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Boundary Objects as a Learning Mechanism for Sustainable Development Goals—A Case Study of a Japanese Company in the Chemical Industry

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Abstract: This paper explores the role of boundary objects in the translation and transformation process of a sustainability concept—Sustainability Development Goals (SDGs)—into a firm’s business practices. The qualitative case study describes the experience where a Japanese company successfully implemented SDGs and generated product innovations through its learning process. The findings of the study identify four types of effective boundary objects: (1) organizational repository boundary objects, including historical contextualization and best practices; (2) a standardized form of boundary objects based on certification process of environmental sustainable products; (3) an ideal type of boundary objects through digital forum based learning platform; (4) a “powerful” community of practices that come across hierarchy and functions. This paper extends the literature by showing the interconnectedness of boundary objects, the possible negative side of technology based boundary objects, and the significance of community of practices as a monitoring and coordination tool to ensure the effective operation and measurement of sustainability.

Keywords: organizational learning; boundary objects; sustainability; sustainable development goals

1. Introduction

The United Nation’s (UN) document *Transforming Our World: The 2030 Agenda for Sustainable Development* includes a declaration of 17 Sustainable Development Goals (SDGs) and 169 targets, along with monitoring and review measures [1]. The 2030 Agenda highlights the essential role of sustainable management of ecosystems and natural resources (SDGs 6, 14, 15), sustainable consumption and production patterns (SDG 12) and urgent actions on climate changes (SDG 13). The idea of SDGs has quickly gained ground because of the growing urgency of sustainable development for the entire world. Although specific definitions vary, sustainability embraces the so-called triple bottom line approach—aiming for a combination of economic development, environmental sustainability, and social inclusion [2–4].

The integration of economic, environmental, and social goals into firms’ business practices can be a hallmark to sustainability development. However, the implementation of sustainability, such as SDGs, represents a number of challenges. To begin with, not all the goals can represent business opportunities or confer a competitive advantage to firms that makes it difficult for firms to foresee business value. Because their inherent value is not immediately evident volumes of seedling ideas with brilliant potential are often ignored [5]. Besides, the value that sustainability brings into the firm can take very long time to show in firms’ financial performance [6].

Second, sustainability embraces tensions that simultaneously accommodate competing yet interrelated economic, environmental, and social concerns which reside at different levels, operate in

different logics and time frames, and in different spatial scales [7,8]; contested social, environmental and economic understandings of sustainability can generate trade-offs and tensions in organization [9], which makes sustainability seem to be too complicated to handle. As a result, although there is a huge potential for companies to take advantage of environmental opportunities, such as cost savings and revenue growth, most companies do not have a vision and road map to sustainability [10].

Third, firm's motivation to "go green" can be influenced by three contextual conditions: field cohesion, issue salience, and individual concern [11] and thereby how to motivate firms integrate sustainability into their business practice varies. Because the profit incentive in most companies is considered to be low, an easy option is to cherry pick a few SDGs that align with firms' business models, and thus most efforts to promote business involvement in SDGs have been based on voluntary approaches [12]. Admittedly, reliance on voluntary approaches is unlikely to be transformative. Subsequently, SDGs is perceived as 'something nice to have' on corporate sustainability reports, but hard to apply in business operations. Smith and Sharic's [13] words probably best describe the situation, "sustainability is making some inroads in organizations but far too many organizations are only 'going through the motions' with predictable results for overall need for improvement" ([13], p. 73).

Understanding the implementation challenges of SDGs in firms' business practices will thus contribute to the field of sustainability. Bocken et al. [2] argues that while eco-innovations, eco-efficiency and corporate social responsibility practices define much of the current industrial sustainability agenda, previous studies are insufficient in themselves to deliver the holistic changes necessary to achieve long-term social and environmental sustainability. Further, the ability of previous studies to explain where the triple values of sustainability behold in firms is limited [14]. Moreover, extant research lacks clarity as to how business values can be generated through sustainability, and what contexts lead to a particular business value, as discussed above and also in Pujari [15]. Likewise, although researchers and practitioners acknowledge that SDGs can accelerate brand relevance, company growth and social impact, how implementing SDGs actually would bring values to firms has not been fully addressed. Extant literature therefore asks for empirical studies to explore how SDGs is actually viewed and practiced in business practices.

For the last decade, a number of authors have stressed the importance of organizational learning in firms' pursuit of sustainability [16,17], and have shown signs of increasing convergence between organizational learning and sustainability [18,19]. The role of learning has been taken up in enabling sustainability to be embedded and maintained [20], in particular through raising sustainability awareness [21,22]. The role of change agents [23,24] and the importance of innovation [14,25] are also raised in the studies of learning and sustainability. Nevertheless, firm's learning ability for sustainability differs. Prugsamatz [26] found that individual motivation to learn, team dynamics, and organization culture practices all have a significant level of influence on organization learning sustainability. Similarly, Ayuso et al. [25] claims that the opportunities that values of sustainability brought to organizations may fail to be realized if firms lack the internal knowledge management processes to convert these into innovation. Thus, organizational learning may face a challenge in the implementation of sustainability.

At first glance, SDGs seem so far away from business practices that they can be viewed as hyper goals. Hence, translating the SDGs into a common language that organizational members can understand could be a good starting point for the learning process. Second, efforts need to be made to transfer the understanding into actions. In order to implement SDGs, firms need to commit to make changes. From this point of departure, we argue that organizational learning can be essential to the implementation of the SDGs. The focus of the presented study is thus on the translation and transformation of the SDGs in firm's practices. In this article, we report a top-down process of organizational learning program for the SDGs. Drawing from the experience of a Japanese company has successfully implemented the SDGs and generated product innovations through its learning process, the article captures the underlying organizational learning mechanisms. The concept of boundary objects [27,28] is re-examined from an organizational learning perspective in the context where the

SDGs are the learning goals. A boundary object refers to an artifact doing the crossing by fulfilling a bridging function [27]. Focusing on sustainability, our study makes a contribution to the literature by extending the notion of 'boundary objects' from its classic value to sharing meanings [27,28] in sustainability management [29,30], and switching its contemporary focus to knowledge transfer, translation and transformation [31,32].

This article is structured as follows: First, we provide a literature review and present our theoretical perspective. An overview of the implementation of SDGs in Japanese firms is also provided. We then bring forward the notion of boundary objects and their roles in learning for sustainability as our central concept. After the methodology section we offer the empirical case, illustrating the learning process of the case company and underlining the four boundary objects that are found most effective for sustainability learning. We conclude this paper by highlighting its contributions to the literatures of sustainability and organizational learning, and suggest the managerial implications as well as future research directions.

2. Background and Literature Review

Integrating sustainability initiatives into business strategies and greening the innovation process are becoming a strategic opportunity for companies [33,34]. Previous studies have found that the number of companies that embrace the concept of environmental sustainability into their business strategy, and developing environmental strategies is growing [11,35]. In Japan, companies start to use SDGs as a checklist against their existing business models [12]. Jamali [36] emphasizes that learning at the organizational level involves creating systems/processes, which institutes long-term capacities to capture knowledge, for supporting knowledge creation and to empower continuous transformation. In the pursuit of sustainability, organizations must effectively and efficiently create, capture, harvest, shape and apply sustainability-related knowledge and insights [13]. In line with the arguments, we present a knowledge-based view of the SDGs to help understand the learning process of the SDGs.

2.1. A Knowledge-Based View of the SDGs

Knowledge has been a central concept in the organizational learning literature. Managing knowledge is difficult, because knowledge is ambiguous, unspecific and dynamic [37]. Managing knowledge is also important because knowledge can be a crucial organizational asset that contributes to firm's competitive advantages and growth [38,39]. In this paper, we approach the SDGs from a knowledge perspective and consider the SDGs as a novel phenomenon that is expected to add to the "business as usual" logic of the firms. If executed well, such process can generate new business opportunities, as well as social, economic and environmental values [34,40].

