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Status of Standardization Activities (Survey on Standardization Activities 2020) (Overview of Results by Industry and R&D Expenditures)

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Abstract

This article presents the results of a survey of the standardization activities of companies and others in 2020. This survey focuses on the standardization activities of companies, the factors affecting their technical characteristics, and the need for standardization. In other words, this survey is not aimed at drafting specific standards for individual technologies. The survey targets companies and others in Japan and covers 10 industry categories, including the manufacturing and non-manufacturing industries. Sector-specific information is obtained on the standardization activities. Additionally, in this survey, the research and development (R&D) expenditures are divided into seven tiers and the differences are investigated. The survey also examines the types of standardization activities undertaken and the reasons for not undertaking standardization activities. Moreover, to see the relationship between the need for standardization and technological characteristics, technology for which standardization is required in advanced technological fields (artificial intelligence and quantum computing) is investigated.

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

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1. INTRODUCTION

This study examined the standardization activities of Japanese companies and other institutions for 2020, focusing on their organizational characteristics and factors influencing knowledge creation. The current work conducted a similar survey as done in 2017, 2018, and 2019 (Tamura, 2019a, 2020, 2021a).[1,2] These previous studies selected institutions with sales equivalent to at least 10 billion JPY (more than one billion USD).[3] The present study examined differences in standardization activities by industry and annual research and development (R&D) amount. The firms' sales data were obtained from the database of Nikkei, a major financial newspaper in Japan.

As for prior studies related to the present study, regarding organizational structure and strategy, the development of patent organizations in Japanese firms and the evolution of their strategies indicate that patent disputes have transformed patent organizations from being administrative departments into departments responsible for implementing corporate strategies (Hirata et al, 2001). The standardization organizations of Japanese companies have changed due to changes in an external environment (Tamura, 2012). In the relationship between R&D and standards, an analysis of the characteristics of standards related to artificial intelligence has been conducted (Tamura, 2019b).

The current survey was conducted to explore the organizational structure of standardization, characteristics of standardization in advanced technology fields, characteristics of knowledge creation related to standardization, and status of management related to R&D information in standardization activities. The survey revealed the following findings: The degree of implementation of standardization seems increasing compared with the previous survey in 2018 and 2017 (Tamura, 2019a, 2020) and the rate of progress in organizational development is almost constant. In the implementation of standardization activities, restrictions on the use of technical information disclosed by standards development organizations (SDOs) are not strict.

2. METHOD AND DATA

2.1. Survey Purpose

The purpose of this study was to examine the means and scope of ongoing annual standardization activities in institutions, elucidate the impact of standardization activities on the institution's provision of goods and services, and to gain insights that will help the institution manage its standardization activities effectively. This study conducted a stated preference survey, which presents the objective observations of respondents, rather than a revealed preference survey.

2.2. Participants and Method

The survey focused on businesses and research institutions (e.g., universities). The respondents, approximately 180 subjects, included those who had responded to at least one of the two previous surveys conducted in 2018 and 2019. Questionnaires were mailed to firms and other institutions, and respondents could submit their

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

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

[3] 1 USD = 100 JPY (approximately)

responses via email or postal mail (n.b., this was not a web-based survey). Both mail and electronic media were used as means of distribution and collection of the survey. This survey was unpaid; the respondents were not compensated.

The questionnaire was sent to those in charge of standardization activities, with the annotation that those involved in standardization activities, such as technology, test and evaluation methods, terminology, and symbols within the institution, were encouraged to respond. The survey questionnaire was prepared and administered in the Japanese language. Thus, the expressions in English (e.g., industry classification) used in this article are provisional translations.

2.3. Survey Period

The survey was carried out from December 2021 to June 2022.

2.4. Survey Scope

This study primarily intended to collect data on standardization activities within institutions. Generally speaking, the activities carried out within an institution are more difficult to monitor than the activities practiced outside the institution. A typical example of an external standardization activity is the development of standard documents in SDOs.

