Is There Innovation or Deviation？

Analyzing Emergent Organizational Behaviors through an Agent Based Model and a Case Design

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***Abstract*—This paper describes a new method for analyzing emergent organizational behaviors, which are causes of innovation and deviation phenomena, through an agent based model and a case design. Organizational deviation is inextricably linked to innovation, because their mechanisms are similar in terms of breaking operational standards. We have assumed that the former and the latter are different in external utilities, and under this assumption, we have developed a unified agent based model. The agent base simulations have been conducted based on the model, for analyzing the emergence process of innovation and deviation. The simulation results have been compared with case analysis in order to obtain an in-depth understanding of inextricably linked organizational phenomena, and to distinguish the similarities and differences between innovation and deviation.**

Keywords-Agent based modeling; organizational deviation; case design; organizational behavior

I. INTRODUCTION

Innovation is the act of producing something newly introduced. Organizational deviation is misconduct in organizational management. Companies tend to control organizational deviation strictly because they would get serious damage when it has been revealed. Direct control of deviation may, however, reduce the power of Innovation, because both deviation and innovation have similar mechanisms of breaking standards.

In sociology, deviation is classified into three categories [1]. First is criminality, second is violating conduct norms, and third is labeling. This paper is based on the concept of the second category, because it contains similar notions to innovation which is achieved from organizational improvement by breaking standards. Our model is built from the belief that organizational deviation and innovation have similar mechanisms, but they are different in the external utility or disutility.

Organizational deviation does not always occur according to immoral agents' wrongdoing [2]. It may emerge from unintentional behaviors of the agents with the bounded rationality, because they tend to act shortsightedly and to converge to local optima. It means that if agents have behaved aiming at Innovation, they would commit deviation unintentionally by producing disutility to the society. The shortsighted behavior is enhanced by the difficulty in recognizing the utility landscape. Therefore, we incorporate a hierarchical utility landscape into our model by expanding the landscape theory [3, 4]. The landscape theory explains the shortsighted behavior of agents by the limited range of view to landscape on which they behave.

The purpose of this paper is presenting a method for analyzing inextricably linked phenomena such as organizational innovation and deviation by combination of agent based simulation, manual simulation and case description.

The rest of the paper is organized as follows: Section II explains our unified model of deviation and innovation; Section III shows the result of computer simulation ; Section IV explains the case design and analysis approach ; Section V presents the results of the manual simulation ; Section VI describes the model based 'virtual' case ; and Section VII presents the conclusion and future work.

II. AGENT BASED MODEL

This section describes our unified model of deviation and innovation, which simplifies a real structure of an organization and the relation between an organization and a society. Agent based modeling method is applied in order to examine the bottom up emergence process of innovation and deviation. In this model, the implemented hierarchical utility landscape consists of three layers: individual, organizational, and social utility.

A. Structure of the Model

Figure 1 shows outline of hierarchical utility landscape in our model.

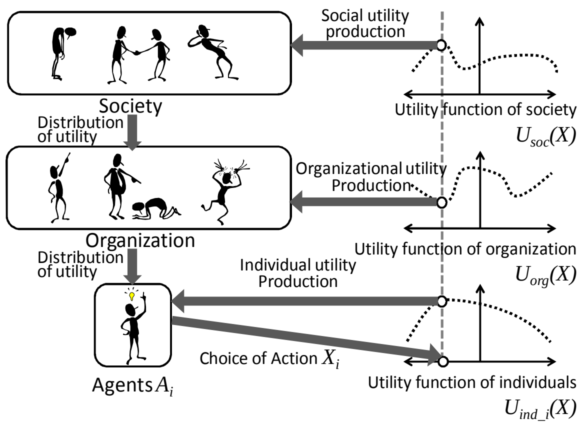

Figure 1. Structure of the Agent Based Model.

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In figure1, Hierarchical organizational structure which consists of three layers is brought into our model, because it is seen in many companies. Utility function of individuals means experience and values of each agent. Utility function of organization means business model of a company. Utility function of society means social norms.

