Policy Proposal AI Aiming at a Sustainable Future

Improving sustainability is a major challenge for Japan as it goes through a paradigm shift driven by an aging population, low birthrate, and changes in the structure of industry, leaving behind its expansionary past and entering a new post-growth era (with no growth or expansion). Having developed a policy proposal artificial intelligence that uses a model of society as the basis for determining the branching structure of a large number of interlinked future scenarios, and the factors influencing how these scenarios branch off from each other, Hitachi has been working with experts from Kyoto University to analyze the sustainability of Japan in 2050. The results identified two possible futures for Japan (a highly urbanized scenario and a regionally decentralized scenario) and indicated that the divergence of these two scenarios would occur about a decade from now.

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1. Introduction

Japan is going through a paradigm shift from an expansionary past to a new post-growth era (with no growth or expansion) that is being driven by an aging population, low birthrate, and changes in the structure of industry. As Japan approaches 2050, when its elderly population will reach its peak both in absolute numbers and in terms of the rate of aging, the major challenges for society will be: sustainability of (1) Population and birthrate, of (2) Fiscal position and social security, of (3) Cities and regions, and of (4) Environment and other resources, as well as (5) Employment, (6) Elimination of disparities, and the (7) Happiness and (8) maintenance and promotion of the Health of its people.

These challenges are in line with the Sustainable Development Goals (SDGs) enumerated by the United Nations as part of a global agenda to address environmental and social problems through economic development, and also those of Japan's Society 5.0 plan for creating a human-centric society through systems that feature a high-level integration of virtual and physical spaces, as set out in the Fifth Science and Technology Basic Plan.

In light of these challenges, a research group based around Professor Yoshinori Hiroi's team at the Kokoro Research Center at Kyoto University is engaged in work on how to achieve a sustainable future for Japan. The Hitachi Kyoto University Laboratory is also a participant, with experiments having been conducted on making use of its artificial intelligence (AI) technology in these policy proposals. This article presents an overview of the simulation techniques that use this AI. Details of the policy proposals generated using AI are published a news release[(1)].

2. Policy Proposal

Confronting the societal challenges described above calls for strategic policy formulation and the timely implementation of the policies so devised. The approach adopted to achieve this was to envisage a number of different future scenarios depicting the sequence of stages that society will go thorough over time, indicating what social circumstances will come about as different aspects of society undergo change. The problem with this, however, is that human experts can only come up a limited number of scenarios for the future, and the content and timing of policies must be considered within this limited number. It was also recognized that a simple extrapolatory analysis of the big data available in the present day is inadequate when considering a future as distant and uncertain as that of 2050. Accordingly, an approach was adopted whereby, in order to model an uncertain future, a computer model was built in which the uncertainties were left in (incorporating the sorts of uncertainty that a human rather than an AI would anticipate), and then AI simulation was used to come up with its own variations on where uncertainty might exist.

3. How People and AI Work Together to Generate Policy Proposals

The policy proposal process typically proceeds in three stages, as shown in **Figure 1**[(2)].

In the initial information gathering stage, the problem to be solved is defined and relevant information is collected and collated, consolidating it into a cause-and-effect model. The next stage is options consideration, in which the cause-and-effect model is used as a basis for enumerating the various possible future scenarios, a process that includes use of AI simulation. The relationships between the future scenarios are analyzed on a time-series basis to determine how and in what order the different scenarios branch off from one another, and the factors that instigate these branchings are identified. In the final strategy selection stage, the different future scenarios are examined in terms of what constitutes a desirable outcome for society, and the chosen scenarios then form the basis of policy proposals for turning the scenarios into reality.

The initial information gathering stage and final strategy selection stage are undertaken by people and the intermediate strategy selection stage by AI. In other words, the process of producing policy proposals is one in which people and AI work in collaboration. The following sections describe in detail what happens at each stage.

