Diagnostic Method of Corporate Innovation Based on Organizational Cybernetics.
- Analytical Framework and Practical Method -

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Abstract—**In this paper, we propose a synthetic scheme for practical diagnosis of enterprise management. For evaluating management organization, we firstly give a new framework based on organizational cybernetics. The proposed framework is referred as F-SCP which is defined by adding organizational "Function" to the existing SCP paradigm. The proposed management diagnosis scheme under F-SCP framework is as follows. F-SCP integrates Beer's VSM (Viable system model) and Barnard's theory of cooperative system. This enables us systematic analysis of organizational "Structure" and "Conduct" in F-SCP. This paper mainly gives a series of practical methods for analyzing "Structure" and "Conduct", in which we analyze quantity, quality and formulation of information exchanged among sections/employees in organization by applying social network analysis, text mining and multivariate statistical analysis. The results of these analyses allow us to evaluate "Function", by which we can finally evaluate organizational "Performance" in F-SCP. As a result, it can help for improving outcome/activity of management organization.**

Keywords—Social network analysis, Text Mining, Organizational cybernetics, Viable system model, Barnard's theory

I. INTRODUCTION

The regional innovation needs to revitalize local companies and they need appropriate diagnosis on their managements. However, it depends conventionally on rough qualitative assessment or even feeling of managers. And there are no scientific diagnosis methods for helping to activate regional companies. In this paper, a new practical management diagnosis technique is proposed based on "Organizational Cybernetics". Organizational cybernetics brings us the following two advantages. (1) A new synthetic framework for diagnosis can be built. This enables us a systematic evaluation of management organization and to apply the wisdom of living things for activating management organizations. (2) The system theory approach can be introduced for management diagnosis. This enables us to apply scientific analysis tools for visualizing and analyzing status and activity of management organization[1-3].

This paper organized as follows. In Section II, we first give a synthetic framework for management analysis and evaluation based on organizational cybernetics. In Section III, we give a series of practical diagnosis methods, in which we show their applications to real world examples. Section IV is devoted for conclusions and future works.

II. ANALYSIS FRAMEWORK BASED ON ORGANIZATINAL CYBERNETICS

We here give a synthetic framework for management analysis based on organizational cybernetics. On this viewpoint, a system theory approach is applied for analyzing management organization, in which we can adopt the information processing model that focuses on "communication and control process" in organization.

In this framework, as shown in Figure 1, we capture a management organization in terms of a relationship among four elements that are organizational "Function", "Structure", "Conduct" and "Performance"[3]. That is newly defined by adding "Function" to the existing SCP paradigm[4] of industrial organizational theory in economics. We thus refer the proposed framework by F-SCP. Static relations among sections/employees in organization are regarded as "Structure" and dynamic behaviors of them are regarded as "Conduct". These two factors consist of "Function" which determines "Performance" of organization. The details for the four elements of F-SCP framework is as follows.
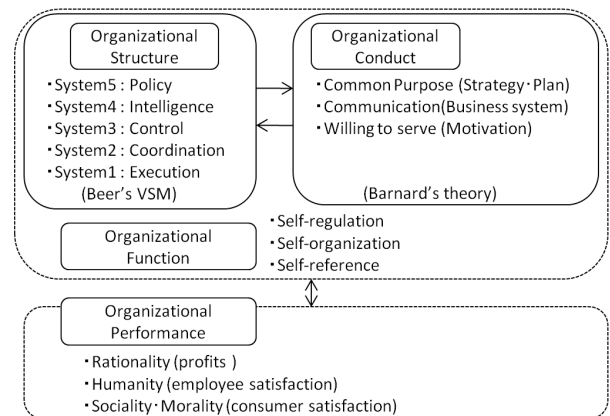

Fig.1 F-SCP framework

(1) **Structure :** Beer's VSM (Viable System Model)[5] of organizational cybernetics is used for representing "Structure". VSM mimics human's nerve system which

is controlled by the central nervous system and the autonomic nervous system. VSM is composed of five subsystems; i.e. system1 to system5 in Fig.1. It has a recursively hierarchical structure. Sections or employees in organization are treated as subsystems in VSM.

