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Results of the Survey on Standardization Activities in 2021 (an overview of standardization activities and the administration system)

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Results of the Survey on Standardization Activities in 2021 (an overview of standardization activities and the administration system)

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Abstract

This study presents the results of a survey on the standardization-related activities of institutions conducted in 2021. This survey was conducted over four years (2017–2020), and this investigation is the fifth in the series. This survey did not investigate the standardization needs in order to select technological items for future standardization. Instead, the survey aims to quantitatively analyze the standardization activities of institutions by examining the ratio of standardization activities implemented in different industries, the progress of organizational development, and the establishment of operating rules. Additionally, the survey focuses on the management of research information in standardization activities. Information was obtained from Japanese institutions, including both manufacturing and non-manufacturing industries. The extent to which standardization activities are implemented is also investigated in terms of R&D expenditure. Additionally, an investigation into the relationship between standardization and the diffusion of advanced technology, such as artificial intelligence and quantum computing, is conducted. The percentage of respondents who consider knowledge gained from SDO activities to be important is rising, indicating that an over-reliance on natural language processing (e.g., large language models applied to generative AI) should be avoided when creating knowledge for standardization activities. Overall, the survey results highlight the importance of human resources engaged in standardization, both in terms of managerial and policy issues. The percentage of standardization activities practiced has been suggested to have increased over the five-year observation period.

Keywords: standardization activities, questionnaire survey, industry, R&D expenditures, advanced technology
JEL: O20, O30.

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[2)] This study corresponds to the policies in Chapter 2.1. (6) of the Sixth Science, Technology and Innovation Basic Plan (FY 2021–2025) developed by the Japanese government.
[3)] This work was supported by JSPS KAKENHI Grant Number 15K03718, 19K01827, and 23K01529 (PI: TAMURA, Suguru). “Research funded by a Grant-in-Aid for Scientific Research is conducted with the awareness and responsibility of the researcher. Thus, the conduct of the research and the publication of the research results are not based on government or any other such requests, and the views and responsibilities regarding the research results belong to the individual researcher.” (*Handbook on Grants-in-Aid for Scientific Research Program* [Japan Society for the Promotion of Science] [in Japanese]).
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1. INTRODUCTION

This study aims to collect statistical data on standardization activities and their social implementation, as statistical data collection techniques for management are not well known. The study covers the years during the COVID-19 pandemic, which saw behavioral restrictions and the digitization of social systems.; the impact of these effects on the items considered in this survey is of interest.[1]

From a social implementation perspective, previous study results have been published in the Research Repository of the International Organization for Standardization (ISO).[2] The publication of these findings in the research repositories of the ISO proves that the social implementation of this statistical item, which is the goal of this project, has been achieved to some extent. This series of studies emphasize statistical connectivity in the result compilation to fulfill the project objectives and research motivation, using the same data format in these continua of surveys conducted over the years.

This 2021 study examines the standardization activities of Japanese corporations and other institutions and mainly focuses on their level of standardization activities and related internal organization. Four similar surveys were previously conducted from 2017–2020 (Tamura, 2019a, 2020, 2021a, 2022a).[3] In addition, the survey focuses on the differences in standardization activities across industries and annual research and development (R&D). The survey also investigates the characteristics of standardization in advanced technology fields, characteristics of standardization-related knowledge creation, and control of R&D information in the standardization process. Conversely, the purpose of the survey was not to identify technologies to be standardized, as is generally done by standards development organizations (SDOs).

The 2021 survey revealed that the level of standardization activities was 68.8%, which is similar to that of the previous year. The level had increased compared to that in 2017 and 2018 (Tamura, 2019a, 2020). In 2021, the rate of progress in organizational development increased from 40% in the previous year's surveys to 44.4%. This number was the highest reported in the past. The control of technical information during the standardization process in SDOs demonstrates a trend toward improvement.

Previous research has analyzed the measurement method for standardization activities and discussed the difficulty in understanding standardization activities within an organization and the resultant limited policymaking (Tamura, 2012, 2013). Regarding qualitative research on organization and strategy, the change in the external environment has transformed patent organizations from administrative to strategy execution departments (Hirata et al., 2001). Arguably, the standardization departments of Japanese institutions have been forced to evolve because of changes in the external environment (Tamura, 2012). However, to the best of our knowledge, there is a lack of quantitative discussion on standardization activities and organizational development.

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[1] In this study, the year in which the survey was conducted differs from the year in which the survey was targeted. When describing the results, the targeted year is intended unless stated otherwise.

[2] These previous survey results have been adopted by the International Organization for Standardization (2021a, 2021b, 2021c, 2022).

[3] The survey's title is "Survey on Standardization Activities" (abbreviated as "SoSA") or "標準化活動調査" in Japanese characters.

2. METHOD AND DATA

This year's survey almost follows the same format that was employed in the previous four years' survey (2017-2020).

2.1. Survey Purpose

This study aims to establish a methodology for measuring the standardization activities undertaken by institutions. Particularly, it investigates the extent of standardization and related organizational activities and acquires knowledge to help institutions effectively manage and plan these activities. Institutions were included if their sales exceeded a certain threshold at the time the survey participant list was generated. The survey mainly targeted institutions with sales of more than one billion USD (e.g., 10 billion yen or more).[4] Firm sales data were retrieved from the database of Nikkei, Japan's leading financial information service. The survey focused on business entities and research institutions such as universities. The list of institutions investigated was approximately 180, including those who responded more than one time in the 2018 and 2019 surveys.

