PRODUCT DEVELOPMENT MANAGEMENT IN THE ONLINE-OR-OFFLINE HYBRID ERA

Kazuma HATSUSHIO[1]

Nobutaka SUZUKI[2]

Abstract

The purpose of this study is to analyze and discuss what kind of product development management is effective and efficient for companies in the current hybrid era, where not only face-to-face (offline) activities, but also remote (online) activities are increasingly used. Product development is becoming increasingly important in a society of growing complexity and uncertainty. Effective and efficient product development requires coordination and integration among various parties. In the past, such activities were mainly conducted offline. However, after the restrictions imposed by COVID-19, companies are experimenting with online use. We conducted case studies on how companies could effectively and efficiently manage product development in the hybrid era. The results suggest that companies can promote inter-organizational communication by further utilizing online, which leads to a reduction of development lead time and development cost, but on the other hand, there is still a sense of quality uncertainty.

Keywords: Product development management, COVID-19, Online or offline, Coordination and integration activities

JEL Classification: L60, M15

1. Introduction

The purpose of this study is to analyze and discuss what kind of product development management is effective and efficient for companies in the current (hybrid) era, where not only traditional face-to-face (offline) activities, but also remote (online) activities are used more and more.

In a society of increasing complexity and uncertainty, product development is becoming increasingly important. Product development occupies an extremely important position in

[1] Nagaoka University of Technology, Information and Management Systems Engineering, Japan, s203369@stn.nagaokaut.ac.jp
[2] Nagaoka University of Technology, Information and Management Systems Engineering, Japan, nsuzuki39@kjs.nagaokaut.ac.jp

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a company's business strategy, and the management of product development strongly influences the direction of the company [1]. Effective and efficient product development requires coordination and integration not only with the product development department, but also with the production department, sales department, suppliers, customers, and other parties. Such coordination and integration activities have traditionally been conducted offline, mainly through face-to-face meetings, training camps, and direct visits on business trips. At Canon, for example, when creating a prototype for a telescopic digital camera, the design, development, and planning departments worked together at a training camp where the existing camera was broken down into its smallest parts, such as lenses and sensors, and each department tried various combinations by trial and error, actually working with their hands like building blocks. Each department tried different combinations by trial and error.

However, due to the behavioral restrictions caused by the novel coronavirus (COVID-19) (hereinafter referred to as Covid), companies have taken measures such as restricting employees' attendance at work, and telework (remote work) and online conference systems have been widely introduced. According to a survey by the Cabinet Office [2], the national average telework adoption rate was 10.3% in December 2019, while it peaked at 32.3% in September-October 2021, and although it declined from there, it was 30.0% in March 2023, an increase compared to before Covid. A similar trend was also observed in a survey of telework adoption rates conducted by Toshihiro Okubo and NIRA [3] and the Ministry of Land, Infrastructure, Transport and Tourism [4]. The digital transformation is accelerating not only in large companies, but also in small and medium-sized companies [5], and the work environment in companies has changed significantly.

Amid such changes in the work environment, it can be inferred that product development activities have remained vigorous even after Covid, except for some industries that have not reduced their activities. According to a survey [6] by the Ministry of Education, Culture, Sports, Science and Technology on research activities in the private sector, respondents were asked whether they had narrowed down or initiated research topics and projects in response to major social and economic changes, including Covid and the Russian invasion of Ukraine. As a result, more than 70% of the firms replied that none of the above applied (or that they were undecided), indicating that a high percentage of firms maintained the scale of their R&D activities even in the face of social and economic changes.

Sasaki [7] analyzed the same survey data by industry and found that the automotive industry may have been affected by the rise in energy prices and may have implemented a change in priorities and selection of R&D projects. In the pharmaceutical manufacturing industry, the study speculated that the development of vaccines for Covid and other viruses and R&D related to therapeutic drugs were promoted, and external collaboration related to drug discovery became more active. On the other hand, Covid's impact on the machinery and equipment manufacturing industry was small, and it is believed that the changes in customer needs related to Covid were moderate and there was no need for them to change their

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strategies. On the other hand, a high percentage of the consumer-oriented industries (B to C) changed their R&D activities, suggesting a possible change in customer needs.

Thus, while the behavioral restrictions during Covid changed the way of working and communicating, and accelerated online activities, product development activities were generally maintained at the same level as before Covid. Even now that the government is no longer imposing behavioral restrictions and requests for voluntary restraint, some companies are maintaining some of their online activities and some are resuming face-to-face activities. Therefore, it is necessary to examine what kind of product development management is effective and efficient for companies in the current (hybrid) era, when not only traditional face-to-face (offline) activities but also remote (online) activities are increasingly used in product development.

The structure of this study is as follows. Chapter 2 discusses product development in this study and examines previous studies on the relationship between product development and information systems. It also discusses the difference between product development and goods such as industrial goods and consumer goods. Chapter 3 explains the research methodology and case selection, and Chapter 4 describes the results of the interview survey conducted with seven companies. Chapter 5 discusses the results of the case study conducted in Chapter 4. Finally, Chapter 5 discusses the conclusions and limitations of this study.

