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A Research Framework for Sustainable Digital Innovation: Case Studies of Japanese Firms

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Abstract: Today's competitive and highly volatile environment calls for a new kind of flexibility and adaptability. Limited studies are available that examine how firms achieve both speed and creativity requirements in this digital era. In view of the rare empirical studies on real-world cases that apply rigorous research methods for sustainable digital innovation (SDI), this research investigates the key strategic requirements of organizational agility and flexibility for SDI. The research framework defines four types of innovators. This study used the benchmark tool to assess the status of their innovation effectiveness. This research framework is useful for firms to classify, assess, and evaluate their innovation type. The study's findings also suggest the road map for future strategic goals. This theoretical framework illustrates the causal relationship between Japanese-style digital innovation and the firms' sustainable competitive advantage. This model might be extended to other firms in different contexts (e.g., Korea, India, USA, Brazil, and a host of other countries). The theoretical and practical implications are discussed for future research.

Keywords: sustainable digital innovation (SDI); case studies; Japanese firms; agility; flexibility

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1. Introduction

Today's competitive and highly volatile environment calls for a new kind of flexibility and adaptability. Global firms seek sustainable innovation and sustainable digital innovation (SDI), which require standardization, efficiency, and scale simultaneously to deliver against margin and profit expectations [1,2]. Top executives search for guidance on how to meet these complex and conflicting requirements simultaneously. They recognize that an innovative business model involves global value chain networks for sustainable innovation outcomes [3]. In the digital technology era, such a value-driven business model needs a careful examination of the digital transformation (DX) processes [4–12]. Digital innovation is not a specific feature of the traditional software organizations anymore. Rather, it extends to the digital sectors, including GAFA (Google, Amazon, Facebook (Meta), and Apple) [6,13,14]. However, it is elusive to address the role of digital technology along with big data analytics capability with greater organizational capability (e.g., organizational ambidexterity). There is a serious call for more empirical studies on real-world cases that apply rigorous research methods for SDI [4,14–17].

In general, digital innovation requires a new business model that involves significant IT-enabled changes. There are two types of digital innovation. One is the regular digital innovation that impacts multiple dimensions (e.g., cost, delivery, technology use, and customer value). However, sustainable digital innovation requires not only the environmental and social factors but also long-term business viability [2,14]. Thus, in this paper, we define sustainable digital innovation as a long-term organizational change process to achieve the firm's longevity needs and the livelihood of its ecosystem. Naturally, sustainable digital innovation contributes to creating value for the societal and the business goals through internal and supply chain network processes [14].

This research investigates the key strategic requirements of organizational agility and flexibility for SDI. Most companies focus on either the agility or the flexibility dimensions, but few firms are excellent in managing both dimensions [18–20]. Few firms are noted for their strong capabilities for achieving responsiveness and adaptability [21,22]. To counter intense global competition, the synergistic organizational capability meets both closed and open innovation requirements. In the subsequent section, the literature review explains the research context and the research need. A conceptual framework defines four types of innovators. After describing the case research process, the case study results and findings are presented. The theoretical and practical implications are discussed for future research.

2. Supply Chain Integration for Sustainable Digital Innovation

Supply chain integration (SCI) is built on both cross-functional collaboration and external network coordination. In the digital era, the scope of collaboration further expands to the digital ecosystem beyond the digital supply chain network.

2.1. Manufacturer–Supplier Integration

In the turbulent competitive climate, no firm may survive with its own capabilities alone [23]. If the market demand remains fixed, OEMs and suppliers strive to obtain their rightful share of the limited market, which could result in a zero-sum game, with some winners and many losers [24,25]. In contrast, the innovative environments with rising technology frontiers may expand greater market opportunities, which invite more firms to pursue win–win solutions, not a zero-sum game [26,27]. Firms—both OEMs and small suppliers—compete and collaborate to increase their chances of survival and growth. Increasingly, more open network collaboration between manufacturers and suppliers in the digital ecosystem involves managing tensions and contradictions for sustainable resource dependence, supply chain risk management, and value chain resilience [11,28–33].

