Organizational Activities for KAIZEN or the Worse: A Unified Agent-Based Model

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Tokyo Institute of Technology

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Abstract

This talk addresses the issue of organizational activities related to security problems. We employ agent-based modeling in order to explain both the KAIZEN and the worse. The principle is that such activities must break standards in usual operations. Based on this, we have developed a unified agent based model and have carried out intensive simulation for analyzing the emergence process of the activities.
One Slide Overview

• Background
  – Security Problems of a Company Depend on Management
  – Kaizen or the Worse

• Objective
  – To Explore a Unified Model to Explain both Firms’ Kaizen and Deviation Activities

• Approach
  – Agent Based Simulation Models
  – Case Grounding of Simulation Results

• Experiments
  – Intensive Simulation Studies

• Result
  – The Model is promising
Outline of the Presentation

• Introduction
• Problem Description
• ABS, Cases, & Utilities
• Developing an ABS
• Experiment & Discussions
• Concluding remarks
Outline of the Presentation

• Introduction
• Problem Description
• ABS, Cases, & Utilities
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• Concluding remarks
Introduction

• TOYOTA is famous …
Kaizen & Deviation of TOYOTA Case

Brake System of A Car Maker

Kaizen
Deviation

Our Focus
Outline of the Presentation

• Introduction
• Problem Description
• ABS, Cases, & Utilities
• Developing an ABS
• Experiment & Discussions
• Concluding remarks
Problem Statements

Organizational Deviation

- Excessive Kaizen activities may lead to misconducts as a result

Kaizen Activities

- Breaking current operation standard is indispensable in companies

Similarity

- The border between Kaizen and deviation is subtle

Problem

- What is the branch condition of deviation and Kaizen?
- How should we harness them?
Comparison of Kaizen & Deviation

Similarity

Breaking current operation standard
to change organizational behaviors

Deviation and Kaizen are two sides of the same coin
Definitions of Org. Deviation

– Deviation categories in sociology

1) Criminality

2) Violating standard norms
⇒ Our model is based on this category

3) Labeling
Our Definition of KAIZEN & the Worse

Distinguish Innovation (KAIZEN) and deviation (the Worse) by Social utility increase or decrease

<table>
<thead>
<tr>
<th></th>
<th>Organizational Utility</th>
<th>Social Utility</th>
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<tbody>
<tr>
<td>KAIZEN</td>
<td>↑</td>
<td>↑</td>
</tr>
<tr>
<td>The Worse</td>
<td>↑, →</td>
<td>↓</td>
</tr>
</tbody>
</table>

We develop the model based on this definition.
Outline of the Presentation

- Introduction
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Agent and the Artificial

- Agent: Model of Human or Organizations
  - With Functionalities of Internal States, Decision Making, & Communication
- Artificial Agents: The simpler, the better
  - Keep It Simple, Stupid Principle [Axelrod]
- Social Complex Systems
  - Artificial!
  - No First Principles
Principe of Agent-Based Modeling

Macro Structure

Models with Macro-Level Variables

ABM: Bottom-Up Model from Micro-Level

Interaction via Micro-Macro Link

Agent: Internal States
Decision Rules
Interaction Rules
At KBS, instruction method centers on the case method. Roughly 90% of core courses and 60% of elective courses are taught by the case method. The other courses consist of lectures for basic concepts, small group projects, and company visits.

Through experiencing a large number of cases, students are able to gain insights into real management and operations within companies, and to learn how to identify and solve managerial problems in the various real business contexts.

KBS holds approximately one thousand and five hundred cases in our case library, and you can search and purchase our cases on the web.
Shapes of Utilities: Real & Mental
Shapes of Utilities: Real & Mental
Shapes of Utilities: Real & Mental
Outline of the Presentation

• Introduction
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• Concluding remarks
Framework of the ABM

Utility function of society

Utility function of organization

Utility function of individual

Utility Production

Choice of Action

Society

Organization

Agents

U_{soc}(X)

U_{org}(X)

U_{ind_i}(X)
Agents’ Decision Making & Learning

I

Individual utility amount
(ex. self-content)

Reward from organization

Contribution for social utility
(a sense of accomplishment)

Total Satisfaction of agent

II

Imitate the actions of other agents
- whose actions are similar
- receiving more rewards
Some Technical Tips I