2. Previous Studies

2.1 Product Development

Clark and Fujimoto [1] showed that the key factor for superior performance in product development is for the product development manager to coordinate the various departments of the company, other companies, etc., to achieve both internal and external integration of product coherence to conduct effective and efficient product development. In addition, Fujimoto and Yasumoto [8] extended their analysis to industries other than automotive and pointed out that important factors such as the type of product development leader differ by industry and product. For example, products such as beer and apparel, which have highly ambiguous needs but are not structurally complex, do not require a strong leader, but do require the concept creation skills of designers and marketers. On the other hand, in the assembly and processing of mechanical products (such as automobiles), the role of the development leader is also important due to the complexity of the product, and external integration with the customer is also considered important.

Tsuru, Tokumaru, Fukuzawa, and Nakajima [9] focused their analysis on the relationship between product development activities and human management. According to Tsuru et al., more ways to obtain external information, a higher degree of integration within the organization, and better marketing and development may by themselves be unrelated to

product development outcomes or lower outcomes. However, we show that the inclusion of non-monetary incentives, such as job descriptions and evaluation of expertise, can improve development outcomes.

From the perspective of organizational capability, it has been suggested that process capability, i.e., communication and experience sharing among departments, functions as an important core capability for product development performance and that this has a strong relationship with the competitive advantage of Japanese firms [10].

In other words, coordination and integration activities and information sharing within and among departments are necessary for superior product development, and information systems are considered as one of the tools to facilitate such activities.

2.2 Product Development and Information Systems

The impact of online information systems and teleworking on product development is analyzed by Maekawa [11] based on a case study of the development of a digital multifunction device. She argues that the effect of introducing an information system for information sharing and coordination among projects depends on the product architecture of the subsystems that make up the product. If the product is an integral type, close communication among engineers between projects is emphasized, and the introduction of an information system was not successful. On the other hand, in the case of the modular type, the introduction of an information system was effective in reducing the burden on engineers to adjust specifications. Durmusoglu and Kawakami [12] found that the frequency of using information system tools was significantly related to task performance in each stage of discovery, development, and commercialization. They show that the frequency of use of information system tools has a significant impact on task proficiency in the discovery, development, and commercialization stages, suggesting that such proficiency is strongly related to product development performance.

Fukuzawa, Sugie, Park, and Shi [13] analyzed the use of information systems from a value chain perspective. They showed that both companies are actively working on the implementation of IoT and the construction of information systems, and that information systems make important contributions to improving company operations and management efficiency. Particularly noteworthy examples include process visualization, productivity improvement, and lead time reduction. It is also mentioned that the use of information systems is gradually shifting from partial optimization to total optimization.

Here we examine the impact of teleworking on product development, which was the focus of attention at the time of the action constraint: Coenen and Kok [14] studied the impact of telework on team performance in new product development projects for five projects of two telecommunication providers The results showed that telework can have a significant impact on the performance of teams within an organization. The results showed that

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teleworking has a positive impact on the performance of new product development in the organization. Telecommuting improves product quality during development by enabling the involvement of internal and external stakeholders with knowledge that is missing from the project. It also improves the speed and quality of the development process by bringing internal and external stakeholders closer together. However, this effect is only apparent when there is a balance between both types of contact (face-to-face and telework). The authors point out that the ideal combination of face-to-face and telework depends on the development process, as the need for face-to-face contact decreases as development progresses.

On the other hand, some papers suggest that telecommuting is detrimental to productivity; Kitagawa, Kuroda, Okudaira, and Owan [15] found that telecommuting was associated with lower productivity in the Japanese manufacturing industry during Covid. They suggest that contributing factors include inadequate access to critical information and specialized equipment due to inadequate remote work facility environments and poor communication with workplaces and customers.

Thus, it has been pointed out that studies differ on the impact of remote work on worker productivity [16], and there is room for debate on how to distinguish between online and offline use in product development coordination and integration activities.

2.3 Product Development and Goods

We focus on the possibility of online adoption for different goods, such as consumer goods and industrial goods. For consumer goods, it is important to accumulate the ability to analyze market research and data to know consumer preferences in terms of collecting demand information [17]. Therefore, in order to obtain more consumer preferences, consumer participatory product development using the Internet has become widespread.

According to Osaki [18], it is defined as an activity that involves a large number of consumers in a variety of product development processes to conduct high-density direct communication in an open, low-cost, and short time, and he points out that it is more effective than conventional product development in approaching consumer needs, improving product completion, developing original products, and improving information gathering. The report also points out that the following points are more effective than conventional product development: approaching consumer needs, improving product perfection, developing original products, and improving information gathering.

Furthermore, Nishi [19] showed that the recognition rate of consumer participation in new product development is high regardless of age due to the proliferation of the Internet and smart phones. In addition, the product categories in which consumers have participated in and purchased consumer-participatory new product development are concentrated in those that are familiar to consumers, such as food, clothing and clothing-related products, and

household and miscellaneous products. In addition, consumer participatory development is often conducted mainly through social networking services (SNS), but the number of occasions that triggered such efforts and purchases was as high in stores as in SNS, indicating that offline information dissemination is also important.

Thus, in the case of consumer goods, the customers are unspecified, and it is possible for the company developing the product to independently choose the tools to collect information. On the other hand, industrial goods depend on the ability to elicit latent demand from customers to seek functions and technologies that meet their clear objectives, and the ability to absorb demand information (contact with customers and observation of customers) is more important than information collection and analysis techniques [17]. In other words, since continuous relationships with customers are important for industrial goods, it is difficult for seller-side enterprises to independently change their coordination and integration methods online. In other words, in terms of customer information collection, industrial goods are considered to be more difficult to implement online than consumer goods, and depend on the method desired by the customer firm.

