How to Overcome the Chasm and Promote Digital Transformation Using Goal-setting Theory

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Abstract; This study questions the assertion of previous studies that promoting digital transformation (DX) requires small organizations to operate autonomously and with high agility. If the chasm theory is applied to organizational change, only a small number of innovators and early adopters are willing to utilize technology, while the majority of organizations are technologically backward-looking. Therefore, this study considers that encouraging high agility in organizations is not necessarily positive for DX to take advantage of technology. In this study, DX is modeled by combining the Bass diffusion model and an adaptation prediction model. In particular, the goal of learning the technology to be utilized for DX is incorporated into the model. The results show that even if the agility of the majority of the organization is low, if appropriate goals are set, the word-of-mouth effect from innovators and early adopters will increase and the agility of the entire organization will increase.

Key words; Goal setting theory, Chasm, Bass model, AI, Digital transformation

1. Introduction

In recent years, digital transformation (DX) using AI has been popular in firms (Stolterman and Fors, 2004). In relation to DX, the organizational change theory has accumulated many achievements. The organizational change process (Bridges and Bridges, 2017; Nadler and Tushman, 1997; Lewin, 1951) and the know-how of necessary skills and points to note (Nadler et al., 1995; McCaulley, 1975) have been clarified. Nevertheless, this recent DX is not necessarily working well (Björkdahl, 2020; Correani et al., 2020). In particular, previous organizational change theory has focused on discussions of leader behavior and macroscopic perspectives on the entire organization (Hill et al., 2012). However, as will be discussed below, some members of an organization are advanced with regard to technology, while others are conservative. In light of the fact that DX is not progressing well in the real world, the approach of "delegating authority and moving flexibly in small organizations centered on middle management, rather than a top-down approach" (Kahl et al., 2022; Muhammad et al., 2022; Schaninger et al., 2023, p.78), which was often pointed out in previous research on DX, may not actually be an appropriate approach to organizational change. This study considered that even if the aim is simply to move flexibly in a small organization, DX will not progress well unless the characteristics of the advanced or conservative members of the organization are fully considered.

Despite the fact that the implementation of technologies such as AI and agility are problematic in previous research, it is difficult to say that the level of setting of transformation goals and the superiority of transformation speed have been sufficiently discussed. For example, it is difficult to imagine that any organization could suddenly master the latest AI and transform itself. By using system dynamics (SD) simulations, this study aims to clarify the differences in DX promotion depending on the level of the goals set for transformation and the speed of transformation, and to consider measures for promoting DX. In the field of SD, in particular, traditional research has been conducted by Milling (1996) and Maier (1998). Wunderlich et al. (2014) also modeled the way in which organizations change. However, these previous studies were not focused on DX. In particular, Wunderlich et al. (2014) generalized the discussion, so they did not consider the goal setting for organizational change due to the implementation of technology. DX has a goal that it wants to achieve by introducing technology. The diffusion activity called DX is just a means to reach that goal. In addition, the affinity of the progressive and conservative groups towards technology is not considered, and the difference in level between these two groups is not taken into account. The aim of this study is to clarify how the difference in level between groups involved in goal-setting and diffusion affects the promotion of DX, and to derive measures for promoting DX.

2. Review of Previous Research

This section reviews previous research related to organizational change, chasm, and system dynamics, and explains the research issues involved in promoting DX. It then provides an overview of this research.

Organizational Change Theory

In terms of DX within the organization of a firm, it is said that in order for the organization to adapt to changes in the external environment, it is important to delegate authority and repeat trial and error with high agility (Westerman et al., 2019; Kane, 2019, p.155). In the past, organizations were led by top management (Simon, 2019, p.41; Teece, 2007; Cruz et al., 2021), but it is now more desirable to delegate authority and have middle management take the lead in a flexible manner, as this makes it easier to deal with ambiguity and complexity is easier to deal with (Kahl et al., 2022), and it is desirable for keeping up with social change (Muhammad et al., 2022; Schaninger et al., 2023, p.78).

However, organizations form organizational culture (Schein, 2017). Using the metaphor of organizational inertia, the difficulty of changing organizational culture has been pointed out (Volberda, 1998, p. 47). Therefore, while the aim of delegating authority is to move flexibly, it is not easy to change an organizational culture that has not been accustomed to flexibly repeating trial and error to advance work. For example, middle managers who are unwilling to change, such as “frozen middle managers”, are treated as heretics in organizational change theory (Saldanha, 2019, p.99; Byrnes, 2005). However, considering the inertia of organizations, frozen middle managers are not heretics, but rather behaving typically of middle management. In fact, only around 50% of middle managers think that their organization encourages trial and error (Kane, 2019, p.209). As for how to deal with the remaining 50% of frozen middle managers and lead organizational change, the importance of dialogue and action by top management has been pointed out (Schaninger et al., 2023, p.52; Kotter, 1995). However, this often only results in the imposition of top management's intentions and lacks middle managers' initiative; in such cases, it is difficult to obtain the commitment necessary for organizational change (Senge, 2006, p.198), and in discussion of organizational inertia, there is a view that organizational size is not necessarily related to a decrease in organizational responsiveness to change (Kelly and Amburgey, 1991). According to these views, it does not necessarily follow that a smaller organization will be more agile.

Chasm Theory

On the other hand, Heifetz and Leane (1997) pointed out that while mere technical challenges can be solved by experts, adaptive challenges require the empathy of organizational members and a shift in new values, beliefs, and approaches to the work to which they feel loyalty. Based on this point, DX is not exactly a technical challenge, but an adaptive challenge, because it requires the implementation of technologies, such as AI, that are different from the values and approaches to work used in the past, and a shift to AI-enabled work. This is because not everything can be solved by having experts create superior AI. Therefore, let this paper consider the adaptation of the chasm theory in high-tech marketing (Moore, 2014) to DX by assuming the DX of a firm and considering the firm's constituent members as marketing objects.

By adapting the theory of the chasm to DX, the process of DX diffusion among organizational members, i.e., changes in the state of adaptation to new values, etc., will be captured. According to the theory of chasm, there are roughly 15% of innovators and early adopters among organizational members who are willing to accept and use DX even if the quality is insufficient, 35% of early majority, 35% of late majority, and 15% of laggards who have no interest in technology at all (Moore, 2014, p.15). It has been pointed out that a chasm exists between early adopters and the early majority. A chasm refers to the gap between those who are highly interested in technology and have high technical skills, and can therefore repair problems in prototype services and use them themselves, and those who cannot fully use technology without support services (Moore, 2014, p.21). Also, in order to overcome the chasm, it is important to provide whole products, i.e., products that are close to users' ideals, including not only the core functions provided by the product but also maintenance support services and auxiliary functions for the users of the product (Moore, 2014, p. 130). In other words, unless this chasm is overcome, it is dif-

ficult to complete a transformation that involves the entire organization, including the early and late majorities that make up the majority.