2.2. Customer Integration

Supply chain integration aims to meet the immediate and end-customer requirements [34]. The increasing complexity of customer requirements motivates firms to collaborate differently with their customers through a more interactive and integrated supply chain process [35,36]. As a practical way of customer integration, firms implement customer relationship management by sensing and responding to customer buying behaviour patterns and changing expectations [37,38]. Such success includes the processes that balance both perspectives to develop, deploy, and manage the appropriate strategies for meeting customer expectations. Thus, the development of sustainable competitive advantage is the result of how effectively firms respond with their value propositions to dynamic customer needs [39,40].

2.3. Integrated Manufacturing Information System

In the age of the digital era, firms use various IT system measures and product architecture strategies, and organizational capabilities [41–43]. For global supply chain integration, a variety of digital technologies, such as IoT, blockchain, and AI are necessary [44]. An integrated manufacturing information system (IMIS) responds to both the known existing needs and the hidden/emerging needs (new customer requirements) through the strategic planning of design information [42,43,45]. It also identifies the key processes in terms of: (1) frontend development deriving product concept; (2) product planning integrating customer needs—expressed or unspoken—and design information; (3) product design visualizing design information; (4) procurement and manufacturing transferring design information through media choices; (5) sales and marketing engaging customers by design information; and (6) maintenance activities managing design information as process routes.

2.4. Closed and Open Innovation for Two Aspects of Supply Chain Integration

For supply chain integration (SCI), global firms consider both internal and external supply chain integration. An ambidextrous innovation strategy has two aspects of supply chain integration [46]. In an environment of intense global competition, closed innovation is necessary because a company's strong technological and management resources need protection [43]. On the other hand, open innovation promotes external collaboration using widely available supplier–customer networks and ecosystem capabilities [47–50]. Among Japanese firms, Komatsu adopts an open innovation in new technologies such as Komtrax and AI [51]. Komatsu's core technology is said to be a combination of engines, hydraulic equipment and cabs, material technologies, and production bases. Meanwhile, new AI, IoT, and other DX technologies are applied to create and deliver customer value, involving start-up companies around the world.

2.5. Sustainable Digital Innovation through Ambidextrous Supply Chain Integration

The turbulent and highly competitive business environment highlights the need for global firms to manage beyond the organization's boundaries. Thus, global firms try to find and improve their capabilities in order to integrate their supply chains. SCI, such as supplier and customer integration, and internal SCI can become the key enablers to developing sustainable competitive advantages. Firms no longer approach their product flows in terms of their own product brand. Rather, they look more deeply into examining all the supply chain partners and moving forward to the demand chain in the global markets, including the emerging markets. Such changing market realities require building network capabilities that respond to the diverse customer demands from the global market [43]. In the turbulent and highly competitive business environment, sustainable digital innovation through ambidextrous supply chain integration is crucial.

As a presentative example, Fujifilm realized the product substitutability of exploratory products and existing core products and built the cannibalistic and complementary types of ambidextrous organizations in the era of DX. Though Scuotto et al. (2019) introduced a new perspective on ambidextrous innovation orientation, looking at how the current digital transformation is accepted in the fashion industry in Italy, they did not analyze big firms [46]. Thus, in this paper, we analyze the sustainable digital innovation practices of Japanese big firms.

3. A Research Framework

In an environment of intense competition and cooperation on a global scale, a closed strategy is also important, one in which a company's strong management resources (such as technology competencies) become its core competence. Meanwhile, an open strategy is also needed, one which uses external resources to respond to the rapidly changing environment. Both the closed and the open network strategies have their own strengths. Hence, a successful DX innovation requires balancing both closed and open strategies.

Figure 1 shows a conceptual framework with two axes of DX. The horizontal axis is about the innovation approach (i.e., operational efficiency and market value) towards creating existing and new market values. The vertical axis is about the collaboration scope (internal cross-functional collaboration and open network collaboration). This 2 × 2 typology provides four types of innovators.

