Chapter 3
Influences of Faultlines On Organizational Performance

Fumiko Kumada and Setsuya Kurahashi

Abstract The diversification of employment and work styles in organizations is in progress in Japan, where the labor force is shrinking because of a declining birthrate and an aging population. It is important that we demonstrate how to manage a diversified organization. Using the concept of faultlines, which are hypothetical dividing lines that may split a group into subgroups of people based on their multiple attributes, this paper examines the relationship of influences of an associated diversity (i.e. the faultline strength and the number of subgroups) and a method of communication within an organization. The methods are verified by an agent-based model based on a survey of Japanese organizations. Thus, this paper clarifies that appropriate communication is related to the associated diversity of an organization. Therefore, it is important for a manager to grasp a structure of diversity of an organization and to design communications accordingly.

Keywords Diversity management · Faultlines · Agent-based model

Introduction

Ensuring a stable workforce in Japan is becoming more important, given the country's shrinking labor force due to a declining birth rate and an aging population. Therefore, the acceptance of foreign workers and work-style reforms are in progress, leading to the diversification of workers and work styles. In the field of diversity management, diversity is known to affect organizational performance either positively or negatively. Therefore, clarifying the factors that are positively affected by diversity in Japan is important.

F. Kumada (✉) · S. Kurahashi
University of Tsukuba, Tokyo, Japan
e-mail: kumafumi@gmail.com

S. Kurahashi
e-mail: s1845005@s.tsukuba.ac.jp

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This paper focuses on the concept of the faultlines perspective defined by Lau and Murnighan [7] to derive one of the solutions to managing a diversified organization to enhance organizational performance. In the following sections, we first introduce previous studies. Second, we explain an agent-based model (ABM) based on the concept of faultlines. Next, we survey Japanese organizations to learn about the attributes of their members. Subsequently, we simulate using the ABM with the results of the survey. We conclude by summarizing the results of the simulations.

Previous Studies

The Field of Diversity Management

Williams and O'Reilly [13] proposed an integrated model that represents how diversity affects organizational performance and explained that diversity could have both positive and negative effects. The integrated model reflects three theories.

The first theory is the social categorization theory. This theory explains that people categorize themselves and others using demographic attributes, such as age, gender, and others, and that they may experience conflicts in their communications and relationships. The second is the similarity-attraction theory. This theory explains that highly similar individuals feel an attraction to each other and strengthen their solidarity while causing conflict with those who are less similar. The third is the information and decision-making theory. This theory explains that diversity increases knowledge and information types, providing an organization with positive effects. Based on the integrated model, the key point dividing positive from negative may be related to the smoothness of communications.

Faultline Perspective

Lau and Murnighan [7] proposed the concept of faultlines, which are hypothetical dividing lines that split a group into subgroups based on one or more individual attributes to explain the causality of diversity based on attributes of organizational members and conflicts within the organization.

Many previous studies on the faultline perspective reported that they increased conflict. Regarding studies that focused on subgroups, Plzer et al. (2006) reported that an uneven group size could achieve high performance. Carton and Cummings [2] conducted a field survey that showed that three or more subgroups could achieve high performance. In addition, Flache and Mäs [3], Grow and Flache [4] and Mäs et al. [8] revealed the mechanism of the faultline perspective by an agent-based model.

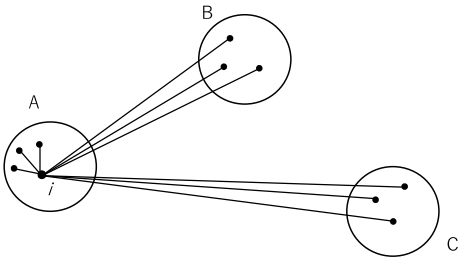

Fig. 3.1 Relationships of elements involved in the computation of *s(i),* where the object *i* belongs to cluster A [11]

Faultline Measurement Methods

Previous studies proposed more than 10 faultline measurement methods. Suzuki et al. [12] stated that the rating scale for cluster analysis proposed by Meyer and Glenz [9], the average of silhouette width (ASW) had various advantages. For example, the ASW could handle continuous and categorical variables and divide target organizations into proper subgroups.