Knowledge is often described by its explicitness, which categorizes it into tacit knowledge and explicit knowledge. According to Polanyi [41], tacit knowledge resides within individuals that can be extremely difficult (or even impossible) to articulate adequately to others. In an organizational context, tacit knowledge is rooted in action, commitment and involvement, which embeds tacit knowledge into a highly personalized quality. Explicit knowledge appears to be 'standard', manifesting in the form of transmittable, formal, and systematic language. Yet, explicit knowledge is also grounded on personal judgment and tacit commitment [42], and necessarily contains a "personal coefficient" [41]. Hence, both tacit and explicit knowledge have a 'personal touch', which explains why learning can be situated in individuals, and knowledge is difficult to be transferred. From this point of view, the written 17 goals and 169 targets in the SDGs are essentially explicit knowledge. Individuals can have different understanding and approach to the goals and targets, which makes the written 17 goals and 169 targets in the SDGs have the tacit dimension in the learning process.

According to Nonaka [43], organizational knowledge is created through a continuous dialogue between the tacit and the explicit knowledge through four modes of knowledge conversations. The first mode is creating tacit knowledge through shared experience, referred as "socialization". The second is creating explicit knowledge from explicit knowledge, through a reconfiguring process of

existing information by sorting, adding, re-categorizing, and re-contextualizing, which is referred as “combination”. The third is from explicit knowledge to tacit knowledge, referred as “internalization”, where “action” is deeply related. And, the fourth one is from tacit knowledge to explicit knowledge, referred as “externalization”, where metaphors play an important role. Applying this theoretical lens, we argue that the learning process of the SDGs involves all types of knowledge conversation. Therefore, firms shall contextualize the SDGs in the ‘local language’ through the process of “combination”.

As discussed at the beginning of the paper, the 17 SDGs and 169 targets are often viewed as hyper slogans or a philosophy that lacks a common ground. Contextualization of the SDGs in accordance with a firm’s business practices can be essential for the generation of a local understanding of sustainability. Previous evidence has indicated a relative lack of understanding on sustainability in Japanese firms [44,45]. In recent years, a marked growth and consolidation of corporate social responsibilities, particularly in environmental responsibility has risen in Japanese firms [46]. Further, a most recent survey from IGES and United Nations Global Compact Network Japan in 2018 shows that only 9% of middle managers in Japanese firms are aware of the SDGs [12]. The Japan Business Federation (Keidanren) has been calling on its members to deliver the SDGs through the realization of Society 5.0 [47]. According to a translation of the revised Charter of Corporate Behaviour, “member corporations should fully recognize that their development is founded on the realization of a sustainable society, and they should exercise their social responsibilities by creating new added value and generating employment that will be beneficial to society at large and by conducting their business in a manner that takes the environment, society, and governance into consideration. Corporations should also encourage behavioral changes not only within their own corporations, but also in their group companies and supply chains, and, by fostering partnership and collaboration with a diverse range of organizations, act toward the realization of Society 5.0 and through that, deliver on the SDGs” [47]. Understandably, Japanese firms can be obliged to work with the SDGs and demonstrate that they are good corporate citizens that follow the Charter/Keidanren.

Further, from a knowledge perspective, firms shall ‘translate’ the explicit knowledge of the SDGs into tacit knowledge through the process of “internalization”. As Nonaka [43] suggests, the key is taking actions. Nevertheless, very few Japanese firms have undertaken specific SDG-related actions. A 2016 survey in the Global Compact Network Japan shows that out of 254 companies, 163 companies used the SDG Compass as a reference, among which 43 percent were still understanding the SDGs, 25% were still defining priorities, 13% were setting goals, 8% were integrating SDGs, and only 8% were reporting and communicating actions on the SDGs. Although many Japanese companies have referred to the SDGs in their sustainability reports, few have started mainstreaming the SDGs into their core business, except for a countable number of firms. Examples include Omron’s development of a medium-term business plan with the consideration of the SDGs, Sompo Japan Nipponkoa Insurance’s SDGs targets for each business area, and the Tokyo Marine Group’s mapping of the company’s core themes (providing safety and security; protecting the Earth; and supporting people) against SDGs.

The difficulty in foreseeing business value can be the major barrier in the integration of the SDGs in firms’ business. Taking a knowledge-based view of the SDGs, we argue that the potential business value of the SDGs is held in the new knowledge creation process. In order to reveal such value, firms shall, first, ‘translate’ the hyper goals and targets into contextual knowledge and create a ‘personalized’ understanding on sustainability. In other words, it is a combination process from existing explicit information to new explicit knowledge. Second, firms shall transform this new personalized explicit knowledge into actions, which is from explicit knowledge to tacit knowledge through the “internalization” process. Herewith, the challenge is not only translating different meanings of the SDGs, but also negotiate interests and make trade-offs among actors [32,48,49]. The ‘translation’ thus entails a process of generating a common language across domain-specific knowledge that can be adequate for participants to share and assess. Additionally, firms shall combine the common knowledge with the participants’ domain-specific knowledge for the generation of new knowledge so that the SDGs can be transformed into actions. Our argument is in line with Fenwick [20], where she posits

that sustainability is learned through everyday practices and interactions, as people share, question, tinker with and invent sustainability approaches. As the study indicates, one way of approaching the effective learning of sustainability is to do it through boundary objects.

2.2. 'Boundary Objects' as Learning Mechanisms for the SDGs

The concept of boundary objects was first developed by Star [27] and Star and Griesemer [28] to show how artifacts can fulfill a specific function in bridging intersecting practices. Star and Griesemer [28] described a boundary object as any element that has the capacity to be understood by actors in more than one setting. Drawing from Star [27] and Star and Griesemer [28], a number of scholars have applied the concept of boundary objects in the context of product development to investigate the learning between different departments in an organization [31,50], between designers and engineers [51], and between politicians and scientist [52]. The notion of 'boundary objects' has been applied extensively in innovation, knowledge management and learning studies, such as new product development [31], new technology implementation [53], knowledge sharing [32], adoption of innovative idea, product or technology [54], initiating and facilitating change [55], as well as in context of educational practices [56], social relations [57], government [52], and software engineering [58]. In this paper we follow Carlile's [31] pragmatic view of knowledge and boundaries to describe a boundary object "as a means of representing, learning about, and transforming knowledge to resolve the consequences that exist at a given boundary" [31] (p. 442).

In specifics, boundary objects can be representations, abstractions or metaphors that have the power to "speak" to different communities of practice [28] (p. 412), as tools or visual representations, discourses, terms, concepts, processes, or technologies [28,59], and drawings and prototypes [60]. In Star and Griesemer's original typology [28] (pp. 410–411), boundary objects were categorized into:

- (1) Repositories indexed in a standard fashion, enabling access by people from differencing communities of knowledge or practice (such as a library catalogue).
- (2) An ideal type, representation or abstraction that is 'good enough' to serve different communities even though it lacks detail.
- (3) An object whose boundaries are the same for different communities, although the content that is bounded differs.
- (4) A standardized form that can be completely by actors within differing knowledge communities.

Recent studies have made progress on the types of boundary objects, such as 'structural objects' for coordinating work [61], or referred as shared infrastructure around which groups organize; 'visionary boundary objects', or a conceptual objects that prompt emotive responses from a range of people and is regarded as so sacred that it is difficult to argue against [62]. Because boundary objects are "plastic enough to adapt to local needs and the constraints of the several parties employing them, yet robust enough to maintain a common identity across sites" ([28], p.393), they can be used to create common language in translating the SDGs from explicit knowledge into personalized understanding. Moreover, boundary objects can potentially enable the generation of new knowledge and shared understanding, allowing for collective learning, practices, or capabilities generated within the boundaries around various communities to be shared across those boundaries [48,59].

