from the cell (*PathExp*).

Among these three values, we exclude *PathExp* because our outlier search always starts at business processes and the direction of search path is determined by business processes.

Firstly, we apply *SelfExp* to detect outliers at a static time slot. For a value $y_{i_1 i_2 \cdots i_n}$ in a cube C at position i_r of the rth dimension d_r $(1 \leqslant r \leqslant n)$, we define the anticipated value $\hat{y}_{i_1 i_2 \cdots i_n}$ as follows:

$$\hat{y}_{i_1 i_2 \cdots i_n} = \mu_{i_1 i_2 \cdots i_n} + c\sigma_{i_1 i_2 \cdots i_n}, \quad (1)$$

$$\mu_{i_1 i_2 \cdots i_n} = E(Y_{i_1 i_2 \cdots i_n}), \quad (2)$$

$$\sigma^2_{i_1 i_2 \cdots i_n} = var((Y_{i_1 i_2 \cdots i_n}) = \left[E\left(Y_{i_1 i_2 \cdots i_n} - E\left(Y_{i_1 i_2 \cdots i_n}\right)\right)\right]^2. \quad (3)$$

The absolute difference between the actual value and the anticipated value is termed as the residual of the model.

$$r_{i_1 i_2 \cdots i_n} = |y_{i_1 i_2 \cdots i_n} - \hat{y}_{i_1 i_2 \cdots i_n}|. \quad (4)$$

Thus, we call a value an exception if the standardized residual, defined as

Table 4
Data samples of summarization.

VOC Registration no.	Process no.	VOC primary cause	VOC characteristics	Cost ($)	Processing time (Day)
1	3	4	4	40	0.4
2	2	5	3	20	2
3	6	1	4	30	0.8
4	5	1	4	20	1.6
5	3	2	5	30	0.8
6	5	1	2	40	1.6
7	6	5	1	30	0.8
8	4	4	2	10	1.2
9	1	1	2	10	1.6
10	6	1	2	10	0.4
11	2	5	4	40	1.2
12	5	3	3	10	1.2
13	4	4	1	10	1.6
14	2	3	2	20	0.4
15	1	5	5	20	0.8
16	3	4	2	10	1.6
17	5	4	4	40	2
18	6	4	4	40	1.2
19	6	3	3	10	1.2
20	1	2	4	40	0.4
21	1	2	4	30	1.6
22	6	3	4	20	0.4
23	3	5	2	30	0.4
24	5	4	2	10	0.4
25	6	1	1	10	1.2
26	5	1	4	40	1.2
27	6	4	4	20	0.8
28	5	3	4	20	1.6
29	5	5	3	40	0.4
30	4	3	3	40	0.4
31	6	5	5	10	2
32	4	2	4	30	2
33	5	4	5	10	1.2
34	6	3	4	40	0.8
35	2	1	1	10	1.6
36	1	5	4	20	1.6
37	2	1	4	20	2
38	5	5	2	40	1.2
39	6	1	5	10	1.2
40	7	2	3	30	0.8
41	2	1	1	10	2
42	2	3	5	40	1.2
43	1	2	2	10	2
44	5	2	1	40	0.8
45	5	2	5	40	0.4
46	2	3	4	30	1.6
47	6	2	2	20	0.4
48	6	4	4	30	2
49	2	4	3	20	1.2
50	1	4	2	30	0.8
51	7	2	4	10	0.8
52	7	2	3	20	2
53	6	1	2	10	1.6
54	7	4	4	30	1.6
55	5	4	4	30	2
56	6	4	3	40	2
57	7	3	4	20	1.2
58	6	5	1	30	1.6
59	7	4	3	40	0.8
60	1	4	2	30	1.2
61	7	1	1	20	2
62	6	5	5	20	1.6
63	4	5	3	20	0.4
64	3	3	4	10	1.2
65	3	3	4	10	1.6
66	4	3	3	40	1.6
67	4	3	1	10	0.8
68	6	1	4	40	1.6
69	5	2	4	10	0.8
70	6	1	4	40	0.4
71	1	4	2	30	1.2
72	3	3	4	10	2

Table 4 (*continued*)

VOC Registration no.	Process no.	VOC primary cause	VOC characteristics	Cost ($)	Processing time (Day)
73	3	1	3	30	0.4
74	7	4	5	40	0.8
75	7	5	2	30	1.6
76	5	3	3	40	1.6
77	1	3	2	40	1.2
78	4	2	1	30	0.8
79	3	4	3	20	0.4
80	5	5	3	30	0.4
81	7	3	3	10	1.2
82	3	5	4	20	0.4
83	5	1	4	40	0.8
84	6	5	3	10	2
85	4	5	4	20	1.2
86	4	5	4	40	1.6
87	2	5	1	30	0.8
88	2	2	2	20	2
89	4	5	3	40	0.4
90	6	3	4	10	0.8
91	7	4	5	40	2
92	2	1	5	40	2
93	6	3	4	10	2
94	3	3	3	30	2
95	4	2	4	40	1.2
96	1	4	4	20	1.6
97	2	4	2	40	1.2
98	3	5	1	10	0.4
99	6	3	2	10	1.6
100	7	1	1	30	0.8