(2) **Conduct :** Bernard's cooperative system theory[6] is applied for analyzing a principle of "Conduct", in which the behavior of organization is explained by interactions among subsystems in VSM. Barnard stated a necessary and sufficient condition to construct a cooperative system. The conditions are imposed on three executive elements which are "common purpose", "communication" and "willingness to serve". The interdependency of these three elements determines internal and external equilibrium of organization.

(3) **Function :** In viewpoint of organizational cybernetics, "Function" is evaluated in terms of two principles which are "law of requisite variety"[7] and "homeostasis". Application of these two principles are checked by evaluating three functions which are Self-maintenance, Self-organization and Self-reference[3]. Self-maintenance is a function to maintain stability of organization. Self-organization is a function to realize autonomy of organization and to produce "emergence" in its improvement. And self-reference is a function to refer oneself and to change oneself (innovation) by reflections.

(4) **Performance :** "Performance" directly corresponds to outcome or activity of organization. It is determined by "Function" and is evaluated by three indicators which are "rationality", "humanity" and "sociality".

Under F-SCP framework, we give a systematic diagnosis scheme of management organization. In that scheme, we first analyze "Structure" and "Conduct" with respect to the Beer's VSM and Bernard's theory respectively. This result helps for capturing "Function", which is in turn used for evaluating "Performance".

The analysis is conducted based on variety types of data that are obtained from inside management organization. The target data is especially on information exchanged inside organization since it is considered to reflect internal status and activity of organization well. We thus focus on quality, quantity and formulation of the exchanged information in our analysis. Nowadays, data on the exchanged information are available digitally in e-mail, groupware and SNS and so on. For analyzing these types of data, we introduce data-driven tools such as SNA(social network analysis), text mining and multivariate statistical analysis. In the next section, we will explain our diagnosis scheme by showing its applications to actual examples of companies, in which those tools are applied for analyzing mainly "Structure" and "Conduct".

III. PRACTICAL METHOD FOR DIAGNOSIS

Table 1 shows the relationship between targets of analysis in Fig.1 and the corresponding analysis tools. In the following sub-sections, according to Fig.1, we show examples of analysis of actual data exchanged on groupware at 2009 in the existing small and medium-sized manufacturing company. The number of employees in the company is 49. The target company is referred by COMP below.

Table.1 Relationship between tool and target part of analysis

Analysis Target		Tools	Chart
Structure	Conduct		
relation in VSM	—	SNA	VSM Chart
—	communication (vertical)	SNA	Organizational Chart
—	communication (horizontal)	SNA	Business Flow Chart
balance in VSM	—	OV	Organizational Vector graph
—	common purpose / willingness to serve	Text Mining	Scatter Chart (PCA/CA)
Function		—	—

A. Evaluation of "Structure" based on VSM with SNA

In Fig.2, we here create VSM of COMP as ontology model. In Fig.2, a network graph is overlapped on VSM chart. In VSM representation, vertical relationship among systm5, 4 and 3 shows a vertical control line of corporate governance, which is regarded as the central nervous system. And horizontal relationship in system3, 2 and 1 indicates autonomy of individual execution system, which is regarded as the autonomic nervous system. We can evaluate the structure of management organization by relations of five subsystems. In Fig.2, nodes in the graph correspond to sections in COMP. The size of circle of node shows "betweenness centrality" that is defined in SNA. It measures degree of importance of nodes, sections here, as hubs in network. Line width of connections represents frequency of exchanged information. In the overlapped network graph, we can see that the vertical control system (system5-3) is weak. On the other hand, the horizontal relationships (system3-1) is comparatively active with having some bias in frequency of exchanged information. This implies that VSM representation enables us to find working conditions through relationships of subsystems.

