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Results of Survey on Standardization Activities for 2018 (State of Implementation, Advanced Technologies, and Organizational Design)

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Results of Survey on Standardization Activities for 2018 (state of implementation, advanced technologies, and organizational design)

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Abstract

This study discusses the results of a survey conducted in 2018 targeting standardization activities in organizations. The questions covered: (1) the state of the implementation of standardization, (2) interest in the standardization of advanced technologies, (3) knowledge sources for standardization activities, (4) types of standardization activities, (5) organizational designs of standardization activities, and (6) the control system for standardization activities. The participants of the survey were Japanese organizations including firms and research institutions. Advanced technology topics included (1) AI-related technology and (2) quantum computing technology. The standardization needs for specific technology areas including (1) method of performance evaluation, (2) data style, and (3) ethical aspects, among others, were surveyed.

Keywords: standardization activities, questionnaire survey, knowledge sources, organizational design, artificial intelligence, quantum computing

JEL: O20, O30.

This study was conducted as part of the Research Institute of Economy, Trade and Industry (RIETI), Japan. The author appreciates the support of the Technical Regulations, Standards and Conformity Assessment Unit at the Ministry of Economy, Trade and Industry (METI) and Japanese Standards Association (JSA). The author appreciates the cooperation of the survey respondents. This work was supported by JSPS KAKENHI Grant Number 19K01827.

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1. INTRODUCTION

In this study, I discuss the results of a survey conducted on standardization activities during 2018.[1] The survey targeted standardization activities within organizations and the questions covered: (1) the state of the standardization implementation, (2) interest in the advanced technologies standardization, (3) knowledge sources for standardization activities, (4) types of standardization activities, (5) organizational designs of standardization activities, and (6) the control system for standardization activities. The participants of the survey were Japanese organizations, including firms and research institutions.

The survey questions comprised three main categories: (1) degree of standardization activities, (2) knowledge sources for standardization, and (3) organizational designs of standardization activities. Advanced technology topics included: (1) AI-related technology and (2) quantum computing technology. Moreover, the need to standardize specific areas of such advanced technology was surveyed.

The items surveyed for standardization needs in specific technology areas are *inter alia*: (1) method of performance evaluation, (2) data style, and (3) ethical aspects. Based on the results of the survey, the following items were examined: (1) the organizational structures of standards, (2) the characteristics of standardization within the field of advanced technology, and (3) the knowledge creation characteristics pertinent to standardization.

The results provided academic insight. That is, the need for standardization is low at the entrance to the initial stage of advanced technology, but this need increases once the initial stage is somewhat advanced and the product becomes more marketable.

2. METHOD AND DATA

2.1. Survey Purpose

The purpose of this survey was to gain useful insight into the management of standardization activities by understanding how and to which extent companies implement such activities.

2.2. Survey Subject and Method

This survey was a stated preference survey related to standardization, which presents the objective observations of respondents, rather than a revealed preference survey.

This survey was carried out in the Japanese language.[2] This is predominantly due to

[1] The survey title is the Survey on Standardization Activities (SoSA).

[2] The English expressions (e.g., industry categories) used in this article are tentative translations at the time of writing the article. Original expressions are in Japanese.

the survey subjects being located within Japan. Hence, it was easier for respondents to communicate in Japanese than in other languages. From a practical viewpoint, a higher response rate was expected for Japanese communication.

As for survey subjects, the focus was on (1) firms and (2) research institutions (e.g., universities). With respect to the selection of firms as survey subjects, organizations with reported sales of over 100 million USD (10 billion yen) were chosen.[3] The sales data of firms were obtained from the Nikkei database. Nikkei is a major financial newspaper company in Japan. The total number of survey subjects was about 1,600.

Regarding communication methods, the questionnaire was sent to corporations and other organizations via postal mail. The responses were also obtained via postal mail (i.e., this survey was not an internet survey).

This survey was sent to the subjects with a note stating that, as far as possible, the answers should be provided by people within the organization who are engaged in standardization activities, such as, *inter alia*, standardization of technology, tests and evaluation methods, and terminology and symbols.

As for the classification of industrial categories, ten categories were used:[4]

(1) Machine industry
(2) Electric machine
(3) Transportation machine
(4) Business machine
(5) Other manufacturing
(6) Construction
(7) Information and telecommunications industry
(8) Wholesale and retail
(9) Other non-manufacturing
(10) Education / TLO

The industry field is reported by the 'respondent's choice.

2.3. Survey Period

The survey was carried out from January 2020 to February 2020.

2.4. Survey Scope

2.4.1. In this survey, the definition of standardization was: Standardization means

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[3] One US dollar was equal to approximately 100 Japanese yen at the time of the writing of this article.