3. 1
Information Gathering Stage

Information gathering starts by defining the problem and clarifying the issues to be resolved. The problem in this case was defined as how to achieve sustainability in Japan in 2050. Next, a number of experts with knowledge of this problem were invited to a workshop to identify the relevant cause and effect relationships in society. This involved listing the

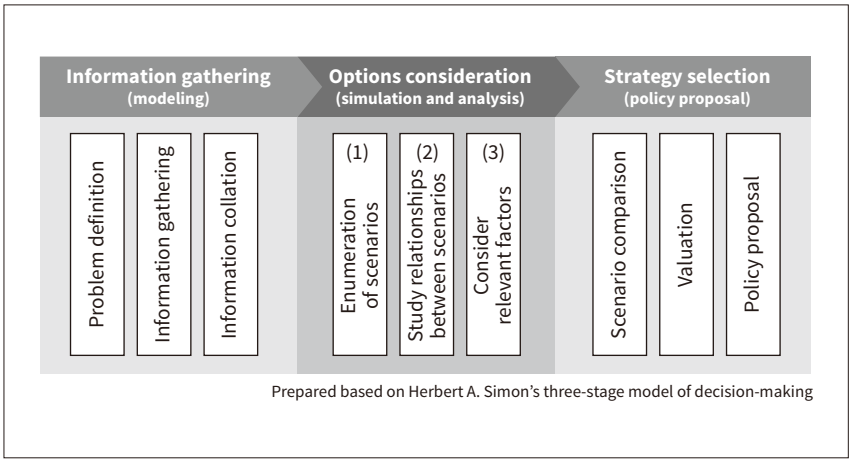
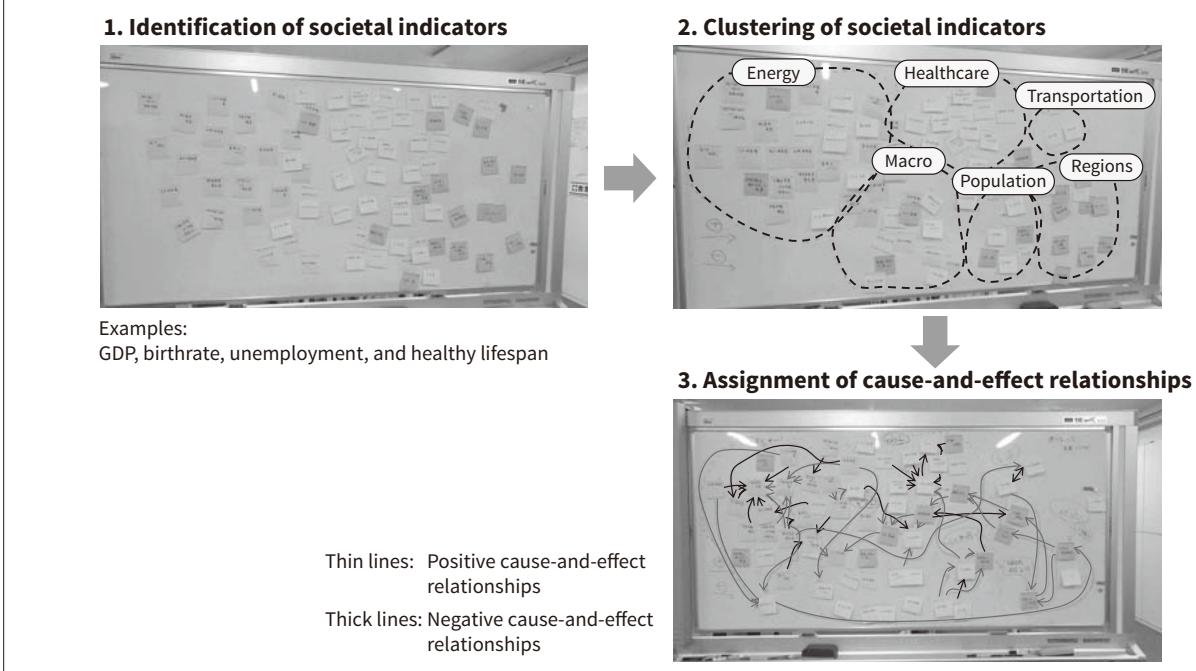