Furthermore, boundary objects are useful for tackling the challenge in the transformation process of the SDGs into actions. The role of boundary objects in knowledge management has been particularly highlighted in the literature. It is suggested that boundary objects work as ways of facilitating knowledge that flows across functions, because they can provide a concrete means of representing different functional interests and facilitating their negotiation and transformation in new product development settings, such as drawing up prototypes [60] and connecting different "thought worlds" that lead to variances in meaning or language across functions [63]. Additionally, boundary objects are important to learning because they enable connecting and shared focus [20], which is crucial to the successful implementation of sustainable practices in organizations. Boundary objects also

facilitate learning by transferring, disrupting, and transforming knowledge about sustainability that is accomplished with social relationships [30,64]. Thus, boundary objects are recognized as means of “transforming knowledge and changing practices across occupational and professional boundaries” ([55], p. 180; see also [31,65,66]). Conclusively, boundary objects play a pivotal role in translating and transforming information like the SDGs across specialized knowledge domains, as well as initiating and facilitating change to prompt learning.

However, it remains unclear which objects can perform these functions. To our knowledge, there are only a few studies explored the role of boundary objects in sustainability. Benn et al. [30] suggests that the use of knowledge sharing and generation tools in the form of selected boundary objects can promote the development of communities of practice, and hence facilitate the integration and institutionalization processes of learning when it is applied to sustainability. By tracking two boundary objects that emerge and dissolve during time, specifically a ‘sustainability checklist’ and the concept of ‘carbon reduction’, Hawkins et al. [64] examines the agential role of boundary objects in learning, showing how power relations enable and foreclose the possibility for sustainable actions in organizations. Nevertheless, we still know little about how the boundary objects function and what makes them effective. As Fox [54] suggests, the research on boundary objects needs to move from the descriptive to the analytical. This study is thus designed to answer such call, to provide a rich account and thick description to show how firms view SDGs, and how they generate business value from the SDGs by using boundary objects.

3. Methodology

A qualitative approach based on a single case study methodology [67] was employed in this research in order to gain deeper insights on the implementation of the SDGs in firms’ business practices. The research site is chosen to be in one of the biggest Japanese firms in the chemical industry, referred as the Chemical Company (pseudo name). The Chemical Company is one of the leading chemical companies in the world and one of the biggest in Japan. The presented case study was conducted at its headquarters in Tokyo, Japan.

The Chemical Company was selected for this research for, at least, four reasons. First, the company’s started its business based on environmental sustainable solutions dated back in 1910s and has over 100 years’ history in working with environmental sustainable products. Second, the company has been widely recognized for being socially, environmentally responsible by their Japanese and international stakeholders. Third, the top management team has endorsed numbers of strategies and actions to show their commitment in being a responsible corporate citizen through demonstrating chemical safety and ethical behavior for over decades. Hence, it is very interesting to be included in the study from a management perspective. Fourth, the UN has awarded the company several times for its recent contributions to the SDGs and previous contributions to Millennium Development Goals (MDGs).

The research design is based on two sequential steps. First, a literature review was carried out on sustainability and learning, particularly the SDGs, Corporate Social Responsibility, knowledge management and organizational learning, in the sustainable management literature, the environmental studies, and the general management literature. The second step is to carry out the empirical study. Through personal contacts, the researchers have gained access to the Chemical Company. A relationship was soon established between the research team and a middle manager from the company. The middle manager was briefed about the research project, the intention of the research and the research plan before the project officially started. The manager then introduced the interviewees for the presented research and has shown his great support to this research project through the entire process.

The qualitative data was collected in one year, including interviews with five key participants respecting the corporate social responsibility (CSR) department, the responsible care department, the business department and the top management team. The content of the interviews focused on finding information on the implementation of the SDGs within the company, and the company’s green

innovations based on the SDGs. A semi-structured interview guideline was sent to each respondent before the face-to-face interviews so that the interviewees can be prepared. The interview guideline with example questions is presented in Appendix A. On average, each interview lasted about one hour. Some exceptional interviews were extended to two hours. All interviews were transcribed and sent to the interviewees for verification and clarification.

An array of documented material concerning sustainability was used for this study. It includes the company's annual reports, CSR reports (Sustainability Data Book in company's term), product information, R&D reports, and news releases in 10 years' time between 1999 and 2019. The archival study examined the company's specific endeavors in integrating and implementing the SDGs in their business from 2016 to 2019. Articles and web material related to the specific environmental product innovations were also collected from various sources. The available secondary data regarding strategies and CSR practices was used to triangulate with the empirical material from the interviews to increase research reliability. External sources such as media reports were also used to gather additional information regarding the case company's contribution to the SDGs and the relevant green innovations.

4. Findings

4.1. The Organizational Repository Boundary Objects

According to Star and Griesemer [28], people from different worlds can use or borrow from the repositories for their own purposes without having to negotiate differences in purpose directly. In the following, we present two types of organizational repository boundary objects: the historical contextual repository and the best practice repository. As it shows in the case, these two organizational repositories have successfully 'translated' sustainability into the company's local 'language'.

4.1.1. The Historical Contextual Repository

A firm's historical root is where all the stories begin. Interpreting from the history of the Chemical Company, it shows that the company history itself has been a boundary object to connect the firm to sustainability. As it states in the company's 100 years history book:

"The Chemical Company commenced its business based on the spirit of corporate social responsibility (CSR), contributing to society through its business activities, long before the term became popular."

The company's fertilizer factory was the predecessor of the Chemical Company. It started its business from taking on two environmental sustainable missions: 1) to resolve the pollution caused by gas emissions from copper production; 2) to produce fertilizers in an effort to help farmers improve their harvests. To solve gas emission issue in early 1900s, an executive manager was assigned to oversee their copper mining business. He sought a fundamental solution and took radical steps to relocate the plant and its smelting operation to an uninhabited island. The estimated cost of the move was equivalent to two years of profits of the copper mine, and eventually cost three times of the original estimation. This executive manager also took over reforestation of the mountains around the mine that had been removed due to gas emissions and deforestation. As the amount of produced copper increased, more and more wood was consumed in the form of firewood, charcoal, and pit prop. About 60,000 to one million trees per year were then planted to compensate the loss in the forest. This executive manager was quoted as saying that the Chemical Company must return the entire mountain area around the copper mine to its former lush natural state. The executive manager's work was carried on by his successor, another executive officer, who later on expanded the company's forestry business throughout Japan.

The employees at the Chemical Company often quote the story above as the "*origin of the firm*". They believe that it is because of such an origin—the company was founded to solve environmental problems that the company has created a tradition of "*maintaining the harmony between individual,*

the nation, and the society" (cited from the CSR reports). Sustainability is not perceived as a new phenomenon by the employees; rather, it is their historical heritage. As one of the CSR managers that we interviewed stated:

"Our business must not only benefit our interest, but also our society at large . . . We consider both are very important for us. This is the spirit of The Chemical Company. We think sustainability has both benefits—for the company and for the society."

A similar view is also shared by the employees outside of the CSR department, as one of the middle managers in the business department put it:

"I believe what makes our company unique is its origin. We developed our products by solving the environmental problems. It is very different in comparison with other chemical companies. The origin, which is the most important in the sense of CSR and sustainability, is also connected to our philosophy and is still respected in our company."