[4] These categories are different from the Japanese industrial standards (JIS) or International organization for standardization (ISO) technological classification for standards documents. These classifications are based on the idea of industrial classification. JIS and ISO classifications are based on technological differences of each standard.

unifying (1) technical specifications, (2) test evaluation methods, and (3) terms and symbols within a specific technical field.

The standardization of *de jure* and *de facto* standards are included in the survey scope. Consortium standardization activities are also included. However, the standards here do not include the calibration standard to maintain the measurement accuracy of an instrument. Moreover, the standardization activities here do not include both certifications based on standards (e.g., ISO and JIS certifications) and activities related to the maintenance and management of certifications.

Activities aimed at the development of technical standards themselves are considered part of research and development (R&D) activities and not considered standardization.

2.4.2. Regarding the survey scope of the personnel engaged in standardization activities, the scope includes personnel involved in the following:

(1) Standard planning, deliberation, and investigation.

(2) Survey activities, such as data acquisition for standard establishments.

(3) Management of established standards.

(4) Activities related to standardization for education and dissemination.

It is worth noting that there are two types of standardization activities: (1) activities within organizations, and (2) activities outside organizations. This survey implicitly aims to focus on collecting data on standardization activities within organizations. Theoretically, activities within organizations cover broader activities related to standardization than the standardization activities in standards development organizations (SDOs). Moreover, this survey does not distinguish between domestic and international standardization activities. Thus, both types of data are collected as part of standardization activities.

3. RESULTS

3.1. Number of Respondents by Industrial Category

Approximately 1,600 subjects were surveyed. A total of 126 responses were received via postal mail. The number of respondents increased from 104 last year to 126 this year. Table 1 shows the distribution by industry. Out of the 126 respondents, three did not answer the category. The other manufacturing, electric machine, and other non-manufacturing industries produced the highest number of respondents.

[Insert Table 1. here]

3.2. R&D Budget Distribution

Table 2 represents the distribution of R&D budgets. The mode was found to be category 6, ranging from 1000-9,999 million yen (10,000-99,999 thousand US dollars). The share of category 6 was 33.7%, and the number of respondents was 35. The second tier was category 7, ranging from 10,000 < million yen (100,000 < thousand US dollars). The third tier was category 5, ranging from 100-999 million yen (1,000-9,999 thousand US dollars). This budget allocation tendency is the same as that of the survey results from the previous year (Tamura, 2019a).

[Insert Table 2. here]

3.3. Practice of Standardization

Table 3 represents the number of institutions practicing standardization activities. Among the respondents, 62.4% (78 observations) answered that they practiced standardization activities. This number is almost the same as that of the previous survey, with a percentage of 60.8% (62 observations). This two-year comparison of results shows that the practicing rate of standardization activities was stable across both years. Namely, the figure is approximately 60% in each year. Table 4 shows the presence of standard activities by industrial sector and Table 5 presents the difference by R&D budget.

[Insert Table 3. here]

[Insert Table 4. here]

[Insert Table 5. here]

3.4. Types of Standardization Activities

As shown in Table 6, standardization activities related to products and services obtained the largest share (63.9%) among the activity types being practiced, followed by manufacturing process (33.0%) and measurement (30.9%). Activities related to designs and symbols comprised 15.5% of the standardization activities (multiple answers are allowed).

The order of the types was the same as the previous year's survey results. The important point to note is that the standardization activities related to designs and symbols were found to have a certain volume. Since the previous survey was the first ever conducted, it is difficult to tell whether the number is reliable. Nevertheless, the results for both years are sufficient to conclude that the standardization activities for designs and symbols prevail. These types of standardization activities are seemingly extant in organizations.

The role of standardization activities for designs and symbols has recently been discussed using *de jure* standard document data from Japan (Tamura, 2018, 2019b). Designs and symbols are largely related to corporate intangibles, such as brands. Brands of consumer goods are important for the private sector. They are sources to increase profit, whereas standardized designs and symbols promote social welfare as public brands. Standardization of designs and symbols plays an important role in building a new social system. To cope with the recent coronavirus pandemic (COVID-19), standardization of designs and symbols has helped citizens communicate important information non-verbally both in their personal and professional lives. Thus, at present, design and symbol standardization activities are worth discussing as relevant policy tools.

[Insert Table 6. here]

3.5. Reasons not to Practice Standardization Activities

Table 7 presents reasons firms may not practice standardization activities (multiple answers are allowed). From these reasons, I explored whether there is a need for policies.

The most frequent reason is that standardization activities are not needed for the goods and services the respondent provides. The second most frequent reason is that they are "using already-established standards, rather than forming standards." These two reasons are attributed to the design of goods and services that firms provide.