Figure 1 — Three Stages of Policy Proposal

The policy proposal process typically proceeds in three stages: (1) The information gathering stage (defining the problem to be solved and collecting relevant information), (2) The options consideration stage (enumerating the scenarios and investigating relationships between them and relevant factors), and (3) The strategy selection stage (examining the different scenarios and formulating policy proposals). The work described in this article involved people and AI producing policies collaboratively, with people undertaking the first and last stages and AI used for the intermediate stage.

Figure 2 — Identification of Relevant Cause and Effect Relationships in Society

Experts were first invited to a workshop where they listed up the societal indicators that express what is going on in society. Next, clustering analysis was used to eliminate duplicates and to consolidate any overlapping indicators. Finally, the cause and effect relationships between the indicators were assigned.



societal indicators that express what matters to present day and future society, namely such parameters as gross domestic product (GDP), birthrate, unemployment, and healthy lifespan. After an initial clustering analysis of these indicators to consolidate those that overlap, relationships of cause and effect between the indicators were assigned (see **Figure 2**). Because the resulting cause-and-effect model is subject to so much uncertainty, especially when used to predict the distant future, uncertainty was included as a parameter in the developed model. This was done by including parameters for the strength and time lag of each cause-and-effect relationship as well as meta-parameters representing the variability of these. The result was the quantitative model of cause and effect shown in **Figure 3**. The model contains 149 societal indicators and 333 cause-and-effect relationships, with thin lines representing positive relationships and thick lines representing negative relationships.

3. 2
Options Consideration Stage

Options consideration uses the cause-and-effect model produced in the information gathering stage to run AI simulations of the dynamics of change. The 149 societal indicators evolve over time in mutually interacting ways, giving rise to a large number of future scenarios depending on the degree of variability represented by their meta-parameters. In other words, the process generates parallel worlds that depict the different branching futures for Japan. Over the 35-year time period from 2018 to 2052, the number of these diverging future scenarios totaled around 20,000. **Figure 4** shows 23 typical scenarios. The AI technique developed for this work has the following features.