The belief that sustainability is something that the company has kept in its tradition is also evident in the quote below from another middle manager outside of the CSR department:

"For more than 100 years, we have tackled different types of social problems, such as food safety, where we found necessary social needs and allocated our resources for human challenges. We have also overcome pollution. It is why the company has survived in the past, even in difficult time."

The company's history has become an organizational repository boundary object through which it connects sustainability with their business principle. Specifically, it is expressed in the company's strategy that the company shall strive for solving problems that society faces in the areas of environment, food, resources, energy, health and society. Clearly, the strategy is in line with the SDGs in an array of aspects, not only covers the environmental aspects such as energy, materials/resources, pollution/toxic waste, but also the issues around health and society. Overall, the historical contextualization of the firm has paved the way for the further integration and implementation of the SDGs in its business practices.

4.1.2. The Best Practice Repository

If the historical contextual repository suggests that sustainability targets at solving the environmental problems, the best practice repository gives a broader meaning of sustainability by expanding the scope not only to environment but also to the society at large. As one of the oldest firms in Japan, the Chemical Company has been praised for being 'society-friendly' because of its strong corporate governance, close co-ordination with government economic policy and life-long employment. The company has also demonstrated its good corporate citizenship through a list of "best practices" in sustainability related work. This includes conventional CSR practices, such as community involvement, philanthropic donation, good corporate governance, implementation of 'green policies', and managing the company's relationship with society. The most prominent work is its green product innovations that have created values not only for its own business, but also society and environment. We select one of their most representative sustainability innovations as an example in this paper.

The Chemical Company has been actively working on supporting 'Malaria No More' campaign through its mosquito net business for nearly two decades. This special mosquito net is made from polyethylene fibers in which an insecticide is incorporated, and used as an effective means of protecting people from the mosquitoes that transmit malaria. It is the first net endorsed by the World Health Organization (WHO) in 2001 as a long-lasting insecticidal net. In 2003, the Chemical Company started local production with free licensing of manufacturing technology to an African textile manufacturing company in Tanzania. A joint venture was also established and hired the locals in Tanzania. In 2012, the Chemical Company set up R&D laboratory for new product development in Tanzania. A new product line based on the original product was further launched. So far, the annual production of

the mosquito nets has reached 60 million globally and the products have been sold in 80 countries. The market effect of the mosquito net has also brought social changes to the local communities. Up to 7000 local jobs were created in Tanzania since. Schools have been established from the donation of the Chemical Company so that local kids in Africa can be educated.

In 2013, an upgraded product was developed, which is a type of spray that can be easily applied to the wall for the protection from insect bite. However, the marketing channel has not been fully established. The Chemical Company is now using non-governmental organizations (NGO) to promote the sales of the spray. The quote below indicates the close work relationship between the Chemical Company and the UN, and the collaboration between different parties in the joint pursuit of sustainable innovations, as one of the CSR managers explained:

“... it is difficult to buy this product in Africa. So we used NGO to fund the spray. I think UN and the NGOs, as well as the donations play an important role in funding the new product.”

The success of the mosquito net has become an organizational repository demonstrating the firm's contribution to sustainability. The Chemical Company continues their participation in the United Nations Foundation's "Nothing but Nets" campaign and entered the third year of their partnership to help protect women, children, refugees, and vulnerable populations from malaria. The success of the mosquito net is considered as one of the best practices of the firm that has connected its CSR to the firm's core business, which directly contributes to solving health and economic problems caused by malaria in Africa.

The product development process itself functions as a boundary object that effectively connects people from different functions and product areas. In 1973, a scientist named Ito joined the Chemical Company and was assigned to the second pesticide development laboratory. Another scientist named Okuno joined the company in 1971 and was assigned to the central laboratory and appointed as the project leader of agriculture section. The third key person of this project was Kawasaki, who was a salesman for Sumithion (fenitrothion), an insecticide product that prevents from infection of malaria. In the early 1980s, Kawasaki was in the overseas agro division and he came to know Ito. At that time, Okuno, who did not know the rest two people, was in the environmental science laboratory. The sales amount of the Sumithion was high, but because it could not maintain the effect, a replacement product was desperately needed in the market. Hence, Kawasaki started his search with a special target on against malaria and was advised that soaking mosquito nets in insecticide liquid can maintain a long lasting effect.

Ito and Okuno got to know each other and had a chance to work together for the development of a medicine that prevents epidemics diseases. As an expert in resin and high polymer chemistry Okuno noticed that it was important for the insecticide to bleed from resin slowly so that the effect can continue for long time. However, Okuno thought there was too little profit from the products due to limited market demand. Therefore, Okuno did not pursue the idea and started looking for alternative products. His team later successfully made screen doors with insecticide. Ito noticed this new business success and asked Okuno to make the mosquito net with a similar technique, but Okuno declined it considering the unforeseen profit.

Kawasaki was interested in the mosquito net that Ito proposed because he had to find a replacement for Sumithion to fight malaria. He finally managed to persuade Okuno to produce the mosquito nets and it turned out to be a big technology success. The new mosquito net achieved the long lasting effects for estimated seven years in the test, and the final product was launched with a guarantee of more than three years lasting insect killing effect. Combining Okuno's expertise in resin production, Ito's knowledge in insecticide, and Kawasaki's business insight, the company successfully developed a very special product that created a new business for the firm, and saved lives in African communities.

The above story shows how new business opportunities can be developed based on social needs. It is evident that sustainability unlocks innovation potentials through learning in the organizational

field by combining existing technologies and applying of existing technologies in new product areas. Furthermore, while the need to develop new product facilitated the formation of a cross-functional product development team (lead by aforementioned three key persons), the need to scale up the mosquito net business successfully connected the company to NGOs and the UN, which suggests a multiple stakeholder involvement in sustainability innovation.

4.2. The Standardized Form of Boundary Objects

Star and Griesemer [28] defines the standardized forms of boundary objects as methods of common communication across dispersed work groups. At the Chemical Company, we have found the designation process of sustainable product innovation can be regarded as the standardized form of boundary objects for sustainability, especially for environmental sustainable innovations.

The project of Sustainable Solution started in November, 2016. The overall purpose was to designate the products and technologies that contribute to mitigating global warming and reducing environmental burdens. From the corporate perspective, it was to communicate their engagement of sustainability to the society and the stakeholders. The manager who is responsible for this project put it frankly:

“We want to communicate what the society and stakeholders want through this kind of certification. Nothing is business as usual.”

“Nothing is business as usual” indicates changes, but does not necessarily imply pressure. Firms can either react to the change, or do nothing about it. In the case of the Chemical Company, they hold a proactive attitude toward the change. The same manager explained,

“We see huge opportunities ahead in this company. We need to capture them. It is good for our business and also for the environment. We have 5 mega business areas. Each has demonstrated their best solutions, but as a group company they are not recognized. The products were not streamlined and did not have a system. Our eco-friendly products were not well communicated with outside customers.”

In order to “*well communicate*” to the customers, the company assigned an internal organization called “the Designation Committee” to officially designate products and technologies that satisfy certification requirements and contribution to environmental protection. Four major requirements are set for the certification of “green chemical” products, including:

- (1) Climate change efforts through contribution to: (a) reducing greenhouse gas emissions; (b) products, parts and materials used for development of new energy sources; (c) use of biomass-derived materials; (d) adapting to climate change impacts, such as for vector control and building a resilient city.
- (2) Reducing environmental burdens through contribution to: (a) reducing wastes, hazardous substances and other environmental burdens; (b) reducing environmental burdens for increasing food production.
- (3) Effective use of resources through contribution to: (a) resource savings and promotion of recycling; (b) effective use of water resources.
- (4) Others that contribute to building a sustainable society.