The third most frequent reason is that there is "no organization for standardization activities." The fourth most frequent reason is that there is a "shortage of labor forces for standardization activities." The third and fourth reasons can be categorized as management-based reasons rather than as characteristics of the goods and services firms provide. To organize the structure to control standardization activities, knowledge related to the actual standardization activities is essential. Thus, these answers suggest the need for organizational capability development.

The fifth most frequent category is the "high cost of standardization activities." For example, the present system used by SDOs is to hold SDO meetings where participants gather and discuss drafts of standards. The costs accompanying traveling to such meetings are usually paid by participants themselves. Another common cost is the annual membership fees required by SDOs. This result indicates that the support for such accompanying costs is still important. In the sixth most frequent category, the need for trade secret protection can be observed. This result indicates that firms are anxious about these issues.

[Insert Table 7. here]

3.6. Standardization of Advanced Technology

3.6.1. Artificial intelligence technology

In Table 8, attitudes toward advanced AI technologies are shown. The difference per industry is also shown (Table 9). In this questionnaire, respondents were asked about the importance of the term AI in general, without pursuing specific details. This is because the ISO has not decided on a definition of the term yet.[5,6] About 36% of the respondents answered that the standardization of AI technology is “important” or “relatively important.” This was an increase from the 33% in last ’year’s results, indicating a substantial rise in the need for standardization of AI. Namely, the diffusion of artificial intelligence technology has begun to improve rapidly, and the R&D for the technology is moving from the stage of basic research to the stage of applied and development research. This means that the initial market for goods and services involved in AI technology appears to be substantial. In my own experience, from last year to this year, the number of products and services that use artificial intelligence has increased considerably around the world.

The increase in the numbers indicates the spread of AI technology in society. As technology becomes more widely used within society, the need for standardization increases. Standardization increases the need for technology, while increasing its social impact. The implementation of technology in society, the need for standardization, and the value of technology interact with each other like a spiral. The difference between the two years seemingly reflects the progress of this phenomenon.

Standardization is considered to have played an important role in increasing the academic value of results of basic research. The phenomenon is observed in the case of photocatalyst (Ministry of Education, Culture, Sports, Science and Technology, 2008, p.102). Namely, the example is standardization following the discovery of the “Honda-Fujishima effect” of photocatalyst (Fujishima and Honda, 1972). During that time, the international standardization of the measurement and evaluation of photocatalysts was promoted. Owing to standardization, the marketization of technology then progressed. Consequently, the increased social impact of photocatalysts directly results in their increasing academic value. This is an example of how academic achievements can be conveyed to the market, owing to standardization.

[Insert Table 8. here]

[Insert Table 9. here]

Table 10 shows the results of the technological areas considered important among artificial intelligence technologies. (1) Performance evaluation, (2) data style, and (3) ethical aspects of AI are considered the most important.

The result indicates that the need for benchmarking or setting technical goals for

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5 Technical classifications for the patent classification of AI are largely formulated (Fujii and Managi, 2018; Tseng and Ting, 2013). The International Patent Classification (IPC) is used to specify AI-related patents (Fujii and Managi, 2018; Tseng and Ting, (2013).

6 Tamura (2019) classified the *de jure* standards for Japan (JIS) to formulate data regarding the AI - related standards and discuss their effective terms through survival analysis.

conducting R&D is high for AI technologies. The setting of standards for performance measurements is considered important for distinguishing among different products and services when marketization is underway and market competition is beginning to intensify.

Regarding the standardization of the data format, the standardized format of the data makes subsequent data processing easy. Standardization of the ethical aspect is important for the social acceptance of artificial intelligence technology because standards related to ethical aspects contribute to preventing the social and legal misuse of the AI. The preparation of such standards related to AI leads to social acceptance of the technology.

[Insert Table 10. here]

3.6.2. Quantum Computing-related Technology

Quantum computers are expected to become the next generation of information processing technology. In this questionnaire, respondents were asked about the importance of the term quantum computing-related technology in general, without pursuing specific details. This is because the ISO technological classification does not have the category of the technology yet (International Organization for Standardization, 2005). The percentage of responses indicating “important” and “relatively important” was 15.4% (Table 11). This percentage was lower than the importance of standardization for artificial intelligence technologies. It should be noted that 60% of the respondents selected “not important / do not use such technology” for quantum computing-related technology. This result may reflect the situation in which quantum computing-related technology is not yet being used in services and products aimed at the public. The difference per industrial sector is also shown (Table 12).