2.4 Focus of the Study Based on Previous Research

Previous studies have shown that product development management is important for product development managers to realize the integration of product coherence both internally and externally, and that online product development management can lead to improvements in quality and development speed. However, some conditions have been pointed out, such as product architecture, the need for a balance between face-to-face and online operations, and the suggestion that productivity may decrease if online facilities are inadequate. In addition, although the study of product development activities for consumer goods using online is underway, the study of coordination and integration activities using online for industrial goods, which require more integration by organizations than consumer goods, is still open to discussion. However, it is necessary to examine how to use offline and online in coordination and integration activities not only with product development departments, but also with internal departments, suppliers, and customers, and to consider the effectiveness and efficiency of such activities.

In this study, we focus on industrial goods, which are tangible goods that require integration by the organization, and ask two research questions: (1) How has product development been changed by behavioral constraints, and how has the use of offline and online been differentiated? (2) What type of product development has been shifted online and how have performance indicators such as lead time changed? (Figure 1)
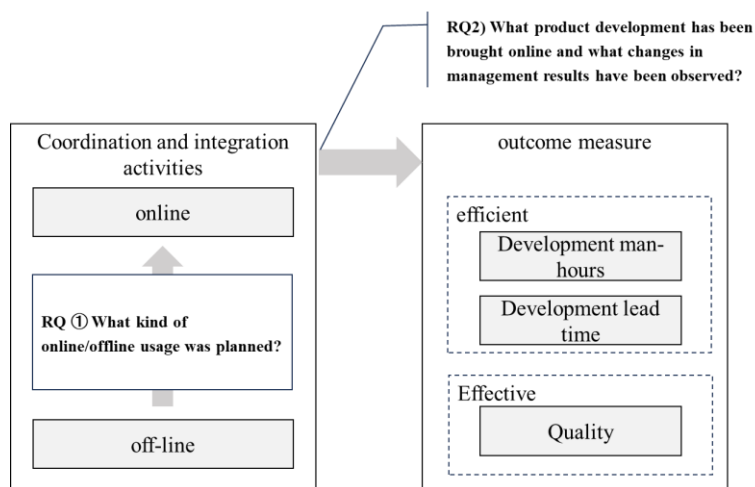
Figure 1. Analytical Framework of this Study

3. Research Methods

The research method used in this study is qualitative case study. Case studies are an effective method for identifying causal relationships in business behavior and an effective method for analyzing complex or novel events [20][21][22]. Yin [23] states that case studies are desirable as a research method when the question of how or why is presented, when the researcher has little control over the event, and when the focus is on current phenomena in a real context. Yin [23] states that case studies are desirable as a research method when the question of how or why is presented, when the researcher has little control over the event, and when the focus is on the current phenomenon in a real context. Therefore, we believe it is appropriate to use case studies to investigate how online applications are used in product development through the phenomenon Covid in this study.

In this study, from October 2021 to February 2023, we conducted a semi-structured interview survey with seven companies (Table 1), including five manufacturers of industrial goods and two retailers of consumer goods, which are considered easier to adopt online information collection than industrial goods based on previous research. We conducted semi-structured interviews with seven companies (Table 1).

Among the five industrial goods firms, we interviewed the automobile-related firms (Firms A and E), which Sasaki [7] mentioned as showing a change in R&D activities, and the production machinery and equipment manufacturing firms (Firms C and D), which were not shown to have changed significantly. To account for differences in capitalization, we also interviewed large firms and small and medium-sized firms (Firms B and D), and retailers (Firms F and G) were interviewed as end users (B to C) whose customer needs were said to have changed.

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In the case of company D and company F, the interviews were conducted in person by visiting the companies after having been informed in advance about the following questions. The other five companies were interviewed online using online meeting tools such as Zoom and Microsoft Teams (hereafter referred to as Teams).

Based on Maekawa [11] and other previous studies, we asked about changes in internal communication and interactions with external suppliers and customers before and after the Covid, as well as changes in remote working and product development methods. We also asked about the impact of these changes on overall product development, focusing on efficiency in terms of development person-hours and lead time, as well as the impact on quality. Finally, respondents were asked to rate the quality of product development before Covid and the quality of product development after Covid on a scale of -5 to +5, and to give reasons for their ratings.

Goods	Company name	Enterprise	Industry	Date	Interview Style	Position and number of interviewees
Industrial goods	A	EBU	Manufacturing (Automotive components)	2021/10/11	Online	Staff
	B	SMB	Manufacturing (Industrial machineries)	2021/10/21	Online	President
	C	EBU	Manufacturing (Machine tools)	2022/03/15	Online	Manager
	D	SMB	Manufacturing (Industrial machineries)	2023/02/08	Face-to-face	President and three members
	E	EBU	Manufacturing (Automotive components)	2023/02/17	Online	Three Section Chief
Consumer goods	F	EBU	Retail (Supermarket)	2021/10/14	Face-to-face	Two merchandisers
	G	EBU	Retail (Supermarket)	2022/04/16	Online	Manager

Table 1 Summary of Interview Survey

4. Results of the interview survey

4.1. Case Study of Company A

Company A is a large company that designs automobile parts. During Covid, the company set a target for the percentage of employees coming to work, and remote work was implemented. However, employees had to come to the office for meetings involving the actual products or for confidential work that could not be done outside the company. Since the remote work system was suddenly introduced with a rapid increase in the number of infected employees, there were problems with digitizing documents, securing the

communication environment, etc. The system is gradually improving, but many of the documents are difficult to digitize from the point of view of confidentiality.