2.2. Survey Scope

The survey primarily aims to gather information on standardization activities within individual institutions. Typical examples of external standardization activities include attendance at SDO meetings for standards document development. As with the number of patents, data on the number of standard documents developed have accumulated in the past. In previous studies, the number of standard documents was often the subject of analysis. In contrast, the activities conducted within an institution are often difficult to capture.

The definitions of terminologies used in the survey are the same as those used in previous studies (Tamura, 2019a, 2020, 2021a, 2022a).[5]

2.3. Communication and Responding Method

Surveys were mailed to participating institutions directly, and respondents could submit their responses via email or mail (this was not a web-based survey). Both methods were used to distribute and collect survey questionnaires. This was a voluntary, unpaid survey, and the respondents were not compensated.

The survey was addressed to the department in which the respondents had previously registered. If the person

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[4] 1 USD = 100 JPY (approximately)

[5] i) Standardization activities

The unification of technical specifications, test and evaluation methods, terminology, and symbols in a specific technical field. Activities aimed at formulating technical standards themselves are classified as R&D activities, not standardization activities. The scope includes the standardization of de jure, de facto, and consortium standards. Calibration standards for maintaining the accuracy of measuring instruments are excluded. The survey also excluded activities related to standards-based certification (International Organization for Standardization [ISO] certification, Japanese Industrial Standards [JIS] certification) and maintenance and management of certification (Tamura, 2022b).

ii) Personnel involving standardization activities

Workers involved in the following: (1) standard planning, deliberation, and investigation; (2) survey activities, such as data acquisition for standard establishment; (3) Management of established standards; and (4) activities related to standardization for education and dissemination (Tamura, 2022b).

in charge of standardization activities was known, the questionnaire was addressed to them. The questionnaire was prepared and administered accordingly, and the answers were submitted in Japanese. Therefore, the English expressions used in this document (e.g., industry classifications) are provisional translations of the original Japanese expressions.

2.4. Survey Period

The survey responses were collected from January to March 2023.

3. RESULTS

Approximately 180 questionnaires were sent, and 75 responses were received. The response rate was approximately 40%, which was low compared to the collection rate in the previous year's survey (Tamura, 2022a).[6] The total number of respondents to the 2021 survey was 75. Among these, 70 responded to the 2021 survey as well as the 2020 survey; five of the 2021 respondents were respondents who had not responded to the 2020 survey.

3.1. Number of Respondents by Industrial Category and by R&D Budget Distribution

The respondents were mostly from manufacturing industries (e.g., steel, chemicals, and others), electrical machinery, and non-manufacturing industries (e.g., transportation) in Table 1. This distribution is similar to that observed in the previous year. Respondents were allowed to choose from 10 different industry classifications and select the classification based on their opinion. These categories differ from the technical categories used in the JIS and ISO standard documents (the JIS and ISO employ categories based on technical differences, not differences between industries).

Categories with higher annual R&D expenditures tended to share more responses (Table 2). This distribution trend is consistent with the results of three previous surveys (Tamura, 2020, 2021a, 2022a).

[Insert Table 1. here]

[Insert Table 2. here]

3.2. Practice Level of Standardization

3.2.1. Distribution by Industrial Category and R&D Budget

This indicator was a primary objective of this study. Among the respondents, 68.0% (51 observations) indicated that they had practiced standardization activities. Compared with previous years, this number corresponds with the data obtained in the 2020 survey and is the highest (Table 3). The high level of standardization activities is consistent with the trend toward promoting digitalization. This result can be attributed to the increased use of digital technologies in social systems. This change may be due to behavioral restrictions imposed due to COVID-19. Future observations are required to examine the changes observed after the pandemic; it is necessary to closely monitor whether this trend will continue in the future. For

[6] In this survey, the respondents were not reminded of their responses during the survey period. This treatment could be a reason for the decrease in the response rate from the previous year. The survey was conducted without reminding the respondents to avoid the bias caused by reminding survey participants when collecting the data.

respondents who commonly responded both in 2020 and 2021, the percentages of implementing standardization activities were 74.3% and 70.0%, respectively. While a decrease in percentages was observed, these figures are still higher than that of all respondents in 2021 (68.0%).

The level of standardization activities by the industry and R&D budget is represented in percentages in Tables 4 and 5, respectively. [7] Industrial sectors such as information and telecommunications, machinery, and transportation demonstrate higher than average frequencies compared to other industries. As in previous surveys, the implementation rate of standardization activities tends to be higher for firms with larger research budgets.

As a different example of economic analysis using standardized data, the impact of standardization on the economic growth of Germany, France, and the United Kingdom has been analyzed in relation to the number of standards enacted (AFNOR, 2009; Department of Trade and Industry, 2005; DIN, 2000).

[Insert Table 3. here]

[Insert Table 4. here]

[Insert Table 5. here]

3.2.2. Types of Standardization Activities

The following results were obtained for the types of standardization activities that were implemented. Multiple responses were allowed for this item. Among types, standardization activities related to products and services were the most common (62.3%), followed by measurement (27.5%) and manufacturing processes (24.6%)—these three with traditional conceptions of standards as functions. Activities related to design and symbols, which can be considered the role of new standards, account for 8.7% of standardization activities (Table 6). The existence of a certain number of standardization activities regarding designs and symbols is evident from the results of the previous surveys. This type of standard corresponds to designs and symbols such as pictograms, which are very important for the information and communication industry and service industry. They are also fundamental in constructing basic social systems (e.g., emergency exit signs) and social branding (International Organization for Standardization, 2019; Tamura, 2020, 2021b). Although there are a few studies on the economics of this type of standardization, research using Japanese de jure standard documentation data has shown that this type of standard has a statistically significant relationship with the life span of the standard (Tamura, 2017, 2018, 2019b).