It has been said that DX implementation requires broad involvement (Kotter et al., 2021, p.58). However, as reviewed so far, the approach of increasing agility in a small organization and raising the service level through a series of trial and error may well work for innovators and early adopters. However, from the perspective of organizational inertia and the conservative characteristics of the majority, it will not work for the early and late majorities that make up the majority of the organization. There is no room to deny the necessity of improving agility for organizational change, but the organizational change theory so far seems to be working against overcoming the chasm. It cannot be said that measures for organizational members who are slow to change, such as the frozen middle, early majority, and late majority, are sufficient.

Therefore, in this study, it will be examined what measures are effective for the early majority and late majority by utilizing system dynamics (SD). In particular, in previous studies, the discussion has centered on the process and skills of organizational change, and the speed of change has not been fully discussed. By taking advantage of being able to compare and verify the speed of change in simulations using SD, this study aims to derive measures that will lead to more rapid change.

In the field of SD, Wunderlich et al. (2014) have modeled organizational change using the Bass model (1969). As Sterman (2000, p.342) also pointed out, in some cases, such as replacement, the purchaser may return to being a purchaser. In Wunderlich et al. (2014)'s research, they also point out that in organizational change, there is a possibility that the phenomenon of the adopter returning to being a non-adopter may occur due to negative communication from the non-adopter. As this discussion is based on a generalized mathematical model, the concept of commitment is not taken into account. However, in research that specifically focuses on DX, as in this study, it is necessary to consider commitment. This is because, in the DX process, rather than negative communication from non-adopters to adopters, a decrease in commitment is the factor that causes adopters to return to non-adopters. The meaning of the concept of commitment differs between the fields of business and psychology, and there is no widely accepted consensus. Based on Meyer and Allen (1991), the phenomenon of returning to the non-adopter occurs as a result of recognizing that one or more of the following are lacking: affective commitment (affection for the organization, sense of identification), continuance commitment (awareness of the costs and benefits of leaving the organization), and normative commitment (sense of obligation to stay in the organization). In other words, when the values that the adopters have committed to are not actually obtained, they will withdraw from the position of the adopter. This is largely due to communication with the leader of the adopter group, i.e., the supervisor in the position of the adopter, rather than communication from the non-adopter. For example, instructions to lower salaries because the DX effect is not being obtained may also be a factor in lowering continuous commitment. It has also been pointed out that a lack of trust in the managers leading the DX and other transformations can also be a factor in lowering commitment (Senge et al., 1999, p.186). Therefore, in this study, the stance that the communication from non-adopters is a factor when transitioning from adopters to non-adopters is not adopted. It is necessary to extend the Bass diffusion model so that the gap between the goals that firms want to achieve by promoting DX and the reality becomes a factor in returning from adopters to non-adopters.

In addition, in relation to the above, this study also needs to discuss the goal setting that satisfies the values of the adopters as a result of the commitment. In Wunderlich et al. (2014), it is difficult to say that the goal setting was sufficiently discussed. However, as Loke (1968) pointed out, in goal setting theory, appropriate goal setting is positively correlated with improved performance. On the other hand, it has also been pointed out that setting goals that are too difficult to achieve can reduce performance (Weinberg, 1994; Locke and Latham, 2019). In other words, appropriate goal setting has an impact on the speed of organizational change. Therefore, this study will conduct a simulation by linking the adaptive expectations model (Sterman, 2000, p.426) and Bass diffusion model (Sterman, 2000, p.332) from the perspective of goal setting. Already, Sterman (2000, p. 532), Barlas and Yasarcan (2007), and Ceresia (2009) have also discussed goal setting in SD research. In particular, these previous studies pointed out that goals are not necessarily fixed, but rather variable. They also presented a model of the dynamics

that form goals themselves. However, they assumed the dynamics that occur within a single group, and so cannot be applied to this study, which focuses on DX. In the process of promoting DX, organizations are made up of groups with different attributes, such as advanced and conservative groups in relation to technology. This research will first take the goal itself as a fixed starting point, but will then work to incorporate a model of goal setting theory that assumes two different groups with different attributes and that applies to the case where the two different groups are working towards the same goal.

Then, this research shows that if the agility of the entire organization can be increased, contrary to the chasm theory, the diffusion and enlightenment of DX will indeed advance, as pointed out in the previous studies. At the same time, this study also shows through simulation that if the agility of the majority is not increased based on the chasm theory, the diffusion and enlightenment of DX will not progress. As a measure, innovators and early adopters are to be change agents (Golembiewski, 2001, p. 640) who promote, implement, and support DX. Then, assuming that the agility of the majority will not increase, it is indicated that the involvement of the majority through careful diffusion and education activities and appropriate goal setting over time from both of these change agents is an effective measure that can advance DX at the same speed as the improvement of agility toward DX.

3. Theory and Method

3.1. Causal Loop and Reference Mode

Fig. 1 summarizes the DX status of the organizations shown above as a causal loop and indicates the reference mode.

Previous studies have suggested that promoting autonomy, increasing agility and repeating trial and error will lead to many members and markets accepting DX promotion, thereby advancing DX. However, that is the story of innovators and early adopters (R). In reality, the chasm becomes apparent among the early majority and late majority, and they stop following DX (B1). Therefore, the number of DX promotion members in an organization converges to a value determined by the self-reinforcing loop (R) and the balancing loop (B1) as time passes.

At that point, the intensity of the balance loop (B2, B3) also changes depending on the level of technology implemented and the awareness activities conducted by innovators and early adopters toward early majority and late majority users. As a result, the intensity of the self-reinforcing loop (R) and balance loop (B1) also changes. The organization presents the vision it wants to achieve through DX and determines the technology that should be implemented. If there is a significant gap between the technology and the level of proficiency within the organization, the chasm will widen, and the early majority and late majority will be unable to follow (B2). As a result, it is difficult to expect an increase in the number of DX promotion members within organizations. However, conversely, innovators and early adopters who are interested in new technologies explore and acquire the skills to utilize them (B3). Then, based on the acquired skills, deploy those skills to the early majority and late majority (B4). These activities will lower the threshold for crossing the chasm and increase the number of DX promotion members within the organization. As such, unless the level of technology implemented is set at an appropriate goal for both groups with conflicting characteristics, namely innovators and early adopters, and early majority and late majority, the system as a whole will not be effective in increasing the number of DX promotion members within the organization. Furthermore, it is necessary to consider that the diffusion and awareness activities by innovators and early adopters shown in balance loop B4 need to proceed smoothly. In this case, as mentioned above, it will be difficult to promote and raise awareness unless appropriate goal setting values are established. In other words, if the skill gap indicated by balance loop B2 is large, no matter how hard innovators and early adopters work to diffuse and raise awareness (B4), the effect will be negated by B2. Furthermore, as shown in Balance Loop B5, if DX does not produce the expected effects, some members will withdraw from the DX promotion team. This will also weaken the momentum of DX promotion.