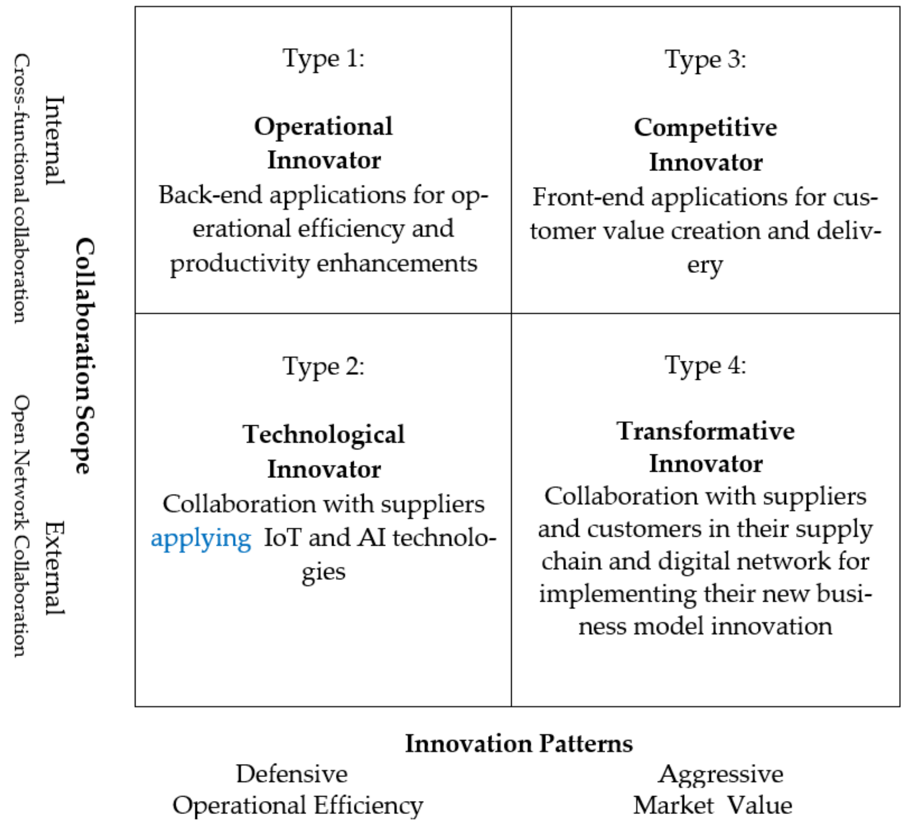

Figure 1. A Research Framework: Four types of Sustainable Innovation.

The operational innovator (Type 1) is characterized by back-end applications of operational efficiency and productivity enhancement through focusing on internal cross-functional collaboration and a defensive innovation approach. The technological innovator (Type 2) has a broad scope of collaboration through open network collaboration with suppliers while applying various available technologies, such as IoT, blockchain, and AI. The competitive innovators (Type 3) are noted for their front-end applications (R & D, marketing, and strategy) of customer value creation and delivery with their aggressive pursuit of customer market value. The transformative innovators (Type 4) are distinct in that their suppliers and customers are also involved in their open digital network for the business model innovation

4. Research Methodology

4.1. Case Study Process

In this paper, we adopt the deductive, qualitative, and exploratory research of the case studies [52]. Figure 2 shows the case study process in terms of (1) the planning process and (2) the implementation outcomes. The planning process has three steps (i.e., a literature review, the case study selection criteria, and the final selection), whereas the implementation outcomes include a research framework, digital innovation forums, and case interview details. They are summarized in Figure 2, Tables 1 and 2.