There have been no major changes in the product development process itself.

Internal communication used to be mainly through morning meetings, conferences, e-mails, and conversations in the workplace, but with Covid, morning meetings and team meetings were changed in addition to e-mails. Because online meetings could not be held while actual parts and other items were being viewed together, there were differences in perception when the actual items were later confirmed. In addition, the frequency of communication decreased, making it difficult to understand each other's situation and to build and maintain trust among employees.

In the past, communication with external suppliers was mainly by phone, e-mail, and personal visits. However, during Covid , online communication was mainly by phone and e-mail, and in some cases, online meetings via teams were added. However, in unavoidable cases, such as when confirming and receiving the actual product, the company handled such cases offline, taking sufficient infection control measures.

Most of the communication with customers was done by visiting the parent company's department in the same building in person, and there was no change even after the Covid.

The performance rating for the work during Covid was -2. Although there was no change in the product development process itself, the quality of work decreased because paper documents had to be converted to electronic form through remote work, which was hastily introduced due to behavioral restrictions, and this was done in addition to the original development work. As a result, development was delayed in some areas.

4.2. Case Study of Company B

Company B is a small to medium sized company that designs, manufactures and sells automated labor saving machines for assembly, inspection, shipping and packaging. The company did not implement remote work because on-site manufacturing was required during the Action Constraint.

No major changes were observed in the product development process itself.

Internal communication was conducted through morning meetings and internal groupware developed by the company. In addition to regular meetings with the president and supervisors, smooth communication within the organization was promoted through internal recreational activities such as holiday parties and trips. However, the company felt a decrease in communication due to the voluntary suspension of internal recreational activities due to behavioral restrictions, so managers increased the frequency of workplace visits and made efforts to integrate opinions at the same level as before.

Communication with external suppliers has traditionally been conducted by telephone, e-mail, and direct visits if the supplier is in the neighborhood, and there were no major changes during Covid.

Covid did not cause any major changes in the company's communication with its external customers. In addition, Covid prompted the company to focus on digital marketing, create a dedicated website, and adopt a pull strategy rather than a push strategy by using online technical seminars and direct mailings.

The performance rating for the work during Covid was ±0. The reason for this is that although sales decreased, the profit margin increased. In particular, the introduction of online marketing was very effective.

4.3. Case Study of Company C

Company C is a large company that designs, manufactures and sells machine tools such as machining centers and electric discharge machines. About 70% of its sales are overseas, and the company routinely interacts with employees who live overseas. The company implemented remote work in all departments except the manufacturing site due to behavioral restrictions. The company provided headsets and other equipment necessary for remote work, and the team environment was in place before the conduct restrictions, so the transition went smoothly.

There were no major changes to the product development process itself. However, the internal and external meetings were changed, and the market had to be changed by the action restrictions, and the company was forced to change its plans for reduced sales and changes in the models to be developed.

Traditionally, internal communication had been conducted mainly through morning meetings, e-mails, face-to-face meetings, and telephone calls. During Covid, travel between sites, which used to take more than an hour each way, was eliminated and online meetings using Teams were used. Although the restrictions on activities were loosened, the general consensus was that Teams was sufficient, and the company was closer to improving the efficiency of its operations.

Communication with external suppliers had traditionally been done by phone, e-mail, or in-person visits, but with Covid, the company responded on a case-by-case basis, with some communication online and some in-person, depending on the policies of both the supplier and the company.

In the past, information from customers was collected by the sales and engineering departments and passed on to the development department, and information from customers to the service department for support was reflected in the development process. In the case

of Covid, the sales department is also focusing on online marketing, and online technical seminars are being held.

The work performance evaluation during Covid was rated +1. It was a slowdown due to market changes, but it was an opportunity to review our work. The company was able to correct some of the work that had been done as a matter of course, and this was rated as a positive factor.

4.4. Case Study of Company D

Company D is a small-to-medium-sized company that designs, manufactures, and sells industrial machinery such as deburring machines and dust collectors in the Koshinetsu region. Remote work was not performed due to the lack of an online work environment and facilities.

There were no major changes in the product development process itself. However, design changes and manuals were made to enable customers to install the products themselves, rather than having the company's personnel install a design change.

Internal communication has traditionally included morning meetings, conferences, phone calls, in-person visits, and chat tools. The chat tool is used only by several employees who have loaned PCs. Therefore, the use of chat tools is limited, and the main means of communication are phone calls and face-to-face visits. There is no particular change due to Covid. Rather, the president's policy is to actively hold offline in-house events to promote employee self-improvement through human connection, a measure to increase communication within the company.

Communication with external suppliers is mainly by fax, with some use of e-mail. There is no particular change due to Covid, and since there is no online point for suppliers to receive orders for parts, etc., the current method of communication using faxes is a reliable way to communicate with the suppliers.