[Insert Table 6. here]

3.2.3. Reasons for Not Implementing Standardization Activities

Table 7 presents the reasons why business entities and research institutions do not implement standardization activities. Knowing the reasons is essential for developing policies to encourage such organizations to implement standardization activities. The response mostly observed was that standardization is not required to provide products and services because they only use standards. This outcome indicates that the need for standardization activities has a significant relationship with the business models of institutions, including the

[7] Fisher's exact test indicated a significant difference (5% level) among the industry and budget categories.

products they manufacture. In this context, consideration should be extended to respondents who are unaware of the potential need for standardization.

[Insert Table 7. here]

3.3. Standardization of advanced technologies

As the ISO does not have technical definitions for the terms "artificial intelligence" and "quantum computer," this survey asked about their importance as general terms (International Organization for Standardization, 2015).[8]

3.3.1. Artificial intelligence technologies

Tables 8 and 9 present the respondents' perceptions of the importance of standardization in artificial intelligence (AI) technologies. Approximately 46% of respondents stated that the standardization of AI technologies is "important" or "relatively important." In the previous years' (2017–2020) results, approximately 30% of the respondents selected these two, which indicates that the necessity for standardization regarding AI had stabilized at some level. This outcome reflects the recent promotion and social implementation of AI technologies. As for the technical areas in which standardization is considered important, data formats, performance evaluations, and computational algorithms are the most important area (Table 10).

[Insert Table 8. here]

[Insert Table 9. here]

[Insert Table 10. here]

3.3.2. Quantum computer-related technologies

Approximately 14% of the respondents chose "important" or "relatively important" (Table 11), a lower percentage than for the standardization of AI technologies. Table 12 presents the results for each sector.

Performance evaluation methods, computational algorithms, and hardware are the primary areas in which standardization is important (Table 13).

[Insert Table 11. here]

[Insert Table 12. here]

[Insert Table 13 here].

Standardization of technology is thought to promote the marketability of new discoveries (e.g., the Honda-Fujishima effect in photocatalysis; MEXT, 2008, p. 102; Fujishima and Honda, 1972). The characteristics of general purpose technology (GPT; Lipsey, Carlaw, and Bekar, 2005) influential across sectors can be considered similar to the technological characteristics of standardization. Standardization of technology is effective in promoting cross-sectoral acceptance of technology, thereby facilitating social and industrial use of technology. Although GPT can be characterized as a standardized technology accessible across all sectors,

[8] A classification analysis of standards related to AI has been conducted on Japanese de jure standards, and the results have been made public for academic and educational use (Tamura, 2019b, 2019c).

conceptual discussions on GPT have traditionally overlooked this standardization aspect. Electricity and steam engines are examples of GPT (Helpman and Trajtenberg, 1996). Electricity, in particular, is a good example of illustrating the role of standardization and GPT outlined herein. Assuming that progress in standardization coincides with the transition to GPTs, this shift currently appears to occur more in AI than in quantum computer-related technologies. The transformation to GPT and the progress in standardization are expected to occur in a reciprocal manner.

3.4. Important Sources of Knowledge in Standardization Activities

Respondents indicated that standardization documents were an important source of information they used in the development of standards; this trend is similar to the previous surveys conducted in 2017, 2018, 2019, and 2020 (Table 14; Tamura, 2019a, 2020, 2021a, 2022a). Additionally, information from SDOs was considered an important source of information, regardless of whether the information was used or not. (Table 15). These results suggest that both explicit (e.g., information from standards documents) and implicit knowledge (e.g., information flowing in standardization activities, not in the textual context in SDO activities) are important for standardization activities. Knowledge gained from standardization documents can be considered explicit knowledge, and the level remains the same at approximately 57%, while knowledge gained from activities in SDO can be considered implicit knowledge, and the level increased from approximately 55% to 60%.

This argument demonstrates that, in de jure and consortium standards, human action and agreement among the involved parties are important. Excessive reliance on natural language processing (e.g., large language model [LLM] applied in Generative AIs) should be avoided when creating knowledge for standardization activities because natural language processing theories only use explicit knowledge that has been documented in the past.

[Insert Table 14. here]

[Insert Table 15. here]

3.5. Protection of R&D Information and Trade Secrets

The survey asked whether administrative guidelines supervising standardization activities existed within the institution and whether these documents included provisions for research information. Approximately 24% prepared and implemented institutional guidelines supervising standardization activities (Table 16). The differences regarding administrative guidelines by industry sector are presented (Table 17). Moreover, approximately 63% of the companies developing guidelines indicated that their guidelines included terms controlling trade secret protection (Table 18). This figurative trend is consistent with the results of the previous surveys. Differences by industry sector regarding the inclusion of trade secret protection are summarized in Table 19.

Table 20 shows the respondents' views on the control of R&D information in SDOs. Standardization activities in SDOs can be considered as a joint marketing process of R&D results among standard-setting participants. In this perspective, standardization activities in SDOs can be positioned as an R&D collaboration. Non-disclosure agreements are often necessary contractual requirements for implementing joint R&D activities. Approximately 15.5% stated that confidentiality of information was required, but a non-disclosure agreement (NDA) was not mandatory, or that confidentiality of information was not required. However, in

12.1% of the cases, an NDA was concluded, although opinions differ as to whether this figure is considered high or low. Understanding this situation may be useful for policymakers in competition policy, as standardization activities may take place among companies from a single country, or many countries. Additionally, the handling of standardized knowledge, which is neither a completely confidential technology nor one wherein the academic achievements of the publisher are protected by the prohibition of academic plagiarism (such as academic results presented at conferences or articles), is a matter of future business policy that may not be fully recognized, even by the SDO's participating parties in standardization activities. This future of standardized knowledge is considered a pressing issue that should be addressed.