Notes:
VOC Primary Cause Column.
1 – Man-customer, 2 – man-employee, 3 – materials, 4 – methods, 5 – machinery.
VOC Characteristic column.
1 – Information validation omission, 2 – process validation omission, 3 – reception omission, 4 – transmission omission, 5 – process exception.

$$s_{i_1 i_2 \cdots i_n} = \frac{|y_{i_1 i_2 \cdots i_n} - \hat{y}_{i_1 i_2 \cdots i_n}|}{\sigma_{i_1 i_2 \cdots i_n}} \tag{5}$$

is higher than some threshold t_1 and then the value $y_{i_1 i_2 \cdots i_n}$ is reported as DP. As we use $t_1 = 2.5$ corresponding to a probability of 99% in the normal distribution, the value of t_1 is determined by manager and then the anticipated value $\widehat{y}_{i_1 i_2 \cdots i_n}$ plays a role of the upper control limit (UCL). If there is no exception, the case of maximum $s_{i_1 i_2 \cdots i_n}$ is reported as DP. In this manner, we apply the standardized residual as the *SelfExp* value to select DP automatically.

Secondly, we propose the pre-computed indicators, namely *Self-Instability index* to detect outliers at dynamic time slots. It examines whether the VOC occurrence patterns are stable along the time axis and helps to identify outliers for consecutive periods. It is proposed to complement the weakness of trend analysis. In trend analysis that evaluates the slopes of linear regression curves, only the case of a curve with the positive slope (increasing trend) is reported as a problem. However, even if the occurrence pattern showed extremely up and down pattern, the regression curve could have a negative slope or almost-zero slope. So the trend analysis that reports the case of a curve of positive slope as DP is the prerequisite.

For *Self-Instability index*, we assume that a process is stable when the VOC occurrence patterns are linear including constant increase or decrease as well as a status quo. We define *Self-Instability index* as:

$$InstabilityIndex_{self} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(p_i - MA_i)^2} \tag{6}$$

with p_i equal to the portion of VOC at ith period, MA_i equal to the moving average at ith period.

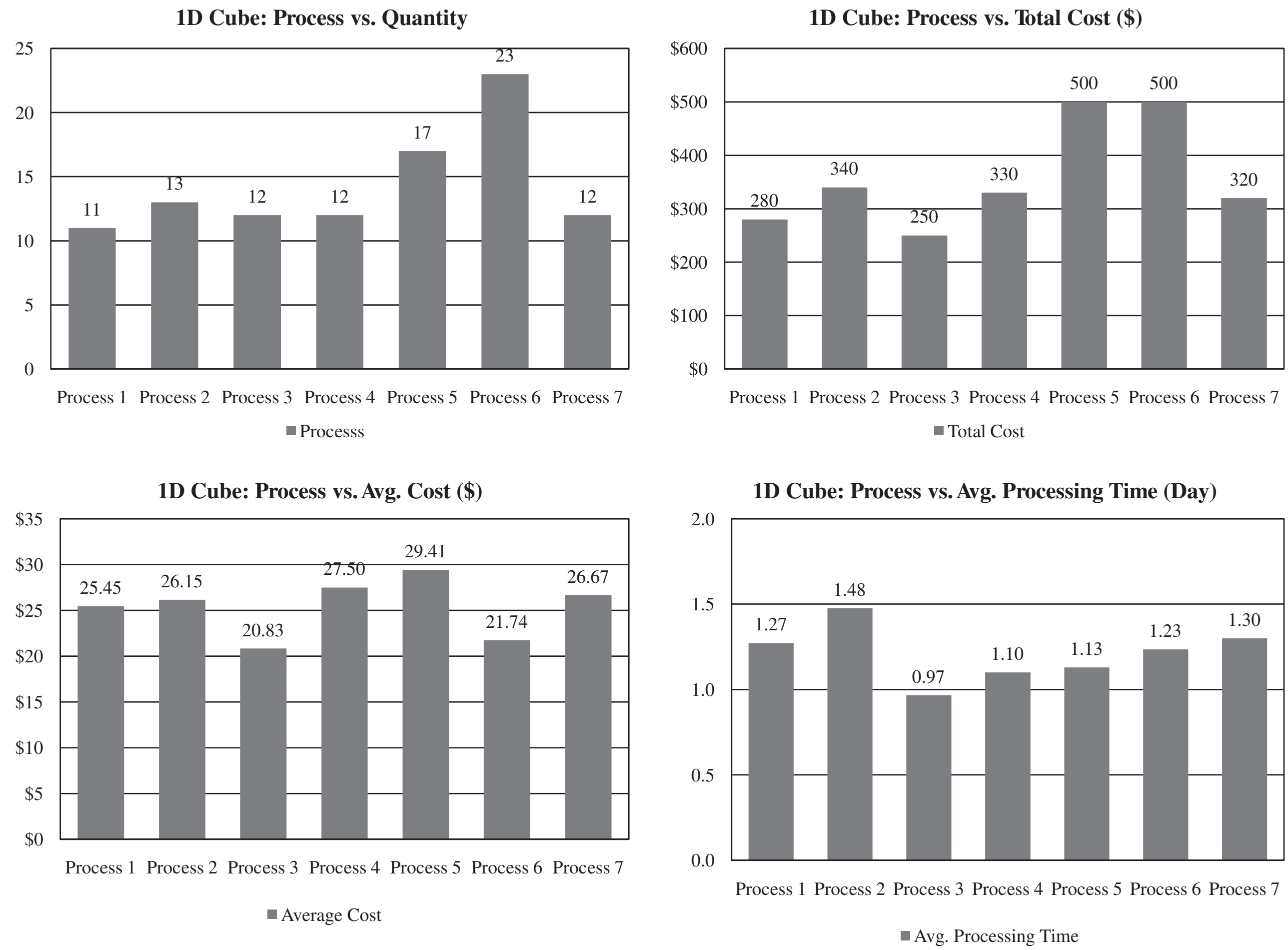


Fig. 6. 1D Examples of summarization.