2.4.1. Definition of standardization activities

For this survey, standardization is defined as 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.

2.4.2. Scope of personnel involving standardization activities

This study included a survey item on the number of employees engaged in standardization activities. Employees include 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, 2022).

3. RESULTS

Questionnaires were sent to approximately 180 survey respondents. A total of 124 responses were received by mail or email (as of June 2022), for a response of 67%. Both the response rate and the number of respondents were high compared with previous surveys (Tamura, 2019a, 2020). These respondents consisted of those who responded to surveys conducted in the current year and the last as well as those who did not respond to the last year's survey but responded to it in the current year. Some subjects, however, responded to the last year's survey but did not respond to it in the current year.

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

The highest number of respondents represented other manufacturing (e.g., steel and chemical industries), electric machinery, and other non-manufacturing industries (e.g., transportation industry). This trend is the same as that of the previous year (Table 1). The respondents were asked to select from 10 industry categories and allowed to choose which industry category they fell into at their discretion.[4] These classifications are different from the technical classifications used by the JIS and ISO standards documents. The JIS and ISO classifications are based on technical differences between the respective standards rather than differences between industries.

Regarding annual R&D expenditures, the most frequent category was Category 6, which was between 1,000–9,999 million JPY (10,000−99,999 thousand USD) (Table 2). This trend in the distribution of annual R&D expenditures matched that in the previous three surveys (Tamura, 2019a, 2020, 2021a).

[Insert Table 1. here]

[Insert Table 2. here]

3.2. Practice of Standardization by Industrial Category and R&D Budget Distribution

Of the respondents, 68% (83 observations) indicated that they practiced standardization activities. This figure is almost identical to that of 67.4% (62 observations) observed in the 2019 survey results but higher when compared to that of 62.4% (78 observations) observed in 2018 and 60.8% (62 observations) observed in 2017 (Table 3). Differences in values were observed. The increases coincide with the timing of recent advances in digital technology and may reflect the results of the increasing use of digital technology in the social system. Further observations are thus needed. In the yearly comparison of results, the percentage of standardization activities practiced was about 60–70% for four years.

Tables 4 and 5 show the frequency of standardization activities by industry sector and R&D budget, respectively.[5] Industries with higher-than-average values were information and telecommunications and electric machine, whereas industries with lower values were wholesale and retail. In terms of R&D budgets, companies with larger research budgets tended to have a higher percentage of standardization activities.

[Insert Table 3. here]

[Insert Table 4. here]

[Insert Table 5. here]

3.3. Types of Standardization Activities

Regarding the type of activities conducted, standardization activities related to products and services were the most common (63.9%), followed by manufacturing processes (33.3%) and measurement (30.6%). Activities related to design and symbols represented 16.7% of standardization activities (Table 6). All of the 2017−2020 results indicate a certain amount of standardization activity related to designs and symbols. Multiple-choice responses were allowed for this item.

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[4] This industry classification is not necessarily consistent with the Japan Standard Industrial Classification (JSIC).

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

The role of design and symbol standards has been discussed using Japanese de jure standard document data (Tamura, 2018, 2019b).[6] Designs and symbols are important because they play a major role in the information and communication service industry, such as pictograms. They also play an essential role in constructing social systems (e.g., emergency exit signs) and social branding (International Organization for Standardization, 2019; Tamura, 2020, 2021b).

[Insert Table 6. here]

3.4. Reasons for Non-Practice of Standardization Activities

Table 7 lists the reasons given by companies for not engaging in standardization activities (multiple responses allowed). These reasons are essential information when considering policies to promote standardization activities. The most common reasons given were that the products/services offered by the respondents did not require standardization activities and that they already used established standards. These two reasons were attributed to the characteristics of the company's products and services. The next most common reasons were the risk of technical information leakage and cost of participation. Concerns about the former may reflect a growing awareness of the issue of economic security. These results indicated that the degree of implementation of standardization activities is influenced mainly by the nature of the goods and services supplied by the companies and the technical novelty of those goods and services.