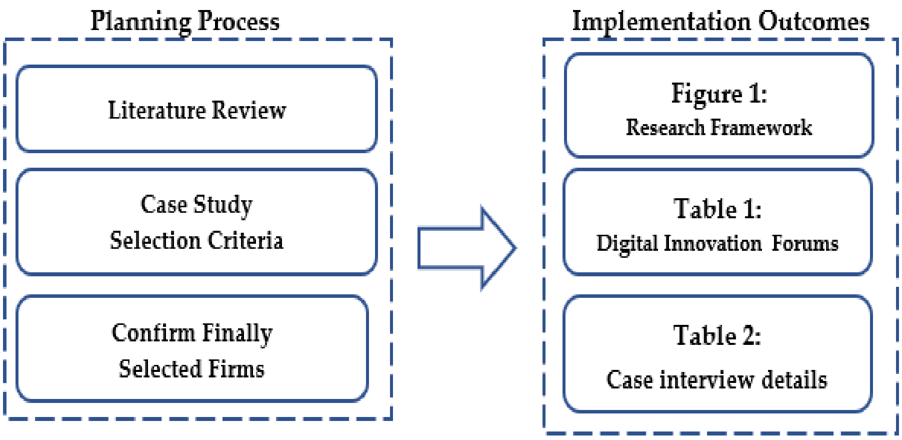

Figure 2. Case Study Process.

Table 1. Characteristics of Regular Digital Innovation Forums.

Organizers	2020–2021	Outcomes
• Team of researchers at the University of Tokyo • Participating researchers from Saitama University and network researchers from other universities • Because of COVID-19, all the meetings are virtual meetings and video-recorded.	• Total of six universities (7 faculty members) • 26 large Japanese firms (CEOs, senior managers) who plan and value digital innovation practices • Monthly two-hour meeting • Theoretical presentation by academic researchers • Practical case presentations (two+ firms per month presentation of specific projects and follow-up discussion, feedback, and comments)	• Each month, lecture and case presentation materials are documented and recorded. • The research team and students summarize the lessons and findings. • Final check by the senior research team • Receive feedback from the participating forum members. • Finalize the documentation of each month's report materials.

Table 2. Summary of 4 Case Studies.

Type	Type 1	Type 2	Type 3	Type 4
DX Project Presentation Firms	7 Firms (Kagaku, FJ, OH, SM, LX, MP, YH)	1 Firm (Automo)	2 Firms (Semito, BN)	2 Firms (Kosmi, OT)
Percentage	58%	8%	17%	17%
Selected Firm	Kagaku	Automo	Semito	Kosmi
Category	Chemical Device	Battery Device	Vacuum Device	Cosmetics
Firm Description	Chemical materials, medical devices, and camera	Automotive parts and electronic components Battery device firm	Automation-related products	Japanese cosmetics
Project leader	Director of DX innovation	Director of IT system	Director of Engineering Design	Director of R&D Center

4.2. Organization of Research Projects: A Team of Researchers and Senior Managers from 26 Firms

From 2020–2021, the team of researchers from the University of Tokyo, Saitama University, and other affiliated researchers organized a multiple-year innovation workshop in which 26 Japanese manufacturing executives (including one game software development firm) participated. The participants represented the major Japanese manufacturing firms (e.g., automotive, chemical, electronic, and component parts). Regular monthly meetings usually lasted two hours. Academic researchers were responsible for planning and organizing the meetings. They presented changing global innovation dynamics, discussed the current competitive business issues, and monitored the innovation projects with the participating senior managers. In each meeting, several presenters were scheduled to share the progress details of their specific innovation projects and receive feedback from other participating managers and academic researchers. These ongoing research workshops resulted in a series of working papers. Table 1 summarizes the overall organization of the research endeavors.

4.3. Profiles of Four Firms

For the purpose of this research paper, 4 manufacturing firms among 26 firms were selected as case firms based on the following considerations: (1) these participating firms were distinct in terms of economies of scale, high brand recognition, and advanced manufacturing systems. (2) They represented each type of our research framework (Figure 1) and had been implementing DX innovation projects. Twelve firms among the twenty-six firms presented their DX projects. Seven firms are classified as Type 1 (58%). Only one firm (Automo) is Type 2 and Semito and BN, a game software developing firm, are classified as Type 3. Two firms (Kosmi and OT) are included as Type 4. Table 2 is a summary of the case studies.