In this model, agents choose their actions according to the rewards from organization and information from neighbors. As a result, their utility production which means contribution to an organization and a society is determined based on utility landscape. The accumulated organizational utility is distributed to all agents based on their amount of contribution through the system of rewards. The result-based reward is applied in this model Agents can recognize their own utilities, however, they cannot recognize organizational and social utility landscape completely. Therefore, both deviation and Innovation may emerge depending on experiment conditions, and this is the advantage of our model. Based on the model, we define two types of phenomena as shown in table 1 : a) Innovation is the increase of both organizational and social utility production, b) Organizational deviation is the decrease social utility production.

For example, in a Japanese pastry company case, the reduction of product disposals is consistent with their beliefs, in other words employees could recognize their individual utility. However they could neither recognize the social regulations, nor company's damages due to consideration of violating law. In other words, they could neither recognize social utility nor organizational utility landscape thoroughly. As a result, they conducted organizational deviation despite of aiming at innovation.

TABLE I. THE DEFINITION OF INNOVATION AND DEVIATION

	Definition	Organizational utility production	Social utility production
a)	Innovation	increase	increase
b)	Deviation	increase/decrease	decrease

B. Utility Function

The Utility functions which are described in the previous section, are based on the NK fitness landscape model [5, 6]. NK model determines the values of N integer sequences, and utility landscape is defined by the combinations of K integers. Figure 2 shows a sample of integer combinations and their values, in case of N=6 and K=1.

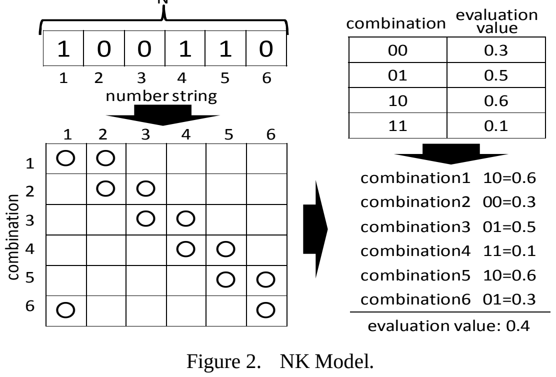

Figure 2. NK Model.

The variation of utility functions is described by number sequences and their evaluation values. Evaluation value is given between 0 to 1 depending on combinations of integers. The complexity of utility landscape depends on the number of integers and their combinations..

C. Choosing Actions of Agents

Each agent changes their action in order to increase their satisfaction according to the formula (1). In formula (1), the degree of satisfaction of agents increases along with the rising of their individual utilities: *Uind_i(X)*, rewards from organization: Re_i, and contributions for social utility: *Usoc(X)*. The index *i* means the number of agents.

$$S(U_{ind_i}(X), Re_i) = U_{ind_i}(X) + Re_i + U_{soc}(X) \quad (1)$$

Agents imitate the actions of other agents whose actions are similar to them and receiving more rewards from organization according to the formula (2). P_j means the probability that agent_i imitates the action of agent_j. *k* means the number of agent. *Lij* means the similarity of action between agent_i and agent_j. Agents evaluate their satisfaction after imitation, and then return to original action when their degrees of satisfaction have been declined by the imitation.

$$P_j = \frac{Re_j \times L_{ij}}{\sum_{k \neq i} Re_k \times L_{ik}} \quad (2)$$

The agents produce their own utility, and contribute to organizational and social utility as the result of their actions. The contributions of agents are accumulated in an organization and a society.

III. COMPUTER SIMULATION EXPERIMENT

Based on the descriptions of the model in previous section, we have developed the simulator according to agent based computational architecture [7] in Java language. This section describes settings and results of the agent based simulation experiment. Those results are confirmed by manual simulation and case description in following section.

In this experiment, the change in utility production amount of an organization and a society is analyzed by shifting the diversity of agents from 0% (uniform organization) to 100% (diversified organization). All agents have unique individual utility functions in the organization with 100% diversity, while they have common utility functions in the organization with 0% diversity. The other conditions are fixed.

Figure 3 shows the result that is emerged when improving diversification in agents. In figure 3, both social utility and organizational utility productions are increasing with improving diversification. This result suggests that the diversification in agents prompts Innovation type activities according to the definitions in Table1, and the result is corresponding to previous study [8].