[Insert Table 16 here]
[Insert Table 17 here]
[Insert Table 18 here]
[Insert Table 19 here]
[Insert Table 20 here]

3.6. Organizational Arrangements Aimed at Managing Standardization Activities

This figure is a crucial indicator in this survey to monitor the level of standardization in institutions. Forty-four (approximately 44.0%) respondents indicated that they had an administrative system (i.e., organization) to monitor standardization activities (Table 21). This result echoes the trend observed in 2017, 2018, 2019, and 2020 investigations (Tamura, 2019a, 2020, 2021a, 2022a). The proportion of respondents having developed organizations was the highest in previous surveys. For respondents who commonly responded both in 2020 and 2021, the rates of maintaining an organization supervising standardization were 50.0% in 2020 and 44.8% in 2021. Although these figures decreased in both years, they were higher than that of all respondents in 2021 (44.0%).

The differences in the organizational arrangement according to industry sector and R&D budget are presented (Tables 22 and 23).[9] Information and communications, electrical machinery, and other industries tend to have more organizations in place. Business entities that budget larger R&D tend to possess a higher proportion of standardization management systems. This trend is also true for the implementation of standardization activities. Companies with higher R&D expenditures demonstrate a higher propensity to implement standardization activities.

[Insert Table 21.]
[Insert Table 22.]
[Insert Table 23.]

Subsequently, the survey examined the strategic locations of the departments managing standardization activities; in approximately 25 (78.1%) companies, the departments were within the headquarters as shown in Table 24. This outcome contradicts the practice of conducting corporate standardization activities within individual business units as technical quality control activities (Tamura, 2021c). Standardization activities currently tend to be more centralized at headquarters than in business divisions, which indicates a shift of

[9] Fisher's exact test indicated a significant difference (5% level) among the industry and budget categories.

standardization activities towards a company-wide strategic approach.

[Insert Table 24. here].

A more detailed question was asked about the organizational structure from the perspective of patent management, which complements prior academic work on organizational changes in the patent division (Hirata et al., 2001). The results related to patent organization obtained may enrich academic and practical insights from this survey.

Approximately 41% of the respondents indicated that patent-related and standardization-related work were part of the same department (Table 25). This outcome suggests that these companies mutually coordinate their management. This trend was consistent with those observed in 2017, 2018, 2019, and 2020. Conversely, standardization and patent departments were separate in 19 cases (59.4%). Regarding affiliation, when the same department manages standardization and patents, they are often located at the headquarters (approximately 80%) (Table 26). This outcome indicates that headquarters oversees the management function regarding patents and standardization. As intellectual property (IP) management mainly regarding patents has long been centralized at headquarters, it is possible that the function controlling standardization is also being added to existing IP management organizations that primarily administer patent-related work.

[Insert Table 25]

[Insert Table 26].

3.7. Size of the Organization and Level of Supervision

Table 27 details the personnel size of the standardization organizations. The largest number was less than 10 in 20 cases (64.5% of the total), followed by 10–49 employees (eight cases, 25.8% of the total). The number of employees is stated in full-time equivalent terms; hence, the results reflect the total workload of employees engaged in standardization work rather than the headcount number.

Subsequently, the survey asked about personnel in positions that control the organization. A method of observing the importance of an internal organization's task is to investigate the supervisor's position. Table 28 presents the position rank of the person supervising the standardization department: in 22 cases (73.3%), the head of the department was responsible for supervising the standardization activities, and in four cases (13.3%), the manager was in charge. In four cases (13.3%), the president or vice president was responsible for the standardization department. These facts help us understand the role of standardization in institutional strategy because standardization activities are expected to be a strategic action for the entire institution if managerial action is taken by senior managers who can facilitate administrative information with other departments.

[Insert Table 27.]

[Insert Table 28.]

4. DISCUSSION

The graph illustrates the changes in the two main survey indicators: the percentage of respondents engaged in standardization activities (referred to as Level of standardization activities [LSA]) and the percentage of respondents with standardization organizations (referred to as Development of standardization organization [DSO]). These metrics are derived from aggregated data collected across various years' respondents (Tamura,

2019a, 2020, 2021a, 2022a). Notably, this marks the inaugural compilation and publication of time-series data concerning the level of standardization activities within Japanese institutions.

Given the relatively limited scope of this analysis, constrained by only five distinct time points, certain correlations have been observed between key indicators and the corresponding years. Over the course of the five years, a significant positive trend was observed in the degree of standardization activities based on correlation estimates derived from pooled data. Conversely, no significant trend was observed in organizational development. This difference potentially underscores the varying degrees to which standardization activities are strategically adopted within institutions (referred to Appendices A1 and A2). The relationship between the two is that, intuitively, the greater the degree of standardization activity, the higher the rate of development of the organization. An inverse relationship could also be considered.

The period under study, from 2019 to 2021, is a time of accelerated digitalization in social life, catalyzed by external shocks caused by the coronavirus disease. The findings of this study propose that this external influence has positively impacted the implementation rate of standardization activities. To verify the robustness of the results, further observation will be necessary.

When considering the policy implications, it is noteworthy that the organizational aspects of standardization activities have not progressed commensurately with the surge in the adoption rate of said activities. It is important for companies interested in standardization as a corporate strategy to develop their organizations to improve their competitiveness in this area. Furthermore, developing human resources with a certain level of knowledge to implement standardization activities remains essential. The results of this survey indicate that direct participation in SDOs will remain important for standardization (refer to Table 15). This implication reveals the limitations inherent in using generative AI for enhancing institutional competitiveness within the standardization realm. This observation is important in considering the efficient implementation of standardization strategies in an environment where the spread of AI is accelerating.