The research team also conducted additional follow-up, multiple, semi-structured interviews with the participating senior managers. Table 2 summarizes the actual profiles of these four companies. For the proprietary nature, the actual names of these firms are not disclosed, and all the names of the firms are changed.

5. Case Analysis and Findings

5.1. Kagaku

Kagaku is a chemical manufacturing company. Its core competence is in developing and manufacturing automotive component parts. The two projects of Kagaku are the following. (1) The first one is to improve quality outcomes and increase customer satisfaction. Since 2016, the long-term project goals have been stated as, “rapid improvement of quality, process rationalization, and customer satisfaction”. Specifically, big data analysis is performed by combining the process data (accumulation of the process data) collected from the production management systems of manufacturing lines and other support systems (ERP, MES, etc.). The digital project team system is applied to the production technology sector and the field manufacturing process sector. The stated project goals reflect the growing customer quality issues and the shortening product lifecycle imperatives. Additionally, at the work-floor level, there was an increasing frequency of process problems (e.g., work stoppage) daily. For the correct assessment and timely resolution of recurring floor-level issues, it is critical for supervisors to troubleshoot and respond with technical and leadership skills. By using the real-time process data and field-level quality reports (e.g., inspection results), the supervisors determine a causal relationship (e.g., asking “why did it happen?”). In addition, by utilizing AI-based predictive analytics (e.g., key process parameters of the defective products), the system generates the fast feedback to customers. As a result, customer satisfaction improved. In addition, as the causal relationship (e.g., “why did it happen”?) was clarified, the early detection of defective products (quality issue) improved the inspection-passing ratio (e.g., good products) and the reduction in the waste of raw materials.

(2) The second project is the development of an experimental database and AI analytics. This project goal was initiated in 2018. It is an experimental field mechanism formed by generating real-time Excel data. The field-test results are converted into the database. In addition, it involved the utilization of statistical analysis and experimental design processes. Using these experimental data mechanisms, it was building AI-based data analytics for the interpretation of the process results and the prediction of key performance indicators. At

the start of the second project, the skilled people were selected and deployed in the project planning and the experimental designs. In addition, better cross-functional communication and cooperation routines were established. Furthermore, AI-enabled molecular simulations allowed the real-time search of process issues, the early definition of optimal size, and the selection of the right materials out of hundreds of thousands of candidates.

5.2. Automo

Automo is promoting DX innovation in the energy business (e.g., batteries). The project goals of the activity, such as "work efficiency improvement" and "quality improvement", are put forward. Other specified goals are "labor cost saving", "procurement material management", and "quality stabilization". The business scope of Automo includes home appliances (refrigerators, washing machines, vacuum cleaners, etc.), electronic products (TVs, etc.), and B2B (automobile parts, etc.). Among them, this project is an example of an energy business that develops and manufactures different types of batteries (e.g., storage and vehicle installation batteries). The project leader is responsible for the utilization and visualization of the data gathered on the factory floors and in the administrative offices. In production plants, quality problems arise. The project focus is on the cases of "improving yield" and "reducing material loss" using DX technologies. In addition, the project extends to "productivity enhancements". In conventional Japanese *monozukuri*, any defective work in the design concept process (e.g., the front-end planning process) or assembly (e.g., the mid-end work process), if not detected early, may pass through until the inspection process (e.g., the back-end final process). Too often, a large number of defects (e.g., the whole lot) raise the system risk. Furthermore, defect discovery in the inspection process is not necessarily reliable if the production lead time is very short.

However, in this digital transformation (DX) project, quality inspection is conducted from the very beginning stage. Such early detection of defects prevents the system from producing "a large number of defects". Such a well-planned system process also removes defects "in advance" (e.g., through a variation of inspections for each process). Specific questions are, "What is the realistic probability of detecting defects in the inspection process?" and "What if factors causing defects are detected in the design planning process or during assembly process?" An outlier (e.g., out-of-normal value), when found, is immediately removed from the process, and thus, quality risk is reduced. Preventive quality management collects relevant data for statistical process analysis. For example, engineers collect data from the manufacturing execution system (MES) and conduct process analysis with their own PC.