Although the certification criteria are presented in a standardized form, it is not executed rigidly. The company is currently developing other criteria so that the product categories are not limited to the environmental aspects. The manager who is in charge of the certification explained:

“Our product portfolios are huge, from pharmaceutical to food. The current certification only looks at the environmental side. How about the health side? Other criteria are not included right now. We are evaluating other criteria but it takes very long time. How can we

find evidence of those contributions? What would be the criteria? At least, I can say these 9 criteria are not final. The society needs changes. We also consider other options.”

Clearly, the ‘standard’ form remains its flexibility, which can be considered as a typical feature of standards for sustainability; that is, the sustainability standards may change according to the change in regulations, or new scientific discovery.

The standard certification process of environmental sustainable products has brought additional business profit to the company. In FY 2016, 34 products and technologies were designated as “green chemical” products with sales of 293.4 billion JPY. In FY 2017, designated products and technologies increased to 44 with sales of 335.7 billion JPY, and contributed to a reduction in greenhouse gas emissions of approximately 53 million tons. From 2016 to 2017, the sales of green chemicals have increased 15%. The sales revenue in FY 2017 reached 335.7 billion yen, which shows a rise of 6% year on year. These designated products accounted for 15.3% of all sales revenue and specifically contribute to SDGs 2, 3, 7, 12 and 13 (see Appendix B for detailed information). The manager who is in charge of the certification commented in the following:

“44 products are not enough. The target is to double it. By increasing the number of the products we also increase sales.”

There is an evident ambition of certificating more products into the sustainable category in the company. However, the long product development life cycle in the chemical industry has prolonged the process of innovation. The same manager justified:

“I am one of the members to evaluate the initiative. First of all, these are internally developed products, not from licensing from other companies. This is not easy two large candidates as “green chemical” products take 5–10 years to develop, even 20 years in the case of chemicals for the safety and clean tests. We have challenges.”

Further challenge is identified on the political side. Since the SDGs are set by the European governments to what extent Japanese firms can drive the change remains a question:

“To put it simple, chemical companies have complicated business that is communicated into the SDGs. We materialize what type of the SDGs we can contribute more. What kind of stakeholders can we target? And then we allocate it. It is just an example. There are lots of advanced views on sustainability. Lots of sustainability related reports are drafted and regulated by European governments or companies. Some Japanese companies are followers. Is that really a good thing? It is very difficult.”

Despite of the difficulty, the product development teams at the Chemical Company seem to strive for getting their new products certificated, not only for the business interest, but also for the internal recognition. Hence, the establishment of the certification process of sustainability product effectively creates a shared communication across dispersed work groups, and has become an important incentive to integrate the SDGs into product innovation.

4.3. The Ideal Type of Boundary Objects

Star and Griesemer’s [28] ‘ideal’ type of boundary objects can be understood as a vague concept with multiple possibilities for actions. At the Chemical Company, we found a program called ‘Sustainable Tree’ that serves the purpose for being an ideal type of boundary objects.

The majority of the 17 goals and 169 targets in Agenda 2030 seem very far from the Chemical Company’s business scope. Issues include eradicating poverty, reducing inequalities and promoting inclusive and sustainable economic growth simply are too vague to grasp by the employees. Besides, ideas expressed in the SDGs such as sustainable management, conservation and restoration of terrestrial and aquatic seem far broad to be put into business practice. Because of the ambiguity in SDGs, the Chemical Company sometimes refers the SDGs as a ‘philosophy’, as it stated in their news release in 2017 as follows:

“The Chemical Company’s spirit emphasizes, ‘harmony between the individual, the nation and society’, meaning that every subsidiary must seek to benefit not only its own business, but also the nation and society. This guiding principle being long inherited as our corporate DNA, The Chemical Company shares the view of the United Nations as expressed in the philosophy of the SDGs.”

Treating the SDGs as a philosophy has made individual understanding of the SDGs difficult. When the company started the learning project for the SDGs, the awareness of the SDGs was very low. One of the CSR managers told us:

“When we started it, almost nobody knew what the SDGs are, so we made a cartoon and promoted the understanding of the SDGs by using the manga.”

A manga was posted on the company website to explain what the SDGs are and how they are related to the firm’s business. Furthermore, the company launched a three-year program called the “Sustainable Tree” to promote the understanding. The program is a participation-type project where all employees at the Chemical Company are expected to think about how they can contribute to creating a sustainable society through their day-to-day work. To take the thoughts in actions, they were asked to post their views and ideas on a website dedicated to the project. SDGs icons were displayed on the dedicated website with information about each goal and targets. Information about products and technologies in connection with the SDGs gives examples of how the company contributes to the SDGs through its product, supply chain, and so on. Participants are expected to select some of the 17 SDGs to focus on and post their efforts on the website. The campaign lasted for 100 days and was conducted in 2016, 2017 and 2018.

FY 2016 was the first year of the project. The dedicated website was named “Our Sustainable Tree: Things We Can Do to Build a Sustainable Society”. As the very first step, the goal was to help the employees understand the SDGs. During the first 100 days posting period, 6,005 submissions were received, both inside and outside Japan. Examples of the posts include:

“We want to contribute to world food production by increasing the yield per unit area through the development and launch of excellent pesticides.”—for Goal 2 Zero Hunger

“Working in the chemical industry, how can we contribute to global issues such as resources, energy and climate change? To solve these issues, we, believing in the infinite possibilities of chemistry, should take the lead in technological innovation. We are committed to taking on the challenge of realizing technological innovation together with our colleagues at home and abroad.”—for Goal 9 Industry, Innovation and Infrastructure

The program manager from the CSR department commented in the following:

“The post content in the first year is very simple, but it is a good start.”

FY 2017 was the second year of the campaign. The expectation was that the employees should consider the SDGs through the business operations. The company named the campaign “Our Sustainable Tree Step 2, Work Together towards the SDGs” and limited the content of the postings to work or workplace related only. Team discussions were organized to aid the learning process, as noted by the staff of the CSR department who has been responsible for the program:

“It is better to discuss ideas not only for posting, but also for how to make improvement (at work based on the SDGs).”

In total, 23,654 participants uploaded 9,099 posts in the campaign of 2017. Named “Our Sustainable Tree 3.0”, 2018 was defined as “the action year” where the company expected every single employee to find business solutions that contribute to the SDGs. As one of the CSR managers described the goal:

“We want employees to fully demonstrate their creative capabilities and come up with solutions that create new value through the power of chemistry.”

“Be creative” and “create new value” were the key words for 2018, implying the aim for innovations and business opportunities. One example of the creativity is that workers in one of their factories selected three icons from the SDGs and put them on the helmet. In total, 7,700 postings were received from 30,598 participants in the campaign of 2018. Although the number of postings decreased in 2018, the content changed significantly. The previous posts from 2016 and 2017 were mainly about broad discussion on the SDGs and social contributions from individuals. In 2018, the discussions took place on finding solutions. For example, the Singapore unit presented an energy report for setting up solar panel and an initiative to clean up the beach in Singapore. Similar examples were also found in Japan and Brazil, suggesting how to increase crop production that contribute to agriculture, and how to achieve a work-life balance.

As a learning forum, the program offers a platform for the employees to interact and work together for a common goal—posting a solution for the SDGs. It also gives an impetus for knowledge sharing, allowing the employees to gain access more readily to external information about various issues from climate change to improvement at workplace. However, there is limitation in the program. Sustainable Tree itself limits confidential information sharing, even though it is recognized as an essential explanatory platform for understanding the SDGs. Since the employees cannot write confidential information on the website, it is difficult to share ideas that are related to technology or product development. As the CSR manager explained:

“This is a big problem when using a (Group-wide) site like this. Although we are in the same Group Company, the individual companies are different, with patents and so on. It is also difficult when we try to connect more products with new solutions when using this site.”