Fostering standardization activities hinges on developing human resources with the acumen to discern the technological areas warranting standardized frameworks to catalyze market entry, juxtaposed with areas necessitating product differentiation sans standardization. Such knowledge is also important for competitive strategies to avert the wastage of corporate resources through unnecessary participation in standardization competitions. Survey findings spotlight the critical role of direct involvement in SDOs, underscoring that the consensus-building process integral to establishing de jure and consortium standards hinges upon engaged stakeholders. Generative AI that uses a large-scale language model to generate documents based on the probability of occurrence of each word in available text data, non-verbal information of participants at meetings, among others, cannot be captured as data (even if some of it is recorded in text form in meeting minutes, among others, it is likely to be limited). Language processing technologies are incapable of processing information that is not explicitly expressed in words. Despite its limited scale, such implicit information remains present in both contemporary and future information-driven societies. The limitations arising from this technological characteristic in handling the negotiation process of standardization activities through generative AI constitute an important implication of this study. This observation is particularly significant when considering the improvement of competitiveness through the efficient implementation of standardization strategies by businesses and other entities within an environment marked by the rapid proliferation of AI.

The introduction of generative AI constitutes an external shock that will affect supply and demand in the labor market and reallocate managerial capital, especially human capital, within an institution. The reallocation of managerial capital within an institution is less likely most optimized than in the market because of the asymmetry and misallocation of information about the characteristics of operations within the institution. Consequently, judicious reassignment of human capital that could be substituted by generative AI should target other work while recognizing tasks that may be difficult to substitute (e.g., the standard negotiation process). This perspective is essential for business management in the new competitive environment where the introduction of generative AI is fully underway.

[Insert Figure 1 here]

5. CONCLUSION AND POLICY IMPLICATIONS

Five years of ongoing surveys have provided fruitful insights into the standardization activities of various institutions. Particularly, as the current and previous surveys were conducted during a period of rapid social digitization owing to social behavioral restrictions during the COVID pandemic, it is important to consider the influence of these social environments in the evaluation of the obtained results on standardization activities. Trends in the two major indicators of this survey are described below.

The proportion of companies that implemented standardization activities has increased over the past two years. In this year's survey, it was slightly below 70% (approximately 68%). This number has remained constant for the past two years. The increase in the percentage of implementation of standardization activities shown in five surveys can be attributed to the changes in the social structure. Such transformation is increasingly accompanied by the standardization of the goods and services. As a supplementary explanation, for respondents who responded for both 2020 and 2021, the percentage of standardization activities in 2020 was 74.3%, while the percentage of standardization activities in 2021 was 70.0%.

The rate of establishment of standardized organizations also increased by approximately 44%, which is higher than that obtained in the previous year. The results show that progress has been made in the development of management organizations. As a supplementary explanation, for respondents who responded both in 2020 and 2021, the percentage of maintaining an organization to manage standardization was 50.0% in 2020 and 44.8% in 2021. These two key indicators' results can be regarded as benchmark figures that provide an overview of the standardization activities in institutions in Japan.

Second, in the field of advanced technologies, the necessity for standardization in 2021 is greater for AI than for quantum computers, as in the past. This outcome is in line with the increasing prevalence of AI-based service deployment. Understanding technology traits and market distinctions is crucial to gain insights into the effects of standardization in these technology areas.

Finally, the crucial reason for some institutions not conducting standardization activities is their ability to utilize standards and offer products or goods unrelated to standardization. This outcome may be because either their offerings do not require standardization or they are unaware of the potential need for standardization. The latter case is primarily attributed to the lack of relevant knowledge. Developing human resources capable of accurately assessing the necessity of standardization activities based on the characteristics of their offerings is an important managerial and policy issue. A similar argument can also be gleaned from the answers to the

question on the important knowledge concerning standardization activities. Excessive reliance on information processing technology and theory regarding natural language processing (e.g., LLM applied in Generative AIs) should be avoided; they should not be trusted excessively when creating knowledge for standardization activities. An important observation obtained from this series of studies is that although standardization in the field of AI technology is required, the use of AI in standardization activities should be viewed with caution.

Endnote:

Note 1: The most important research objective of this study series is to conduct a nearly identical survey continuously. Five articles, including the current one, have been published as of 2023 (Tamura, 2019a, 2020, 2021a, 2022a, 2023). Due to the research background of these articles, the following points are stated as disclaimers: The format and wording of the tables, figures, and related content herein (including the titles and notes), the description of questionnaire items, the scope of the survey, and the result description style have been described in the same manner as that in the series of articles to ensure academic data comparability, accumulate statistical data, unify descriptive words and phrases, and improve the academic and practical readability regarding these articles because the SoSA has been conducted for consecutive years and will continue in the future.

Note 2: Not all respondents answered all questions in this survey. Thus, the number of responses to the questions varies and differences may occur in the total number of responses for calculating percentages across survey items.

Appendices:

[Insert Appendix A1. here].

[Insert Appendix A2. here].

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Appendices:

A1. Estimation results

Variables	Level of standardization activities	Development of standardization organization
year	2.00	0.74
	[3.96]**	[1.19]
constant	-3972.68	-1452.9
	[-3.90]**	[-1.16]
R-squared	0.84	0.32
Adj-R-squared	0.79	0.094
n	5	5

Note: [ ] t-value, ** $p<0.05$.