The results of this year’s surveys regarding artificial intelligence and quantum computing-related technologies allowed us to examine the process through which advanced technologies transform into general purpose technology (GPT) (Lipsey, Carlaw, and Bekar, 2005). These results reflect that quantum computing-related technology seemingly has not yet become a GPT. The presumption is that, as the technology becomes more generalized and widespread, the need for standardization increases. This is also the same presumption for when technology becomes GPT. In other words, the standardization and the technological transformation to GPT are considered to interact with each other while they are progressing. This phenomenon is a trend observed both in this year’s and in the previous year’s results in relation to artificial intelligence technology (Table 8).

[Insert Table 11. here]

[Insert Table 12. here]

Table 13 shows the results for the technology areas considered to be important among quantum computing-related technologies. In the future, as R&D progresses in this area of technology, the need for marketization will increase. Consequently, standardization becomes necessary in relation to the development of technology.

As for the need for standardization of quantum computers, the major technological areas are: (1) performance evaluation methods, (2) hardware such as arithmetic elements, and (3) data formats. Performance evaluation methods make it possible to compare the performance of quantum computers with each other. Evaluation methods play an important role in this technology to set R&D targets.

In comparison to the case of artificial intelligence technology, the notable difference is that there are substantial needs for standardization regarding arithmetic elements in quantum computing-related technology. The development of the computing elements is a technical challenge to be solved in the case of quantum computers. From other aspects, this reflects the fact that in the case of quantum computing, hardware development is still taking place. On the other hand, the technical development of hardware has nearly been completed in the case of artificial intelligence technology. From the aspect of the technological development, artificial intelligence technology is at the stage of algorithm development, assuming mature hardware technology.

In the same level of importance, the development of standards of terminology and the development of standards in terms of ethics are both considered important. For example, when nanotechnology emerged as a new technology, the formation of basic concepts such as terminology in nanotechnology was required for the improvement of R&D in the technology. In the case of the quantum computing-related technology, the situation appears similar to the case of nanotechnology (Blind and Gauch, 2009).

[Insert Table 13. here]

3.7. Knowledge Sources for Standardization Activities

The most important sources of information are: (1) information from SDOs, and (2) standardized documents. Standardization documents and information from SDOs, account for a high proportion of important activities in the development of standards. This trend is almost identical to last ’year’s trend (Table 14).

Since the development of standards requires consensus from all parties concerned, this could mean that it is important to capture not only the subjective but also the objective opinions of participants in the development of standards. For the knowledge that is formed through an agreement process, reciprocal communication is considered important. The results of this study showed that, even with digitized communication in web conference form, human-to-human communication is important. It has been made clear that knowledge from bibliographic information alone is not sufficient for the formation of technical standards. I find this is the novel knowledge creation mechanism that has not been explicitly recognized by the public.

[Insert Table 14. here]

3.8. Degrees of Importance of Knowledge Sources for Standardization Activities

To show the degree of importance in a more detailed manner, the results of a five-point scale evaluation are demonstrated (Table 15). Both (1) standardization documents and (2) information obtained from SDO meetings appear to be of a high frequency in importance.

It is indicated that information from SDOs consists of not only written information through the bibliography but also essential information exchanged during human communication (Tables 14 and 15). This is because collective decision-making actions to reach consensus are essential for the formation of standards.

With the development of new information processing technologies, such as artificial intelligence technology, it is increasingly believed that knowledge creation is possible without the need for direct communication between humans. However, knowledge creation of technical standards is seemingly not possible through bibliometric analysis alone.

This survey found that the knowledge creation of standards is one counterexample to the current academic approach that emphasizes non-human interaction information. Namely, unlike other typical knowledge creation disciplines, bibliographic information alone is not sufficient for the knowledge creation of standards. Standardization requires the sharing of knowledge among humans in SDOs. This characteristic of standards was only implicitly implied in the past. The results of this year's and the previous year's surveys present new insights regarding the difference in knowledge creation between (1) standards and (2) patents and academic articles.

[Insert Table 15. here]

3.9. Protection of R&D Information and Trade Secrets

About 30% of respondent companies have developed institutional guidelines for standardization activities, while 70% have not (Table 16). The difference per industrial sector is also shown (Table 17).

Approximately 68% of companies that developed institutional guidelines reported that they include trade secret protection notices in their standardized guidelines (Table 18). The extent of these results is similar to the results of last 'year's survey. The difference per industrial sector is also presented (Table 19).

[Insert Table 16 here]

[Insert Table 17 here]

[Insert Table 18 here]

[Insert Table 19 here]

3.10. Organizational Designs for Standardization Activities

As for the development of an organization to oversee standardization activities, 46 respondents (42.6%) answered that such an organization was developed (Table 20). The number of cases, and the percentage, have increased compared to that of the previous year. Table 21 shows the difference by industrial sector and Table 22 presents the difference by R&D budget.