In the past, communication with external customers was mainly through exhibitions and e-mails, and especially at exhibitions, products were proposed to customers to elicit their requests and lead to inquiries. Since some exhibitions were canceled due to Covid, online meetings (Zoom and Teams) are also being used by the customer's system environment. However, the company has the impression that it is difficult to understand the other party's response, and the percentage of use is about 10-20% of the total. In addition, in early 2023, the company put up more online marketing efforts by launching an Instagram page, strengthening its YouTube presence, and collaborating with craft YouTubers by providing them with materials. As a result, the number of inquiries has increased. In this way, the company kept in touch with customers and created regular opportunities from design, sales,

and manufacturing for employees to gather and discuss requests received at various locations, which are reflected in the products.

The workmanship evaluation during Covid was rated as +3. The reason for this is that the pandemic allowed the company to change its development concept to make the product easier for customers to install. Another reason for the positive evaluation is that the company reaffirmed the importance of communication and created opportunities for interaction within the company, which helped employees improve their skills by gaining insights from their relationships with other people.

4.5. Case Study of Company E

Company E is a large company that designs, manufactures, and sells automobile wiring harnesses and other automobile-related parts. About 70% of its sales come from overseas, and some of its products are manufactured in overseas plants, so the company routinely interacts with employees who live overseas. Due to behavioral constraints, remote working was implemented. Headsets and intercoms were provided by the company, and VPN (virtual private network) access was arranged. In addition, staggered work hours and flexible work schedules were introduced. Even after the restrictions on activities were relaxed, about 20 to 30 percent of employees still work remotely, while the remaining 70 to 80 percent come to work.

The product development process itself remained unchanged, but the increase in online meetings and the reduction in time spent traveling allowed the company to make better use of that time, resulting in cost savings.

Traditionally, internal communications have included morning meetings, e-mail, phone, face-to-face visits, Skype and, in some cases, chat tools. In my opinion, web-based meeting tools such as Teams and chat tools have become widely used and established. As a result, younger employees in particular are more likely to attend meetings. As a result, younger employees find it easier to ask questions that were difficult to ask via e-mail, and chat has made communication easier. However, the older generation tends to value phone calls over chat, and there are some differences between age groups. In addition, business trips to overseas factories have been reduced, and information can now be shared via webcams and images, reducing business travel costs to almost zero. As a result, the approval required from supervisors to take business trips has become more stringent, and even when behavioral restrictions were relaxed, opportunities to visit the sites were extremely limited. As a result, some employees have never been to the production site, and when dealing with complicated problems, those who know the site can easily imagine what is happening, even through a web camera that shows only a part of the site, but those who have never been there feel that it takes time to grasp the situation, and although this has not yet surfaced,

They concerned that there may be some impact in the future, although it has not yet surfaced.

In the past, communication with external suppliers involved exchanging parts and data by phone, e-mail, and in-person visits. In the case of Covid, the quality of parts cannot be trusted without seeing the actual product and confirming the process, so the company visits the site in person.

In the past, communication with external customers was mainly through face-to-face meetings, such as winning projects through contests, dinner meetings, and in-person kick-off meetings. However, during Covid, face-to-face meetings are rare, and since customers sometimes work remotely, online meetings have inevitably increased. In addition, where once prototypes created by 3D printers were brought together to update designs, now 3D models are created and designs are updated via virtual reality (VR). This has made it easier to share data than when prototypes were created and brought together, and has led to increased efficiency, such as shorter development time. In addition, as a total supplier that handles planning and development, the system has played a role in improving the ability to make technical proposals to customers and is expected to make it easier to understand customer requirements and improve the final quality of the product. On the other hand, there are cases where the completeness of the 3D data is low and it is impossible to know until a prototype is made.

The performance rating during Covid was +3. Although the finished products developed during Covid have not yet been released to the market, the company believes that the reduction in business travel due to the establishment of online meetings has improved efficiency in terms of both money and time, and that the time spent on product development will lead to improved product quality. Therefore, the Company will continue to implement IT to improve efficiency. On the other hand, online meetings have reduced the ability to communicate with customers because of the minimum number of comments required, making it difficult to reflect the intent of customer requests in proposals. Although this has not affected the company, it cannot shake off its concerns.

4.6. Case Study of Company F

Company F is a large company that operates a general supermarket business and develops its private label (PL) products. In the department responsible for developing PL products, employees worked remotely one or two days a week, and some employees worked remotely three days a week in April 2020, when there were behavioral restrictions.

There were no major changes to the product development process itself. However, the development lead time for a product sample that was to be outsourced for production overseas had to be extended due to a temporary logistics disruption caused by the behavioral restrictions.

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Internal communications had traditionally been conducted through morning meetings, emails, phone calls, and in-office conversations. During Covid, in addition to the traditional methods, a chat tool (LINEWORKS) has been used since October 2020, with accounts distributed to all headquarters personnel, but the use of the tool is limited to communication within departments because it is not fully mastered.

Communication with external suppliers has traditionally been done by phone, e-mail or personal visits. During Covid, the company mainly uses Zoom, an online meeting tool. In the case of overseas manufacturers, WeChat is also used. We feel that online communication is sufficient for confirming processes, etc., and we have declined requests from suppliers to visit their factories in person. In the future, the company intends to use remote visits as well, taking into account what can be learned by visiting factories in person (factory atmosphere, greetings, employee movements, lineup of shoes, etc.) to achieve effective development.

