When formulating mission-oriented STI policies, it is important to visualise how science, technology and socio-institutional initiatives can contribute to specific societal challenges. In order to map the interrelationships, a survey was conducted to gather researchers' opinions on how science, technology and societal approaches are expected to contribute to these challenges. The survey sought to envision the future state of society and to concretise future societal challenges and value creation through a backcasting approach. It is expected that such an approach would lead to new insights into the links between societal issues and science and technology that cannot be found through a forecasting approach alone, as well as to new discoveries in interdisciplinary research.

1. Introduction

In response to growing expectations of science and technology innovation (STI) to address various societal challenges, many governments have adopted a mission-oriented approach to STI policy formulation. Mission-oriented approaches can take many forms, depending on their objectives and scope, but are mainly characterised by multi-stakeholder involvement and a multidisciplinary approach (Larrue, 2021; Mazzucato, 2018). When formulating mission-oriented STI policies, it is important to visualise how science, technology and socio-institutional initiatives can contribute to specific societal challenges. In order to map the interrelationships, a survey was conducted to gather researchers' opinions on how science, technology and societal approaches are expected to contribute to these challenges. The survey sought to envision the future state of society and to concretise future societal challenges and value creation through a backcasting approach. It is expected that such an approach would lead to new insights into the links between societal issues and science and technology that cannot be found through a forecasting approach alone, as well as to new discoveries in interdisciplinary research.

2. Methods

An online questionnaire survey was conducted among approximately 1,600 professional surveyors registered with the Network of Science and Technology Experts of the National Institute for Science and Technology Policy (NISTEP) of the Ministry of Education, Culture, Sports, Science and Technology (MEXT), Japan.

2.1 Outline of the expert panel

The Network of Science and Technology Experts has been operated by NISTEP since 2001 with the aim of collecting basic information for the review of science and technology policy and has 1,675 experts (surveyors) from academia, government and industry. Of these, 74% are from universities, 13% from public institutions and 12% from industries. 21% of the surveyors are in their 30s, 51% in their 40s and 21% in their 50s. The proportion of women is 21%, while the proportion of men is 79%. The majority of respondents work in the natural sciences and engineering (32% in natural sciences, 38% in engineering, 10% in agriculture
and 11% in health), although a small number of researchers are also registered in the social sciences (6%) and humanities (2%).

2.2 Outline of the survey implementation

We conducted an online survey from 8 - 28 September 2021. The number of respondents were 794 (1,682 sent). Respondents were asked to select 2-3 themes from below themes.
- A: Health, broad-mindedness and life extension (479 respondents)
- B Resilient cities and societies (270 respondents)
- C Energy society (347 respondents)
- D Digital social environment (208 respondents)
- E Climate change and global environmental issues (249 respondents)

2.3 Respondent demographics

More than 60% of respondents were university-based researchers, with others coming from industry and public institutions. In terms of age, just under 30% were in their 40s, over 20% were in their 30s and only 10% were in their 50s. In addition, 20% are female and 80% male. More than 40% specialise in engineering, more than 30% in natural sciences and the rest in agriculture, health, social sciences, etc. The graph below shows the distribution of respondents' research fields by theme.

Figure1: Research areas of respondents per theme

2.4 Questionnaire structure.

The broad structure of the questionnaire is as follows.

Step 1: For each theme, present a description of "a possible future state / form of society" developed from various foresight literatures.
Step 2: Choose whether to respond to the theme or not → If not, move on to another theme.
Step 3: Present examples of issues that need to be addressed and new values that are emerging in the "envisioned state / form of society in the future".
Step 4: Using the examples as a starting point, ask what issues and new values could arise in the future (free text answers, at least 3-5 main answers).
Step 5: Prioritise the answers.
Step 6: For the top three items, ask the following questions (open-ended)
   i) Contribution from own field of research
   ii) Contributions made possible by collaboration with other research areas
   iii) Approaches from outside science and technology

3. Results

3.1 Understanding the overall trend

First, a word cloud analysis was conducted using the response results to identify overall trends.

Figure2: Theme A Word cloud for structuring health open-mindedness and life extension

3.2 Structurization

Responses were then structured in two ways.
- Manual structuring.
- Clustering by natural language processing

i. Manual structuring

The content of the social issues/values identified in step 4 was manually classified into categories. As an example, the structured social issues/values of Theme A 'Health, open-mindedness and prolonging life' are shown in the diagram below.
The content of the responses was then organised as social issues/values, as there was a mixture of perceived changes and their consequences/recurring events. The table below shows an extract from the organisation of Theme A: 'Medicine and health through the active use of technology' as an example.