• Agents’ Decision Making & Learning

  Individual Satisfaction

  +

  I Rewards form the Firm

  Exploration

  +

  Social Contribution

II Imitation

Imitate Others’ Behaviors
- from Similar Agents
- from whom, get more Rewards

(If Satisfaction Level Decreases, then Cancel it)

As rewards are determined by the firm’s system afterward, the decisions are based on organizational utilities.

\[ S(U_{\text{ind}}(X), Re_i) = U_{\text{ind}}(X) + U_{\text{org}}(X) + U_{\text{soc}}(X) \]

\[ S : \text{Satisfaction Level of Agents} \]
\[ Re : \text{Agents’ Rewards} \]
\[ U_{\text{ind}}(X) : \text{Individual Utilities Generated by Agents} \]
\[ U_{\text{org}}(X) : \text{Org. Utilities Generated by Agents} \]
\[ U_{\text{soc}}(X) : \text{Social Utilities Generated by Agents} \]

\[ P_j = \frac{\sum Re_{kj} \times L_{ij}}{\sum Re_{kj} \times L_{ik}} \]

\[ P_j : \text{Imitation Probability of Agent } j \text{ from Agent } i \]
\[ L_{ij} : \text{Similarity of Decision of Agent } i \text{ & } j \]
\[ Re : \text{Rewards Agent } i \text{ gets} \]
\[ N : \text{Length of numerical states} \]

\[ L_{ij} = \frac{\sum_{k=1}^{N} \delta(x_{ik}, x_{jk})}{N} \]
Some Technical Tips II

Myopic Imperfect Information Environment Defined by Kaufmann’s NK Landscape Model

In Our Simulation Model, We Set:

- N=5
- K=2
- Range of Numbers: 0~4
- Dependency: Random

Case of N=6 & K=1

<table>
<thead>
<tr>
<th>number string</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
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<td>combination3</td>
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<td>combination6</td>
<td>01=0.3</td>
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evaluation value: 0.4
Some Technical Tips III

To Represent multimodal complex utility landscapes and reciprocal relationship, NK model is useful

<table>
<thead>
<tr>
<th>Complexity of the Landscape</th>
<th>Reciprocal Relations of the Landscape</th>
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</thead>
<tbody>
<tr>
<td>N: Small Easy to Get Max</td>
<td>Combination</td>
</tr>
<tr>
<td>K=0 Unimodal</td>
<td>00</td>
</tr>
<tr>
<td></td>
<td>01</td>
</tr>
<tr>
<td></td>
<td>10</td>
</tr>
<tr>
<td></td>
<td>11</td>
</tr>
</tbody>
</table>

Numerical Sec: N

Reciprocity: 100%

Dependency: :K

Threshold: 0.5
Outline of the Presentation

• Introduction
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Simulation Case I

- Contradiction of Social and Organizational Landscapes

Utility function of society: $U_{soc}(X)$
Utility function of organization: $U_{org}(X)$

synchronized: 0

contradiction: 1
Case I: Results

- Contradiction of landscapes

⇒ Conflict in the utility landscape prompts organizational deviation and also causes stagnation.
Simulation Case II

- Diversity of Agents’ Utilities: Uniform & Diversified Firms

0% Uniform

100% Diversified

Utility function of individual
Case II: Results

- Diversity of Agents’ Utilities

- Diversification in agents prompts Kaizen type activities
Case II: Results

• Results of 1,000 Simulation Runs

Utility production distribution

Number of dots = 1000

- Uniform organization’s behavior is more unpredictable than diversified organization.
Case II Discussion

Analysis - Diversity of Agents’ Utilities

In a uniform organization…

- Agents could improve their satisfaction by increasing their individual utility amount.
  ⇒ Neglect social utility as a result.

- Agents tend to behave uniformly.
  ⇒ Swing over to Kaizen to deviation by chance.

\[
\text{Individual utility amount} \quad (\text{ex. self-content}) \quad + \quad \text{Reward from organization} \quad + \quad \text{Contribution for social utility} \quad (\text{a sense of accomplishment})
\]

\[
\text{Total Satisfaction of agent}
\]

\[
\text{mutual learning}
\]

\[
\text{Utility function of individual}
\]

\[
\text{0% Uniform}
\]
Simulation Case III

• Effects of Result-Based Reward Policy

L, M, H: Contribution Level
Case III: Results

- Effects of Result-Based Reward Policy

⇒ At the beginning both utility amounts are increasing.
⇒ Then they are decreasing with strengthening result-based reward.
Case III Discussion
Analysis: Effects of Result-Based Reward Policy

Agents could ....