As shown in the reference mode in Fig. 1, the number of DX promotion members in an organization tends to change over time depending on the strength relationship between each loop (R, B1, B2, B3, B4, and B5). The behavior will be explained based on Case 1 in Reference Mode. The stronger the self-reinforcing loop R is compared to B1, the more the number of DX promotion members will

increase in a short period of time, provided that the strength of other loops remains unchanged. However, as B1 increases in strength relative to R, the slope of the increase in the number of DX promotion members gradually becomes gentler, as in Case 2. Furthermore, as shown in Case 3, when the strength of B2 becomes stronger than in Case 2, the increasing trend is further suppressed. If the strength of B3 becomes stronger than Case 3, the behavior shown in Case 4 will occur. Furthermore, when the strength of B5 increases beyond that of Case 4, the number of DX promotion members will gradually decrease, as in Case 5.

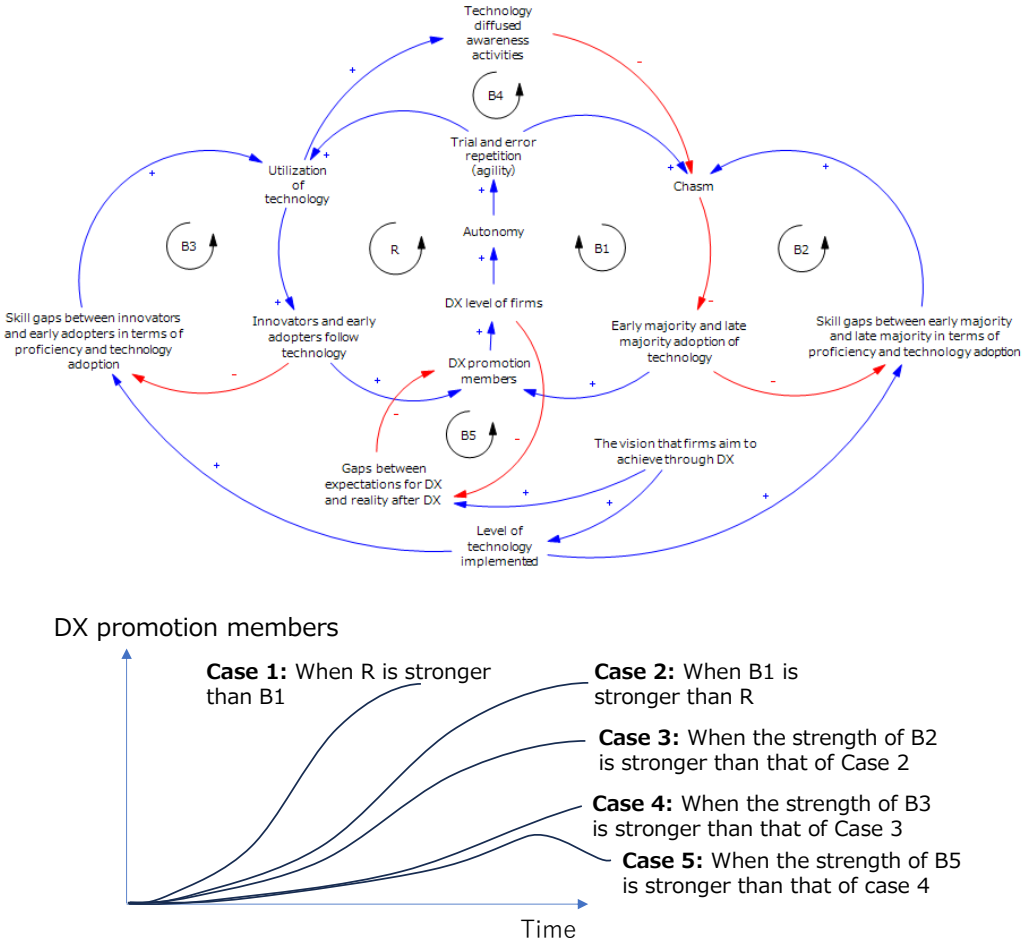

Fig. 1: Causal Loop and Reference Mode of Digital Transformation

The behavior of this system shows various changes in the real world depending on the strength of each loop (R, B1, B2, B3, B4, B5) and the vision that firms aim to achieve through DX and the level of technology implemented. For example, if the early majority and late majority are able to maintain sufficient quality in their work using their current methods, they will not think to adopt new technologies that involve trial and error. This is because there is a risk that adopting unfamiliar technologies will actually reduce the quality of work. Most employees in the field have the basic premise that the quality of new technologies must be guaranteed and that work methods using them must be established before they can be adopted. On top of this, if they do not feel that the new technology is superior to their own methods, they will not proceed with the adoption of the new technology. In fact, there are reports that digital transformation is difficult in South America because the benefits are not being felt (Sanchez et al., 2022). This is an example of a case where the degree of digital transformation

promotion does not improve because, based on the causal loop (Fig. 1), even if a firm tries to improve agility, the acceptance of the early majority and late majority does not increase, and the balance loop (B1) becomes stronger than the self-reinforcing loop (R). Furthermore, even if digital transformation is promoted, the balance loop (B2) may be affected, and the degree of promotion may gradually weaken. In the IT industry, trends change as quickly as in fashion (Jacobson et al., 2010). For this reason, there is no shortage of examples of firms that try to use IT, which is a superficial trend, but do not succeed (Attaran, 2004; Marks, 2006; Paper and Chang, 2005).

3.2. System Dynamics Model

In order to show that improving the agility of an organization is an obstacle to DX, this paper will utilize the Bass diffusion model (Sterman, 2000, p.332) and the adaptive expectations model (Sterman, 2000, p.426) of system dynamics (SD). This research will model the process of learning about the technologies used by innovators and early adopters, and early majority and late majority, in DX, using an adaptive expectation model based on the "level of technology used in DX". The level of know-how accumulated in this learning process is used as a stock, and this stock is linked to the Bass diffusion model via the variables "degree of influence" and "acceptance rate". The Bass diffusion model models the process by which the early majority and late majority, who are skeptical about technology, become DX proponents (Fig. 2).