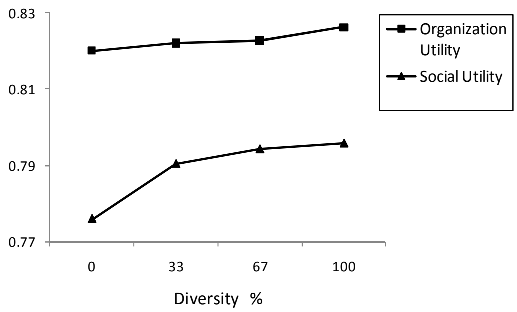

Figure 3. Utility production change that occurs with diversification.

This result means that mutual imitation in diversified organization makes individual utility production decline, because individual utility functions of agents are different from each other. As a result, agents tend to increase organizational utility and social utility production amount in order to complement the lowering of individual utility production, and to maintain their satisfaction which is determined by the formula (1).

IV. CASE DESIGN AND ANALYSIS APPROACH

Figure 4 presents the steps of case design and analysis. The simulation results in previous section are confirmed through these steps moreover innovation and deviation phenomena are analyzed from different point of view. The overview of case design and analysis approach is as follows.

The first part is Case Settings. In this part, the model elements are converted to the business management elements. Then case story template and utility landscape are developed according to those elements. The second part is Manual Simulation which is described in chapter V. In this part, manual simulation is conducted based on our model. The third part is Confirmation of Simulation Results. The result of agent based simulation which is described in chapter III is confirmed by the manual simulation in this section. The fourth part is Case Development. The could-be cases are developed in line with the case story template and the results of manual simulations in chapter VI.

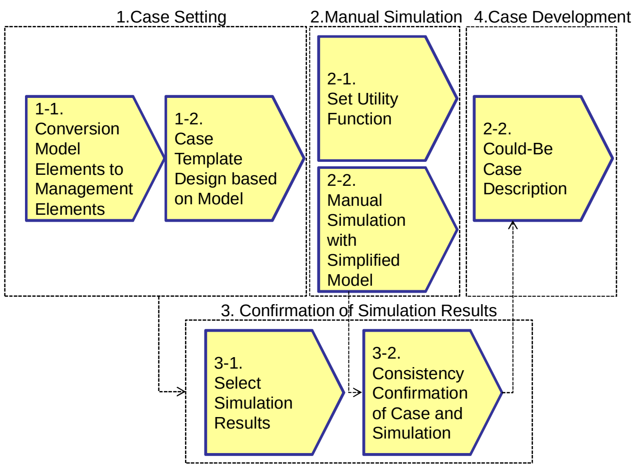

Figure 4. Case Design and Analysis Approach.

The elements of the model described in chapter II are aligned with agent based model definition standard [9], and converted to the elements of business management in order to develop the template for case description. Table 2 shows the result of conversion.

The elements of business management listed in table 2 are organized and mutually interrelated in figure 5 as a template for case description. The common template shown in figure 5 is customized according to specific situations, and case stories are developed based on the template.

TABLE II. COMPARISON OF MODEL ELEMENTS AND BUSINESS MANAGEMENT ELEMENTS

Category	Elements of Agent Based Model	Elements of Business Management
Landscape	Hierarchical Landscape: Social Utility, Organizational Utility, Individual Utility	Social Norms, Business Model, Individual Value
	NK Model: Conflict between Social Utility and Organizational Utility	Conflict between Social Norms and Business Model
Characteristics of Organization	Utility Distribution	Personnel System
	Diversity of Individual Utility	Diversity of Organization
	Network Structure	Communication Environment in Organization
Behavior of Organization Members	Network Setting Up Rule	Encounter among Employees
	Behavior Status Change of Agents	Behavior Change of Employees
	Structure of Agent's Satisfaction	Source of Employee's Motivation
	Hill Climb and Imitation Algorithm	Learning Mechanism of Employees
	Incomplete Information Environment	Cognitive Limit
Result of Behavior	Variation in Social Utility, Organization Utility, Individual Utility Production	Variation in Legal Compliance, Corporate Earnings, Employee's Motivation