[Insert Table 20. here]

[Insert Table 21. here]

[Insert Table 22. here]

In the past, companies' standardization activities predominantly focused on the technical quality control activities of each business unit. Today, however, standardization activities have become a company-wide strategy. Whether the organization managing the standardization activities is located in the business units or within the headquarters is shown (Table 23). Overall, 87.0% (40 cases) were located within the headquarters. Compared to last year's results, the percentage of standardization organizations established within the headquarters has increased. This result indicates that the current management structure for standardization activities is largely centralized. Namely, the standardization division is becoming a part of the function of company headquarters more rather than a business unit.

[Insert Table 23. here]

The human resource aspects of standardized organizations were studied in detail (Table 24). The highest frequency in the number of employees for the size of the management organization for standardization is less than ten employees. This is followed by 10-49 employees. Namely, the largest number of cases were ten or fewer, with 32 cases accounting for 74% of the total number of cases. This is followed by 9 cases within the range of 10 to 49 employees. It is important to note that the number of employees is on a full-time equivalent (FTE) basis. Thus, the result is a good reflection of the actual amount of staff involved in the work.

[Insert Table 24 here]

One indicator of the importance of a department is to look at the level of the person responsible for controlling the department. Table 25 shows the results of the position level of the heads of standards departments. Officials in charge of department heads are also responsible for the management of standardization activities and account for 26 cases, or about 60%. This is followed by the managers in 12 cases, or 28%. It is worth noting that, in five cases (about 12%), the president or vice president is responsible for the standardization department. In those five firms, the standardization appears to be the strategy of the whole organization because they are controlled by high-ranked managers.

[Insert Table 25. here]

3.11. Organizational Integration

When examining whether the patent organization and the standardization organization belong to the same organization, about 34% of respondents said they belong to the same organization (Table 26). This trend is almost identical to last ’year’s results. However, there are 29 cases, or about 66%, where the standardization organization and the patent organization existed separately. In these firms, patent management and standards management are conducted in separate departments. As for the location, when the standard and patent management function is in the same division, the organization is likely to be in the headquarters (Table 27).

[Insert Table 26. here]

[Insert Table 27. here]

4. CONCLUSION AND POLICY IMPLICATIONS

This was the second time the survey was conducted and followed its first administration in the previous year (Tamura, 2019a).

First, this year’s and the previous year’s survey results demonstrate that the percentage of companies implementing standardization activities was about 60%. The percentage of companies developing standardized organizations was about 30%. These results should be validated continuously in the future for further observation, but they can be used as approximate figures to tentatively explain the index.

Second, in terms of organizational structure, standardization activities are not activities managed by the business units. Rather, they are a part of the headquarters functions. The trends over the past two years have clearly shown that standardization activities are managed by the headquarters. This result is consistent with the results of the case study presented earlier (Tamura, 2012). Namely, the results show that standardization activities have become an enterprise-wide institutional strategy, rather than the management issue of business units. This development can be supported by theory and academic research (Chandler, 1962; Hirata et al., 2001; Sasaki et al., 2001; Tamura, 2012). Previous research shows that corporate strategies are changed in response to changes in the external environment, and organizational changes take place to implement these adjusted strategies (Chandler, 1962).

Third, within the field of advanced technology, differences in the need for standardization were found between artificial intelligence and quantum computing. These differences may reflect the fact that artificial intelligence technologies experience some degree of marketization of the products and services using AI technologies, whereas in quantum computing, the marketization of products is not yet common. At present, quantum computing-related technology is considered a hardware infrastructure for central processing, rather than a commodity for general consumers. This may be the reason that the need for standardization is low. The difference between these two provides academic insight into the relationship between GPT and standardization. Namely, the need for standardization will increase as technology becomes GPT, even if the need appears low during the earlier stage.

Finally, as a major academic and practical achievement of this study, I am able to recognize that the knowledge creation mechanism of standard formation is different from other knowledge creation systems (i.e., academic articles and patents). Namely, despite advances in information processing technology, direct communication is essential for the knowledge creation of standardization.

Notes:

All the citations expressing "(Tamura, year)" in this article refer to my previous studies. By coincidence, previous research by other researchers of the same name is not cited.