### Table: Changes and broader impacts in 'proactive use of technology in medicine and health'. (Excerpt.)

<table>
<thead>
<tr>
<th>Item</th>
<th>Change</th>
<th>Broader impacts (consequences, recurrent events)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use of robots in medicine and care,</td>
<td>Not a substitute/replacement for labour</td>
<td>Worker unemployment.</td>
</tr>
<tr>
<td>telemedicine</td>
<td>Contacts with people in need to be strengthened</td>
<td></td>
</tr>
<tr>
<td>Precision and personalised medicine using</td>
<td>Use of systematic data</td>
<td>From treatment to prevention/prevention of disease</td>
</tr>
<tr>
<td>personal data</td>
<td>Home health checks, early disease diagnosis</td>
<td>(Increased insecurity due to knowing)</td>
</tr>
<tr>
<td></td>
<td>Automated medication management, seizure prediction</td>
<td>Protection of personal data</td>
</tr>
<tr>
<td></td>
<td>Free choice of personalised menus, including cognitive, exercise,</td>
<td>Monopoly of health information big data</td>
</tr>
<tr>
<td></td>
<td>nutritional and sleep interventions</td>
<td>Higher medical costs, widening inequalities, pressure on social security costs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>More important options other than advanced and expensive medicine</td>
</tr>
<tr>
<td>Extension of bodily functions</td>
<td>Organ replacement</td>
<td>Ethical aspects</td>
</tr>
<tr>
<td></td>
<td>Regenerative medicine</td>
<td>Mental aspects from organ memory</td>
</tr>
<tr>
<td></td>
<td>Cyborgisation</td>
<td>Unknown defects from using a body with a mixture of old and new parts of the body</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Prejudice, coexistence with humans</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Verification and regulation of brain and body functions in various licensing systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased individual decision-making and choice of whether or not to accept the technology</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Need for scientific literacy</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Increased accountability of doctors</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Crisis management measures, safety nets (e.g. during power outages, hacking response, system errors)</td>
</tr>
</tbody>
</table>

ii. Clustering using natural language processing
The free-text responses obtained in step 4 Social issues/future value and Contribution from own research area in step 6 were then clustered into 4, 8, 16, 32, 64 and 128 classifications across themes (A to E) using natural language processing. The clustering results were visually checked, and each cluster was annotated (labelled) and keywords were created.

4.3 Preliminary findings

Visualisation of the crosscutting nature and complexity of social issues and values

The clustering of responses across themes made it possible to analyse the interrelationships and cross-cutting nature of social issues, as well as disciplinary links. The diagram below visualises the links between the clustered issues/values (8 categories) and respondents' research areas (8 field categories) across themes.

Figure 3: Linkages between issues/values (8 categories) and respondents' research areas

In addition, a visualisation of the linkages between the clustered issues/values and the clustering of the solutions/technology seeds contributing to them was carried out.
Furthermore, the clustering of issues/values and solutions/technological seeds is hierarchically clustered into 4, 8, 16, 32, 64 and 128 categories, which also enables the visualisation of linkages in more detailed categories. By clustering across themes, many cases were observed where a particular social issue was tied to several (or all) themes.

The following are examples of cross-thematic issues/values.
- Social division, inequality and the state of society: distributed across all themes
- Urban/regional state (centralised/decentralised): distributed across all themes
- Linkages between digitalisation and energy/environmental issues: distributed across all themes
- A Intersection of healthcare + D Digitalisation + C Energy
- Information protection, privacy, human rights and human dignity: A Medical, D Digital
- Low carbonisation, natural environment and sustainability: B resilience, C energy, E climate change
- Work and wellbeing: A healthcare, B resilience, D digital

5. Discussion

The survey attempted to clarify the embodiment of future social issues and value creation and the contribution of science and technology and the social side to these issues using a backcasting approach, but also revealed a number of issues.

4.1. Design of questionnaires

Several issues were discussed in the design of the questionnaire. The first was whether or not to provide information to respondents and the appropriateness of the granularity of the information. In the absence of information, it might be difficult for respondents to come up with ideas, and it might also be difficult to analyse the results afterwards due to the large
number of differently granulated responses. Therefore, a document explaining "a possible future state/form of society" was included in the questionnaire. Although we asked people to use this information only as a starting point for ideas and to encourage free thinking, it could be seen as a leading or guiding response. In fact, there were several cases where some of the information provided was used verbatim or only partially modified in the content of the responses, so it is likely that some degree of inducement was involved. It will be necessary in the future to examine whether and to what extent there is a difference in the content of the responses with and without the pre-provided information.

4.2. Method

A combination of manual and natural language processing was used to analyse and structure the content of the responses. Due to the issue of the inseparability of future issues/values and technology, a qualitative analysis based on manual is necessary to interpret the content of the responses, but more efficient and effective methods need to be introduced. The clustering analysis was done using natural language processing, but the naming of clusters was done manually, so subjectivity and arbitrariness could not be eliminated. Automated naming would be desirable. On the other hand, given the scale of the number of clusters, even in the 128 most detailed classifications, the homogeneity of content was low and varied, and there were many cases where the cluster labels seemed to differ significantly from the content. More consideration needs to be given to what level of classification is desirable.

4.3. Interpretations of the results

A more fundamental problem is that there is a complex overlap between the societal challenges created by technology and the societal challenges for which technology is the solution, and that societal and technological challenges are inextricably linked. For this reason, many technological challenges were included in the items asking about future challenges and values, and many challenges and values were described in the items asking about technological solutions. As it is difficult to interpret using simple mechanical methods alone, visual checks were also used. Although visual structuring remains important, it is labour intensive and difficult to reproduce, so more advanced natural language processing may need to be applied.

In addition, there are many issues that are viewed differently by different experts, not only in terms of defining problems and values, but also in terms of technological solutions and seeds. Examples include the impact of AI on employment, the issue of decentralised energy and nuclear energy. At present it has not been possible to visualise these differences, but the power of the survey results would be enhanced if case studies could be used, and methods developed to visualise the diversity of expert perspectives.

Open science practices
Results will be published by the end of 2023, attachment with data partially.

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Competing interests
None.
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References