A2. Descriptive statistics

Variables	Mean	Standard deviation	Maximum	Minimum
Level of standardization activities	65.32	3.45	68	60.8
Development of standardization organization	41.16	2.07	44	39

Tables:

Table 1. Industrial categories

No.	Category	*n*	%
1	Machinery	2	2.7
2	Electric machinery	16	21.3
3	Transportation equipment	3	4.0
4	Business machinery	1	1.3
5	Other manufacturing	30	40.0
6	Construction	6	8.0
7	Information and telecommunications	1	1.3
8	Wholesale and retail	1	1.3
9	Other non-manufacturing	9	12.0
10	Education / TLO	6	8.0
	Total	75	100.0

Note: Due to rounding, the simple sum of the percentages may not equal 100%.

Table 2. Budget allocation for R&D

No.	Budget		*n*	%
	(thousand US dollar)	Reference: (million yen)		
1	0	0	3	4.5
2	<100	<10	3	4.5
3	100–499	10–49	0	0.0
4	500–999	50–99	0	0.0
5	1,000–9,999	100–999	14	20.9
6	10,000–99,999	1,000–9,999	18	26.9
7	100,000<	10,000<	22	32.8
8	Unknown	Unknown	7	10.4
	Total		67	100.0

Note 1: One US dollar was equal to approximately 100 Japanese yen.
Note 2: Due to rounding, the simple sum of the percentages may not equal 100%.

Table 3. Practice of standardization activities

No.		*n*	%
1	Yes	51 (83)	68.0 (68.0)
2	No	24 (39)	32.0 (32.0)
	Total	75 (122)	100.0 (100.0)

Note: Figures in parentheses represent the results for the previous year, 2020.

Table 4. Practice of standardization activities by industry

No.	Category	Yes	No	Total
		Percentage	Percentage	Percentage
1	Machinery	100.0%	0.0%	2.7%
2	Electric machinery	87.5%	12.5%	21.3%
3	Transportation equipment	100.0%	0.0%	4.0%
4	Business machinery	0.0%	100.0%	1.3%
5	Other manufacturing	70.0%	30.0%	40.0%
6	Construction	33.3%	66.7%	8.0%
7	Information and telecommunications	100.0%	0.0%	1.3%
8	Wholesale and retail	0.0%	100.0%	1.3%
9	Other non-manufacturing	66.7%	33.3%	12.0%
10	Education / TLO	33.3%	66.7%	8.0%
	Total	68.0%	32.0%	100.0%

Table 5. Practice of standardization activities by R&D budget

No.	Budget		Yes	No	Total
	(thousand US dollar)	Reference: (million yen)	Percentage	Percentage	Percentage
1	0	0	33.3%	66.7%	4.5%
2	< 100	< 10	66.7%	33.3%	4.5%
3	100–499	10–49	0.0%	0.0%	0.0%
4	500–999	50–99	0.0%	0.0%	0.0%
5	1,000–9,999	100–999	64.3%	35.7%	20.9%
6	10,000–99,999	1,000–9,999	44.4%	55.6%	26.9%
7	100,000 <	10,000 <	90.9%	9.1%	32.8%
8	Unknown	Unknown	57.1%	42.9%	10.4%
			65.7%	34.3%	100.0%

Table 6. Types of standardization activities being practiced

No.		*n*	%
1	Standardization activities related to products and services	43	62.3
2	Standardization activities related to the manufacturing process of products and services	17	24.6
3	Standardization activities related to the measurement	19	27.5
4	Standardization activities related to design and symbol	6	8.7
5	Do not practice	22	31.9
	(Total)	(107)	

Note: The total number of responses (107) is not equivalent to the number of respondents (69) because multiple answers are allowed for this question. The percentage column shows n/69 × 100.

Table 7. Reasons standardization activities are not practiced

No.		*n*	%
1	Standardization activities are not needed for marketing own products and services.	9	39.1
2	No established organization for standardization activities.	4	17.4
3	The management capacity for standardization activities is scarce.	0	0.0
4	Labor force for the standardization activities is scarce.	2	8.7
5	Existence of outflow risk of technology information and related trade secret.	1	4.3
6	The cost of practicing the standardization activities is higher than the benefit gained from the activities.	3	13.0
7	Using already established standards rather than formulating standards.	14	60.9
	(Total)	(33)	

Note: The total number of responses (33) is not equivalent to the number of respondents (23) because multiple answers are allowed for this question. The percentage column shows n/23 × 100.

Table 8. Importance of standardization for AI-related technology

No.		***n***	**%**
1	Not important/do not deal with the technology	14	29.2
2	Relatively not important	2	4.2
3	Neutral	10	20.8
4	Relatively important	13	27.1
5	Important	9	18.8
	Total	48	100.0

Table 9. The importance of standardization for AI-related technology by industry

No.	Category	1.Not important/do not deal with the technology	2.Relatively not important	3.Neutral	4.Relatively important	5.Important	Total
		Percentage	Percentage	Percentage	Percentage	Percentage	Percentage
1	Machinery	0.0%	0.0%	100.0%	0.0%	0.0%	4.2%
2	Electric machinery	7.7%	15.4%	7.7%	30.8%	38.5%	27.1%
3	Transportation equipment	33.3%	0.0%	0.0%	66.7%	0.0%	6.3%
4	Business machinery	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	Other manufacturing	55.0%	0.0%	25.0%	15.0%	5.0%	41.7%
6	Construction	0.0%	0.0%	0.0%	50.0%	50.0%	4.2%
7	Information and telecommunications	0.0%	0.0%	0.0%	100.0%	0.0%	2.1%
8	Wholesale and retail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	Other non-manufacturing	0.0%	0.0%	40.0%	40.0%	20.0%	10.4%
10	Education / TLO	50.0%	0.0%	0.0%	0.0%	50.0%	4.2%
	Total	29.2%	4.2%	20.8%	27.1%	18.8%	100.0%