$$MA_i = \frac{1}{N}\sum_{j=1}^{N} p_{i-j}, \quad i = 1, 2, \ldots, n. \tag{7}$$

The value of N is determined by managers in consideration of market circumstances. For scale adjustment, the values are normalized. If the *Self-Instability index* is larger than the threshold t_2, the VOC cube is reported as DP. Intuitively, *Self-Instability index* is analogous to a variance. While a variance is the deviation from the mean, *Self-Instability index* is the deviation from moving average. In case of status quo, *Self-Instability index* is equal to the variance.

Thirdly, we apply *InExp* to identify the abnormal patterns at any level of aggregation and propose the pre-computed indicators, namely *Subordinate-Instability Index*. It informs the necessity of drill down analysis on the lower level. For *Subordinate-Instability Index*, we assume that a process is stable when the VOC for the sub-processes evenly occurs. For calculation, we draw two curves which use the normalized values for scale adjustment; a cumulative curve of values in Pareto chart and a straight line that has a slope of average in values. The values of Pareto charts are drawn by a descending order. If the process is stable, the second curve resembles the first cumulative curve as Fig. 9. *Subordinate-Instability Index* is related with an area between the upper cumulative curve and the lower straight line, whose slope is the mean of p_i. When *Subordinate-Instability Index* is zero, the upper curve coincides with the lower straight line. When two curves form a right triangle, *Subordinate-Instability Index* has a maximum value. It is observed that as the difference between p_1 and p_2 increases, *Subordinate-Instability Index* increases monotonically. We define *Subordinate-Instability Index* as:

$$\textit{Instability Index subordinate} = \sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(C_i - i \times m)^2} \tag{8}$$

with p_i equal to the portion of VOC about ith item and $\sum_{i=1}^{n} p_i = 1, p_1 \geqslant p_2 \geqslant \cdots \geqslant p_{n-1} \geqslant p_n, C_i$ equal to the cumulative values from first item to ith item, m equal to the average of p_i. If the *Subordinate-Instability index* is larger than the threshold t_3, the drill down analysis on the lower level should be followed.

Fig. 10 shows the analysis flows of summarization and exception module.

3.3.3. Comparison module

The comparison module is designed to discover temporal patterns for forecasting. As data preprocessing, we divide time series of VOC data cubes into the set of splits of a small time frame, and encode splits by linear regression. They are encoded as 1, −1, and 0 for the positive, negative and almost-zero slope of regression curve.

According to the objects of analysis, we divide intra-entity analysis and intra-entity analysis as shown in Fig. 11. In intra-entity analysis, two kinds of VOC data cubes are investigated for their association relationship on the same time point. If fluctuation shapes are detected and there exists a sequential relationship, the time lags are discovered. The information of association or sequence relationships is used to cluster business processes into the groups for managerial purpose. In inter-entity analysis, the occurrence patterns per time window are investigated for the specific VOC data cube. Fluctuation shapes per time window and the cycle times are detected.