[Insert Table 7. here]

3.5. Standardization of Advanced Technology

3.5.1. Artificial intelligence technology

Tables 8 and 9 show the awareness of the importance of advanced artificial intelligence technologies and the differences by industry, respectively. Notably, the ISO has not yet defined the term.[7] The survey asked about the importance of the term "artificial intelligence" in general. About 36% of the respondents said that standardization of artificial intelligence technology is "important" or "relatively important." The results for 2017−2020 generally showed that about 30% of respondents chose these two options, indicating that the need for artificial intelligence standardization is fairly stable. This result suggests that standardization is becoming more important as this technology becomes widespread.

Standardization in artificial intelligence technology is expected to have the effect of facilitating marketization. In the case of photocatalysis, standardization has played a major role in enhancing its academic value (Ministry of Education, Culture, Sports, Science and Technology, 2008, p. 102). The discovery of the Honda−Fujishima effect of photocatalysis (Fujishima and Honda, 1972) led to the international standardization of methods for measuring and evaluating photocatalytic performance. Consequently, a commodity market was established for photocatalysts and their academic value increased.

[Insert Table 8. here]

[Insert Table 9. here]

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[6] The list of the type of standards is disclosed in electric data format (Tamura, 2017).

[7] Tamura (2019b) classified Japanese de jure standards (Japanese Industrial Standards [JIS]) to gather data on artificial-intelligence-related standards and made them public.

Table 10 shows the technical areas in artificial intelligence technology where standardization is important. The areas of performance evaluation, data format, and ethical aspects are considered the most important. These results indicate a high demand for setting benchmarks for the performance evaluation of artificial intelligence technologies. Setting standards for performance measurement enables distinction among different products and services. Standardization on ethical aspects is important to prevent social and legal abuse of artificial intelligence technologies and establish trust in the technology and its operation.

[Insert Table 10. here]

3.5.2. Quantum computing-related technology

The current survey asked about the importance of the general phrase "quantum computer-related technologies." As in the case of artificial intelligence, the ISO technology classification does not yet have a category for this technology (International Organization for Standardization, 2015). The percentage of respondents who answered "important" or "relatively important" was about 19% (Table 11)—higher than nearly 14% of the previous year but lower than that for the standardization of artificial intelligence technologies. The increase in the percentage of respondents who considered it essential from 2019 could indicate that the marketability of quantum computer-related technologies may be increasing. The results by industry are shown in Table 12. The effectiveness of technology standards is considered a background mechanism for technological acceptance across sectors. Standardization can serve as a means for effective technological coordination across industry sectors. General-purpose technologies (GPTs; Lipsey, Carlaw, and Bekar, 2005) can be characterized as standardized technology, although this technical feature has not been explored in conceptual discussion regarding GPTs.

The present results on artificial intelligence and quantum computer-related technologies shed light on the role of standardization in transforming advanced technologies into GPT. GPT is a technology that can play an important role in economic growth. Steam engines and electricity are considered examples of GPT (Helpman and Trajtenberg, 1996). Assuming that the progress of standardization coincides with the transition to GPT, the transition of quantum computer-related technologies to GPT is considered to be in progress. Standardization and the technological transition to GPT are expected to proceed while influencing each other.

[Insert Table 11. here]

[Insert Table 12. here]

Performance evaluation methods, terminology, and computational algorithms are the main areas where standardization is important. Performance evaluation methods enable the comparison of the performance of quantum computers. Standardization of terminology is critical in communicating new technological concepts. For example, when nanotechnology emerged as a new technology, basic terminology was standardized (Blind and Gauch, 2009). The need for standardization of computational algorithms can be seen as a sign that efficient algorithms for this new hardware technology are being explored. Table 13 lists the technical items that will require standardization in the future.