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Tables:

Table 1. Industrial categories

No.	Category	N	%
1	Machine	7	5.7
2	Electric machine	18	14.6
3	Transportation machine	7	5.7
4	Business machine	2	1.6
5	Other manufacturing	48	39.0
6	Construction	8	6.5
7	Information and telecommunications	5	4.1
8	Wholesale and retail	3	2.4
9	Other non-manufacturing	18	14.6
10	Education / TLO	7	5.7
	Total	123	100.0

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

Table 2. Budget allocation for R&D

No.	Budget		N	%
	(thousand US dollar)	Reference :(million yen)		
1	0	0	6	5.8
2	<100	<10	6	5.8
3	100–499	10–49	3	2.9
4	500–999	50–99	3	2.9
5	1,000–9,999	100–999	20	19.2
6	10,000–99,999	1,000–9,999	35	33.7
7	100,000<	10,000<	23	22.1
8	Unknown	Unknown	8	7.7
	Total		104	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 does not equal 100%.

Table 3. Practice of standardization activities

No.		N	%
1	Yes	78	62.4
2	No	47	37.6
	Total	125	100.0

Table 4. Practice of standardization activities by industry

No.	Category	Yes		No		Total	
		Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
1	Machine	6	85.7%	1	14.3%	7	5.7%
2	Electric machine	16	88.9%	2	11.1%	18	14.8%
3	Transportation machine	5	83.3%	1	16.7%	6	4.9%
4	Business machine	0	0.0%	2	100.0%	2	1.6%
5	Other manufacturing	31	64.6%	17	35.4%	48	39.3%
6	Construction	2	25.0%	6	75.0%	8	6.6%
7	Information and telecommunications	2	40.0%	3	60.0%	5	4.1%
8	Wholesale and retail	1	33.3%	2	66.7%	3	2.5%
9	Other non-manufacturing	11	61.1%	7	38.9%	18	14.8%
10	Education / TLO	2	28.6%	5	71.4%	7	5.7%
	Total	76	62.3%	46	37.7%	122	100.0%

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

No.	Budget		Yes		No		Total	
	(thousand US dollar)	Reference : (million yen)	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
1	0	0	1	16.7%	5	83.3%	6	5.8%
2	<100	<10	3	50.0%	3	50.0%	6	5.8%
3	100–499	10–49	3	100.0%	0	0.0%	3	2.9%
4	500–999	50–99	2	0.0%	1	0.0%	3	2.9%
5	1,000–9,999	100–999	11	55.0%	9	45.0%	20	19.2%
6	10,000–99,999	1,000–9,999	22	62.9%	13	37.1%	35	33.7%
7	100,000<	10,000<	22	0.0%	1	0.0%	23	22.1%
8	Unknown	Unknown	4	50.0%	4	50.0%	8	7.7%
			68	65.4%	36	34.6%	104	100.0%

Table 6. Types of standardization activities being practiced

No.		N	%
1	Standardization activities related to products and services	62	63.9
2	Standardization activities related to the manufacturing process of products and services	32	33.0
3	Standardization activities related to the measurement	30	30.9
4	Standardization activities related to design and symbol	15	15.5
5	Do not practice	27	27.8
	Total	166	

Note: The total number of responses (166) is not equivalent to the number of respondents (97) because multiple answers are allowed for this question. The percentage column shows N/97 × 100.

Table 7. Reasons standardization activities are not practiced

No.		N	%
1	Standardization activities are not needed for marketing own products and services.	27	58.7
2	No established organization for standardization activities.	11	23.9
3	The management capacity for standardization activities is scarce.	3	6.5
4	Labor force for the standardization activities is scarce.	8	17.4
5	Existence of outflow risk of technology information and related trade secret.	3	6.5
6	The cost of practicing the standardization activities is higher than the benefit gained from the activities.	6	13.0
7	Using already established standards rather than formulating standards.	16	34.8
	Total	74	

Note: The total number of responses (74) is not equivalent to the number of respondents (46) because multiple answers are allowed for this question. The percentage column shows N/46 × 100.

Table 8. The importance of standardization for AI-related technology

No.		N	%
1	Important	14	20.9
2	Relatively important	10	14.9
3	Neutral	19	28.4
4	Relatively not important	2	3.0
5	Not important/do not deal with the technology	22	32.8
	Total	70	100

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

No.	Category	1 Important	2 Relatively important	3 Neutral	4 Relatively not important	5 Not important/do not deal with the technology	Total
1	Machine	20.0%	20.0%	20.0%	0.0%	40.0%	7.7%
2	Electric machine	30.8%	30.8%	15.4%	7.7%	15.4%	20.0%
3	Transportation machine	25.0%	0.0%	25.0%	0.0%	50.0%	6.2%
4	Business machine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	Other manufacturing	10.3%	6.9%	44.8%	3.4%	34.5%	44.6%
6	Construction	100.0%	0.0%	0.0%	0.0%	0.0%	1.5%
7	Information and telecommunications	50.0%	0.0%	50.0%	0.0%	0.0%	3.1%
8	Wholesale and retail	0.0%	0.0%	0.0%	0.0%	100.0%	1.5%
9	Other non-manufacturing	33.3%	33.3%	11.1%	0.0%	22.2%	13.8%
10	Education / TLO	0.0%	0.0%	0.0%	0.0%	100.0%	1.5%
	Total	21.5%	15.4%	29.2%	3.1%	30.8%	100.0%