Another manager shared a similar view that the Sustainable Tree helps to connect people but there are problems in inspiring innovation. He said:

“We have about 33,000 employees group wide. Sustainable Tree is a wonderful map to provide opportunities for the group-wide employees to connect, share and post their thoughts. But when it comes to the real work, to develop state of art technology or new products, it needs confidential agreement.”

Likewise, the staff of the CSR department who has been responsible for this program also put it frankly:

“This project is not aimed to make new product based on our technology. This is for promoting the SDGs and sustainability. We don’t know if there is any new technology invented through it. But in long term this attitude and motivation (toward sustainability) maybe have impact on our products.”

Therefore, the learning platform clearly has its limitations for information sharing. But overall, the program has successfully facilitated the learning process of the SDGs and enables employees from different functions to share ideas on how to “work with” the SDGs in their daily life, from issues on gender equality to work-life balance. Moreover, it opens the door for the company to see the positive energy brought by collective learning, which further triggers more actions on integrating the SDGs to organizational practices.

4.4. *The Community of Practice Type of Boundary Objects*

Developed by Lave and Wenger [68], Brown and Duguid [49] and Orr [69], ‘community of practice’ refers to the activity of sharing practice, knowledge needs and interests at work. We have identified two types of community of practice as boundary objects to ensure the implementation of SDGs at the case

company: a top manager community of practice, and a cross-functional community of practice. Top managers tend to consider showing their commitment to sustainability as a way of gaining legitimacy and regard green innovations as ‘the best practice’ in their organizational field [70] and thereby they are considered to be drivers for sustainability development [71]. The first type of community of practices for sustainability is a group of top managers who are assigned to monitor the implementation of the SDGs.

In 2018, the company initiated an approach named T-S-P for implementing sustainability with the strong leadership of top management (T) through its business solutions (S), and with the participation of all employees (P). The CSR managers emphasized:

“... having each top manager to join this project and have a message to the employee is an important part... If we just set the policy, it is not enough. You need to promote it at the employee level.”

After involving the top managers, the posting rate has increased from 11% to 15% from 2017 to 2018. Seeing the positive effect, the top management team further strengthened their involvement by participating in Sustainability Promotion Committee. Established in April 2018, the committee aims to accelerate measures related to resolving social challenges. The Chemical Company states that the establishment of this special committee serves for three purposes: 1. To oversee the group’s sustainability promotion activities; 2. To comprehensively verify contributions to sustainability; 3. To accelerate efforts to solve issues in society, including the SDGs. The Committee is chaired by the president of the Chemical Company, and consists of executive officers from each business division, and the presidents of each regional headquarters. In other words, the committee members are the top managers from regional headquarters from different functions. Certainly, it indicates a high level of top management commitment. As the CSR manager described:

“It comes from a high level involvement to examine our efforts in sustainability, including SDGs.”

The secretariat in this committee is consist of 9 departments in the headquarter and they are the CSR promotion department, the corporate communications, the legal department, the human resources department, the corporate planning department, the research planning and coordination department, the responsible care department, the purchase department as well as the logistics department. The CSR department is the secretary in the secretariat. The secretariat in the Committee is responsible for proposals that are submitted to the committee. After the committee discusses the proposals, they report to the board of directors for approval. The widespread involvement of different departments is considered to be crucial to ensure an effective monitoring from the special committee, as emphasized by the CSR manager:

“Because one department cannot achieve sustainability by it alone, we cooperate with many departments.”

The second type of community of practice is organized at the function level. The CSR department collaborates with almost all the other departments in the headquarters of the Chemical Company in Tokyo. It is evident in the following conversation between the CSR Dept. Manager and RC Dept. Manager:

CSR dept. manager: “The collaboration with our XX department is very important. For example, the secretaries in the committee are from both CSR and XX. We discuss about our sustainable products in our secretaries’ meeting. It is very important for us to communicate between the two departments”.

RC dept. manager: “I think we may communicate a bit too much”.

The interaction of the CSR department with the other department generated positive results for the participation in Sustainable Tree program. As a manager from a business department described:

“As a participant, in my personal feeling, only those who are related to the (sustainability) issues participated in this project (Sustainable Tree) in 2016. But then people from other functions such as management, business planning and marketing joined this project in the following years. At the group meeting we had the CSR department joined us. In my personal feelings, the functions have expanded gradually, year by year.”

It is thus clear that the cross-functional community of practice with the involvement of the CSR department has facilitated the understanding of SDGs. Further, it seems that the learning outcome also contributes to the development of new ideas for innovation. Take the development of polymer OLED lighting as an example. Organic Light Emitting Diodes (OLEDs) are devices that provide light emitted by organic materials. The Chemical Company has been developing this next-generation lighting technology since 1989. A manager who has been involved in the development of polymer OLED stressed the benefit that they have gained from meeting with the CSR department as follows:

“Through meetings and gathering we got some insights from perspective of the CSR to develop OLED lighting. That kind of effect is very positive.”

Because of the energy efficiency and reduced light emission, the product has been certificated as one of the Sustainable Solution products by meeting two SDGs: Goal 7—Affordable and clean energy; and Goal 13—Climate action (See Appendix B for details). Although it is difficult for the CSR staff to claim that their efforts have contributed to the success of green innovations it is clear the mindset has changed in the R&D department. Sustainability is considered as an important element for the R&D team as emphasized by an executive manager in the following quote:

“Although our R&D does not focus on sustainability, sustainability is considered to be an important motivation for the team for product development.”

Despite that sustainability is not the main trigger for product development, the consideration of sustainability has opened the mind of the engineers and broadened the scope of applications of the chemical materials. Another example is polyether sulfone (PES) material, which is an additive for carbon fiber reinforced plastics (see Appendix B for details). Because of its high performance in the material itself, it makes aircraft significantly lighter and hence fuel-efficient. The environmental benefit of PES has extended its application from airplane manufacturing to car manufacturing. PES is also one of the certificated Sustainable Solution products that meet Goal 7 and Goal 13. As summarized by the executive manager who is in charge of the R&D department:

“PES is a rare case that we didn’t experience before. It’s not originally designed for green chemicals or sustainability . . . It’s kind of afterthought, but now we are making efforts on exploring the utilization of our products. In the future, maybe, the sustainability will become the most important sales point.”

To sum up, it is obvious that the integration and implementation of SDGs has positive impact on the organization in general. The case has shown a stronger belief that sustainability is rooted in the company history. Such value is further strengthened by the company’s efforts to solve social problems through its innovations. Moreover, it indicates a changing mindset of the local employees and managers with increased sustainability thinking in their work practices. Although it is difficult to measure the direct relationship between the learning of SDGs and green innovation outcomes, it becomes clear that the organization has benefited significantly not only from the increased sales in their certificated sustainable products, but also a long-term benefit from the recognition by the UN and the local communities for its contribution to the society. Table 1 shows the supporting data.

Table 1. Data analysis.