ASW is a rating scale used to evaluate cluster analysis results, as proposed by Rousseeuw [11]. The following items are defined in Fig. 3.1:

- *a(i)*: average dissimilarity of *i* to all other objects of A.
- *d(i, C)*: average dissimilarity of *i* to all other objects of C.

$$s(i) = \frac{b(i) - a(i)}{max\{a(i), b(i)\}} \tag{3.1}$$

Where the smallest value of *d(i, C)* for all the clusters other than A is calculated as *b(i)* according to the above definitions, and cluster B becomes adjacent to A. Equation (3.1) expresses the adequacy of sample *i* to belong to cluster A.

Meyer and Glenz [9] defined this overall mean edge width, $\bar{s}$, as the faultline value. Where the mean edge width is $\bar{s}\ (k)$ when there are k clusters, for which maximums $\bar{s}\ (k)$ are selected. The clusters become subgroups, where k is the number of subgroups.

Review of Previous Studies

Only a few prior studies addressed the faultline perspective for Japanese organizations. Therefore, this paper reports on a survey of Japanese organizations on their attributes and indicates diversity by plural dimensions using the faultline perspective. The associated diversity that is defined as the constitution of team members consists of the faultline strength and the number of subgroups because the ASW

enables subgroups to extracted to make faultlines stand out in a different dimension from diversity. Moreover, the ABM is used to examine the relationship between the associated diversity and communication. We utilize the ABM because it is appropriate for verifying the influences generated by people's actions toward the entire organization.

Outline of the Proposed Model

In organizational activities, a number of problems occur daily. To solve these problems, both formal communications such as business meetings and informal communications such as chatting occur in an office. Through these communications, members of an organization understand and affect each other. Therefore, the model examines how to influence an entire organization by the associated diversity and communication.

In this model, agents are similar to members of an organization, and they interact with each other to update their evaluation values. Then, the evaluation values of the entire organization (i.e., the sum of the evaluation values of each agent) before and after the interactions are compared to verify the increase or decrease.

Agent Attributes

Each agent has a six-gene array comprised of 0 s and 1 s. This gene array is regarded as the decision-making attitude attribute. Interactions between agents affect each agent's decision-making attitude attribute and update the evaluation value.

The decision-making attributes apply the multi-attribute attitude model of consumer behavior theory. The multi-attribute attitude model describes a scenario in which a consumer evaluates a product, more than one of the attributes receive attention, and all of the evaluations of each attribute result in a comprehensive product evaluation. While replacing products with agents using this concept, the characteristics of how to approach issues are represented by plural attributes, and the sum of the evaluation values of the attributes is regarded as a comprehensive evaluation for solving a problem.

The initial six-gene array of each agent is calculated using the ASW to determine the faultline strength and the number of subgroups. Here, the initial decision-making attitude attribute is assumed to depend on the demographic attributes, such as age and gender, because it reflects before being influenced by other agents.

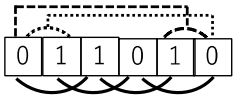

Fig. 3.2 Structure of NK landscape (N = 6, K = 2)

Table 3.1 Example of fitness [5]

Genes	000	001	010	011	100	101	110	111
Fitness	0.141	0.592	0.653	0.589	0.793	0.233	0.842	0.916

Evaluation Function

The NK model by Kauffman and Levin [6] is used as the evaluation function for the decision-making attitude attributes (six-gene array) held by each agent. The NK model is a genetic algorithm that mimics the process by which living organisms evolve and is utilized in various fields, including organizational learning.

The evaluation value of the NK model is referred to as "fitness". The NK model is based on N genes that are related to K genes. Figure 3.2 shows a specific example of N = 6, K = 2, where the evaluation value is expressed as Eq. (3.2).

$$W = \frac{1}{N}\sum_{i=1}^{N} w_i \tag{3.2}$$

W_i: The fitness in the fitness function of each gene.