Table 10. Standardization items considered important to AI-related technologies

No.	Category	*n*	%
1	Related to computational algorithms.	20	52.6
2	Related to the form of data used in computation.	22	57.9
3	Related to the encryption of data used in computation.	12	31.6
4	Related to hardware, such as arithmetic elements, used in calculations.	11	28.9
5	Related to the transmission of data associated with computations (but excluding those related to encryption).	11	28.9
6	Related to the measurement and evaluation of performance accuracy of computation results.	22	57.9
7	Related to the measurement and evaluation of energy-saving performance in operations.	9	23.7
8	Related to the terminology used to describe artificial intelligence-related technologies.	15	39.5
9	Related to ethical aspects of use and exploitation.	18	47.4
10	Other.	2	5.3
	(Total)	(142)	

Note: The total number of responses (142) is not equivalent to the number of respondents (38) because multiple answers are allowed for this question. The percentage column shows n/38 × 100.

Table 11. Importance of standardization for quantum computing-related technologies

No.		*n*	%
1	Not important/do not deal with the technology	28	58.3
2	Relatively not important	1	2.1
3	Neutral	12	25.0
4	Relatively important	2	4.2
5	Important	5	10.4
	Total	48	100.0

Table 12. The importance of standardization for quantum computing-related technologies by industry

No.	Category	1.Not important/do not deal with the technology	2.Relatively not important	3.Neutral	4.Relatively important	5.Important	Total
		Percentage	Percentage	Percentage	Percentage	Percentage	Percentage
1	Machinery	0.0%	0.0%	100.0%	0.0%	0.0%	4.2%
2	Electric machinery	38.5%	0.0%	23.1%	15.4%	23.1%	27.1%
3	Transportation equipment	33.3%	0.0%	66.7%	0.0%	0.0%	6.3%
4	Business machinery	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	Other manufacturing	80.0%	0.0%	15.0%	0.0%	5.0%	41.7%
6	Construction	100.0%	0.0%	0.0%	0.0%	0.0%	4.2%
7	Information and telecommunications	100.0%	0.0%	0.0%	0.0%	0.0%	2.1%
8	Wholesale and retail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	Other non-manufacturing	40.0%	20.0%	20.0%	0.0%	20.0%	10.4%
10	Education / TLO	50.0%	0.0%	50.0%	0.0%	0.0%	4.2%
	Total	58.3%	2.1%	25.0%	4.2%	10.4%	100.0%

Table 13. Standardization items considered important to quantum computing-related technologies

No.	Category	n	%
1	Related to computational algorithms.	13	46.4
2	Related to the form of data used in computation.	8	28.6
3	Related to the encryption of data used in computation.	7	25.0
4	Related to hardware, such as arithmetic elements, used in calculations.	11	39.3
5	Related to the transmission of data associated with computations (but excluding those related to encryption).	9	32.1
6	Related to the measurement and evaluation of the performance accuracy of computation results.	13	46.4
7	Related to the measurement and evaluation of energy-saving performance in operations.	9	32.1
8	Related to the terminology used to describe quantum computer-related technologies.	10	35.7
9	Related to ethical aspects of use and exploitation.	10	35.7
10	Other.	5	17.9
	(Total)	(95)	

Note: The total number of responses (95) is not equivalent to the number of respondents (28) because multiple answers are allowed for this question. The percentage column shows n/28 × 100.

Table 14. Importance of data sources for standardization activities (1)

Data source		Importance		Total
		Use	Not use	
Academic article	*n*	25	22	47
	%	53.2	46.8	100.0
Patent information	*n*	25	22	47
	%	53.2	46.8	100.0
Standardization document	*n*	20	28	48
	%	41.7	58.3	100.0
Design right information	*n*	29	17	46
	%	63.0	37.0	100.0
Information obtained from the SDO meetings including the participants	*n*	18	31	49
	%	36.7	63.3	100.0
Other sources	*n*	3	6	9
	%	33.3	66.7	100.0

Table 15. Importance of data sources for standardization activities (2)

Data source		Importance					Total
		5.Important	4.Relatively important	3.Neutral	2.Relatively not important	1.Not important	
Academic article	*n*	12	14	9	2	1	38
	%	31.6	36.8	23.7	5.3	2.6	100.0
Patent information	*n*	10	16	9	2	2	39
	%	25.6	41.0	23.1	5.1	5.1	100.0
Standardization document	*n*	25	12	6	1	0	31
	%	56.8	27.3	13.6	2.3	0.0	100.0
Design right information	*n*	2	8	11	3	7	31
	%	6.5	25.8	35.5	9.7	22.6	100.0
Information obtained from the SDO meetings including the participants	*n*	28	14	2	1	0	45
	%	62.2	31.1	4.4	2.2	0.0	100.0
Other sources	*n*	3	0	1	0	1	5
	%	60.0	0.0	20.0	0.0	20.0	100.0

Note: Due to rounding, the simple sum of the percentages may not equal 100%.

Table 16. Stipulation of institutional guidelines for management of standardization activities

No.		*n*	%
1	Stipulated	17 (32)	23.6 (28.6)
2	Not stipulated	55 (80)	76.4 (71.4)
	Total	72 (112)	100.0 (100.0)

Note: Figures in parentheses represent the results for the previous year, 2020.