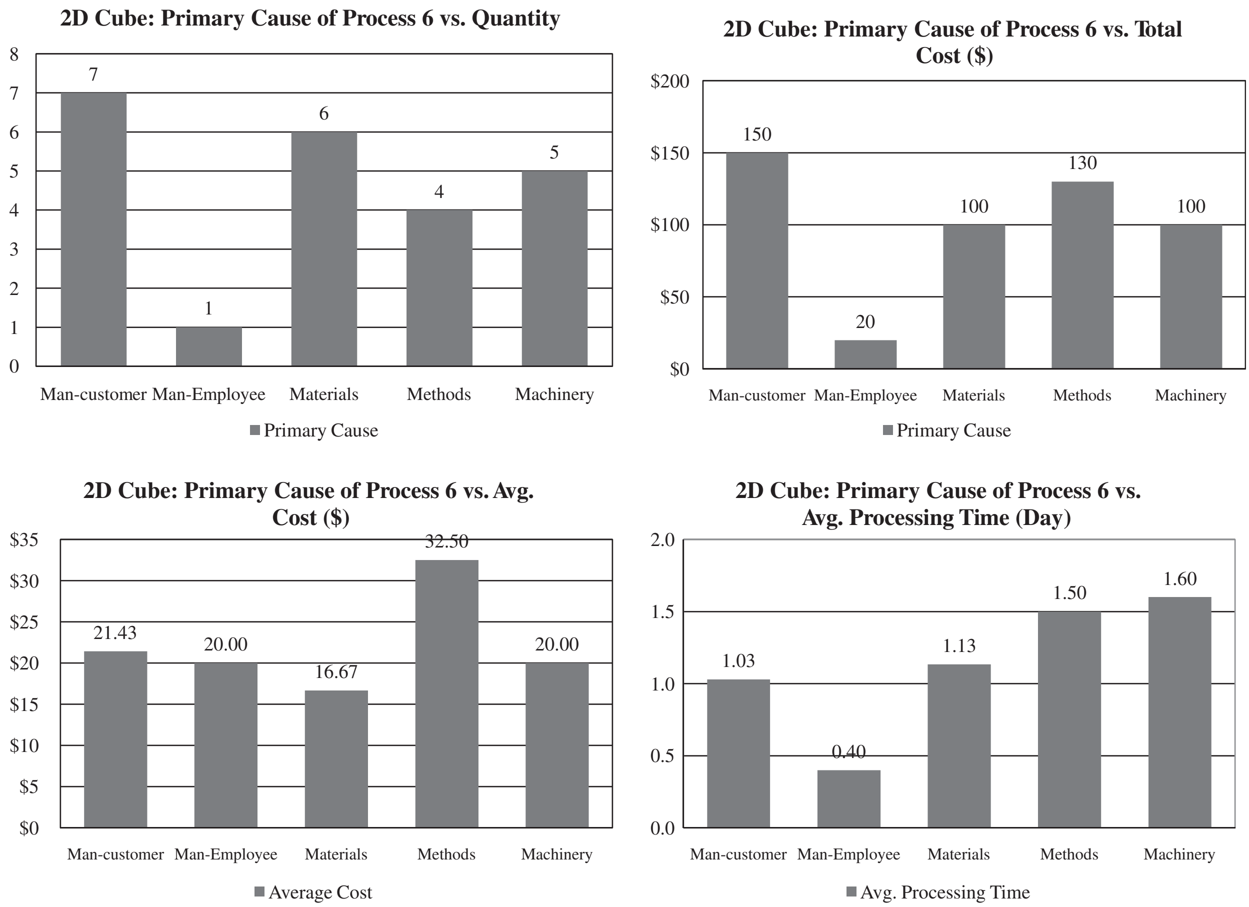


Fig. 7. 2D Examples of summarization.

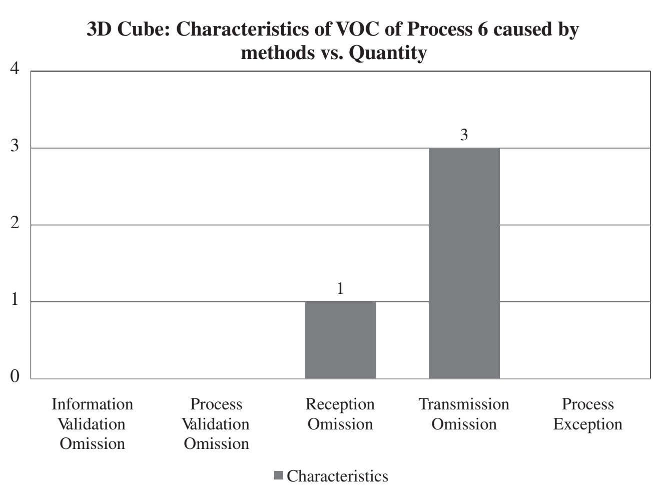


Fig. 8. 3D Example of summarization.

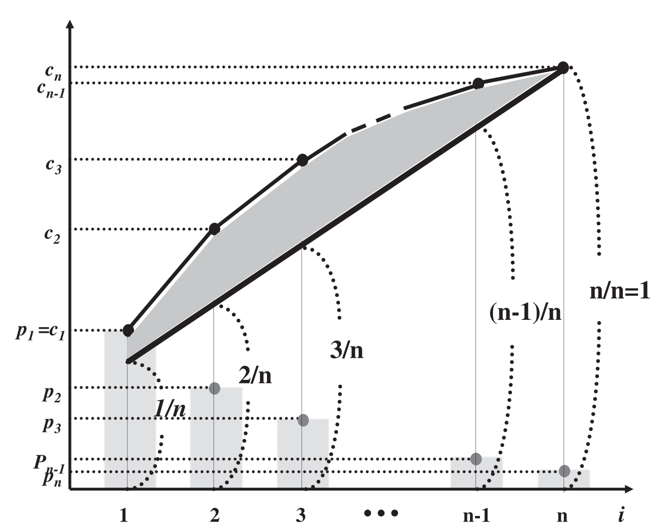


Fig. 9. Subordinate-instability index.

4. Application

We applied our BPM framework with VOC in a credit card service company. It is one of the largest credit card service companies in South Korea, and receives VOC principally through call centers. The number of VOC per month is around 4,000,000. A repetition of the same kind of VOC transfer had impeded internal business processes.