Figure 3.2 shows the case of K = 2. Thus, one evaluation value is calculated with a succession of the agent's genes and the other two genes. There are six sets of genes from the left: (001), (011), (110), (101), (010), and (100) (four sets with a bold line and two sets with dashed lines). The following shows the calculation result of applying the example of adequacy arrays in Table 3.1 based on these six sets. (0.592 + 0.589 + 0.842 + 0.233 + 0.653 + 0.793)/6 = 0.617.

Interaction Method

Initial Method

One organization comprises 18 agents. The six-gene arrays of the 18 agents are evaluated using the ASW. As a result, the faultline strength and the number of subgroups are calculated, and the associated diversity is defined as the constitution of team members. The associated diversity is indicated in Fig. 3.3.

The interaction is defined by "whom" (i.e., the criteria to select an agent), "when" (i.e., the conditions for interaction), and "how" (i.e., the interaction method). The objective of this model is to clarify the type of interactions that have a positive impact

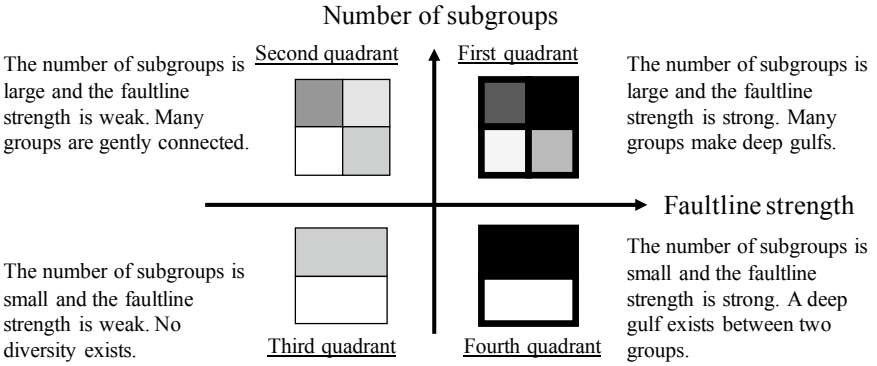

Fig. 3.3 Features of each quadrant in the associated diversity

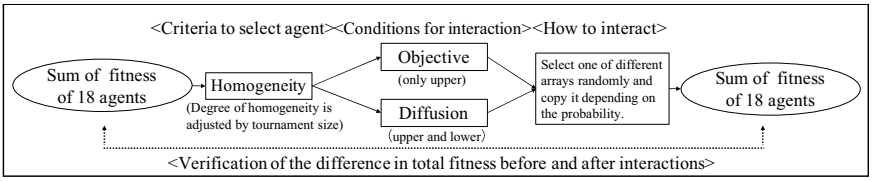

Fig. 3.4 Overall flow of the interaction

on an organization and the quadrant of the associated diversity that effectively affects an organization. Figure 3.4 illustrates the overall flow of the interaction.

Criteria for Selecting An Agent

Williams and O'Reilly [13] reported that the conflict in an organization hinders communication and decreases performance. Thus, a situation of communicating with similar members by conflict is represented, that is named homogeneity selection.

Homogeneity selection comes from the social categorization theory, which is based on the faultline perspective. Similar members gather, and communication is hindered by conflict. The relationship between the degree of homogeneity and organizational performance is verified. As a parameter of homogeneity, tournament size ranges from two to 17. The larger the tournament size, the higher the homogeneity. Figure 3.5 illustrates homogeneity selection process. First, agents are selected randomly according to tournament size. Second, an agent selects another agent with the highest homogeneity (i.e., the closest Hamming distance). Hamming distance is the number of digits of different values at corresponding positions when comparing two values with the same digit number. For example, the Hamming distance between the attitude attributes (011010 and 001010) is 1.