[Insert Table 13. here]

3.6. Important Knowledge Sources for Standardization Activities

The respondents identified standardization documents and SDOs as key sources of information in standards development. A similar trend was observed in the three previous surveys in 2017, 2018, and 2019 (Table 14) (Tamura, 2019a, 2020, 2021a). The five-point scale results, which explicitly indicate the level of importance, were also nearly identical (Table 15).

The results indicated the presence of different mechanisms for knowledge creation in standards, patents, and academic research. Moreover, the results highlighted the importance of information in negotiations: the creation of standards requires the parties' agreement. In other words, human-to-human communication is important for knowledge creation for standardization, even if the means of communication is the digitized form of web conferencing. With this background, knowledge from bibliographic and textual information alone is not sufficient for forming technical standards. The formation of de jure and consortium standards requires the sharing of knowledge among people in the activities of SDOs.

[Insert Table 14. here]

[Insert Table 15. here]

3.7. Protection of R&D Information and Trade Secrets

Unlike 71% of the responding institutions, approximately 29% have developed institutional guidelines for standardization activities (Table 16). Differences by industry are shown in Table 17. A half (50.0%) of the companies that have developed guidelines indicated that they included matters related to trade secret protection (Table 18). This result matched that in previous years' surveys conducted in 2017, 2018, and 2019. Differences by industry sector are shown in Table 19.

Standardization activities in SDOs are conducted to protect technical information. Table 20 presents the survey results on the actual management of research information in SDOs; activities in SDOs can be considered a process of jointly marketing the results of R&D. In this sense, standardization activities in SDOs can be regarded as a form of joint research.

Of the respondents that confirmed their participation in standardization activities, nearly 27% answered that they need to keep information confidential but do not need a non-disclosure agreement (NDA) or do not need to keep the information confidential; in 8.6% of the cases, they conclude an NDA. It would be beneficial for policymakers to understand the causes of this situation.

[Insert Table 16 here]

[Insert Table 17 here]

[Insert Table 18 here]

[Insert Table 19 here]

[Insert Table 20 here]

3.8. Organizational Designs for Standardization Activities

Forty-four respondents (40.0%) indicated that they had developed an organization to oversee standardization activities (Table 21). The results are similar to those in 2017, 2018, and 2019 (Tamura, 2019a, 2020, 2021a). Differences by industry sector and R&D budget are shown in Tables 22 and 23, respectively.[8] The information

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

and telecommunications, electrical machinery, and other industries adopted this organizational structure. In relation to the R&D budget, the ratio of companies with a larger R&D budget tended to be higher in having a standardization organization. This trend is similar to that in implementing standardization activities: the larger the budget, the higher the implementation rate.

[Insert Table 21. here]

[Insert Table 22. here]

[Insert Table 23. here]

Of the organizations managing standardization activities, 34 (72.3%) were located within the headquarters (Table 24). This situation is different from the past when a company's standardization activities consisted primarily of the technical quality control activities of the individual business units (Tamura, 2021c). Currently, standardization activities tend to be centrally managed, and the results indicated that standardization activities represented a company-wide strategy.

[Insert Table 24. here]

About 41% of the respondents indicated that patent and standardization organizations belonged to the same division (Table 25). These organizations practiced the mutual coordination of patents and standardization management. This trend again matched those in 2017, 2018, and 2019. Conversely, in 29 cases (59.2%), the standardization and patent organizations were separate entities. Regarding the affiliation within an institution, when the standardization and patent management functions were located in the same department, the department tended to be located in the head office (nearly 79%) (Table 26). This structure indicated that the management of patents and standardization was often centralized in the headquarters department.

[Insert Table 25. here]

[Insert Table 26. here]

3.9. Personnel Issues

Table 27 gives the staffing size of standardizing organizations in detail. Regarding the number of employees, the largest number of cases (30, 61.2% of the total) had fewer than 10 employees, followed by 10−49 employees (12 cases, 24.5% of the total). Since the number of workers was counted in full-time equivalent terms, these results reflected the workload of the employees engaged in standardization tasks.