For external customers, the department in charge has conventionally collected and shared the opinions of customers in stores and through an inquiry form on the Internet. During Covid, in addition to the conventional method, a smartphone application is being used to conduct product questionnaires to absorb customer requests. In addition, we feel that the awareness of customers themselves has changed, and the lack of information such as word-of-mouth due to behavioral restrictions has led to an increase in the number of customers researching and inquiring about products themselves.

The performance rating during Covid was rated ±0. Both negative and positive aspects were cited as reasons for this. On the negative side, they felt that the behavioral constraints resulted in insufficient listening to the market and manufacturing sites and insufficient refinement of the product. On the positive side, they were able to cope with the introduction of new online tools that improved efficiency in terms of time and cost. In addition, they have realized that by going online they can reduce unnecessary communication, and they plan to use both online and offline tools to improve the quality of their work in the future.

4.7. Case Study of Company G

Company G is a large company that operates a general supermarket business and offers its private label (PL) products. Remote working is practiced only by some employees working in the head office, which is about 2% of the total workforce. Head office employees are loaned laptops and smartphones to enable them to work remotely. In addition, a booth for Zoom business meetings has been set up in the company, and headsets and speakers are available.

The product development process itself has not changed, but the method of selecting manufacturers to outsource manufacturing has. In the past, the company selected the best products from manufacturers across Japan. However, due to the company's policy of not making business trips to Japan, the company has shifted to a policy of calling on

manufacturers and wholesalers in the prefecture where the company is located to find a suitable manufacturer from a possible range of products.

Internal communication has traditionally been conducted mainly through departmental meetings, telephone calls, and internal e-mail. During Covid, a chat tool (LINEWORKS) was introduced in July 2021 in addition to the conventional methods in anticipation of simultaneous checks of stores in the event of emergencies such as earthquakes and disasters.

Communication with suppliers outside the company has traditionally been conducted by telephone, e-mail, and direct visits. Business meetings are mainly conducted by personal visits, while other changes in specifications and quotations are conducted by e-mail to keep an electronic record. Regarding the behavioral constraints during Covid, manufacturers in the prefecture follow the conventional method, and some distant companies conduct online business negotiations using Zoom. The manufacturers outside the prefecture had sent us samples of their products in advance, and we had conducted business meetings with them via Zoom. However, it was difficult to convey the manufacturers' enthusiasm, and none of the products were marketed. Now that the restrictions on activities have been eased, manufacturers from outside the prefecture are allowed to visit in person, but if the content of the visit is little more than a greeting that can be completed online, the visit can be conducted online.

In the past, communication with external customers was based on a system in which customer requests and complaints were communicated to the relevant departments through stores, customer service offices, and e-mail forms. Information is shared internally and with suppliers, and root cause analysis and response documents are prepared. However, customer requests are rarely received, and even when they are, they are difficult to implement and are not reflected. However, the company does receive many useful requests from store employees, which are collected during store visits and used to improve products and create new products in the future. There was no change even after Covid.

The performance rating during Covid was +3. The reason for this is that the time spent on information gathering and competitions was spread over several areas, but the time spent on a single product was increased by taking advantage of the action restrictions to focus on manufacturers in the prefecture, and good product development was achieved. As a result, they were able to promote locally produced products to their customers, which led to an increase in sales.

4.8. Sub-summary

Table 2 summarizes each case study from the interview survey. A comparison of the cases shows that the circumstances of each company's use of online communication were varied.

First, we could not identify any case in which the entire product development process itself was significantly changed by the behavioral constraints due to Covid. On the other hand, online communication in the product development process with both internal and external parties varied from company to company, but it is suggested that online communication is used to supplement or replace traditional offline communication.

In terms of internal communication, groupware and online meetings have been introduced in addition to traditional face-to-face (offline) activities, especially in large companies, and are gradually becoming established. This has reduced procedures such as reserving and coordinating meeting locations and travel time, and has led to improved efficiency in terms of man-hours and lead time by facilitating the timely exchange of information. On the other hand, this trend has not been observed in small and medium sized companies, which, although they have eliminated farewell and retirement parties due to behavioral restrictions, continue to emphasize offline communication as in the past.

Next, looking at changes in interactions with external suppliers, in addition to traditional methods, there is a change in some companies to promote online use, mainly through online meetings. One company (Company F) commented that the use of online enabled them to avoid excessive face-to-face sales activities from suppliers and to secure more time for development. On the other hand, there were a few companies that did not actively use online communication with their suppliers. Company D said that their suppliers did not have an environment for online communication in the first place and that fax was the best way to communicate with them. Company G uses both online and offline communication depending on whether they are in or out of the prefecture, but they have not been able to conclude business negotiations using online communication because their enthusiasm for the product is not conveyed to customers.

In addition, when we looked at the changes in external customer interactions, we found that in addition to traditional interactions, many companies are actively conducting online marketing, especially promotions on YouTube and webinars, to capture customer needs and gather information. In addition, Company E is also updating designs and making technical proposals with 3D data using VR, and some said that sharing data and changing models is easier and more efficient with digital data than in meetings where prototypes are brought, and quality improvement can also be expected. It is also worth noting that SMEs that had previously focused on offline activities are now putting more effort into online sales activities.