Firstly, we revised the VOC code structure to be analysis-oriented. As shown in Fig. 12, we divide the entire processes into 9 classes and add two classes for the registration of unexpected obstacles (code number 10) and the others which are not classified into main 9 classes (code number 11) on the 1st level. We represent the “process” dimension from the 1st level to the 3rd level and VOC characteristics on the 4th level. The primary causes are

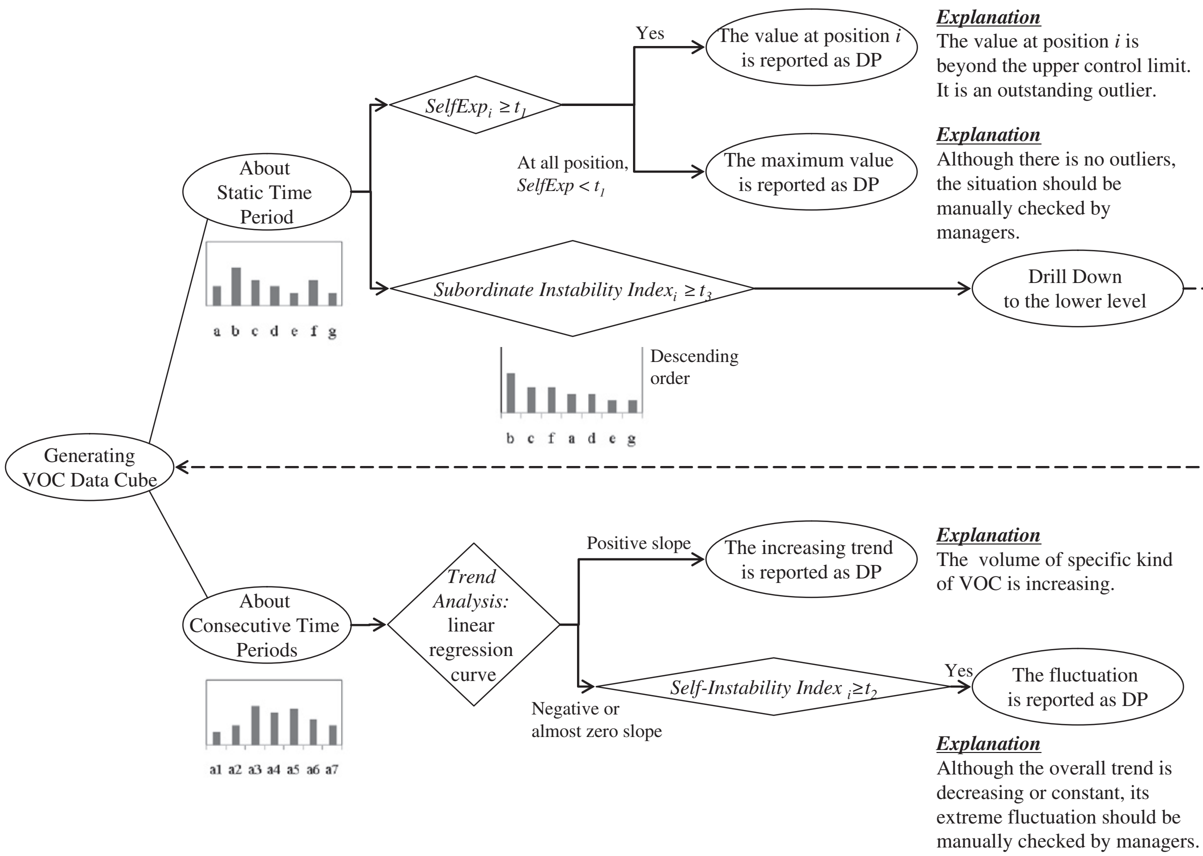
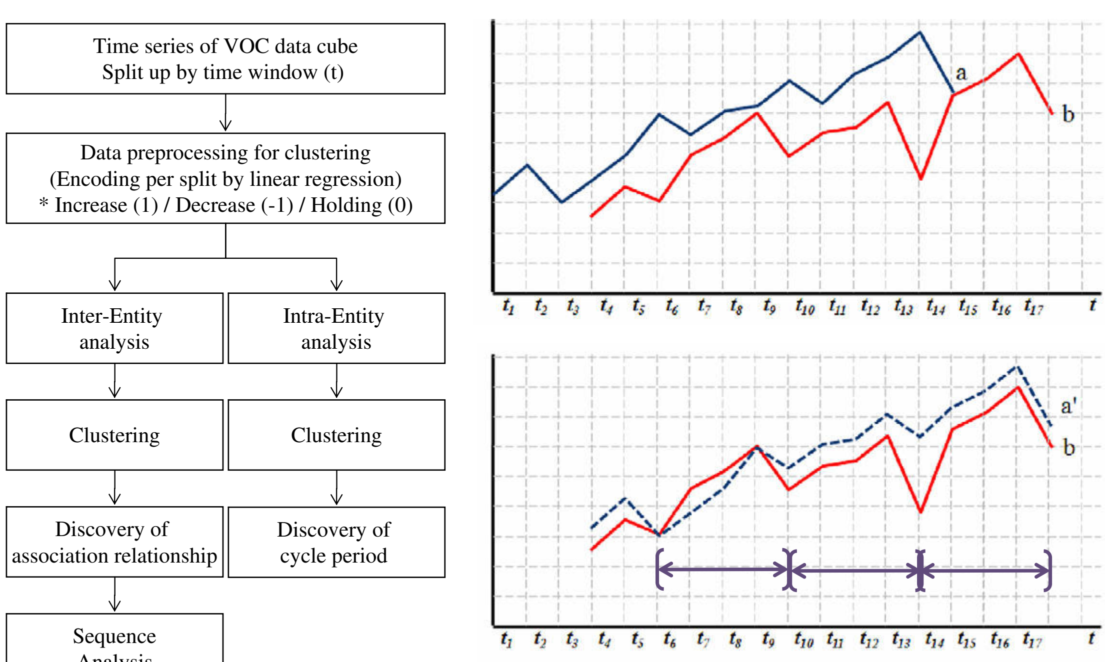