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

No.	Category	N	%
1	Related to computational algorithms.	13	34.2
2	Related to the form of data used in computation.	20	52.6
3	Related to the encryption of data used in computation.	10	26.3
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).	10	26.3
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.	10	26.3
8	Related to the terminology used to describe artificial intelligence-related technologies.	13	34.2
9	Related to ethical aspects of use and exploitation.	18	47.4
10	Other.	6	15.8
	Total	133	

Note: The total number of responses (133) 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. The importance of standardization for quantum computing-related technologies

No.		N	%
1	Important	7	10.8
2	Relatively important	3	4.6
3	Neutral	13	20.0
4	Relatively not important	3	4.6
5	Not important/do not deal with the technology	39	60.0
	Total	65	100.0

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

No.	Category	1 Important	2 Relatively important	3 Neutral	4 Relatively not important	5 Not important/do not deal with the technology	Total
1	Machine	0.0%	25.0%	0.0%	0.0%	75.0%	6.3%
2	Electric machine	23.1%	7.7%	15.4%	0.0%	53.8%	20.6%
3	Transportation machine	0.0%	0.0%	0.0%	25.0%	75.0%	6.3%
4	Business machine	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
5	Other manufacturing	3.6%	0.0%	32.1%	7.1%	57.1%	44.4%
6	Construction	0.0%	0.0%	0.0%	0.0%	100.0%	1.6%
7	Information and telecommunications	0.0%	0.0%	50.0%	0.0%	50.0%	3.2%
8	Wholesale and retail	0.0%	0.0%	0.0%	0.0%	100.0%	1.6%
9	Other non-manufacturing	33.3%	11.1%	11.1%	0.0%	44.4%	14.3%
10	Education / TLO	0.0%	0.0%	0.0%	0.0%	100.0%	1.6%
	Total	11.1%	4.8%	20.6%	4.8%	58.7%	100.0%

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

No.	Category	N	%
1	Related to computational algorithms.	7	25.9
2	Related to the form of data used in computation.	10	37.0
3	Related to the encryption of data used in computation.	4	14.8
4	Related to hardware, such as arithmetic elements, used in calculations.	10	37.0
5	Related to the transmission of data associated with computations (but excluding those related to encryption).	8	29.6
6	Related to the measurement and evaluation of the performance accuracy of computation results.	14	51.9
7	Related to the measurement and evaluation of energy-saving performance in operations.	4	14.8
8	Related to the terminology used to describe quantum computer-related technologies.	9	33.3
9	Related to ethical aspects of use and exploitation.	9	33.3
10	Other.	4	14.8
	Total	79	

Note: The total number of responses (79) is not equivalent to the number of respondents (27) because multiple answers are allowed for this question. The percentage column shows $N/27 \times 100$.

Table 14. Data sources for standardization activities

Data source		Frequency		
		Use	Not use	Total
Academic article	N	40	14	54
	%	74.1	25.9	100
Patent information	N	35	17	52
	%	67.3	32.7	100
Standardization document	N	49	6	55
	%	89.1	10.9	100
Design right information	N	21	30	51
	%	41.2	58.8	100
Information obtained from the SDO meetings including the participants	N	42	12	54
	%	77.8	22.2	100
Other sources	N	1	8	9
	%	11.1	88.9	100

Table 15. The importance of data sources for standardization activities

Data source		Frequency					
		Important	Relatively important	Neutral	Relatively not important	Not important	Total
Academic article	N	17	19	11	3	0	50
	%	34.0	38.0	22.0	6.0	0	100
Patent information	N	15	12	16	1	2	46
	%	32.6	26.1	34.8	2.2	4.3	100
Standardization document	N	26	21	6	0.0	0.0	53
	%	49.1	39.6	11.3	0.0	0.0	100
Trademark information	N	7	9	15	2	5	38
	%	18.4	23.7	39.5	5.3	13.2	100
Information obtained from the SDO meetings including the participants	N	23	18	7	1	1	50
	%	46.0	36.0	14.0	2.0	2.0	100
Other sources	N	0	1	4	0	0	5
	%	0	20.0	80.0	0	0	100