- Pursue short-term gains of reward because of relative evaluation system
  ⇒ Converge on local optimum of utilities

- Improve satisfaction by reward from organization
  ⇒ Decline their intention to contribute to social utilities

Individual utility amount (ex. self-content)

+ Reward from organization

+ Contribution for social utility (a sense of accomplishment)

Total Satisfaction of agent
Case Development

- Comprehensive understanding of inextricably linked innovation and deviation by the set of multiple method

I. Computer Simulation
   - Confirm
   - Compare
   - Real Phenomena

II. Manual Simulation
   - Narrate

III. Model Based
    - Could-be Case
    - Assume

Model
Use Case I Experiment

- Condition of computer simulation - Diversity of Agents’ Utilities

0% Uniform

100% Diversified

Utility function of individual
Results of ABS

Why?
Hand Simulation of Case I

- **Experimental Settings**

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<th>Action Alternatives</th>
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<th>11</th>
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<tbody>
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<td>Social Utility</td>
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<td>Medium</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>Organizational Utility</td>
<td>Low</td>
<td>Medium</td>
<td>Medium</td>
<td>High</td>
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</table>

### Case A: Uniform Organization

<table>
<thead>
<tr>
<th>Action</th>
<th>Society</th>
<th>Organization</th>
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</thead>
<tbody>
<tr>
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<tr>
<td>01</td>
<td>0.3</td>
<td>0.4</td>
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<tr>
<td>10</td>
<td>0.2</td>
<td>0.3</td>
</tr>
<tr>
<td>11</td>
<td>0.1</td>
<td>0.2</td>
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</table>

### Case B: Diversified Organization

<table>
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<th>Action</th>
<th>Society</th>
<th>Organization</th>
</tr>
</thead>
<tbody>
<tr>
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<td>0.10</td>
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</tr>
<tr>
<td>010</td>
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<td>0.27</td>
</tr>
<tr>
<td>100</td>
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<td>0.27</td>
</tr>
<tr>
<td>011</td>
<td>0.20</td>
<td>0.30</td>
</tr>
<tr>
<td>110</td>
<td>0.20</td>
<td>0.30</td>
</tr>
<tr>
<td>101</td>
<td>0.20</td>
<td>0.30</td>
</tr>
<tr>
<td>111</td>
<td>0.10</td>
<td>0.20</td>
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</table>

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**Action Alternatives and Evaluation Value**

<table>
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<tr>
<th>Action</th>
<th>Evaluation Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>00</td>
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</tr>
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<td>01</td>
<td>0.3</td>
</tr>
<tr>
<td>10</td>
<td>0.2</td>
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<tr>
<td>11</td>
<td>0.1</td>
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<table>
<thead>
<tr>
<th>Case: Uniform Organization</th>
<th>Case: Diversified Organization</th>
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<tbody>
<tr>
<td><strong>Evaluation Value</strong></td>
<td><strong>Evaluation Value</strong></td>
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<td>Individual</td>
<td>Individual</td>
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<td>Agent 1</td>
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<td>Organization Conscious</td>
<td>Organization Utility Conscious</td>
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<td>0.40</td>
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<tr>
<td>0.2</td>
<td>0.40</td>
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<tr>
<td>0.3</td>
<td>0.40</td>
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<td>0.4</td>
<td>0.40</td>
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<td>Organization 2</td>
<td>Organization Utility 2</td>
</tr>
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<td>0.1</td>
<td>0.20</td>
</tr>
<tr>
<td>0.3</td>
<td>0.30</td>
</tr>
<tr>
<td>0.4</td>
<td>0.40</td>
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<td>Organization 3</td>
<td>Organization Utility 3</td>
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<td>0.20</td>
</tr>
<tr>
<td>0.3</td>
<td>0.30</td>
</tr>
<tr>
<td>0.4</td>
<td>0.40</td>
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<td>Social Utility Balance</td>
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<td>0.30</td>
</tr>
<tr>
<td>0.4</td>
<td>0.40</td>
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</tbody>
</table>