Table 17. Stipulations of institutional guidelines for standardization activities and the management of standardization activities by industry

No.	Category	Yes	No	Total
		Percentage	Percentage	Percentage
1	Machinery	50.0%	50.0%	2.8%
2	Electric machinery	31.3%	68.8%	22.2%
3	Transportation equipment	0.0%	100.0%	4.2%
4	Business machinery	0.0%	100.0%	1.4%
5	Other manufacturing	28.6%	71.4%	38.9%
6	Construction	16.7%	83.3%	8.3%
7	Information and telecommunications	100.0%	0.0%	1.4%
8	Wholesale and retail	0.0%	100.0%	1.4%
9	Other non-manufacturing	12.5%	87.5%	11.1%
10	Education / TLO	0.0%	100.0%	8.3%
	Total	23.6%	76.4%	100.0%

Table 18. Inclusion of trade secret and technology outflow protections in management guideline of standardization activities

No.		***n***	**%**
1	Included	12 (18)	63.2 (50.0)
2	Not included	7 (18)	36.8 (50.0)
	Total	19 (36)	100.0 (100.0)

Note: Figures in parentheses represent the results for the previous year, 2020.

Table 19. Inclusion of trade secrets and technology outflow protections in the institutions' standardization activities guideline and the management of standardization activities by industry

No.	Category	Yes	No	Total
		Percentage	Percentage	Percentage
1	Machinery	100.0%	0.0%	5.3%
2	Electric machinery	50.0%	50.0%	31.6%
3	Transportation equipment	0.0%	0.0%	0.0%
4	Business machinery	0.0%	0.0%	0.0%
5	Other manufacturing	62.5%	37.5%	42.1%
6	Construction	100.0%	0.0%	5.3%
7	Information and telecommunications	100.0%	0.0%	5.3%
8	Wholesale and retail	0.0%	0.0%	0.0%
9	Other non-manufacturing	100.0%	0.0%	5.3%
10	Education / TLO	0.0%	100.0%	5.3%
	Total	63.2%	36.8%	100.0%

Table 20. Entering into a non-disclosure agreement (NDA) with a SDO when participating in the activities of such an organization

No.		*n*	%
1	Confidentiality is not required by the rules of SDOs.	7	12.1
2	NDAs are signed with standards development organizations.	7	12.1
3	Confidentiality is required by standard-setting organizations, but NDAs are not.	9	15.5
4	Not participating in the activities of SDOs.	15	25.9
5	unknown	20	34.5
	Total	58	

Table 21. Establishment of organizations for standardization activities

No.		*n*	%
1	Yes	32 (44)	44.4 (40.0)
2	No	40 (66)	55.6 (60.0)
	Total	72 (110)	100.0 (100.0)

Note: Figures in parentheses represent the results for the previous year, 2020

Table 22. Establishment of organizations for standardization activities by industry

No.	Category	Yes	No	Total
		Percentage	Percentage	Percentage
1	Machinery	100.0%	0.0%	2.8%
2	Electric machinery	60.0%	40.0%	20.8%
3	Transportation equipment	33.3%	66.7%	4.2%
4	Business machinery	0.0%	100.0%	1.4%
5	Other manufacturing	44.8%	55.2%	40.3%
6	Construction	33.3%	66.7%	8.3%
7	Information and telecommunications	100.0%	0.0%	1.4%
8	Wholesale and retail	0.0%	100.0%	1.4%
9	Other non-manufacturing	37.5%	62.5%	11.1%
10	Education / TLO	16.7%	83.3%	8.3%
	Total	44.4%	55.6%	100.0%

Table 23. Establishment of organizations for standardization activities by R&D budget

No.	Budget		Yes	No	Total
	(thousand US dollar)	Reference: (million yen)	Percentage	Percentage	Percentage
1	0	0	0.0%	100.0%	4.5%
2	<100	<10	66.7%	33.3%	4.5%
3	100–499	10–49	0.0%	0.0%	0.0%
4	500–999	50–99	0.0%	0.0%	0.0%
5	1,000–9,999	100–999	35.7%	64.3%	21.2%
6	10,000–99,999	1,000–9,999	27.8%	72.2%	27.3%
7	100,000<	10,000<	66.7%	33.3%	31.8%
8	Unknown	Unknown	42.9%	57.1%	10.6%
			43.9%	56.1%	100.0%

Table 24. Structure of organizations for standardization activities

No.		***n***	**%**
1	Within headquarters	25	78.1
2	Within business unit	2	6.3
3	Other	5	15.6
	Total	32	100.0

Note: Due to rounding, the simple sum of the percentages may not equal 100%.

Table 25. Standardization organization being part of patent organization

No.		*n*	%
1	Yes	13	40.6
2	No	19	59.4
	Total	32	100.0

Table 26. Organizational location where patent and standards management organization is located

No.		*n*	%
1	Within headquarters	12	80.0
2	Within business unit	1	6.7
3	Other	2	13.3
	Total	15	100.0

Table 27. Number of employees for standards management organization

No.		***n***	**%**
1	0	0	0.0
2	< 10	20	64.5
3	10–49	8	25.8
4	50–99	0	0.0
5	100–499	0	0.0
6	500 <	0	0.0
7	Unknown	3	9.7
	Total	31	100.0

Table 28. Supervisor level for standards management organization

No.		***n***	**%**
1	Non-management	0	0.0
2	Management	4	13.3
3	Department head	22	73.3
4	President, Vice president	4	13.3
	Total	(30)	100.0

Note: This results indicate the highest position in the respondent's organization.

Figure 1. Time-series trends in main indicators