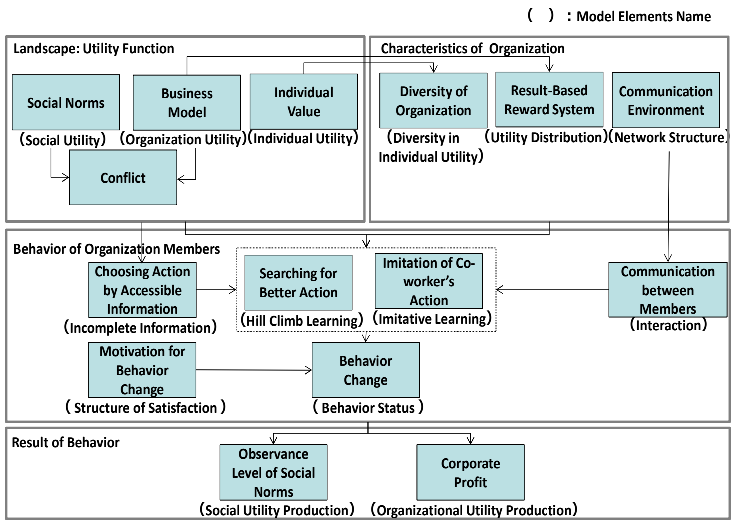

Figure 5. Case Story Template.

V. MANUAL SIMULATION AND CONFIRMATION OF COMUPUTER SIMULATION RESULT

This Before case development, utility landscapes are set in table 3 and table 4 using NK model which is described previously. We have set N=3 and K=1 for case settings and manual simulation. A fictional food maker is assumed in

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this paper. We assume that this food maker is required to reduce the production cost because of increasing competition however there are strict regulations in food industry.

TABLE III. CASE SITUATION SETTINGS ON NK MODEL

Options	Alternatives of manufacturing control (N=3)		
	1. Cost Reduction	2. Use-By Date Setting	3. Quality Control
0	Production Process Efficiency	Based on Guidelines	Bacteria Test by Devices
1	Waste Prevention of Raw Materials	Based on Case-by-CaseJudgments	Flavor Test by Human Work

TABLE IV. DEPENDENCE RELATIONSHIP BETWEEN ALTERNATIVES

Combination of Alternatives	00	01	10	11
Safety of Products	High	Medium	Medium	Low
Cost Reduction Effect	Low	Medium	Medium	High

Manual simulations using simple NK model are conducted based on table 3 and 4. Table 5 and 7 show the case settings which are social norms, the food maker's policy of manufacturing, and each assembly leader's policy. The situation of Case A is that all assembly leaders have same management policy, so that means uniform organization (Table 5). The Case B is that each assembly leader has different management policy, so that means diversified organization (Table 7). The manual simulation enables the confirmation of computer simulation results by tracing the behavior changing of each agent particularly.

A. *Manual Simulation: Case A*

In case A, all assembly leaders have same cost-conscious management policy as shown in table 5, and there is a certain degree of conflict between social norms and food maker's policy. Table 6 describes the process of manual simulation of case A, which is conducted according to landscape settings and behavior rules of agents. Each assembly line leader's behavior has been changed by searching for more satisfactory action, and also imitating of another leader's action according to NK model settings as shown in table 5.

Figure 6 shows the transition of utility production by assembly leaders as the results of behavior change. The social utility production means contribution to society by protecting of food safety. The organization utility means contribution to corporate objectives such as cost reduction. Assembly leaders receive rewards by their contributions. The individual utility means comfort of leaders which are achieved by the consistency with their management policies. As shown in figure 6, deviation type phenomenon emerges because social utility production amount is decreasing while organization utility production is increasing. It is because that all assembly leaders have cost-conscious management policy, and the food maker has also cost-conscious management policy while balancing with food safety.