One way to determine the importance of the task is to observe the position level of the person overseeing the work. Table 28 shows the position level of the individuals responsible for the standardization department: in 30 cases (66.7%), the department head was responsible for managing standardization activities. In 11 cases (24.4%), managers were in charge. In four cases (about 8.9%), the president or vice president was in charge of the standardization department. Standardization can be expected to be smoothly implemented as an organization-wide strategy when a higher-level manager manages it.

[Insert Table 27. here]

[Insert Table 28. here]

4. CONCLUSION AND POLICY IMPLICATIONS

Through the continuous implementation of this survey, this study gained further insight into the standardization activities of institutions. First, the percentage of companies conducting standardization activities, a key indicator in this survey, has been around 60% in the past, but the data from last year's and this year's survey showed an increase to slightly below 70% (approximately 68%). The descriptive statistical increase in the percentage of implementation of standardization activities may be attributed to the fact that changes in the social structure are encouraging standardization in the operational activities of corporations, such as product development and service provision. This change merits continued observation. In addition, the percentage of respondents with a standardization organization was approximately 40%. These results can be considered benchmark figures that also merit further observation.

Second, in the advanced technology area, the percentage of responses indicating that standardization is important increased for quantum computers, although the need for standardization remained higher for artificial intelligence. Quantum computer-related technologies are making progress in practical use in the market, and this change is thought to have led to the increase in the need for standardization. As the use of this technology becomes more common in the future, the need for standardization of related technologies may further increase. Notably, observing both technologies regarding the need for standardization, while paying attention to their different characteristics, will be important in obtaining knowledge regarding the effect of standardization in new technological areas.

Finally, similar to the results of the previous years (2017−2019) on knowledge sources considered important for standardization activities, the results highlighted the difference between the knowledge-creation mechanism of standardization and other knowledge-creation systems (academic articles and patents). In general, some types of knowledge cannot be created by digital information alone, and standards are an example of such knowledge. This result implies that human information exchange remains essential to knowledge creation even in this digitized society where textual information analysis is commonly used.

Regarding policy implications, previous and this survey have shown that the transfer of information among humans is important for knowledge creation related to standardization. The results indicate that the human resources engaged in standardization activities are not economically substitutable by information processing technology. In light of this, it is important to continue to address the development of human resources for standardization activities as a management and policy issue. Excessive reliance on information processing such as text processing technologies should be avoided in knowledge creation for standardization activities.

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Tables:

Table 1. Industrial categories

No.	**Category**	***n***	**%**
1	Machinery	7	5.6
2	Electric machinery	21	16.9
3	Transportation equipment	10	8.1
4	Business machinery	2	1.6
5	Other manufacturing	47	37.9
6	Construction	8	6.5
7	Information and telecommunications	5	4.0
8	Wholesale and retail	2	1.6
9	Other non-manufacturing	14	11.3
10	Education / TLO	8	6.5
	Total	124	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	4	3.8
2	<100	<10	6	5.7
3	100–499	10–49	3	2.8
4	500–999	50–99	2	1.9
5	1,000–9,999	100–999	20	18.9
6	10,000–99,999	1,000–9,999	32	30.2
7	100,000<	10,000<	31	29.2
8	Unknown	Unknown	8	7.5
	Total		106	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	83 (62)	68.0 (67.4)
2	No	39 (30)	32.0 (32.6)
	Total	122 (92)	100.0 (100.0)

Note: Figures in parentheses represent the results for the previous year, 2019 (Tamura, 2021a) .