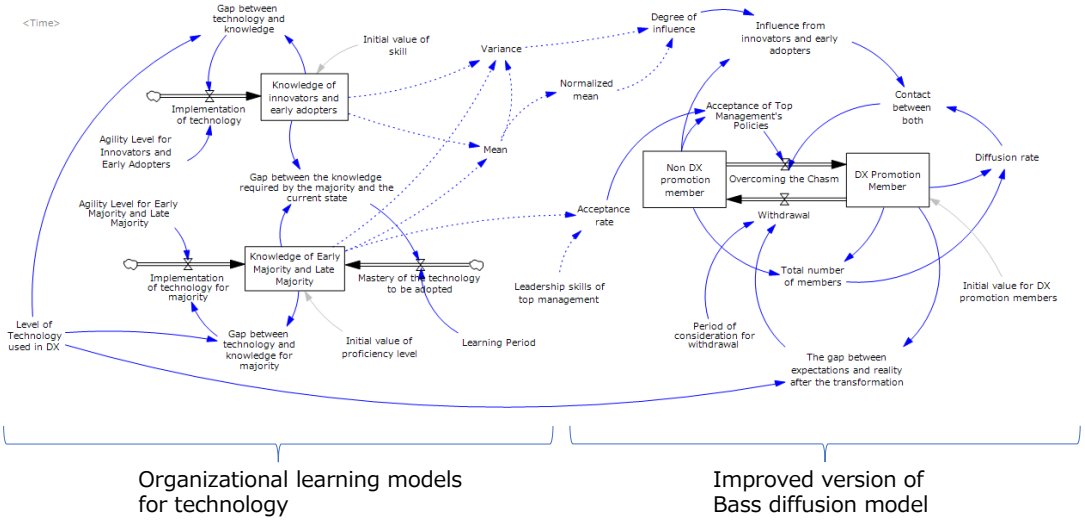

Fig. 2: DX diffusion model

Improvements to the Bass diffusion model

The model for this study is based on the Bass diffusion model (Sterman, 2000, p.332). The stock of early majority and late majority refers to the number of potential customers, and the stock of DX promotion members refers to the number of actual purchasers. The effect of advertising is expressed as a variable for the acceptance of top management policy, and the effect of word of mouth is incorporated through the influence of innovators and early adopters. The model shows how the early majority and late majority, who are potential DX promotion members, actually participate as DX promotion members through the flow of overcoming the chasm (Fig. 2). The stock on the left represents the state of non-DX proponents, and the model shows how they transition to DX proponents through the flow "crossing the chasm".

In particular, as Wunderlich et al. (2014) pointed out, even if a person becomes a DX proponent, if they recognize that they are not achieving the results they or their team expected, they may return to being a non-DX proponent. Therefore, in addition to the Bass diffusion model, this model also in-

cludes a return flow, similar to the replacement model (Sterman, 2000, p.342). In this case, the focus is on the gap between the organizational capabilities (the ideal goal) created by the level of technology implemented and the degree of goal achievement at a certain point in time. Depending on the size of the gap, it is possible to regress to the non-DX promotion faction even if you have once committed to the DX promotion faction. The withdrawal flow that represents this regression is defined by a linear equation corresponding to the size of the gap.

In addition, Wunderlich et al. (2014) did not consider the difference in levels between groups. However, this model focuses on the fact that the level of technology proficiency differs between the groups of innovators and early adopters and the groups of early majority and late majority. It also incorporates the fact that the way in which word-of-mouth effects and acceptance of top-down instructions differ depending on whether the level of technology proficiency is similar or greatly different. Furthermore, this study also considered that the word-of-mouth effect would differ depending on whether the difference in the level of technology proficiency between the two groups was high or low. It is obvious that the higher the level of proficiency, the wider the range of acceptable technology. In addition, it is easier to respond to the instructions of the top management when the level of proficiency is high. The variables "acceptance rate" and "degree of influence" were used to incorporate these effects. The details are explained below.

Acceptance Rate

In order to overcome the chasm, if the leadership skills of top management and the know-how of the early and late majorities are high, it will be easier to promote the change. Therefore, the "acceptance rate" in Fig. 2 was defined as follows based on the leadership skills of top management and the skill levels of the early and late majorities, as shown in Formula [1]. In other words, the variable "acceptance rate" in the SD model is defined as the multiplication of the top leader's leadership skills and the know-how of the early and late majorities. By multiplying the top leader's leadership skills and the know-how level of the early and late majorities, it was considered that no matter how strong the top leader's leadership skills were, if the knowledge level of the two majorities was low to begin with, it would be difficult to increase their motivation to accept the top leader's policies.

$$\begin{aligned} &Acceptance\ Rate \\ &\quad = Leadership\ skill\ of\ Top\ Management \\ &\quad \times Knowledge\ of\ The\ Early\ Majority\ and\ Late\ Majority \end{aligned} \qquad [1]$$

This is because of information stickiness (von Hippel, 1994). Information stickiness refers to the difficulty of communicating information due to the quality and quantity of the information, the medium, and the difference in the abilities of the sender and receiver. Due to this information stickiness, it is difficult for the top management's policies to be conveyed to the early and late majorities. This is because the information conveyed by the top management includes a large difference in the ability of the sender and receiver, and the quality and quantity of information about technology that is difficult to understand for both majorities. If the difference in the ability of the sender and receiver is small, and the quality and quantity of the information is at a level that is easy for the sender and receiver to understand, then communication of the information will also be easy. Due to this information stickiness, it is difficult for both the early majority and the late majority to accept the top management's policies. If, on the other hand, the knowledge level of both the early majority and the late majority is high, then even if the top management does not demonstrate strong leadership, the difference in the ability of the sender and receiver will be small, and it will be easy for them to accept the top management's policies. Note that information stickiness does not refer only to tacit knowledge. Of course, tacit knowledge has high stickiness, but even with explicit instructions from top management, if there is a large gap in ability between the sender and receiver, it will be difficult for the receiver to understand and accept the information, and thus the information will not be effectively communicated.

Degree of Influence

Next, another variable shown in Fig. 2, "degree of influence" (Equation [2]), will be discussed. From the perspective of the information stickiness (von Hippel, 1994) mentioned above, the smaller

the difference (variance value) in knowledge between innovators and early adopters on the one hand and early majority and late majority on the other, the easier it is to implement the technology, so the smaller the variance value, the higher the degree of influence. On the other hand, if there is a large gap in knowledge level, it will be difficult to understand the technology, so people will feel aversion towards its implementation, or their interest will wane, and the impact will be low. In addition, if the level of know-how (i.e., the mean of the two knowledge levels) is high, the implementation of the technology will proceed naturally. Therefore, the higher the mean, the more easily the results of the innovators and early adopters will be accepted, and the greater the impact. On the other hand, if the mean is low, it will be difficult to accept the results, and the impact will be low. In other words, the impact will be greatest when the variance is small and the mean is high.

$$Degree\ of\ Influence\ =\ (1-Normalized\ Variance\ )\ \times\ Normalized\ Mean \qquad [2]$$

Note that the term "Variance" refers to the variance between the "Knowledge of Innovators and Early Adopters" and the "Knowledge of Early and Late Majority". Similarly, the term "Mean" refers to the mean of the "Knowledge of Innovators and Early Adopters" and the "Knowledge of Early Majority and Late Majority".