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**Agent 1**

- Social Utility: 0.4
- Organizational Utility: 0.1

**Agent 2**

- Social Utility: 0.2
- Organizational Utility: 0.2

**Agent 3**

- Social Utility: 0.3
- Organizational Utility: 0.3

---

**Agent 1**

- Social Utility: 0.1
- Organizational Utility: 0.1

**Agent 2**

- Social Utility: 0.2
- Organizational Utility: 0.2

**Agent 3**

- Social Utility: 0.3
- Organizational Utility: 0.3

---

**Agent 1**

- Social Utility: 0.4
- Organizational Utility: 0.1

**Agent 2**

- Social Utility: 0.1
- Organizational Utility: 0.4

**Agent 3**

- Social Utility: 0.1
- Organizational Utility: 0.1
Hand Simulation Results I

- Simplified Model

Each Agent’s Behavior Change Process

Case A: Uniform Organization

<table>
<thead>
<tr>
<th>Agent 1</th>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
</tr>
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<tbody>
<tr>
<td>Behavior Change</td>
<td>Initial Status</td>
<td>Imitate</td>
<td>Imitate</td>
</tr>
<tr>
<td>Combination of actions</td>
<td>000</td>
<td>001</td>
<td>011</td>
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<tr>
<td>Social Utility Production</td>
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<td>0.20</td>
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<tr>
<td>Organization Utility Production</td>
<td>0.10</td>
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<td>0.30</td>
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<tr>
<td>Individual Utility Production</td>
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<td>0.30</td>
</tr>
<tr>
<td>Reward</td>
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<tr>
<td>Satisfaction</td>
<td>0.66</td>
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<td>Individual Utility Production</td>
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<tr>
<td>Satisfaction</td>
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<td>Satisfaction</td>
<td>0.74</td>
<td>0.83</td>
<td>0.80</td>
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</table>
Hand Simulation Results I

- Results of Manual Simulations

Case A: Uniform Organization

Agent 1

Agent 2

Agent 3

Utility production change

Total Utility Producti

Case B: Diversified Organization

- Social Utility
- Organization Utility
- Individual Utility
- Reward
- Satisfaction

Results of Manual Simulations
 Utility production change in diversification
Discussion on Hand Simulation Results I

- **Analysis of Manual Simulations** that occurs with diversification

  **Uniform Organization**
  - Increase satisfaction by pursuing individual utility.
  - ⇒ Neglect social utility as a result.

  **Diversified Organization**
  - Increase satisfaction by balancing all factors of satisfaction.
  - ⇒ Increase social utility as a result.

**Mutual Learning**

- **0% Uniform**
  - Utility function of individual

- **100% Diversified**
  - Utility function of individual

**Total Satisfaction of agent**

- Individual utility amount (ex. self-content)
- Reward from organization
- Contribution for social utility (a sense of accomplishment)
Development of Could-Be Cases

- Simulation Model
  - Transfer model elements to business elements
  - Simplify the model for tracing agent’s behavior

- Results of Manual Simulation
  - Customize for specific case

- Case Template Based on the Model

- Model Based Could-be Case Stories

Enables thinking of events could be occurred in future.
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 from 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 achievement 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.

Comparing to the cases based on real events…

- Disadvantage: Limitations of specifics
- Advantage: 1. Can describe the process of behavior change
  2. Distinguish common and different factors among innovation and deviation case scenarios
Comparison with the Real

- Comparing with real case that occurs with diversification
  A Japanese pastry company’s (Akafuku) misconduct case

Organizational Utility
- Extending products expiration
- Reducing disposal

Social Utility
- Keep freshness of foods
- Protecting consumer’s health

Conflict

Comparing the model based case with the cases based on real events...
- Disadvantage: Limitations of specifics
- Advantage:
  1. Can describe the process of behavior change
  2. Distinguish common and different factors among innovation and deviation case scenarios
Outline of the Presentation

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- Developing an ABS
- Experiment & Discussions
- Concluding remarks
Conclusion

• Proposed unified model of organizational Kaizen and the Worse

• Academic Contribution
  – Clearer definition of Organizational Deviation through comparison with Kaizen

• Implication for Management
  – Direct control of organizational deviation could be a cause of reducing power of Kaizen
    • Such as organization structure, or wage system
  – Improvement of consistency between firm’s and social utility is effective
Our Contributions

– Comprehensive understanding of inextricably linked KAIZEN and the Worse by the set of multiple method
– Reduce unexpected situations by model based case design

Our Approach

Innovation and Deviation