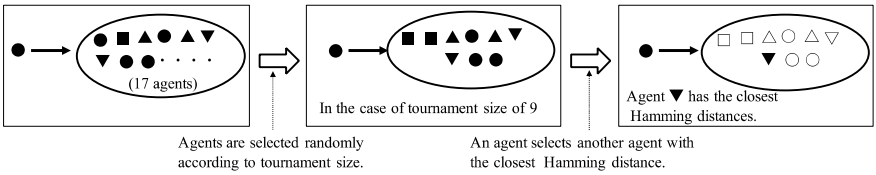

Fig. 3.5 Process of homogeneity selection

Conditions for Interaction

Two conditions for interaction are set for the simulation. The objective type represents each agent attempting to interact with the selected agent when the fitness of a selected agent is higher than that of the agent. In the real social context, it is a situation in which members of an organization communicate to achieve a goal like top-down communications. Business activities usually have goals. Therefore, formal corporate activities are represented by the objective type.

The diffusion type represents each agent's constant attempts to interact with the selected agent regardless of low and high fitness. In the real social context, this type includes, for example, light conversation and information exchange, and lacks goals.

How to Interact

The method of interaction applies the disseminating culture model by Axelrod [1]. This method randomly selected and copied different attributes according to the ratio of the same attributes to the whole. In our model, the ratio of the interaction is set in accordance with the degree of the difference in fitness.

Evaluation Standard

The difference in the fitness of the entire organization before and after interactions serves as the evaluation value. Equation (3.3) shows the evaluation value (E).

$$E = \sum_{i=1}^{n} W_{ei} - \sum_{i=1}^{n} W_{si} \tag{3.3}$$

n: The number of agents.
W_{si}: The fitness of agent$_i$ before the interaction.
W_{ei}: The fitness of agent$_i$ after the interaction.

The evaluation standard is the average of the top 10 out of 100 simulations (except for outliers) as the increasable fitness. Equation (3.4) shows the increasable fitness.

$$Increasable\ Fitness = \frac{1}{10}\sum_{k=1}^{10} E(k) \tag{3.4}$$

$E(k)$: Evaluation value of the top k^{th}.

We observe how the associated diversity and the interaction methods change the increasable fitness, and the relationship between an organizational diversity and performance is clarified.

Simulation for the Verification

To validate the model, we formed six datasets based on the faultline strength and the number of subgroups. The model is valid when faultlines increase conflict and negatively affect organizational performance. In this case, the simulation is performed with the objective type because the faultline is premised as formal communication to obtain a goal within an organization.

Table 3.2 shows the associated diversity of the six datasets and the regression coefficient. The objective variable is the increasable fitness, and the explanatory variable is tournament size. The following two points were reached

– The larger the tournament size, the lower the increasable fitness. A larger tournament size indicates that the degree of homogeneity increases. Therefore, homogeneity selection causes a negative effect on organizational performance.

Table 3.2 Results of simulation for verification

Data set	Faultlne strength	Number of subgroups	Regression cofficient[a]
1	0.687 (strong)	2	−0.395***
2	0.142 (weak)	2	−0.251***
3	0.722 (strong)	3	−0.423***
4	0.308 (weak)	3	−0.264***
5	0.848 (strong)	6	−0.384***
6	0.260 (weak)	6	−0.280***

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$

[a]The objective variable is the increasable fitness, and the explanatory variable is the tournament size

– When the number of subgroups is the same, the stronger faultline strength results in a larger absolute value of the regression coefficient. Therefore, the strong faultlines have a more negative influence.

This model demonstrates the phenomenon in which conflicts arising from the faultline have negative influences on organizations. The evidence validates the model.

Fact-Finding Survey

We run this model by applying the results of a survey of Japanese organizations to concretely clarify the influence of the associated diversity on organizational performance. Therefore, a survey of Japanese organizations was held to collect the data on the attributes of members.

Survey Overview

The survey subjects were five companies and 14 groups in Japan (three groups in one major company in the real estate industry, one group in one mid-size company that is the investigation firm, seven groups in two startups, and three groups in one emerging company that is a call center agency), for a total of 126 respondents. These groups represent the smallest units that a manager controls. Questions about employee attributes addressed four items: age, gender, service years, and type of employment. By using attribute data, the associated diversity was calculated by ASW.