This variable "degree of influence" is the key to implementing the goal-setting theory in the collaborative learning process of two groups, not a single group, but the innovator and early adopter, and the early majority and late majority. Setting the goal high has the effect of raising the mean value of the two groups. At the same time, if the level of the two groups can be matched, the variance value will decrease and the "degree of influence" will increase. As a result, it promotes the transition of the early majority and late majority to DX promotion members. However, the speed of learning differs between the two groups. Therefore, if the goal setting is too high, one group will not be able to keep up. Consequently, the impact will decrease, and the performance of the transition to DX promotion members will decrease. This is the management logic for goal setting for two groups with different attributes.

Learning Model for Organizations Related to Technology

In order to define the "acceptance rate" and "degree of influence" mentioned in the previous section, it is necessary to know the knowledge levels of the early majority and late majority, as well as the knowledge levels of the innovators and early adopters. This section explains the model that defines these knowledge levels.

In Fig. 2, the diagram on the left shows a model of how innovators and early adopters advance DX, and how early and late majorities advance DX. Since the process of advancing DX is based on trial and error, it is seen as a process of accumulating knowledge, and an adaptive expectation model (Sterman, 2000, p.426) is used, with the level of accumulated knowledge used as the unit of stock.

For example, in the case of innovators and early adopters, the model represents the level of knowledge they currently possess as a stock, and throughout the learning period, they fill in the gaps in the knowledge they need to use the technology they are adopting. In the case of early and late majority, they learn the skills necessary to adopt the technology, and at the same time, they learn about the technology based on the knowledge gained by innovators and early adopters, for example, customizing it to make it easier to use within the firm.

The greater the difference in knowledge between innovators and early adopters, and early and late majorities, the greater the variance within the organization, and the more difficult it will be for early and late majorities to accept the technology, i.e., the greater the chasm. Conversely, if the difference in knowledge is small, the chasm is also small, and the variance is also small, and it is thought that the impact in Fig. 2 is likely to be large. In addition, regarding the learning period described as the agility level, if this learning period is long, agility is low, and if it is short, agility is high. In other words, if the organization has high agility, this learning period is short, and it is shown that learning is repeated greedily.

4. Simulation

4.1. Comparison of the speed of change

This section compares changes in the trend of DX promotion by changing the conditions of the early majority and late majority, while keeping the top leadership ability and the agility (i.e., learning period) of innovators and early adopters constant. The default settings for each test scenario summarized in Table 1.

Table 1: Initial values for each measure

Stocks and Variables (unit)	Test1_Normative Scenario	Test2_High Agility of the Entire Organization	Test3_Low Agility of the Entire Organization	Test4_Policy Proposal
Knowledge of Innovators and Early Adopters (Skill)	30	30	5	30
Knowledge of Early Majority and Late Majority (Skill)	0	0	0	0
Level of Technology used in DX (Skill)	15	15	15	45
Agility Level for Innovators and Early Adopters (Month)	10	10	400	10
Agility Level for Early Majority and Late Majority (Month)	100	20	500	200
Learning Period (Month)	100	20	400	200

The normative scenario is simulated as “Test1_Normative Scenario”. In other words, this is a scenario that assumes that the innovator and early adopter have high agility, but that the agility of the early majority and late majority is low. Specifically, the initial value of the stock of “the knowledge of innovators and early adopters” was set at 30, the initial value of the stock of “the knowledge of the early majority and late majority” was set at 0, and the variable “level of technology used in DX” was set at 15. The initial value of 30 was set for innovators and early adopters because they already have the skills to fully use technology. The initial value for the early majority and late majority was set at 0 because they have no skills at all and are still in the process of learning. The agility level was set at 10 months for the innovators and early adopters, who already have the skills, to quantify their high level of mobility, and 100 months for the early majority and late majority, who have low agility. The learning period was also set at 100 months. These agility levels and learning periods are intended to indicate the time required to master the technology.

Similarly, “Test2_High Agility of the Entire Organization” was prepared. The conditions are almost the same as “Test1_Normative Scenario”, but this simulates what would happen if the agility of the early majority or late majority were high. For this reason, the agility level and the learning period were changed from 100 months to 20 months.

Next, the “Test3_Low Agility of the Entire Organization” was prepared as a comparison. It was assumed that all of the innovators, early adopters, early majority and late majority had low agility. The knowledge level of the innovators and early adopters was also low, and the initial value of the stock was set to 5. The initial value of the stock for the early majority and late majority was 0. The initial value of the variable “Level of technology used in DX” was set at 15, which is the same as “Test1_Normative scenario” and “Test2_High organizational agility”. However, the agility level was set at 400 months for innovators and early adopters, and 500 months for the majority, and the learning period for the majority was set at 400 months, assuming that it takes a very long time.

As shown in Fig. 3, “Test2_Agility of the entire organization” is, of course, able to spread DX earlier than “Test1_Normative scenario”. If organizations can increase their agility, not only for innovators and early adopters, but also for early and late majorities, as stated in previous research, organizational change will accelerate and DX will spread more quickly. However, as pointed out in the theory of the chasm, it is difficult in reality to move the early majority and late majority with high agility. As a result, as shown in “Test1_Normative Scenario”, as has been described here, the spread and enlight-

enment usually fall behind schedule.

Then, using "Test4_Policy Proposal", it was simulated how the early and late majorities, who have low agility levels, could be transformed. In the "Test4_Policy Proposal" conditions, only the initial value of the technology and the agility level of the early majority and late majority and the learning period were changed. Specifically, the initial value of the level of the technology used in DX was set to 45, which is higher than the initial value of 30 for the knowledge level of innovators and early adopters. Thus, the technology that needed to be mastered was assumed to be more difficult. On the other hand, the two variable values of agility level and learning period for the early majority and late majority were set to twice the values of "Test1_Normative Scenario" at 200 months. Since innovators and early adopters already have the necessary knowledge, their agility level was set to 10 months, and their agility remained high. As a result, as shown in Fig. 3, even though the agility level and learning period are twice as long as those in "Test1_Normative Scenario", the diffusion of DX is progressing in a period almost equivalent to that of "Test2_High Agility of the Entire Organization", which has an agility level and learning period of 20 months.