B. Evaluation of "Conduct" by Barnard' theory with SNA

In general, organizational chart and business flow chart are used for representing design of organization. It is possi-

ble to obtain overlapped network graphs on these charts, in which we can evaluate "communication" of Barnard' theory as a part of "Conduct". Organizational chart is especially considered to show a chain of command well. Therefore, we can grasp authority and responsibility given from top managers if network graph is overlapped on organizational chart. It is regarded as representing "Conduct" of control system. In the overlapped network graph on organizational chart for COMP, we could find the weakness of relationships among president, director and manager. This result implies the weakness of "communication" in vertical corporate governance. In Fig.2,we can also confirm it by the analysis for vertical structure among system 5-3.

On the other hand, if network graph is overlapped on business flow chart then we can grasp "communication" along workflow in organization. It is regarded as representing "Conduct" of execution system. For example, in the overlapped network graph on business flow chart of COMP, we could see that the frequency of information exchange in business flow is comparatively high under strong participation of quality assurance section. In Fig.2,we can also confirm it by the analysis for horizontal relationships among system3-1, though the business flow itself can't be expressed in VSM.
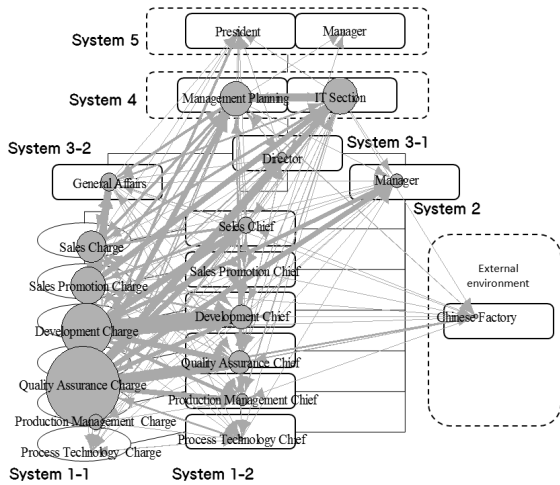

Fig.2 VSM chart and overlapped network graph for COMP

C. Evaluation of balance in VSM

In order to evaluate a balance among activities of subsystems in VSM, we further define OV(organizational vector) which is given by $f = (s_5, s_4, s_{3-2}, s_{3-1}, s_2, s_{1-1}, s_{1-2})$, where s_k denotes the amount of activity measure of the kth subsystem; see [1] for details. In Fig.3, solid line represents OV of COMP. In Fig.3, dashed and dotted lines show two averages of OVs for companies that are categorized into having high and low activities after Lehman Shock respectively. Those

OVs are computed based on data obtained by questionnaire survey in [1]. By COMP's OV in Fig.3, we can find that system1 is quite active while activities of top (system5) and middle manager (sysem2) are weak. If COMP could fix this weak point by improving the formulation of communication, then it can be a company that smoothly adapts environmental changes.
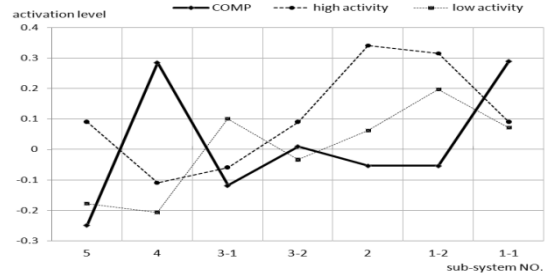

Fig.3 Examples of organizational vectors

D. Analysis of quality of information using text mining

"Common purpose" and "willingness to serve" of "Conduct" in F-SCP can be read from information exchanged among employees or sections. More specifically, we need to capture quality of exchanged information to evaluate and detect these two factors. To achieve this, we introduce text mining, PCA (principal component analysis), and CA (correspondence analysis). Words data exchanged inside organization are assumed to be obtained. In our method, we first apply text mining to those for obtaining the morpheme data which are categorized into several classes with labels. PCA is applied to data in each class. The first and second factor loadings are then depicted as scatter chart. The degree of similarity of classes of words is measured by the Euclidean distance on the scatter chart. This measure is applicable even when we choose some factor loadings as features.