Survey Results

Table 3.3 shows the associated diversity, and the left side of Fig. 3.6 plots the faultline strength and the number of subgroups of the 14 groups. The results of the regression analysis on the faultline strength and the number of subgroups is as follows:

$$N = 0.687 + 5.721 \times S \tag{3.5}$$

*Coefficient of determination $= 0.522$, $p < 0.05$.
N: The number of subgroups, S: The faultline strength.
The survey results presented two features

– Half of the groups had less diversity because they were in the third quadrant. Thus, the faultline strength was weak and the number of subgroups was low. However, groups belonging to the fourth quadrant did not exist.

Table 3.3 Associated diversity of subject groups

Subject	N of M[a]	FS[b]	N of SGs[c]	N of M in SG[d]
Major company	8	0.404	5	2,2,2,1,1
	7	0.357	4	3,2,1,1
	10	0.324	2	7,3
Startup 1	6	0.328	2	3,3
	7	0.422	3	3,2,2
	9	0.800	5	2,2,2,2,1
	6	0.336	2	3,3
Startup 2	10	0.686	5	3,2,2,2,1
	10	0.615	4	4,3,2,1
	19	0.722	4	11,5,2,1
Emerging company	4	0.297	2	3,1
	5	0.390	2	4,1
	15	0.502	5	4,3,3,3,2
Mid-size company	10	0.351	2	5,5

[a]Number of members, [b] Faultlien strength, [c] Number of subgroups [d] Number of members in each subgroup

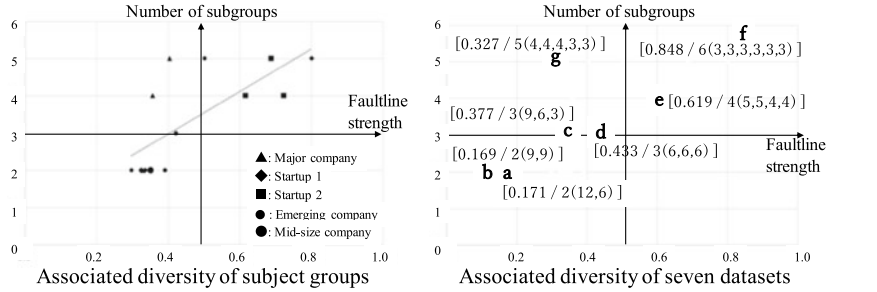

Fig. 3.6 Associated diversity

– Equation (3.5) shows the tendency that stronger faultlines increase the number of subgroups.

Based on Eq. (3.5) six new datasets (a–f), and g, which is in the second quadrant in Fig. 3.3, were formed and simulated. The right side of Fig. 3.6 shows the associated diversity of seven datasets. The survey results confirmed that some groups had an imbalance in the number of subgroup members and some did not. Therefore, datasets were prepared for the case with an imbalance in the number of subgroup members and the case without such an imbalance (a:12,6 and b:9,9; c:9,6,3. and d:6,6,6).

Simulation for Organizational Diversity

To clarify the relationship between an organizational diversity and the various communication methods that actually occur in organizational activities, the simulations are conducted using the datasets based on the survey results. These simulations indicate concretely the influence of the diversity of existing corporate organizations.

The simulation was performed using homogeneity selection as the criteria for selecting an agent, and also the objective type and the diffusion type as the conditions for interaction. Additionally, the evaluation standard applies the increasable fitness, as explained in the third section.

Results of the Objective Type

The results of the objective type with the reproduction of formal corporate activities are indicated in Fig. 3.7 and Table 3.4. At Fig. 3.7, the vertical axis represents the increasable fitness, and the horizontal axis represents the degree of homogeneity in selecting the agent with which to interact. Homogeneity is decreasing toward the right. The following points were clarified

– (b), which has a weak faultline and a few subgroups, is much lower than others when homogeneity is low but is not low when homogeneity is high. This result shows that the possibility of increasing the fitness of an organization with the homogeneity is lower than for an organization with the diversity.