TABLE V. UTILITY LANDSCAPE SETTING: CASE A

Combination (K=1)	Evaluation Value				
	Society	Company	Assembly Line Leaders		
	Safety-Conscious	Safety and Cost Balance	Leader1 Cost-Conscious	Leader2 Cost-Conscious	Leader3 Cost-Conscious
00	0.4	0.1	0.1	0.1	0.1
01	0.3	0.3	0.2	0.2	0.2
10	0.2	0.4	0.3	0.3	0.3
11	0.1	0.2	0.4	0.4	0.4
000	0.40	0.10	0.10	0.10	0.10
001	0.30	0.27	0.20	0.20	0.20
010	0.30	0.27	0.20	0.20	0.20
100	0.30	0.27	0.20	0.20	0.20
011	0.20	0.30	0.30	0.30	0.30
110	0.20	0.30	0.30	0.30	0.30
101	0.20	0.30	0.30	0.30	0.30
111	0.10	0.20	0.40	0.40	0.40

TABLE VI. PROCESS OF MANUAL SIMULATION: CASE A

Step		1	2	3	4	5
Assembly Leader 1	Behavior Change	Initial Status	Imitate	Imitate	Stay	Stay
	Combination of actions	**000**	**001**	**011**	**011**	**011**
	Social Utility Production	0.40	0.30	0.20	0.20	0.20
	Organization Utility Produc	0.10	0.27	0.30	0.30	0.30
	Individual Utility Productio	0.10	0.20	0.30	0.30	0.30
	Reward	0.16	0.22	0.30	0.30	0.30
	Satisfaction	0.66	0.72	0.80	0.80	0.80
Assembly Leader 2	Behavior Change	Initial Status	Search	Stay	Stay	Stay
	Combination of actions	**001**	**011**	**011**	**011**	**011**
	Social Utility Production	0.30	0.20	0.20	0.20	0.20
	Organization Utility Produc	0.27	0.30	0.30	0.30	0.30
	Individual Utility Productio	0.20	0.30	0.30	0.30	0.30
	Reward	0.24	0.33	0.30	0.30	0.30
	Satisfaction	0.74	0.83	0.80	0.80	0.80
Assembly Leader 3	Behavior Change	Initial Status	Search	Imitate	Turn Back	Stay
	Combination of actions	**100**	**110**	**011**	**110**	**110**
	Social Utility Production	0.30	0.20	0.20	0.20	0.20
	Organization Utility Produc	0.27	0.30	0.30	0.30	0.30
	Individual Utility Productio	0.20	0.30	0.30	0.30	0.30
	Reward	0.24	0.33	0.30	0.30	0.30
	Satisfaction	0.74	0.83	0.80	0.80	0.80

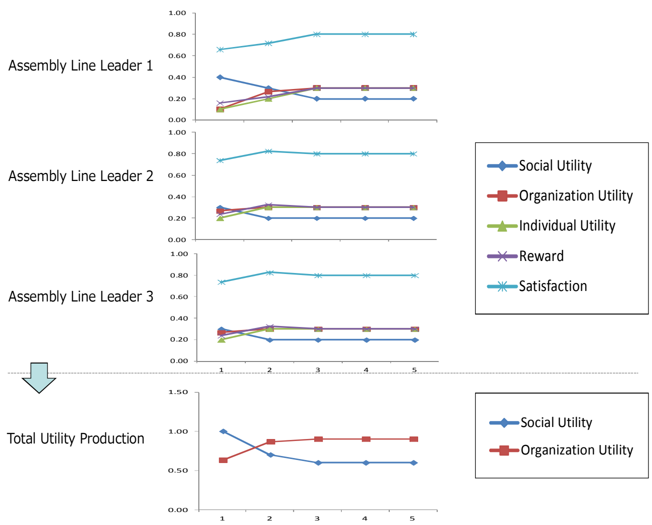

Figure 6. Manual Simulation Result: Case A.