Table 4. Practice of standardization activities by industry

No.	Category	Yes	No	Total
		Percentage	Percentage	Percentage
1	Machinery	71.4%	28.6%	5.7%
2	Electric machinery	90.0%	10.0%	16.4%
3	Transportation equipment	88.9%	11.1%	7.4%
4	Business machinery	0.0%	100.0%	1.6%
5	Other manufacturing	74.5%	25.5%	38.5%
6	Construction	37.5%	62.5%	6.6%
7	Information and telecommunications	100.0%	0.0%	4.1%
8	Wholesale and retail	0.0%	100.0%	1.6%
9	Other non-manufacturing	50.0%	50.0%	11.5%
10	Education / TLO	25.0%	75.0%	6.6%
	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	25.0%	75.0%	3.8%
2	< 100	< 10	66.7%	33.3%	5.7%
3	100–499	10–49	100.0%	0.0%	2.9%
4	500–999	50–99	100.0%	0.0%	1.0%
5	1,000–9,999	100–999	60.0%	40.0%	19.0%
6	10,000–99,999	1,000–9,999	68.8%	31.3%	30.5%
7	100,000 <	10,000 <	90.3%	9.7%	29.5%
8	Unknown	Unknown	37.5%	62.5%	7.6%
			70.5%	29.5%	100.0%

Table 6. Types of standardization activities being practiced

No.		n	%
1	Standardization activities related to products and services	69	63.9
2	Standardization activities related to the manufacturing process of products and services	36	33.3
3	Standardization activities related to the measurement	33	30.6
4	Standardization activities related to design and symbol	18	16.7
5	Do not practice	31	28.7
	(Total)	(187)	

Note: The total number of responses(187) is not equivalent to the number of respondents(108) because multiple answers are allowed for this question. The percentage column shows $n/108 \times 100$.

Table 7. Reasons standardization activities are not practiced

No.		n	%
1	Standardization activities are not needed for marketing own products and services.	16	42.1
2	No established organization for standardization activities.	5	13.2
3	The management capacity for standardization activities is scarce.	2	5.3
4	Labor force for the standardization activities is scarce.	4	10.5
5	Existence of outflow risk of technology information and related trade secret.	6	15.8
6	The cost of practicing the standardization activities is higher than the benefit gained from the activities.	6	15.8
7	Using already established standards rather than formulating standards.	13	34.2
	(Total)	(52)	

Note: The total number of responses (52) is not equivalent to the number of respondents (38) because multiple answers are allowed for this question. The percentage column shows $n/38 \times 100$.

Table 8. Importance of standardization for AI-related technology

No.		**n**	**%**
1	Not important/do not deal with the technology	31	39.7
2	Relatively not important	6	7.7
3	Neutral	13	16.7
4	Relatively important	11	14.1
5	Important	17	21.8
	Total	78	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%	75.0%	25.0%	0.0%	5.1%
2	Electric machinery	16.7%	11.1%	16.7%	27.8%	27.8%	23.1%
3	Transportation equipment	37.5%	12.5%	12.5%	12.5%	25.0%	10.3%
4	Business machinery	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	Other manufacturing	64.5%	6.5%	16.1%	3.2%	9.7%	39.7%
6	Construction	50.0%	0.0%	0.0%	25.0%	25.0%	5.1%
7	Information and telecommunications	20.0%	20.0%	0.0%	20.0%	40.0%	6.4%
8	Wholesale and retail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	Other non-manufacturing	16.7%	0.0%	16.7%	16.7%	50.0%	7.7%
10	Education / TLO	50.0%	0.0%	0.0%	0.0%	50.0%	2.6%
	Total	39.7%	7.7%	16.7%	14.1%	21.8%	100.0%

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

No.	Category	n	%
1	Related to computational algorithms.	19	40.4
2	Related to the form of data used in computation.	27	57.4
3	Related to the encryption of data used in computation.	9	19.1
4	Related to hardware, such as arithmetic elements, used in calculations.	7	14.9
5	Related to the transmission of data associated with computations (but excluding those related to encryption).	12	25.5
6	Related to the measurement and evaluation of performance accuracy of computation results.	27	57.4
7	Related to the measurement and evaluation of energy-saving performance in operations.	8	17.0
8	Related to the terminology used to describe artificial intelligence -related technologies.	15	31.9
9	Related to ethical aspects of use and exploitation.	22	46.8
10	Other.	2	4.3
	(Total)	(148)	

Note: The total number of responses (148) is not equivalent to the number of respondents (47) because multiple answers are allowed for this question. The percentage column shows n/47 × 100.