In speeding up the PDCA (plan-do-check-act) cycle of quality improvement, "Digital Twin" (technology-enabled real-time data corresponding to reality in digital space) is built with the collaboration of external suppliers. For example, as there is a time lag between real production and digital space, continuous error detection might become difficult. In addition, each factory process is in a remote location: the upstream supplier process is in the Kansai plant in Japan, the assembly is in a domestic and an overseas plant, and the final modularization is in an overseas plant. As a result, data management requires consistent error detection and confirmation of each process performance. Each operational process is consistently repeated in the form of a "Twin" system, which connects the manufacturing data through an IT database. Any solution search is available by the user section anywhere through the internet connection. By establishing such a reliable system (DX solution), there was a substantial quality improvement (e.g., waste reduction) in battery delivery to customers. Traceability analysis also made the confirmation of the manufacturing status (e.g., 4M: man-machine-material-method) possible. In summary, digital transformation is breaking away from the past manufacturing methods (i.e., inspection-dependent quality control, etc.). Instead, it is measuring quality and productivity through real-time data (e.g., continuous monitoring of operational processes and rapid detecting of system deficiencies).

5.3. Semito

Semito develops, produces, and sells semiconductor manufacturing components for the smartphone memory devices and surface-conduction electron-emitter display (SED) (next-generation displays). Semito implements a set of DX strategies (e.g., "Breakthrough 2022") that use digital/IT infrastructure from 2020. It is a technology reform system package that includes technological design, purchasing, production process, and an information system network. Enterprise resource planning (ERP) is at the improvement level, but product lifecycle management (PLM), supply chain management (SCM), customer relationship management (CRM), and the manufacturing execution system (MES) are at the reform level. In addition, the visualization of factory work processes is conducted through the utilization of IT systems.

Three specific project goals are worth mentioning here. The first project goal aims at improving the customer retention rate, managing customer satisfaction ratings, and generating activity reports through the CRM system in the sales division. In the past B2B, unlike B2C, reported a limited number of customer-related issues. In recent years, with the globalization of operations, there has been an increase in the number of customer issues. Yet, analog communication responses (by direct human networks) were not effective. The digital visualization of customer performance ratings is necessary.

The second project goal focuses on improving customer value (CV), customer experience (CX), and customer speed (CS). Installing customer devices (CDs) on the factory floor makes remote connection and control possible. The equipment maintenance check is conducted through visualization by smart glasses. Such a project had been considered in-house for a long time, but with COVID-19, the firm was more willing to implement the remote digital connections

The third project goal emphasizes the improvement of the efficiency of customer equipment. It is the visualization of the vital information (e.g., device data, quality data, etc.) on the computer screen. In the past, the customers monitored equipment productivity on their own. In the B2B environment, regulatory requirements (e.g., confidential maintenance of private data) did not permit the examination of the customer database. However, COVID-19 made it possible for engineers to obtain remote access to customer devices.

5.4. Kosmi

Kosmi is a large cosmetics company. Their organizational process involves product development through marketing–manufacturing–distribution interfaces. It started various digital transformation (DX) strategies. One example is a joint venture with a consulting company in 2021. The goal of a joint venture states, " ... it is to establish a global standard IT infrastructure and operations" and further "to strengthen human resources in the digital IT field". Against this backdrop, the cosmetics industry has long been operating a business model to serve many unspecified customer segments and to conduct business at the discretion of the senior management of the headquarters. In addition, it was a company policy that customer needs were served through beauty consultants in its sales stores. During the COVID-19 pandemic, there was a perception that this practice was no longer going to be useful and relevant as very few customers were coming to the sales office because of the lockdown mandates. Despite increasing e-commerce, accounting for precise sales/profit figures as a result of the digital transformation was not as easy as expected. For example, consider the example of how beauty consultants meet with a customer at a store and give a skin diagnosis. With a smartphone, the customer checks her beauty treatment effects through virtual make-up simulation. The individual customer experience data are stored. This firm has the access to the aggregated big data.