We show an analysis example for data from the previously mentioned questionnaire survey data related to Lehman Shock in [1]. In [1], for each target company, it has also been collected words data given by manager and sales tendency at phases before and after Lehman Shock. The words data are categorized into groups before and after Lehman Shock. Data in each group are subdivided into three classes with labels of High, Normal and Low depending on its sales tendency. In Fig.4, we show the scatter chart in this case. In Fig.4, we can visually observe the distance between (After, High) and (After, Low) is large. This implies that the difference in words corresponds to that in activities of businesses after a large environmental change.

Additionally, by using semantic analysis, words data are classified into three groups of context words in terms of strategy types labeled by "Revolution (Innovation)", "Improvement" and "Maintenance". Fig.5 shows the first and

second principal component scores in CA for the classified data. In Fig.5, we also depict the results of CA for the previously classified data in terms of their sales tendency. In Fig.5, we can see that companies classified into "Revolution" are near those in (After, High) and (Before, High). This implies that companies, in which manager sends message relating to "Innovation", tend to be active even when under environmental change. If we apply the similar analysis to information exchanged among sections, we can evaluate quality of communications among sections, which helps for reconsidering or improving internal system.
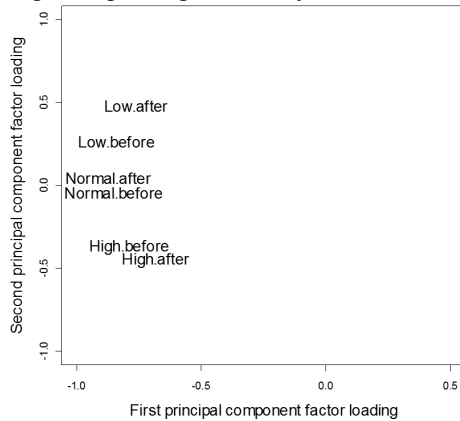

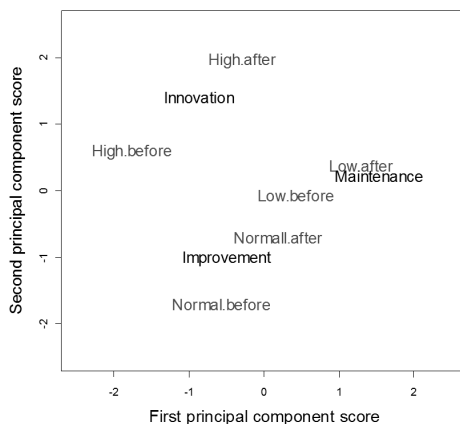Fig.4 Example of scatter chart based on PCA result

Fig.5 Strategy types and business performances

E. Evaluation of "Function" in terms of viability

If we can analyze "Conduct" and "Structure" in F-SCP by using the above methods, we can then evaluate "Function" in which we check self-maintenance, self-organization and self-reference as functions. As a result, viability can be evaluated from the viewpoints of organizational cybernetics. In the example of COMP, we can observe that self-maintenance function in daily operations seems to be well

working because the activity of horizontal relationships was high. However, vertical corporate governance is found to be weak. Therefore the policy and strategy given by top manager are not properly received by employees in lower layer. In addition, due to the weakness of middle manager's activities, we can point out the weakness of self-reference and self-organization functions. Therefore, "emergence" that creates new knowledge and coherence may not work. Moreover, by making effort to keep a proper balance between these three functions, COMP may be able to improve its "Performance" in F-SCP, thus, to improve its activity and outcome.

IV. Conclusions

In this paper, for management of organization, we gave new synthetic diagnosis framework based on organizational cybernetics. In addition, we proposed new analysis methods to visualize and capturing activities of organization by using SNA, text mining and multivariate statistical analysis and showed practical examples of applications of these methods.

The proposed framework and methods will be more effective by using the other existing management diagnosis techniques such as financial, productivity, labor diagnosis and so on. Moreover since VSM is a hierarchical recursive model, we hope that our methods are applicable to regional innovation level which is a collective company.

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