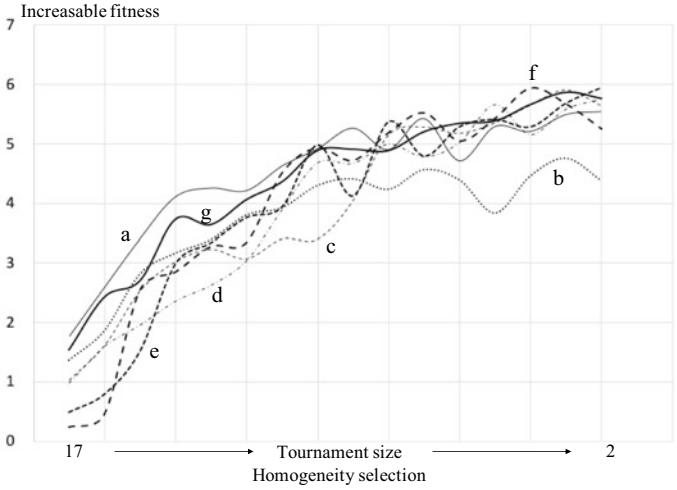

Fig. 3.7 Results of the objective type

Table 3.4 Average and standard deviation of the increasable fitness

		a	b	c	d	e	f	g
Objective type	Average[a]	4.48	3.73	3.97	3.92	3.98	4.06	4.40
	SD[b]	1.05	0.95	1.48	1.54	1.69	1.73	1.25
Diffusion type	Average[a]	2.04	1.93	2.02	1.80	1.77	1.92	2.12
	SD[b]	0.70	0.70	0.94	0.79	0.92	0.94	0.72

[a]The average of the increasable fitness of tournament size from two to 17
[b]The standard deviation of the increasable fitness of tournament size from two to 17

– (e) and (f), which have strong faultlines and numerous subgroups, have the lower increasable fitness than others when homogeneity is high. In contrast, the increasable fitness is higher than others when homogeneity is low.
– (g), which has a medium faultline strength and many subgroups, remains at the middle of seven datasets with the average value and the standard deviation, as in Table 3.4; stability is observed.
– In (a) and (b), the increasable fitness of (b) was always lower than that of (a), despite the faultline strength and the number of subgroups being almost the same. This result confirms that an imbalance in the number of subgroup members affects the organization's performance.

Results of the Diffusion Type

The results of the diffusion type with a reproduction of informal communication such as conversations at lunch and light conversations are provided in Fig. 3.8 and

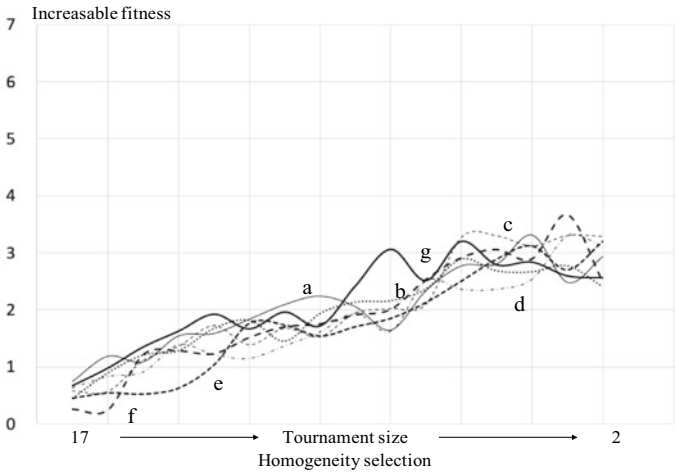

Fig. 3.8 Results of the diffusion type

Table 3.4. At Fig. 3.8, the vertical axis represents the increasable fitness, and the horizontal axis represents the degree of homogeneity when selecting other agents to interact. Homogeneity is decreasing when going to the right. The following points were clarified

- The diffusion type is related to interactions with an agent with lower fitness. Thereby, all increasable fitness averages are lower than for the objective type. In addition, all of the standard deviations are lower relative to the objective type.
- No dataset is much different from the others, such as (b) in the objective type.