As this company expands its business globally, the changing dynamics of market sales requires a real-time update. Customer perception of beauty is influenced by leading fashion trends in the US and Europe. To keep up with the rapid market changes, this DX project aims to update the global sales or profits in real time. The project leader summarizes and explains the meaning of DX in two ways. First, the DX productivity index (e.g., input/output ratio) can be collected by division. The data provide answers to questions such as, "How to improve productivity performance index?" and "How do customers respond to new beauty treatments?" In this way, the real-time data provide an insight into how to evaluate customer value preferences. Second, other key performance indicators need to be considered. For example, key IT system effectiveness indicators include maintenance-cost reduction and improvement in the operational speed and decision-making cycle time and digital IT talent development. In brief, the new digital transformation system is to jointly pursue operational level goals and skills development in digital/IT specialized fields.

5.5. Comparison of Cases

Figure 3 is a summary of the findings of the four cases. First, the first analysis priority is to utilize the company's strengths (e.g., core technology) throughout its internal and external network.

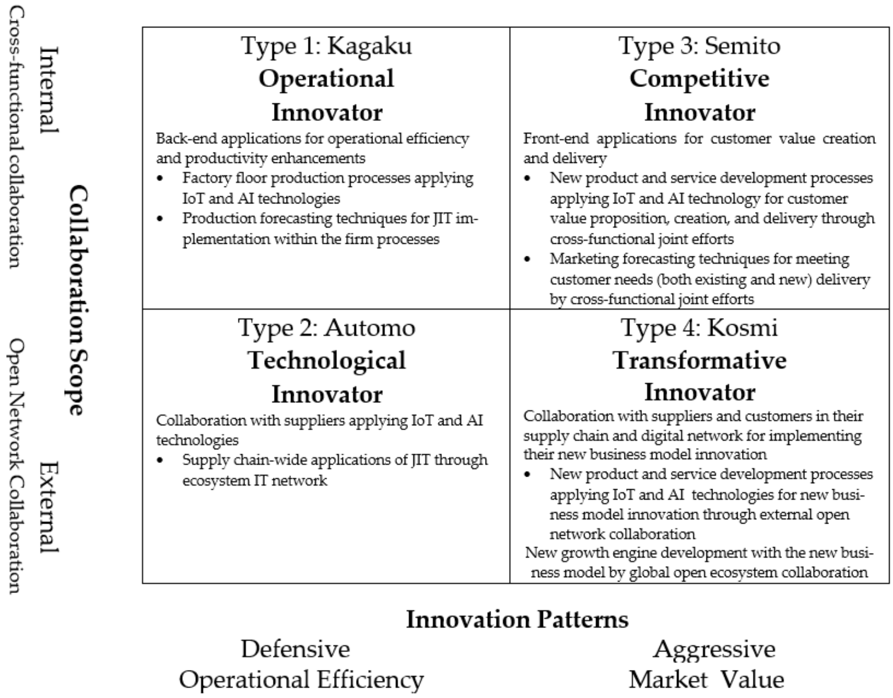

Figure 3. Data Analysis and Comparison of Four types.

Second, it is to nurture digital talents that understand and utilize digital technologies. Kagaku and Semito aim to increase the efficiency of their in-house operations by advancing the DX innovation by cross-functional collaboration. On the other hand, Automo and Kosmi cultivate cooperation with external partners and develop digital human talents that deploy the company's strengths to create greater customer value. Based on DX innovation (i.e., building core strengths, external partnerships, and digital talents), these firms aim for aggressive market value growth. In addition, they implement "open network collaboration" and design a new ecosystem in response to dynamic customer needs. First, Kosmi shows a transformation of the business model (e.g., establishing a JV with other companies, establishing global standard IT infrastructure and operations). Semito indicates manufacturing reform (e.g., DX within the company and DX for customers). However, Automo implements supply chain reform (e.g., quality improvement, rationalization, a countermeasure against inconvenience, etc.) and data-driven material development (e.g., speed development in diversifying customer requirements). Finally, Kagaku shows production DX (e.g., work efficiency, quality improvement, etc.).