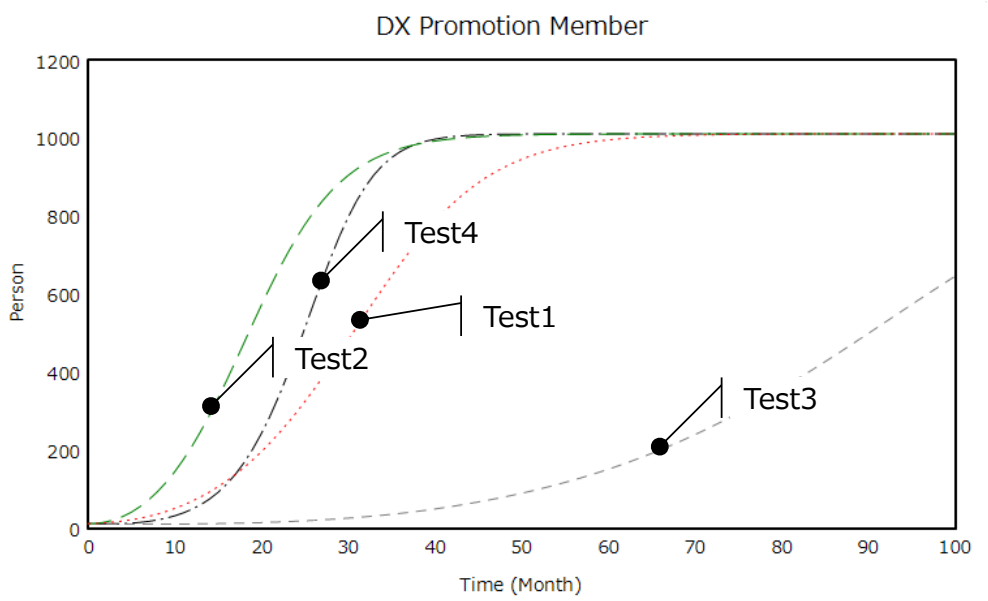

Fig. 3: Comparing the speed of organizational change

4.2. Effect factors in Test4_Policy Proposal

This section will look at the details of why the results were as they were for Test4_Policy Proposal. First, it will check the timeline data for when the early majority and late majority turned into DX proponents, and then it will check the effect of goal setting.

The effects of the Bass diffusion model

Fig. 4 shows the time series changes of the two variables that define the flow of "overcoming the chasm". According to Fig. 4, it can be seen that "Test2_High Agility of the Entire Organization", which increased the agility of the early majority and late majority, was affected by the leadership of the top management and was launched early (graph: Acceptance of Top Management's Policies). After that, the value of the variable in the "Contact between both" graph also peaked. For this reason, the graph for "Test2_High Agility of the Entire Organization" rises quickly, and early diffusion can be achieved. However, in "Test4_Policy Proposal", the impact of top leadership (graph: Acceptance of Top Management's Policies) is about the same as in "Test1_Normative Scenario", but in "Contact

between both", the peak value is the largest compared to the other cases. It can be read that the diffusion and enlightenment of DX is progressing due to the influence of innovators and early adopters, not top leadership. In other words, even if the agility of the early majority and late majority is reduced, the "degree of influence" is increasing. As a result, based on the chasm theory, "Test4_Policy Proposal" can diffuse DX early while maintaining a high level of agility for innovators and early adopters, while keeping the agility level of the early majority and late majority low.

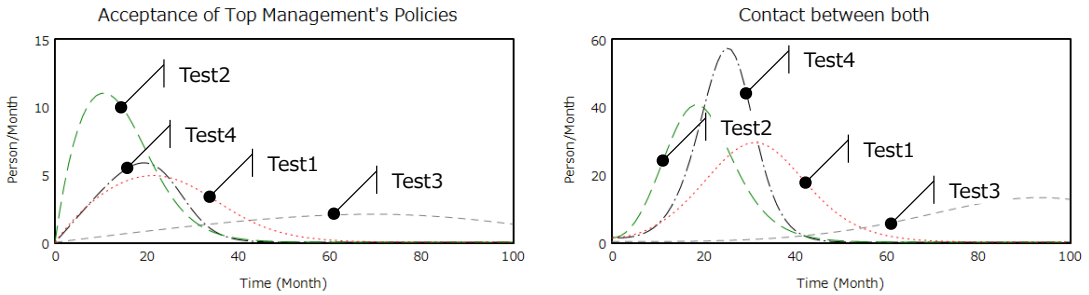

Fig. 4: Time-series changes in the two variables that make up the Bass diffusion model (Acceptance of top-management's policies and Contact between both)

The effect of technology level setting and goal setting theory

Next, it is confirmed from the perspective of the appropriateness of the level of technology to be implemented why the peak value is the largest in "Contact between both" and why the "degree of influence" is large in "Test4_Policy Proposal". Fig. 5 shows the results of the sensitivity analysis for each value of "Level of Technology used in DX" set to 30, 45, 75, 90, and 100. For the sensitivity analysis, the initial value of the stock for "Knowledge of Innovators and Early Adopters" was fixed at 30, the initial value of "Knowledge of Early Majority and Late Majority" was fixed at 0, and "Agility Level for Innovators and Early Adopters" was fixed at 10. The sensitivity analysis was conducted by changing "Agility Level for Early Majority and Late Majority" and "Learning Period" from 100 to 400.