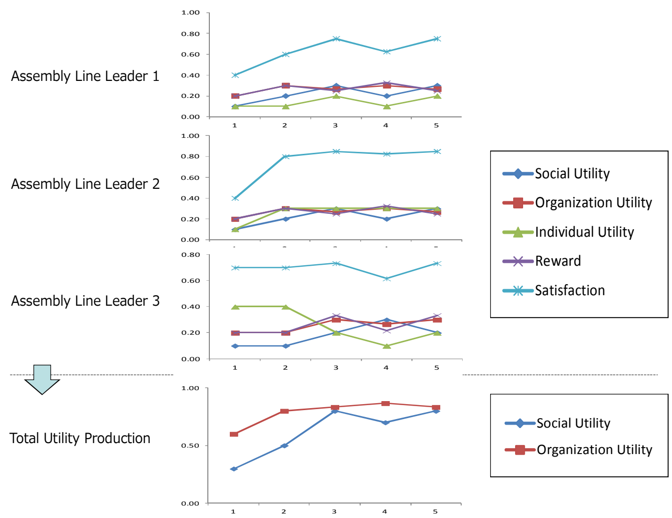

Figure 7. Manual Simulation Result: Case B.

B. *Manual Simulation: Case B*

In case B, each assembly leader has different management policy as shown in table 7, and there is a certain degree of conflict between social norms and food maker's policy. The management policy of leader 1 is safety conscious, leader 2 is balance of safety and cost, leader 3 is cost conscious.

Figure 7 shows the transition of utility production by assembly leaders as the results of behavior change. As shown in figure 7, innovation type phenomenon emerges because social utility production and organization utility production amount are increasing. It is because that leader 1 and 2 have found the appropriate action which enable the increasing of both social utility and organization utility by own searching. And in addition, leader 3 who has cost conscious policy, has imitated their actions although he could not find the appropriate action by himself.

The explanation of manual simulation process of case B is omitted.

TABLE VII. UTILITY LANDSCAPE SETTING: CASE B

Combination (K=1)	Evaluation Value				
	Society	Company	Assembly Line Leaders		
			Leader1	Leader2	Leader3
	Safety-Conscious	Safety and Cost Balance	Safety-Conscious	Balance	Cost-Conscious
00	0.4	0.1	0.4	0.1	0.1
01	0.3	0.4	0.1	0.4	0.1
10	0.2	0.3	0.1	0.4	0.1
11	0.1	0.2	0.1	0.1	0.4
000	0.40	0.10	0.40	0.10	0.10
001	0.30	0.27	0.20	0.30	0.10
010	0.30	0.27	0.20	0.30	0.10
100	0.30	0.27	0.20	0.30	0.10
011	0.20	0.30	0.10	0.30	0.20
110	0.20	0.30	0.10	0.30	0.20
101	0.20	0.30	0.10	0.30	0.20
111	0.10	0.20	0.10	0.10	0.40

C. *Confirmation of Computer Simulation*

The computer simulation result which is shown in figure 3 suggests that the diversification in agents prompts Innovation phenomena. This result is confirmed by manual simulation in Case A and B by observing the behavior change of each assembly leader. The results of manual simulation show that diversified organization tends to emerge innovation type phenomena in case B while uniform organization tend to emerge deviation type phenomena in case A.

VI. CASE DEVELOPMENT

A. *Purpose and Approach*

A model based fictional case is described in this section according to the case story template (figure 5) and the results of manual simulation. There are two purposes of model based case description. The first is to understand the emergence process of innovation and deviation at more detailed level than simulation. The second is to compare the description level of model based case with that of actual case.

The underlined portions are model elements and the italic words in parenthesis are the name of model elements. Only the story of case A is described in this paper. The stories of case B are omitted due to space limitation.

B. *Model based fictional case: Case A*

A food maker applied the product cost reduction policy because of severe competition in food industry. The company intended to balance cost reduction and product safety (*Organizational Utility Function*), however its policy was not completely fit to the requirements from consumers (*Conflict between Social Utility and Organizational Utility*).

In the food maker, the education programs were conducted for employees in order to strengthen their sense of cost reduction. As a result, most employees shared strong cost-consciousness(*Individual Utility Function*) in that company. Under the situation, cost reduction activities were executed in one of the factory in the food maker as follows.

There were three assembly line leaders in the factory whose cost reduction policies were different from each other at the beginning. The assembly line leader 1 applied the safest way in three leaders. He sought production process efficiency, set use-by date based on guidelines, and conducted bacteria test for quality control (*Behavior Status*). The leader 2 applied same method of cost reduction and use-by date setting as leader 1, however he conducted flavor test instead of bacteria test (*Behavior Status*). The leader 3 pursued waste prevention of raw materials, but ensured product safety by set use-by date based on guidelines, and conducted bacteria test (*Behavior Status*).