Case	Change within the company	Change with suppliers	Change with customers	Outcome

A	**Yes** ▸For online meetings	**Yes** ▸Some meetings are online	No	Failure to respond to remotes causes delays in development.
B	No ▸Decrease in communication volume	No ▸Same as before	**Yes** ▸Use of online marketing	Decrease in sales, increase in profit margin (impact of online marketing)
C	**Yes** ▸Meetings are more efficient	**Yes** ▸In principle, online meetings	**Yes** ▸Use of online marketing	Market changes, development changes. Work has become more efficient.
D	No ▸ Emphasis on face-to-face communication	No ▸Still using mainly fax machines.	**Yes** ▸Online meetings, YouTube communication	Review the development concept, strengthen self-improvement (person to person).
E	**Yes** ▸ Conversation is shifted to chat rooms.	No ▸No progress in online development, because the process cannot be trusted without seeing the process.	**Yes** ▸Proposal and design brush-up through online (VR)	Efficiency in terms of money and time. They were worried that a reduction in the amount of communication could affect quality.
F	**Yes** ▸Implementation of groupware	**Yes** ▸Online meetings are used in principle.	**Yes** ▸Implementation of apps for product surveys	Efficiency is improved in terms of time and travel costs. On the other hand, we are concerned that the products are not sufficiently polished.
G	**Yes** ▸Introduction of groupware ▸Usage ratio is limited.	No change within the prefecture Outside prefecture: online meetings (*No successful business	No ▸Gather information from store employees, etc.	By limiting transactions to local companies, sales increase as a result. Increase in time spent per product.

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		meetings) Factory inspections required		

Table 2 Results of the interview survey

5. Consideration

The results of the interview survey indicate that the use of online and offline tools varies depending on capital, industry, and other factors. With regard to internal coordination and integration activities, groupware and online meetings have been introduced and are becoming established alongside traditional face-to-face (offline) activities, especially in large companies. This has reduced procedures such as reserving and coordinating meeting locations and travel time, and improved efficiency in terms of man-hours and lead time by facilitating timely information sharing. On the other hand, SMEs are not actively using online for internal coordination and integration activities, and although they have canceled farewell parties and other events due to behavioral constraints, they still emphasize offline communication as before. This may be because the extent of internal coordination differs between large and small firms. In large companies, it is not uncommon for coordination activities to take place across multiple locations. In SMEs, however, not only development but also sales and production functions may be located at a single site, and direct visits can be made immediately. From this point of view, we believe that large firms have actively implemented online systems internally, while small and medium-sized firms have been reluctant to do so.

Next, focusing on changes in interactions with external suppliers, in addition to traditional methods, there is a change in the promotion of online utilization, mainly through online meetings in some cases. Online use enabled companies to avoid excessive face-to-face sales activities from suppliers, which led to more time for development. On the other hand, there were a few companies that did not actively use online for reasons of process confirmation and the online environment of their suppliers. This may be due to the regional characteristics of the suppliers. For example, we found a difference in the response of Company F and Company G in the same industry (consumer goods) in terms of communication with suppliers. Company F has a track record of doing business with overseas manufacturers, but it is difficult for them to visit overseas in person when their activities are restricted, so they had no choice but to use online communication. On the other hand, Company G concentrated its business partners not in urban areas but in the vicinity of its business bases, and this limited the scope of business that could be conducted by direct visits, which may have made the company reluctant to use online.

In addition, when we look at changes in interactions with external customers, many companies are actively engaging in online marketing, such as promotions on YouTube and

web seminars, in addition to traditional interactions to identify customer needs and gather information. The fact that small and medium enterprises in particular are focusing on online sales activities suggests that they are trying to increase the number of touch points with many users to expand new sales channels to compensate for the decline in sales due to behavioral restrictions.

In light of the above, the following two research questions can be answered: 1) How has product development changed under behavioral restrictions, and how has offline/online usage differentiated? Coordination and integration activities are not the same as behavioral activities. However, the proportion of online coordination and integration activities has increased due to the behavioral constraint, suggesting that hybrid activities are performed in combination with offline activities (Figure 2). In particular, coordination activities with distant internal and external offices such as overseas, coordination activities among three or more internal and external offices, and information gathering and sharing between the company and many customers and sales representatives may be shifting from offline to online.
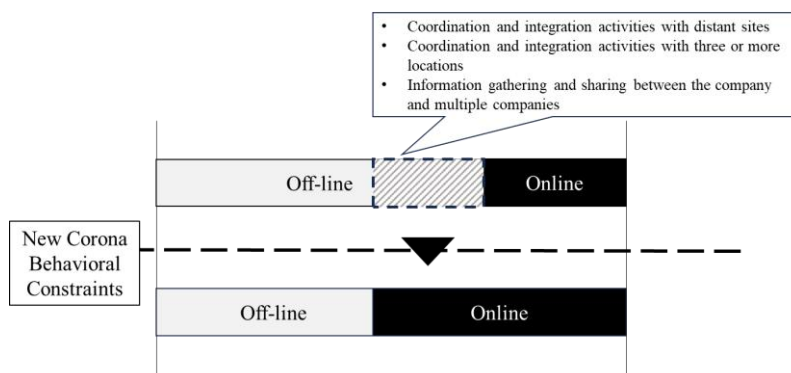