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

No.		**n**	**%**
1	Not important/do not deal with the technology	45	60.0
2	Relatively not important	2	2.7
3	Neutral	14	18.7
4	Relatively important	5	6.7
5	Important	9	12.0
	Total	75	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	25.0%	0.0%	50.0%	25.0%	0.0%	5.3%
2	Electric machinery	44.4%	0.0%	27.8%	5.6%	22.2%	24.0%
3	Transportation equipment	75.0%	0.0%	12.5%	12.5%	0.0%	10.7%
4	Business machinery	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	Other manufacturing	75.0%	7.1%	10.7%	3.6%	3.6%	37.3%
6	Construction	75.0%	0.0%	0.0%	0.0%	25.0%	5.3%
7	Information and telecommunications	60.0%	0.0%	20.0%	0.0%	20.0%	6.7%
8	Wholesale and retail	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
9	Other non-manufacturing	33.3%	0.0%	16.7%	16.7%	33.3%	8.0%
10	Education / TLO	50.0%	0.0%	50.0%	0.0%	0.0%	2.7%
	Total	60.0%	2.7%	18.7%	6.7%	12.0%	100.0%

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

No.	Category	n	%
1	Related to computational algorithms.	14	42.4
2	Related to the form of data used in computation.	11	33.3
3	Related to the encryption of data used in computation.	9	27.3
4	Related to hardware, such as arithmetic elements, used in calculations.	11	33.3
5	Related to the transmission of data associated with computations (but excluding those related to encryption).	11	33.3
6	Related to the measurement and evaluation of the performance accuracy of computation results.	16	48.5
7	Related to the measurement and evaluation of energy-saving performance in operations.	10	30.3
8	Related to the terminology used to describe quantum computer-related technologies.	14	42.4
9	Related to ethical aspects of use and exploitation.	9	27.3
10	Other.	4	12.1
	(Total)	(109)	

Note: The total number of responses(109) is not equivalent to the number of respondents(33) because multiple answers are allowed for this question. The percentage column shows n/33 × 100.

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

Data source		Importance		Total
		Use	Not use	
Academic article	n	51	20	71
	%	71.8	28.2	100.0
Patent information	n	49	22	71
	%	69.0	31.0	100.0
Standardization document	n	64	10	74
	%	86.5	13.5	100.0
Design right information	n	28	42	70
	%	40.0	60.0	100.0
Information obtained from the SDO meetings including the participants	n	57	16	73
	%	78.1	21.9	100.0
Other sources	n	4	16	20
	%	20.0	80.0	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*	21	24	10	4	1	60
	%	35.0	40.0	16.7	6.7	1.7	100.0
Patent information	*n*	22	19	16	2	4	63
	%	34.9	30.2	25.4	3.2	6.3	100.0
Standardization document	*n*	38	22	5	1	0	66
	%	57.6	33.3	7.6	1.5	0.0	100.0
Design right information	*n*	7	13	18	2	15	55
	%	12.7	23.6	32.7	3.6	27.3	100.0
Information obtained from the SDO meetings including the participants	*n*	35	18	9	0	2	64
	%	54.7	28.1	14.1	0.0	3.1	100.0
Other sources	*n*	2	0	8	0	2	12
	%	16.7	0.0	66.7	0.0	16.7	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	32 (20)	28.6 (25.0)
2	Not stipulated	80 (60)	71.4 (75.0)
	Total	112 (80)	100.0 (100.0)

Note: Figures in parentheses represent the results for the previous year, 2019 (Tamura, 2021a) .