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

Table 16. Stipulations of institutional guidelines for standardization activities and the management of standardization activities

No.		N	%
1	Stipulated	32	30.2
2	Not stipulated	74	69.8
	Total	106	100.0

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

No.	Category	Yes	No	Total
1	Machine	33.3%	66.7%	5.8%
2	Electric machine	37.5%	62.5%	15.4%
3	Transportation machine	66.7%	33.3%	5.8%
4	Business machine	0.0%	100.0%	1.0%
5	Other manufacturing	22.5%	77.5%	38.5%
6	Construction	28.6%	71.4%	6.7%
7	Information and telecommunications	25.0%	75.0%	3.8%
8	Wholesale and retail	33.3%	66.7%	2.9%
9	Other non-manufacturing	26.7%	73.3%	14.4%
10	Education / TLO	16.7%	83.3%	5.8%
	Total	28.8%	71.2%	100.0%

Table 18. Inclusion of trade secrets and technology outflow protections in the institutions' standardization activities guideline

No.		N	%
1	Included	21	67.7
2	Not included	10	32.3
	Total	31	100.0

Table 19. Inclusion of trade secrets and technology outflow protections by industry

No.	Category			
		Yes	No	Total
1	Machine	50.0%	50.0%	6.9%
2	Electric machine	83.3%	16.7%	20.7%
3	Transportation machine	25.0%	75.0%	13.8%
4	Business machine	0.0%	0.0%	0.0%
5	Other manufacturing	77.8%	22.2%	31.0%
6	Construction	50.0%	50.0%	6.9%
7	Information and telecommunications	0.0%	0.0%	0.0%
8	Wholesale and retail	100.0%	0.0%	3.4%
9	Other non-manufacturing	100.0%	0.0%	13.8%
10	Education / TLO	0.0%	100.0%	3.4%
	Total	69.0%	31.0%	100.0%

Table 20. Establishment of organizations for standardization activities

No.		N	%
1	Yes	46	42.6
2	No	62	57.4
	Total	108	100.0

Table 21. Establishment of organizations for standardization activities by industry

No.	Category	Yes	No	Total
1	Machine	50.0%	50.0%	5.7%
2	Electric machine	56.3%	43.8%	15.1%
3	Transportation machine	100.0%	0.0%	4.7%
4	Business machine	0.0%	100.0%	0.9%
5	Other manufacturing	40.5%	59.5%	39.6%
6	Construction	28.6%	71.4%	6.6%
7	Information and telecommunications	66.7%	33.3%	2.8%
8	Wholesale and retail	0.0%	100.0%	2.8%
9	Other non-manufacturing	29.4%	70.6%	16.0%
10	Education / TLO	16.7%	83.3%	5.7%
	Total	41.5%	58.5%	100.0%

Table 22. Establishment of organizations for standardization activities by R&D budget

No.	Budget		Yes		No		Total	
	(thousand US dollar)	Reference :(million yen)	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
1	0	0	0	0.0%	5	100.0%	5	5.2%
2	<100	<10	3	60.0%	2	40.0%	5	5.2%
3	100–499	10–49	2	66.7%	1	33.3%	3	3.1%
4	500–999	50–99	1	0.0%	2	0.0%	3	3.1%
5	1,000–9,999	100–999	7	36.8%	12	63.2%	19	19.6%
6	10,000–99,999	1,000–9,999	9	28.1%	23	71.9%	32	33.0%
7	100,000<	10,000<	16	0.0%	7	0.0%	23	23.7%
8	Unknown	Unknown	2	28.6%	5	71.4%	7	7.2%
			40	41.2%	57	58.8%	97	100.0%

Table 23. Structure of organizations for standardization activities

No.		N	%
1	Within designated department	5	10.9
2	Within headquarter	40	87.0
3	Other	1	2.2
	Total	46	100.0

Table 24. Number of employees for the standards management department

No.		N	%
1	0	0	0.0
2	<10	32	74.4
3	10–49	9	20.9
4	50–99	0	0.0
5	100–499	0	0.0
6	500<	0	0.0
7	Other	2	4.7
	Total	43	100.0

Table 25. Supervisor levels for standards management department

No.		N	%
1	Non-management	0	0
2	Management	12	27.9
3	Department head	26	60.5
4	President, Vice president	5	11.6
	Total	43	100.0

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

Table 26. Standardization organization being part of the patent organization

No.		N	%
1	Yes	15	34.1
2	No	29	65.9
	Total	44	100.0

Table 27. Organizational location where patent management and standards management are located within the same department

No.		N	%
1	Within each department	1	6.7
2	Within headquarters	14	93.2
3	Other	0	0.0
	Total	15	100.0