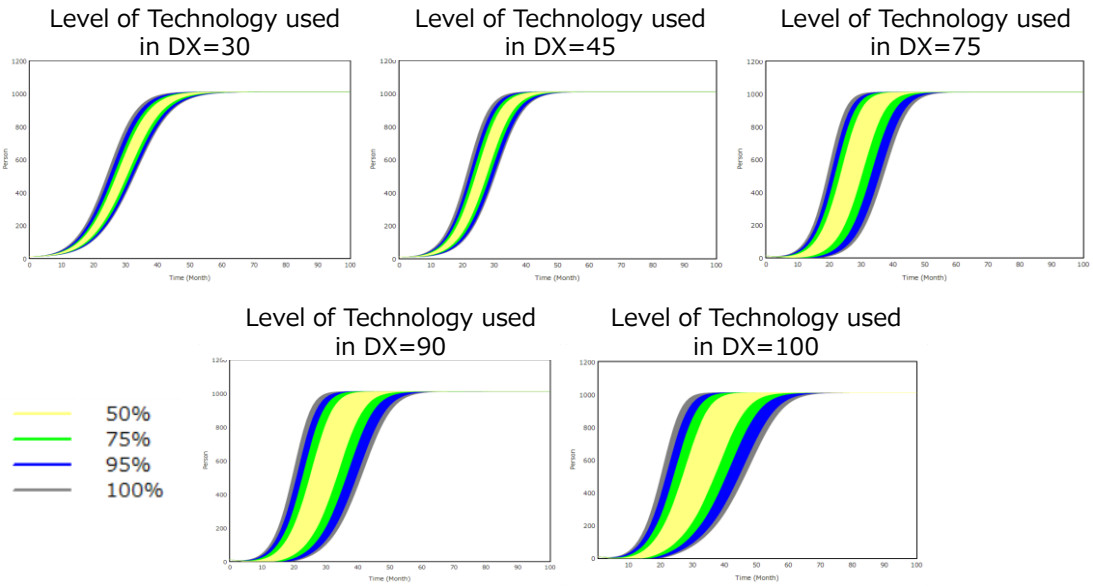

Fig. 5: The convergence status of DX promotion members due to differences in "Level of Technology used in DX"

As shown in Fig. 5, the effect of “Test4_Policy Proposal” also differs depending on “Level of Technology used in DX”. The value of this variable “45” is the peak, and the effect of the measure is seen to fade before and after that. The level of technology adopted in the proposed measure in this study is close to the peak value. Specifically, as the level of technology increases from 30 to 45 and 75, the rate of change in the S-curve increases. However, on the other hand, as the level of technology changes from 75 to 90 to 100, the width of the area graph increases while the rate of change of the curve on the far left of the S-curve remains the same. In other words, there is a limit to the speed of change depending on the level of technology. And at that limit, the width of the area graph increases, and the 50th percentile, which includes many cases, slows down as a whole. The wider the area of the area graph, the more it does not necessarily mean that the speed of change will improve. Raising the level of technology does not necessarily mean that DX can be advanced quickly. The early majority and late majority are unable to keep up, and the variance increases. As a result, “degree of influence” decreases. These results are also in line with goal setting theory (Loke, 1968; Weinberg, 1994; Locke and Latham, 2019), which states that appropriate goal setting improves performance, but excessive goal setting can actually reduce performance. As described above, it found that the setting of reform goals affects the speed of convergence.

From the above, it can be seen that setting the level of the technology implemented in “Test4_Policy Proposal” to 45 has helped to increase the speed of change, and the fact that the width of the area graph is relatively narrow also means that the system has a high level of robustness in the face of other changes in conditions. Therefore, even if the agility of the early majority and late majority is set to a long period, the impact is unlikely to be apparent.

To summarize the above, at first glance, if the level of technology used in DX is low and the agility and learning period are set to be short, this might lead us to think that the implementation of that technology would be easy. However, neither “Acceptance of Top Management's Policies” nor “Contact between both” indicates such a trend. When the effects of goal setting theory (Loke, 1968) are included, it can be seen that even if the agility and learning period are set to a long period, if the goal is set at an appropriate level, it will have a positive effect on “degree of influence”.

5. Discussion

The present study questioned the assertion of previous research that organizational autonomy is necessary for the promotion of DX and that organizations can be transformed through autonomous trial and error. If the Chasm theory is applied to organizational change, the members who are pioneering the transform of the organization are only a very small number of innovators and early adopters, and the majority of the organization are followers of the change called the early majority and late majority. The followers will not utilize the technology used in the transform unless it reaches a level where it can be fully utilized. Unlike innovators and early adopters, they do not like to repeat trial and error themselves. Therefore, it was pointed out that encouraging organizations to become autonomous and to encourage trial and error does not necessarily have a positive effect on DX promotion, and that the discussion with organizational members who do not want to change, such as the frozen middle, early majority, and late majority, is not sufficient.

This research modeled the process of organizational change by combining the Bass diffusion model and adaptive forecasting models. By using this model and simulating it, the study showed that DX progress is slowed down by the early and late majorities, who have low agility. The study also stated that previous research has not sufficiently discussed measures for involving the early and late majorities. The study then showed the importance of these measures, i.e., setting the level of the technology to be implemented and the word-of-mouth effect accompanying technology transfer by innovators and early adopters.

Specifically, the simulation results show that, as stated in previous research, if the agility of all members can be increased, DX will progress. However, as pointed out in previous research, this is difficult in reality, and this study has shown a way to achieve it. First, it was stated that it is important to select the appropriate level of technology to implement in the organization through DX. Ensuring that the level of technology is appropriately high for the organization implementing it will lead to an in-

crease in the mean value without excessively widening the variance of the level of know-how possessed by the members. This effect will increase the “degree of influence”. As a result, this study found that careful and time-consuming diffusion and education activities by innovators and early adopters are efficient and effective, and that the word-of-mouth effect from innovators and early adopters increases, which is an important factor in promoting speedy change. It is more realistic to use innovators and early adopters as change agents (Golembiewski, 2001, p.640) and to promote change centered on change agents than to operate in a small, middle-centered organization with authority delegated to the middle. These two measures showed that it is possible to promote DX at the same level of speed as when all members exhibit high agility, which is difficult to achieve in reality.

5.1. Contributions to System Dynamics Research

This section describes the contribution of this research to SD research from the perspective of goal setting, the perspective of diffusion models, and finally the perspective of expansion into new domain areas.

Until now, many previous studies have discussed the need to increase organizational agility. However, there are also many previous studies that contradict this. It is practically difficult to increase the overall agility of an organization through top-down initiatives. In response to the issues raised in this previous research, this study shows that the “degree of influence” is the multiplication of “1 - normalized variance” and “normalized mean”, as shown in Equation [2]. This equation shows a strategy for integrating the two groups with different attributes of innovators and early adopters, and early majority and late majority, and directing them towards the same goal of DX. Until now, previous research has only discussed organizations that can be grouped together based on a single attribute. This mechanism, which has been demonstrated in this study, is considered to be a useful finding as a model for understanding organizational activities composed of members with diverse attributes.

Next, it describes how the diffused model can be used. Naturally, the use of diffused models has often been to model only the situation in which something is diffused. However, as this study has shown, diffused is done in order to achieve some goal. Diffusion is a tool for achieving goals. For example, firms diffused DX to realize their vision. In this way, the system constructs itself from a perspective one level up from the diffused model and takes a bird's-eye view of the entire system, resulting in a connection between the diffused model and the goal setting theory. This way of thinking helps us understand organizations and social activities from a broader perspective. As a result, SD researchers will be able to gain even deeper insights. System thinking and system dynamics are ideal tools for gaining an overview of such systems as a whole.