Fig. 10. The analysis flow of SEC modules.



	t_1	t_2	t_3	t_4	t_5	t_6	t_7	t_8	t_9	t_{10}	t_{11}	t_{12}	t_{13}	t_{14}	t_{15}	t_{16}	t_{17}
a	1	-1	1	1	1	-1	1	1	1	-1	1	1	1	-1			
b				1	-1	1	1	1	-1	1	1	1	-1	1	1	1	-1
a'				1	-1	1	1	1	-1	1	1	1	-1	1	1	1	-1

Fig. 11. Analysis framework of comparison module.

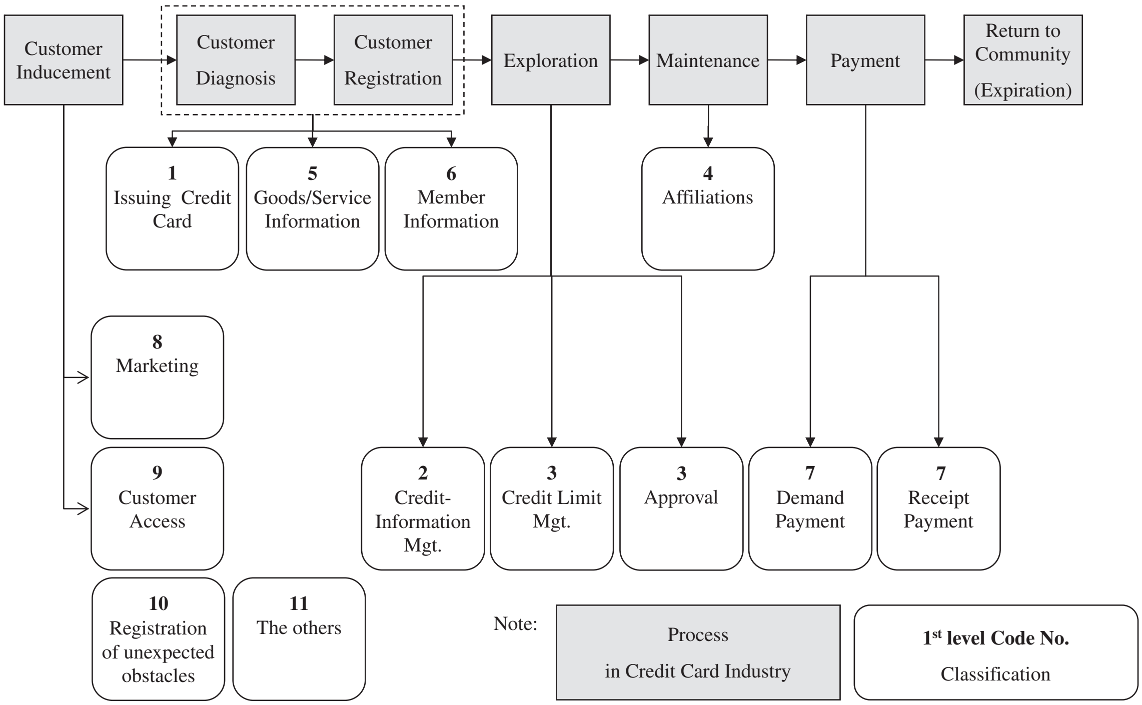


Fig. 12. Process flows and VOC codes in credit card industry.

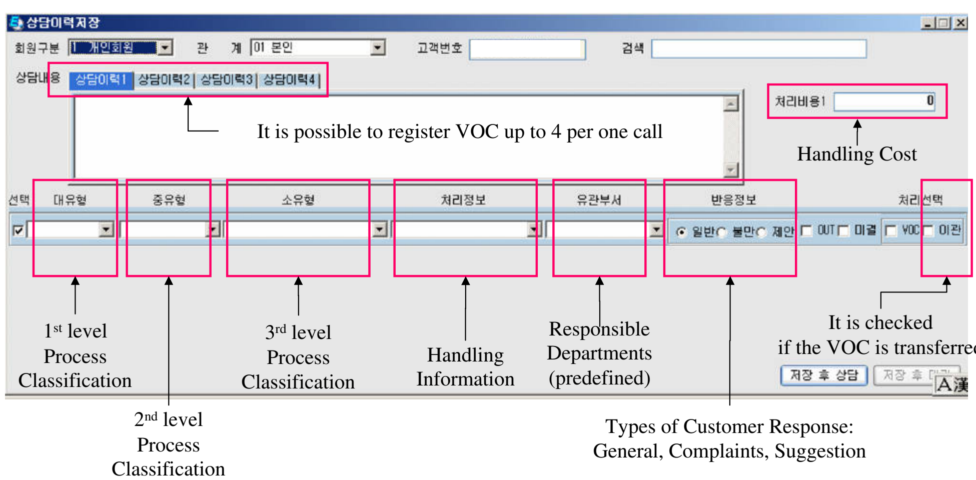


Fig. 13. A registration screen of VMS.

predefined for all of VOC code and are hidden. The total number of VOC codes by the combination is 571. If we exclude the codes used only for this company, such as the product information and processes of the 10th and 11th code on 1st level, we have 331 codes.