In that situation, the assembly line leader 1 who applied the safest policy received the least reward according to the result-based reward system (*Utility Distribution*). The leader 1 was frustrated at less reward and changed his way of quality control form bacteria test to flavor test by imitating the way of leader 2 (*Imitation Learning*). At the same time, the leader 2 and 3 applied the method of setting use-by date based on case-by-case judgments for more cost reduction through their trial and errors (*Hill Climb Learning*). This method had a risk of product safety decreasing, however it was consistent with their cost-conscious policy(*Individual Utility Function*). Therefore the leader 1 received less reward again because the leader 2 and 3 applied more effective cost reduction method(*Individual Utility Function*), even though he imitated the method of leader 2 previously. So that, the leader 1 imitated the method of leader 2 again (*Imitation Learning*), because leader 2 received more reward than him.

As described above, all three leaders applied more effective cost reduction method while sacrificing the safety of products. They recognized the methods which are effective for product safety, but they were not satisfied with those methods because of inconsistency with their cost-consciousness and less reward(*Structure of Agent's Satisfaction*). As a result of assembly line leader's behavior change, the factory achieved cost reduction target (*Organization Utility Production*), however its risk of reducing the product safety increased significantly (*Social Utility Production*)..

VII. CONCLUSIONS AND FUTURE WORK

This paper presented a method for analyzing inextricably linked phenomena such as organizational innovation and deviation by combination of agent based simulation, manual simulation and case description.

As described previously, a Japanese pastry company intended to conduct innovation in order to increase their organizational utilities, however they fell into deviation by unintentional decreasing of social utility because it falsified the expiration dates of products. According to the results of simulation and case description, it is detected that the emergence of deviation or innovation depends on the diversity of organization in this paper. It is also detected that how the diversity of organization impacts on behaviors and learning activities of agents.

The advantage of this method is that it enables to approach toward inextricably linked phenomena with unified model and the combination of multiple method of analysis. The unified model enables to observe that small changes of model parameters would cause both deviation and innovation phenomena. Thus it is the contribution to organizational innovation and deviation research area, because previous studies tend to approach from one side, such as only innovation side [8] or deviation side [10]. The model based 'virtual' case description is the novel method in terms of creating future scenarios compared to standard case study which is based on past phenomena.

In the further work, we would refine the method of manual simulation and case description with applying this method to another type of inextricably linked phenomena. And we would develop the novel method for creating future scenarios by integrating agent based simulation and model based case design. It is expected to reduce unexpected problems in organizational management.

REFERENCES

[1] Hougetsu, M. (2004). Sociology of Deviance and Control. Yuhikaku. (in Japanese)

[2] Baucus, M.S. (1994). Pressure, opportunity and predisposition: A multivariate model of corporate illegality. Journal of Management, 20 699-721.

[3] Axelrod, R. (1999). The Complexity of cooperation. Princeton Univ. Press.

[4] Kijima, K. (2001). Generalized Landscape Theory: Agent-based Approach to Alliance Formations in Civil Aviation Industry. Journal of System Science and Complexity, 14, 2 113-123.

[5] Kauffman, S. (1993). The Origins of Order: Self-Organization and Selection in Evolution, Oxford University Press.

[6] Kauffman, S. (1995). At Home in the Universe: The Search for Laws of Self-Organization and Complexity, Oxford University Press.

[7] Axtell, R., L. (2000). Why Agents? On The Varied Motivations for Agent Computing in the Social Sciences. Center on Social and Economic Dynamics Working Paper No. 17.

[8] Page, S.E. (2007). The Difference. Princeton University Press.

[9] Grimm V., Berger U., DeAngelis D., et al. (2010). The ODD protocol: A review and first update, ecological modeling, 221, 2760–2768.

[10] Reason, J. (1997). Managing The Risks of Organizational Accidents. Ashgate Publishing Limited.