Discussion

This paper aims to clarify how to manage diversified organizations to improve performance. Therefore, we indicated diversity through plural dimensions from the faultline perspective. Through the simulation, we validated how the relationship between diversity and communication could affect organizational performance.

The results indicate that the associated diversity influences organizational performance through means of communication. For this reason, a manager needs to grasp the associated diversity and design communication. Based on the simulation results, the characteristics in each quadrant of the associated diversity in Fig. 3.3 are as follows

- In the third quadrant, in which the faultline strength is weak and the number of subgroups is low, half of the survey groups exist. This diversity has the characteristics that communication methods have a weaker influence on organizational performance than the other quadrants. Therefore, the harm caused by the absence of management is small, but the communication design may be less effective.
- In the second quadrant, in which the faultline strength is weak and the number of subgroups is high, few groups of a major company exist. This diversity has the characteristics that different communication methods result in less variation, and stable and high performance is expected. In addition, communication design has the possibility of improving performance.
- In the first quadrant, in which the faultline strength is strong and the number of subgroups is high, some groups of the startups exist. This diversity has the characteristics that the negative effect of communication within extremely homogeneous people is greater than in other quadrants. In contrast, communication design has the possibility of improving performance.
- In the fourth quadrant, in which the faultline strength is strong and the number of subgroups is low, no survey group exists.

Conclusion

This paper clarifies how the associated diversity influences organizational performance through communications through the faultline perspective that indicates diversity by plural dimensions using the ABM. In conclusion, this paper has demonstrated that the influence of diversity makes a difference according to the associated diversity, and grasping the associated diversity and designing ways of communication are essential.

This paper was based on a survey of Japanese organizations, with the frequency of the interactions converted to time using other surveys. Therefore, further studies should conduct a complete survey. In addition, this paper has as subjects the smallest unit of management. Further studies can target a larger organization. Finally, this paper used homogeneity as a parameter. However, using other parameters, for example, cohesiveness and centrality in network analysis are possible. Such studies could clarify the influence of diversity.

References

1. R. Axelrod, *The Complexity of Cooperation* (Princeton University Press, USA, 1997).
2. A.M. Carton, J.N. Cummings, A theory of subgroups in work teams. Acad. Manag. Rev. **37**(4), 441–470 (2012)
3. A. Flache, M. Mäs, Why do faultlines matter? Simul. Model. Pract. Theory **16**, 175–191 (2008)
4. A. Grow, A. Flache, How attitude certainty tempers the effects of faultlines in demographically diverse teams. Comput Math Organ Theory **17**, 196–224 (2011)
5. S. Iba, *Genetic Algorithm and Mechanism of Evolution* (Iwanami Shoten, Japan, 2002).
6. S. Kauffman, S. Levin, Towards a general theory of adaptive walks on rugged landscapes. J. Theor. Biol. **128**(1), 11–45 (1987)
7. D.C. Lau, J.K. Murnighan, Demographic diversity and faultlines. Acad. Manag. Rev. **23**(2), 325–340 (1998)
8. M. Mäs, A. Flache, K. Takacs, K. Jehn, In the short term we divede, in the long term we unite. Organ. Sci. **24**(3), 716–736 (2013)
9. B. Meyer, A. Glenz, Team faultline measures. Organizational Research Methods **16**(3), 393–424 (2013)
10. J.T. Polzer, C.B. Crisp, S.L. Jarvenpaa, J.W. Kim, Extending the faultline model to geographically dispersed teams. Academy of Management Journal 49(4), 679 692 (2006)
11. P. Rousseeuw, Silhouette: A graphical aid to the interpretation and validation of cluster analysis. J. Comput. Appl. Math. **20**, 53–65 (1987)
12. R. Suzuki, Y. Matsumoto, A. Kitai, The Concept and Analytical Techniques of Faultline. Journal of Political Economy **211**(6), 53–88 (2015)
13. K.Y. Williams, C.A. O'Reilly, Demography and diversity in organizations. A review of 40 years of research. Research in organizational behavior (8), 70–14 (1998)