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%	5.4%
2	Electric machinery	40.0%	60.0%	17.9%
3	Transportation equipment	55.6%	44.4%	8.0%
4	Business machinery	0.0%	100.0%	0.9%
5	Other manufacturing	26.2%	73.8%	37.5%
6	Construction	14.3%	85.7%	6.3%
7	Information and telecommunications	60.0%	40.0%	4.5%
8	Wholesale and retail	50.0%	50.0%	1.8%
9	Other non-manufacturing	0.0%	100.0%	11.6%
10	Education / TLO	0.0%	100.0%	6.3%
	Total	28.6%	71.4%	100.0%

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

No.		n	%
1	Included	18 (12)	50.0 (54.5)
2	Not included	18 (10)	50.0 (45.5)
	Total	36 (22)	100.0 (100.0)

Note: Figures in parentheses represent the results for the previous year, 2019 (Tamura, 2021a) .

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%	8.3%
2	Electric machinery	55.6%	44.4%	25.0%
3	Transportation equipment	66.7%	33.3%	16.7%
4	Business machinery	0.0%	0.0%	0.0%
5	Other manufacturing	33.3%	66.7%	33.3%
6	Construction	0.0%	100.0%	2.8%
7	Information and telecommunications	66.7%	33.3%	8.3%
8	Wholesale and retail	0.0%	100.0%	2.8%
9	Other non-manufacturing	0.0%	0.0%	0.0%
10	Education / TLO	0.0%	100.0%	2.8%
	Total	50.0%	50.0%	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.	10	10.8
2	NDAs are signed with standards development organizations.	8	8.6
3	Confidentiality is required by standard-setting organizations, but NDAs are not.	15	16.1
4	Not participating in the activities of SDOs.	24	25.8
5	unknown	36	38.7
	Total	93	

Table 21. Establishment of organizations for standardization activities

No.		n	%
1	Yes	44 (33)	40.0 (40.2)
2	No	66 (49)	60.0 (59.8)
	Total	110 (82)	100.0 (100.0)

Table 22. Establishment of organizations for standardization activities by industry

No.	Category	Yes	No	Total
		Percentage	Percentage	Percentage
1	Machinery	66.7%	33.3%	5.5%
2	Electric machinery	70.0%	30.0%	18.2%
3	Transportation equipment	55.6%	44.4%	8.2%
4	Business machinery	0.0%	100.0%	0.9%
5	Other manufacturing	31.7%	68.3%	37.3%
6	Construction	0.0%	100.0%	5.5%
7	Information and telecommunications	80.0%	20.0%	4.5%
8	Wholesale and retail	0.0%	100.0%	1.8%
9	Other non-manufacturing	23.1%	76.9%	11.8%
10	Education / TLO	14.3%	85.7%	6.4%
	Total	40.0%	60.0%	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%	4.0%
2	<100	<10	60.0%	40.0%	5.1%
3	100–499	10–49	33.3%	66.7%	3.0%
4	500–999	50–99	100.0%	0.0%	1.0%
5	1,000–9,999	100–999	26.3%	73.7%	19.2%
6	10,000–99,999	1,000–9,999	27.6%	72.4%	29.3%
7	100,000<	10,000<	70.0%	30.0%	30.3%
8	Unknown	Unknown	12.5%	87.5%	8.1%
			40.4%	59.6%	100.0%

Table 24. Structure of organizations for standardization activities

No.		n	%
1	Within headquarters	34	72.3
2	Within business unit	7	14.9
3	Other	6	12.8
	Total	47	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	20	40.8
2	No	29	59.2
	Total	49	100.0

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

No.		**n**	**%**
1	Within headquarters	18	78.3
2	Within business unit	3	13.0
3	Other	2	8.7
	Total	23	100.0

Table 27. Number of employees for standards management organization

No.		n	%
1	0	2	4.1
2	< 10	30	61.2
3	10–49	12	24.5
4	50–99	1	2.0
5	100–499	0	0.0
6	500 <	1	2.0
7	Unknown	3	6.1
	Total	49	100.0

Table 28. Supervisor level for standards management organization

No.		n	%
1	Non-management	0	0.0
2	Management	11	24.4
3	Department head	30	66.7
4	President, Vice president	4	8.9
	Total	(45)	100.0

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