Figure 2 .Product Development Management in the Hybrid Era
(online/offline ratio of coordination and integration activities before and after-action constraints)

As for the other question of what types of product development projects have moved online and changes in performance indicators such as lead time, it is suggested that the elimination of costs associated with business travel and transportation as a result of online coordination activities, information sharing, and information collection at distant internal and external sites and multiple internal and external sites has resulted in shorter development costs and lead times and more efficient product development projects. This suggests that development costs and lead times have been reduced and product development projects have been conducted more efficiently. On the other hand, we believe that the effects of going online are limited in terms of quality and human resource development. There is a sense of uncertainty in product development due to a decrease in communication and an increase in the number of designers who are unfamiliar with the

site and the local environment, which may lead to a lack of understanding of the situation and inadequate guidance (Figure 3).
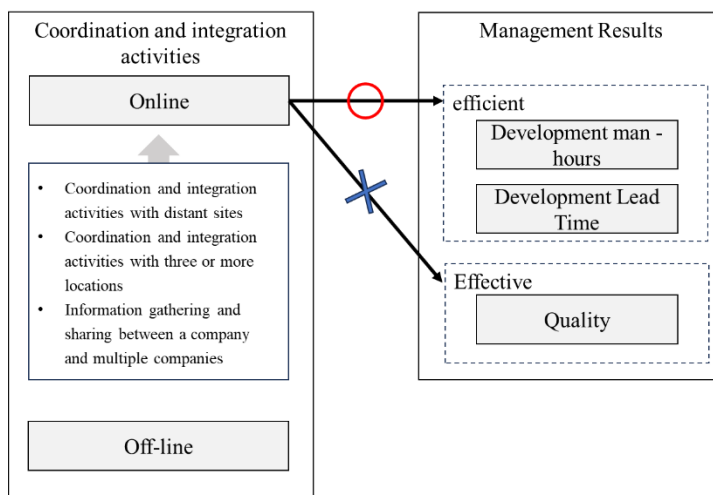

Figure 3. Product Development Management in the Hybrid Era
(Relationship between online development and management results)

Comparing these findings with previous studies, Coenen and Kok [14] found that teleworking or going online improves the speed of the development process, which is consistent with the need for a balance between both types of contact, face-to-face and online. However, the point that quality is also improved shows a different perspective from previous studies, where there are issues in terms of product creation and human resource development.

Kitagawa et al [15] found a relationship between remote work and lower productivity in the Japanese manufacturing industry, pointing to inadequate facilities as a factor. In this study, the ability to move online may differ depending on the extent to which the environment for online use is constructed within the firm, and it was shown that firms that were able to respond online even with behavioral constraints were partially using chat tools and other tools even before the behavioral constraints, reinforcing the point that firms need experience with information systems, i.e., organizational capacity.

It was also suggested that even in machine tools (Company C) and auto parts (Company E), which are considered integral types, the coordination and integration activities, including information systems, may have been made more efficient by the online implementation of information systems. This is somewhat different from the view of Maekawa [11] in her previous study that the coordination process between projects would not have been successful in implementing an information system if the product architecture was an integral type. Even if the product to be developed is an integral type, it suggests a new possibility to realize online coordination and integration activities with the

same or even better reality than face-to-face (offline) activities, such as remote conferencing and VR, to improve efficiency.

Based on the above, it is concluded that online coordination and integration activities contribute to the efficiency of product development, but are not necessarily effective. In other words, the online system is promoted in that it facilitates the collection of information from customers and the sharing of information within the company, thus facilitating efficient product development. On the other hand, from the point of view of human resource development, it is necessary to carefully consider not replacing all coordination and integration activities with online ones, but supplementing them with offline ones, because of the sense of insecurity about quality caused by checking processes through cameras, the increase in developers who do not know suppliers and production sites, and the difficulty of incorporating information obtained by visiting sites in product design. Therefore, it is necessary to carefully consider the possibility of complementing coordination and integration activities with offline activities, rather than replacing them all with online activities.

6. Conclusions

This study analyzes and discusses what kind of product development management is effective and efficient for companies in the current hybrid era, where not only traditional face-to-face (offline) activities but also online activities are increasingly used. The results suggest that in the hybrid era, companies can promote inter-organizational communication by further utilizing online, which leads to a reduction in development lead time and development cost. On the other hand, the results suggest that there are some issues regarding the effects of online utilization on quality, such as a lingering sense of insecurity about the creation process. Another contribution of this study is that it suggests the possibility of improving efficiency by using online communication tools together with offline activities, even if the product architecture is an integral type.

We present three issues that need to be addressed in this study. First, it is unclear how the use of online tools for coordination and integration activities is related to quality. The interviews suggest that there is a sense of uncertainty about the product and concern about engineers who do not know the local area, but it is not shown how these factors affect quality.

Second, the paper does not indicate how the online nature of coordination and integration activities affects coordination with individual departments, such as production and sales. Further research is needed to determine how interdepartmental coordination, which is changed by the online system, affects product development, since the ease and degree of use of online tools in coordinating with each department may differ if the information to be coordinated differs from department to department.

Third, there is a lack of quantitative analysis. In this study, we have shown the current situation in which product development coordination and integration activities change from offline to online and affect management outcomes. However, we were not able to show a quantitative relationship between the ratio of their use and management outcomes. We believe that these issues require further research in the future.

Acknowledgments

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