Types of Boundary Objects	Exemplified in the Case	The Selected Representative Quotes
Organizational repository	Historical contextual repository for sustainability	<p>“The Chemical Company commenced its business based on the spirit of corporate social responsibility (CSR), contributing to society through its business activities, long before the term became popular.”—Company’s 100 years’ history book</p> <p>“I believe what makes our company unique is its origin. We developed our products by solving the environmental problems. It is very different in comparison with other chemical companies. The origin is also connected to our philosophy and is still respected in our company, which is the most important in the sense of CSR and sustainability.”—Middle manager A</p>
	Best practice repository for sustainability practices	<p>“Our founding history is one example (of our work) from preventing environmental pollution to innovation. For more than 100 years we have tackled different types of social problems, such as food safety, where we found necessary social needs and allocated our resources for human challenges. We have also overcome pollution. It is why the company has survived in the past, even in difficult time.”—Middle manager B</p> <p>A special mosquito net was developed by the company to end death caused by malaria. The new product development process functions as a boundary object that effectively connects people from different functions and product areas. After the new product launch, the scale-up process was benefited by the company’s CSR behavior, in connection with NGOs and the UN, as shown in the quote below:</p> <p>“ . . . it is difficult to buy this product in Africa. So we used NGO to fund the spray. I think the UN and the NGOs, as well as the donations play an important role in funding the new product.”—The CSR manager</p>
Standardized type	Certification process of environmental sustainable products	<p>“We want to communicate what the society and stakeholders want through this kind of certification. Nothing is business as usual.” “We see huge opportunities ahead in this company. We need to capture them. It is good for our business and also for the environment. We have 5 mega business areas. Each has demonstrated their best solutions, but as a group company they are not recognized. The products were not streamlined and did not have a system. Our eco-friendly products were not well communicated with outside customers.”—The product sustainability certification manager</p> <p>“Our product portfolios are huge, from pharmaceutical to food. The current certification only looks at the environmental side. How about the health side? Other criteria are not included right now. We are evaluating other criteria but it takes very long time. How can we find evidence of those contributions? What would be the criteria? At least I can say these nine criteria are not final. The society needs changes we also consider other options.”—The product sustainability certification manager</p>

Table 1. Cont.

Types of Boundary Objects	Exemplified in the Case	The Selected Representative Quotes
Ideal type	Learning platform to enable multiple parties to take action, yet it has limitations	“When we started it, almost nobody knew what SDGs are. So we made a cartoon and promoted the understanding of SDGs by using the manga.”—The CSR manager
		“We want employees to fully demonstrate their creative capabilities and come up with solutions that create new value through the power of chemistry.”—The CSR manager
		“This is a big problem when using a (group-wide) site like this. Although we are in the same group company, the individual companies are different, with patents and so on. It is also difficult when we try to connect more products with new solutions when using this site.”—The CSR manager
		“We have about 33,000 employees group wide. Sustainable Tree is a wonderful map to provide opportunity for the Group-wide employees to connect, share and post their thoughts. But when it comes to the real work, to develop state of art technology or new products, it needs confidential agreement.”—Middle manager C
		“This project is not aimed to make new product based on our technology. This is for promoting SDGs and sustainability. We don’t know if there is new technology invented through it. But in long time, this attitude and motivation (toward sustainability) maybe have impact on our products.”—Program manager
Community of practice	Cross-hierarchy and cross-function meetings	“... having each company’s top manager to join this project and have a message to the employee is an important part ... If we just set the policy it is not enough. You need to promote it on employee level.”—The CSR manager
		“It comes from a high level involvement to examine our efforts in sustainability, including SDGs.” “Because one department cannot achieve sustainability by it alone, we cooperate with many departments.”—The CSR manager
		“The collaboration with our XX department is very important. For example, the secretaries in the Committee are from both CSR and XX. We discuss about our sustainable products in our secretaries’ meeting. It is very important for us to communicate between the two departments.”—The CSR manager
		“As a participant, in my personal feelings, only those who are related to the (sustainability) issues participated in this project (Sustainable Tree) in 2016. But, then, people from other functions such as management, business planning and marketing joined this project in the following years. At the group meeting we had CSR joined us. In my personal feeling, the functions have expanded gradually, year by year.”—Middle manager B
		“Through meetings and gathering we got some insights from perspective of CSR to develop OLED lighting. That kind of effect is very positive.” “Even though our R&D does not focus on sustainability, sustainability is considered to be an important motivation for the team for product development.”—Middle manager B

5. Discussion

5.1. The Interconnectedness and Limitations of the Four Boundary Objects

Previous studies have discussed the negative effect of path dependence in innovation. Path dependence implicates good memories make good choices. Path dependent knowledge can hinder organizational learning because the common knowledge used in the past may not have the capacity to represent the novelty now present [72]. It can also constrain the capacity of others to represent the novelty they are facing [73]. Yet, when new business opportunities fall within the domain of the firm's past activities, path dependency can be a source of learning; when the opportunities fall outside the domain of the firm's past activities, path dependency can become source of core rigidity ([74]. In the case of the Chemical Company, the new opportunities presented by sustainability luckily fall within the domain of the firm's past. The organizational historical repository has proved to connect novel knowledge—the notion of sustainability - with their path dependent knowledge—the historical origin of the case company. Expressed in stories, the historical contextualization of sustainability makes the employees to believe that sustainability is something inherited in the firms rather than a novel phenomenon. The reason of such connection could be that the circumstances at the boundary remain stable. In other words, the employees are unlikely to recognize the boundary issues. Therefore, the historical organizational repository has contextualized the understanding of sustainability.

Further, used as a frame of reference, the firm's best practices demonstrate what sustainability actually means to the firm in actions. This finding is in line with Benn et al. [30], where their examination of repositories of best practices indicates the positive effect to sustainability, and such repositories of best practice could be integrated and embedded in different contexts. In this sense, the repository type of boundary object provides a common language that everyone at the Chemical Company can relate and understand what sustainability means to the firm in the past and to the present. Therefore, the presented study is of particular value to sustainability literature because it links both historical and a present-day aspect into the understanding of sustainability. The 'conversation' between existing explicit knowledge in the historical context and the novel explicit knowledge in the form of SDGs thus assists the combination process [43] across syntactic knowledge boundary [32].

While a common language is always necessary, it is not always sufficient for sharing and assessing domain-specific knowledge, as noted in Carlile [32]. Besides, if the common language does not have the capacity to represent a particular actor's knowledge and interests, for instance, if an employee is not aware of the company history or the best practices in their sustainability work, the organizational repository boundary objects may not function as desired. In the case of the Chemical Company, as the pressure to be a sustainable firm grows, the history and best practices of the firm, does not seem to be sufficient to drive sustainability into actions. The problem is that knowing is not as same as doing. Since the case company involves a wide range of business in the chemical industry, building a common platform that links different knowledge domains is difficult but necessary. This gives rise to the emergence of the ideal form boundary object, created not only to allow the different groups to share their understanding of sustainability, but also to learn about each other.

Undeniably, operating globally in a range of business areas from petrochemicals to energy and health can be very difficult when creating a common learning platform. The vagueness of SDGs is embedded with 'interpretive flexibility' [28] that learner from different knowledge domains could find their own interest and ways to relate to. This is evident in the following quote from the CSR manager, who has been responsible for the Sustainable Tree program,

"SDGs are very useful to discuss social issues. Social issues seem very gloomy and serious but studying SDGs, like these icons are very positive. We always tackled social issues so it is very good as a communication tool internally. There are some good effects by using SDGs."

Because of such flexibility, SDGs serve as a means of communicating and cooperating symbolically. In other words, it can be a 'good enough' road map for all parties. It also explains why an ideal type of boundary objects are typically developed and used in change programs to provide a common frame of reference for communication across different domains of knowledge and practice, such as the Sustainable Tree at our case company.

Moreover, the Sustainable Tree program has successfully connected the different divisions in the company from different geographical locations together with the CSR department. It has become a boundary object that helps to across the 'semantic' or interpretive knowledge boundaries [32]. Even though, it does not mean the different interests across functions can be aligned. The restriction of posting confidential information can hinder the development of innovative ideas. In this aspect, we argue that information communication based boundary objects can have explicit features of a positive boundary object, as well as a negative kind. As it indicates in the case, the restriction on posting confidential information has hindered the generation of creative ideas for technology and new product development. This finding echoes Fox [54] where he concludes that not only are there positive and negative boundary objects, but that technological devices or processes may themselves act as facilitative or inhibitory boundary objects during innovation. Similarly, Allen [75] pointed out that technology based boundary object can be negative when stakeholder enrolment are not aligned.