Finally, this research has clarified the structure of endogenous behavior in the new domain of corporate DX by combining adaptive expectation models and the Bass diffusion model, which are known SD model patterns. As a result, while in the past, when people talked about DX, the focus was on organizational agility, this study showed that, in fact, rather than increasing the agility of individual members, appropriate goal setting is the key to increasing organizational agility through the organization's endogenous structure. This is the art of behavior that is created when multiple feedback loops interact with each other. It could be said that DX has not progressed well in the past because it is too clever. In addition, goal setting is also related to the vision that the organization wants to achieve after DX. From the perspective of the importance of setting appropriate goals, it could be said that the importance of the vision of change is also demonstrated in this SD model. This result is also consistent with the results of many organizational change studies. However, the importance of the vision has only been discussed in terms of involving organizational members and commitment. It has not necessarily been discussed in terms of improving the speed of change. The difference is that this study shows the causal relationship between setting an appropriate goal and improving the speed of change.

However, there are also issues that need to be addressed in the future. First, as Sterman (2000,

p.532), Barlas and Yasarcan (2007), and Ceresia (2009) have also pointed out, goals are not necessarily fixed, but rather variable. It is necessary to incorporate these previous studies. By incorporating the dynamics of goal setting, it is necessary to expand the mechanism of goal setting management in the collaborative learning process of teams with different attributes. In particular, the structure of the model is likely to have an impact on the definition of the variables in the flow where withdrawal from the DX promotion team occurs. It is necessary to review this variable definition specified in this study in conjunction with the dynamics of the goals, while taking into account the results of the commitment theory researches.

5.2. Practical Implications

Next, this section will explain the points to keep in mind when actually promoting DX using AI based on the findings of this study.

First, regarding the adjustment of goal setting levels, it is useful to utilize a time axis for this adjustment. If setting a goal that is too high leads to a decline in performance, it is better to set a long-term goal that is too high. On top of that, it is necessary to set an appropriate level of goal setting as a short-term goal. It is important for the project manager promoting DX to have a good sense of balance, finding the right balance while communicating appropriately with the organization. As mentioned in the previous section, this sense of balance can be further developed and deepened theoretically by incorporating the dynamics of goal setting.

As an example of setting specific goals, the case of infrastructure inspections in Japan, including the inspection of utility poles, roads and railways, is instructive. In many cases, there are also legal stipulations, and until now, people have been carrying out the work of regularly patrolling and checking the state of deterioration of the facilities. Such inspections require skilled techniques; for example, when inspecting utility poles, it is necessary to not overlook cracks of a few millimeters. For this reason, in Japan in particular, the work is carried out by elderly, skilled workers. However, as they are getting older, it is forecast that many experienced inspectors will retire in the future, and measures to ensure the quality of inspections are an issue that many companies in Japan will have to address in the near future. Against this background, while looking into extending the retirement age, the implementation of inspections using image AI is being promoted. This kind of rational goal setting is likely to have the effect of increasing the “acceptance rate”. On the other hand, one Japanese company considered setting goals not for AI inspections, but for prediction of deterioration. Prediction of deterioration is an attempt to use data science to predict which infrastructure facilities need to be repaired before failure occurs. In Japan, where the population is forecast to decline, from the perspective of efficiently utilizing the labor force, it is better to repair dangerous facilities in advance than to take emergency measures after a breakdown occurs, because it is easier to equalize the labor force. Data science was also considered to be highly compatible with AI utilization. However, the majority did not respond well to the idea because the technical difficulty level was too high and it seemed to diverge too much from the sense of the issues in the field, and thus, it lacked rationality. In other words, the “acceptance rate” dropped. Therefore, the roadmap was set up with the prediction of deterioration as a future goal.

In addition, the key to overcoming the chasm is to distinguish between the task of consolidating the core of the technology used in DX, including AI, and the task of considering how to make good use of the core of the technology. The former task of consolidating the core of the technology is a task that requires trial and error. Therefore, this task should be carried out by innovators and early adopters. If an organization involves the early majority and late majority in this task, the chasm will only widen. The early majority and late majority should focus on how to make good use of the core of the technology. Consolidating the core of the technology does not just mean creating AI algorithms or selecting the AI algorithms to use. For example, if it is image AI, it also includes imaging technology for

taking images to be judged by AI. It also includes the perspective of how to store images. In the case of the aforementioned example of utility poles, it includes the trial-and-error process of how to take images of cracks in the millimeter range. In terms of how to make good use of the core of the technology, this includes tasks such as collecting images and organizing the data that the AI learns from, and such as considering how to make use of the results of the judgments made by the AI on those images. It is not a bad thing to involve the early majority and late majority in these tasks. In fact, for example, the rust on railway overhead wires varies from serious to minor. There are many things that cannot be identified without utilizing the know-how of experts in the early and late majority. By involving them, a word-of-mouth effect is generated that originates from the mutual cooperation between innovators and early adopters, and the early majority and late majority. This leads to the accumulation of mutual know-how, raising the mean value and suppressing the variance, and increasing the "degree of influence". Even if two groups with different views can agree on their objectives, the next step is whether or not they can find a role-sharing arrangement that suits their respective inclinations. If they can find an appropriate role-sharing arrangement, the organization will move forward.

Finally, practitioners should be aware of the communication skills of innovators and early adopters. As Gladwell (2000, p.200) pointed out, if innovators and early adopters only have a low level of communication skills, such as being unable to use jargon, the early majority and late majority will have a closed-off impression and word-of-mouth effects will not be achieved. As a result, the "degree of influence" will decrease, and there is a possibility that the speed of change will also slow down, and the effectiveness of goal setting may also decrease, and the impact will be significant. The characteristics of the human resources who promote DX as innovators and early adopters are also points that require attention.

As described above, if an organization can set optimal goals, it will be possible to make use of the characteristics of innovators and early adopters, early majority and late majority, and to have them each proceed with creating AI and preparing for its use. If, in the process of exchanging the necessary information, the early majority and late majority can be made to lose their initial skepticisms about the technology, DX using AI will move closer to becoming a reality. If, in the process of preparing to implement AI, it is not possible to maintain the same level of quality as that carried out by humans, or if the expected level of effectiveness is not achieved, then the reliability of the technology will also diminish, and the early majority and late majority will move away from the DX proponents.

6. Conclusion

DX is an important theme for modern organizations. Recently, AI has been attracting a great deal of attention, but AI is just one of the elemental technologies for promoting DX. As this research has shown, how to spread it within an organization, how to use it, and what issues it can solve are all issues for the organization, and it has a dynamic structure for solving problems. In order to gain a bird's-eye view of the behavior of DX derived from the complex endogenous structure of an organization, it is necessary to further improve the system construction ability to accurately combine and expand the resources of SD to date.

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