We developed the web-based VOC management system (VMS) that enables enterprise-widely VOC registration, handling, and sharing. The CSRs' registration screen of VMS is shown in Fig. 13. All of information related with the VOC, such as customer data, the past business transaction data and the history of VOC per customer, is presented from the VOC data warehouse. When a responsible person logs in VMS, he or she is informed of the lists of transferred VOC that are not handled. VMS automatically puts on records of handling cost and processing time for VOC handling on the family of measures (FOM) database.

The summarization module displays the occurrence of VOC according to the processes as shown in Fig. 14. The managers can drill down the specific process by clicking the process name, and then the summarization result on the lower level is displayed.

In this company, we establish an organization, namely VOC control tower (VCT) that is charged with tasks to find a way to improve DPs. VCT prioritizes the order of improvement and decides the allocation of resources. It mediates the task that requires cross-functional cooperation, builds up the foundation of BPM framework and makes the business culture where VOC is not the result of a problem but the clue to a problem. Because the permitted number of VOC registration per one call is 4, it is encouraged to make as many records of VOC as possible. Less than a year after VCT is established, the average processing time is reduced, while the number of VOC is almost doubled as shown in Fig. 15.

As an example of summary and exception module, we introduce the case of credit card issuing process for *renewal* investigated by the VCT. The candidates of issuing for renewal have been selected

Fig. 14. Summarization results on VMS.

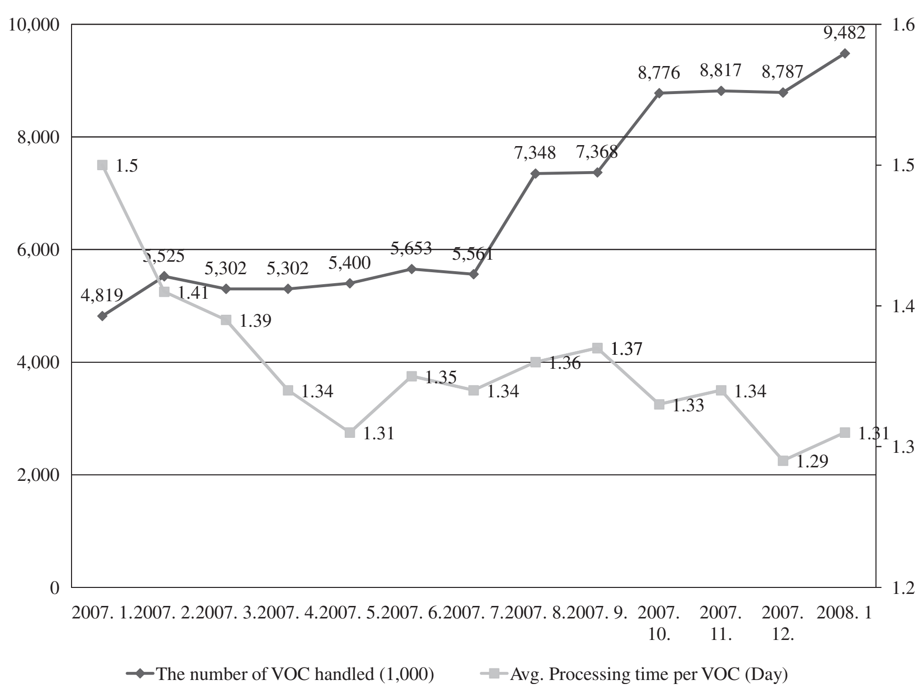


Fig. 15. Change of business culture to VOC.

two months before. Table 5 shows the standards for renewal. There are a few improvements by VCT.

Firstly, quite a number of VOC of renewal process with "material" primary cause were occurred. It is often occurred by the customers with multiple credit cards, whose credit cards were renewed by the standard *a* and *b*. Because the credit card receipt addresses can be different per card, some of renewed credit cards were not delivered to the right address. VCT instructs that customer profiles should be checked by the telemarketers. If telemarketers cannot contact with customers, the credit card receipt address would be revised to the latest receipt address It helps to cut down the delivery cost caused by returns and re-sending. Secondly, many customers had been leaving the company when their credit cards were not renewed. VCT makes an intermediation

Table 5
Standards for renewal.

Issuing for renewal	Type	Standards
Acceptance	Automatic renewal	a. For the customers who are in use of credit cards for the latest 6 months and their credit ratings are good, the credit cards are automatically renewed. A month before the basic month for renewal, renewal notices are delivered by post
	Renewal after screening	b. For the customers who are in use of credit cards for the latest 6 months but their credit ratings are bad or risky, the credit cards are renewed only if their payment capabilities are verified. Deliveries of renewal notices are the same with the automatic renewal case
Rejection	Suspension of credit card use	c. For the customers who make their credit card payments late, the credit cards are not renewed d. For the customers who reject the re-issuing for the lost cards, the credit cards are not renewed
	Disuse	e. For the customers who disuse credit cards for the latest 6 months, the credit cards are not renewed

process for the customers by the standard *c* whose late-payments are inadvertent mistakes. It helps to prevent customer leaving.