In line with Allen's [75] argument, the engagement of individual employees in the Sustainable Tree program may differ, which can lead to a variation of learning outcome. The program sets the ambition to align the interests across functions and business areas around the topics of SDGs where the CSR department has naturally take the lead in the learning process. The abilities of the actors to use the boundary object yet depend on a number of factors, such as absorptive capacity [76], willingness to learn, and the relationship between knowledge and power [53,77]. Cyert and March [78] believe that organizations change their behavior in response to the environment according to well-defined rules. Learning from these rules incorporated in an organization's standard operation procedures can constitute the 'memory' of an organization [79]. This explains why the standard certification of environmental sustainable products is effective for the realization of sustainability into business values.

Following the communities of practice literatures [49,68,69] we have found community of practice functions as another type of boundary object that comes across hierarchical levels and functional levels. Community of practice is suggested as an effective way of learning because people can develop shared understanding and meanings during working together [31]. Defined as informal clusters of individuals who work together for sharing knowledge, solving emergent problems, and exchanging insights and frustrations within organizations, community of practice plays an important role in creating, sharing and applying organizational knowledge [49,68,69]. In this aspect, we have added a new category into the original types of boundary objects by Star [27] and Star and Griesemer [28] and extended the concept.

In the presented study, community of practice is used as a monitoring tool and coordination method to ensure the effective operation and measurement of SDGs. Thus, one can argue that the eager to integrate sustainability into business practices have pushed changes in a firm's coordination and control system. This finding resonances Matten and Moon's [80] research, where they characterize firms' response to institutional pressure for sustainability, including the degree of integration and interdependency of economic processes; the anonymity of employer-employee relations; the degree to which delegation takes place and trust governs relationships; the level of discretion in the task environment of employees; the degree of responsibility of managers towards employees [80]. Our study thus provides empirical evidence to support their propositions, and also gives new meaning to the notion of community of practice in the context where sustainability and green innovations are desired.

Additionally, the high degree of engagement emphasizes the importance of active sense-making [37,81] work by participants, rather than intrinsic capacities of the boundary objects themselves. The involvement of top management indicates the role of power and politics in the institutionalization process of organizational learning [82]. As Carlile [31] argues, a successful boundary object must provide a shared language, allow concerns to be expressed, and enhance knowledge. The aforementioned four boundary objects seem all fulfill those goals.

5.2. *The Learning Outcome—Sustainability Innovations*

Previous studies have provided evidence showing the reluctance of firms in advancing green innovations [11]. The reason can be attributed to the high risks involved - both market success and non-economic sustainability are uncertain [83]. Yet, extant research lacks clarity as to how business values can be generated through sustainability and what contexts lead to particular business value. Although researchers and practitioners acknowledge that SDGs can accelerate brand relevance, company growth and social impact, the relationship between sustainability and innovation has not been fully specified in the literature. Our empirical study fills in part of the void by exploring the link between learning and green innovations.

Previous studies have suggested that learning capabilities can be developed through a firm's CSR activities [10,84]. Through our study, we have found the link between community practice based learning and green innovation outcomes. This finding resonates the view in Vilanova, Lozano and Arenas [85], where they claim that CSR and competitiveness are related through a learning and innovation cycle, through which corporate values, policies and practices are constantly defined and re-defined. Further, our findings indicate that learning takes place when CSR is embedded in business processes, and the key to the integration is through a cross-functional community of practice that has a strong involvement of top managers.

6. Conclusions

The general purpose of this paper is to develop a better understanding of how firms integrate SDGs and generate values through it in their business practices. A knowledge-based view of SDGs is developed to address the varying challenges in the learning process, through which the notion of boundary objects is presented as the central concept in this paper. Relying on a single qualitative case study, this study has tracked the 10 years of CSR practices within a Japanese firm during 1999 and 2019 both in present days and retrospectively, where the focal attention is paid on the work in related to SDGs between 2016 and 2019. The findings reveal four types of boundary objects that are shareable across contexts: 1) organizational repository boundary objects, including historical contextualization and best practices; 2) standardized type of boundary objects for the certification of environmental sustainable products; 3) ideal type of boundary objects through digital forum learning platform; and 4) community of practices across hierarchy and functions.

In terms of managerial implications, the present study shows how sustainability and, in particular, how SDGs are viewed in organizations. The case first showed how the employees felt it was difficult to understand the goals not only because the goals were far from their daily work, but also because the company promoted them as a philosophy. Later, the company introduced manga to explain the goals in a vivid way, which significantly helped the translation process of philosophy values into actionable targets. Based on the findings, the paper provides some concrete suggestions to the practitioners on how to tackle the global challenges from a sustainability point of view. The four types of boundary objects presented in this paper can provide some ideas on how to create a common language for sustainability in local practices, and how to use SDGs as opportunities to generate new business and create values for different stakeholders.

There are some limitations in this study due to several reasons. First, the context of the chemical industry is only representative to discuss environmental sustainability. Future research in other industrial contexts can be beneficial by exploring other aspects of sustainability challenges. Second, effective boundary objects for sustainability may not be limited to the four types that we present in this study. Future empirical study may help to uncover a full range of possible effective boundary objects that assist learning for sustainability. Third, this study only touches upon the link between learning and green innovations. Future research can aim to follow one or a few green innovation projects closely and observe the change along the process in the company's learning program.

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Appendix A The Interview Guide

Example interview questions

- How does CSR division translate SDGs requirement into actions? Could you give an example?
- How did the company start with sustainability initiative in its business?
- How did such initiative integrate into the company's product innovations?
- What is your responsibility at the sustainability promotion committee?
- Do you work with people from different departments/functions?
- Could you describe what type of assignment requires you to collaborate with the other functions?
- Which type of leader support do you have at work? Does your superior get involved in your work directly or indirectly?

Appendix B

Table A1. Examples of the sustainable product innovations at the case company.

	Product	Product Feature (Source: Interviews, Company Material, Website, Media)	Contributions to SDGs
1	Anti-malarial long-lasting insecticidal mosquito net	A mosquito net developed for controlling malaria-carrying mosquitoes, helping reduce malaria infection	Goal 3—Good health and well-being Goal 13—Climate action
2	Polyether sulfone	An additive for carbon-fiber reinforced plastics used in aircraft, making aircraft lighter and hence fuel-efficient	Goal 7—Affordable and clean energy Goal 13—Climate action
3	Feed additive methionine	Adding methionine to poultry feed gives improved balance of amino acids in feed, resulting in reduced nitrogen in poultry excrement - a cause for greenhouse gas emissions	Goal 12—Responsible consumption and production Goal 13—Climate action
4	Polymer OLED lighting	Manufactured using processes that are energy- and resource-efficient due to the coating and printing methods, these lights can produce color over a wide temperature range, from gentle to vivid.	Goal 7—Affordable and clean energy Goal 13—Climate action
5	Lithium-ion secondary battery separator	A material capable of providing high-capacity lithium-ion secondary batteries, contributing to the expanded use of next-generation vehicles, such as electric vehicles.	Goal 7—Affordable and clean energy Goal 13—Climate action
6	CO2 separation membrane	Used in hydrogen production and natural gas refining to remove CO2. It reduces significantly energy consumption for CO2 separation, compared with conventional methods.	Goal 7—Affordable and clean energy Goal 13—Climate action
7	UV curing for polarizer lamination	Achieves substantial energy saving in the manufacturing of a polarizing film for displays, compared with conventional methods.	Goal 7—Affordable and clean energy Goal 12—Responsible consumption and production Goal 13—Climate action

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