6. Conclusions and Discussion

This article provides a research framework and presents case studies that are exploratory in nature. The companies, in this case, are all Japanese firms. Therefore, caution must be exercised when generalizing the findings of this research in the larger context. Despite these limitations, there are several contributions that are worth mentioning.

6.1. Theoretical Implications

First, we present a research framework that is based on two parameters: (1) the scope of collaboration and (2) the patterns of innovation. The 2 × 2 typology presents four types of firms that deal with competitive challenges in four different industries. A research framework with empirical studies is a very crucial step towards moving forward in establishing digital transformation theory [9,53]. Thus, this article suggests two important parameters, collaboration scope and innovation patterns, as important dimensions to understanding digital transformation.

Second, the organization of digital forums for an extended period suggests new forms of case studies in the COVID-19 pandemic context. Firms operate more in the digital ecosystem, which is a much more open network than the previously conceived supply chain level closed network and the concern about sustainability requirements [54,55]. These highly engaging digital forums provide a new innovative research collaboration as to how diverse firms may participate, engage, and interact through regular presentations in a trusting environment; furthermore, they receive regular feedback and demonstrate their effective learning outcomes.

Third, the case study findings suggest the theoretical relevance of the dynamic capabilities. Previous studies on innovation types focused on the analog world of innovation in which face-to-face interactions, personal-team iteration, and intuitive insight were the norms [22]. However, these case studies were conducted in the context of the COVID-19 pandemic where digital interactions, digital connectedness, and digitally shared data are becoming a new normal [4,29,56]. The dynamic capabilities of different firms show drastic improvement in operational effectiveness and business model innovation in a digital world.

6.2. Managerial Implications

First, this study presented the benchmark tool to assess the status of their innovation effectiveness. This research framework is useful for firms to classify, assess, and evaluate their innovation type. Two parameters (i.e., innovation patterns and collaboration scope) also allow senior management to set their specific innovation goals using proper parameters that can be further developed in their organizational context.

Second, case study findings also suggest the road map for future strategic goals. The firms could identify a realistic road map to move forward for their future innovation paths. For example, collaboration type (e.g., internal or external) and innovation patterns (e.g., defensive or aggressive) suggest that firms that are internally focused and adopt defensive innovation patterns (i.e., operational innovator) or that are externally focused for collaboration and yet adopt defensive patterns in their innovation type (i.e., technological innovator) may move forward by taking a real step toward their long-term goals of becoming more externally collaborative and aggressively innovative (i.e., transformative innovator) to increase their market frontiers and technological innovation potential.

Third, this theoretical framework illustrates the causal relationship between Japanese-style digital innovation and the firms' sustainable competitive advantage. Our findings are consistent with previous research. Fukuzawa et al. (2022) showed that IoT investments in Japanese companies improve production activity efficiency; yet, the collaboration among divisions and departments other than production is not sufficient [57]. As indicated in the case of Kagaku, most of the Japanese firms seem to be Type 1 (Operational Innovator). This type focuses on back-end applications for operational efficiency and productivity enhancements. IoT and AI technologies are applied to the factory-floor production processes of these firms. Production forecasting techniques are adopted for JIT implementation within the firm processes. Thus, Japanese firms which want to use DX technologies such as IoT and AI should consider the future digital strategy for Types 2, 3, and 4. Our framework might be extended to other firms in different contexts (e.g., Korea, India, USA, Brazil, and a host of other countries). Firms in other countries may adopt this framework, assess the state of their DX innovation, and select future strategic direction.

6.3. Future Research

For deductive case studies, we examined all the firms that participated in these digital forums. For the purpose of this article, we only selected a small number of firms. However, as most firms are classified as Type 1, further investigation of these firms is necessary in other dimensions through an extended period. To present the findings from additional cases, the theoretical framework may be refined and expanded. For more generalizable results, designing and using reliable survey instruments could be the next step of research that further examines the complex innovation patterns in the digital world. A bigger scale of empirical studies may provide rich and valuable insights into the dynamic nature of the digital innovation.

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