As an example of comparison module, we introduce the case of credit card issuing process for *addition*. The VOC for additional issuing has been clustered with VOC for inquires of marketing events. And it is sequentially related with the VOC for inquires of goods information and its time intervals is about one month. VCT reveals that intermediate activities of CSRs during a call are required to inform the details of issued credit cards. In this case, customers made contacts with call centers for inquiries of the specific marketing event and wanted additional credit cards. But when they did not fully understand the credit cards, it leads complaints for additional credit card issuing or inquires for goods information a month later.

5. Conclusion and remarks

In this study, we apply a systematic service improvement framework to a credit card service industry. In the credit card service industry, companies create value by supporting customers' financial assets and the value creation is highly related with internal business processes. However, business processes have been mostly managed based on experts' experiences or leaders' insights. Continuous process improvement should be based on the data about the performance of each business process and should be strategically considered from the customer viewpoint.

We propose a BPM framework employing customer complaints through call centers, namely Voice of the Customer (VOC), and its handling data. We regard call centers in service industries as data sources which build a bridge between BPM and service improvement. In the proposed framework, VOC is converted from the customer side view to the company side view by use of traditional concepts of traditional quality for data enrichment. We propose an VOC analysis framework composed of summarization, exception, and comparison module. A web-based system embedding the proposed methodology has been implemented in a credit card company of South Korea. Although it has not been verified that the application of proposed BPM framework leads the increase of customer satisfaction, the reduced VOC processing time and the increased number of VOC have been observed less than a year after the application. The proposed BPM framework has contributed to culture change in which VOC is not any more a troublesome object to be handled and call centers are not cost-centers but the profitable centers for information sources for process improvement with aim of customer satisfaction.

References

Bosch, V., & Enríquez, F. T. (2005). TQM and QFD: Exploiting a customer complaint management system. *International Journal of Quality and Reliability Management, 22*(1), 30–37.

Codd, E. F., Codd, S. B. & Salley C. T. (1993). *Providing OLAP (on-line analytical processing) to user-analysts: An IT mandate*. Technical report, E.F. Codd & Assoc.

DeToro, I., & McCabe, T. (1997). How to stay flexible and elude fads. *Quality Progress, 30*(3), 55–60.

Elzinga, D. J., Horak, T., Lee, C. Y., & Bruner, C. (1995). Business process management: Survey and methodology. *IEEE Transactions on Engineering Management, 24*(2), 119–128.

Garvin, D. A. (1988). *Managing quality: The strategic and competitive edge*. New York: The Free Press.

Gray, J., Bosworth, A., Layman, A., & Pirahesh, H. (1995). *Data cube: A relational aggregation operator generalizing group-by, crosstab, and sub-totals*. Technical report MSR-TR-95-22, Microsoft, Redmond, WA.

Griffin, A., & Hauser, J. R. (1993). The voice of the customer. *Marketing Science, 12*(1), 1–27.

Haar, J. W., Kemp, R. G. M., & Omta, O. (2001). Creating value that cannot be copied. *Industrial Marketing Management, 30*(8), 627–636.

Harrington, H. J. (1998). Performance improvement: The rise and fall of re-engineering. *The TQM Magazine, 10*(2), 69–71.

Hawkins, D. (1980). *Identification of outliers*. London: Chapman and Hall.

Hidaka, K. (2006). Trend in services sciences in Japan and abroad. *Science and Technology Trends Quarterly Review*(19).

Huffman, J. L. (1997). The four Re's of total improvement. *Quality Progress, 30*(1), 83–88.

IBM Almaden Services Research Reports (2006). Available (<http://www-304.ibm.com/jct09002c/university/scholars/skills/ssme/resources.html>.

Johnston, R. (2001). Linking complaint management to profit. *International Journal of Service Industry Management, 12*(1), 60–69.

King, B. (1989). *Better designs in half the time* (3rd ed.). Methuen: GOAL/QPC.

Radharamanan, R., & Godoy, L. P. (1996). Quality function deployment as applied to a health care system. *Computers and Industrial Engineering, 31*(1–2), 443–446.

Sarawagi, S., Agrawal, R., & Megiddo, N. (1998). Discovery-driven exploration of OLAP data cubes. *Lecture Notes in Computer Science, 1377*, 168–182.

Shaw, M. J., Subramaniam, C., Tan, G. W., & Welge, M. E. (2001). Knowledge management and data mining for marketing. *Decision Support Systems, 31*(1).

Weske, M., van der Aalst, W. M. P., & Verbeek, H. M. W. (2004). Advances in business process management. *Data and Knowledge Engineering, 50*(1).

Wikipedia (2009). *The free encyclopedia*. Available <http://en.wikipedia.org/wiki/Service_(economics)> Retrieved July 2009.

Zairi, M. (1997). Business process management: A boundaryless approach to modern competitiveness. *Business Process Management, 3*(1), 64–80.