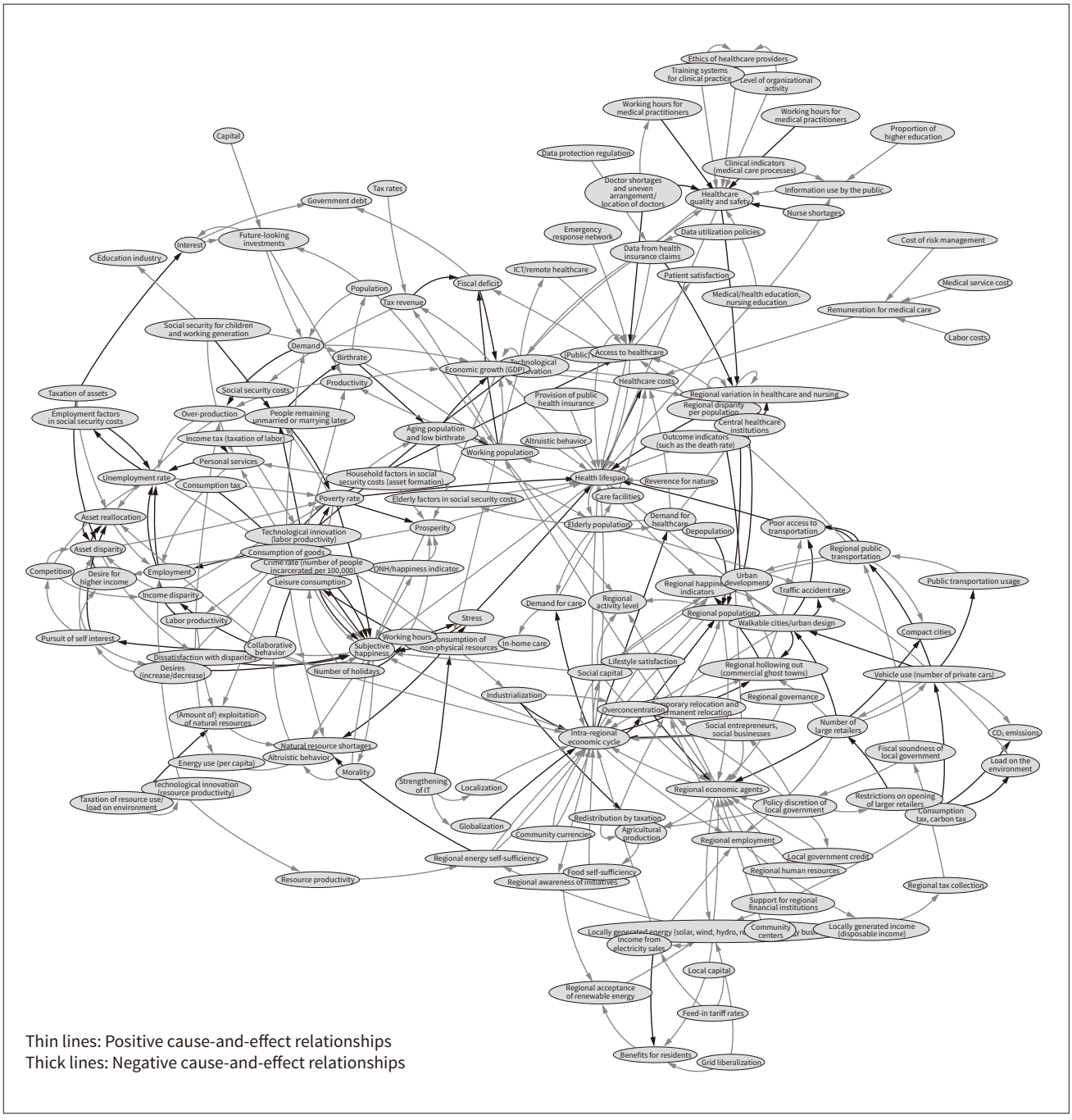
(1) Identification and enumeration of diverse future scenarios

This uses random numbers to run probabilistic simulations based on the cause-and-effect model to generate a diversity of possible futures and a large number of scenarios for how they come about. Clustering analysis is then used to automatically classify these scenarios and select representative examples. The result is to enumerate a diverse range of future scenarios without omissions or bias.

(2) Analysis of scenario divergence to determine the order and timing of the different scenarios branching off from one another

Figure 3 — Cause-and-effect Model

A cause-and-effect model was created by graphing the cause-and-effect relationships between the societal indicators. The resulting model is a "macro model" that applies to Japan as a whole, with 149 societal indicators and 333 cause-and-effect relationships.



The representative scenarios are next subjected to back casting analysis in which random numbers are injected into the simulation as it is run backwards in time from the future to determine the branching structure of the scenarios (where branches occur). This provides information on when and in what order the various scenarios branch off from one another.

(3) Sensitivity analysis to identify what causes scenarios to branch off from one another

The societal indicators that cause scenarios to branch are identified by using sensitivity analysis to determine how much the probability of each scenario is changed by small variations in the parameters at branch points. Knowledge of which societal indicators to focus on to control scenario branching enables specific policies to be proposed that will guide Japan toward a desirable scenario.

Figure 4 — Representative Scenarios

A graph was used to show how the various future scenarios branch off from each other, starting from 2018. Two key branch points are the one in eight to ten years (branch point A), beyond which the highly urbanized and regionally decentralized scenarios no longer intersect, and another in 17 to 20 years (branch point B) where scenarios that are fiscally and environmentally unsustainable split off from the regionally decentralized scenarios.

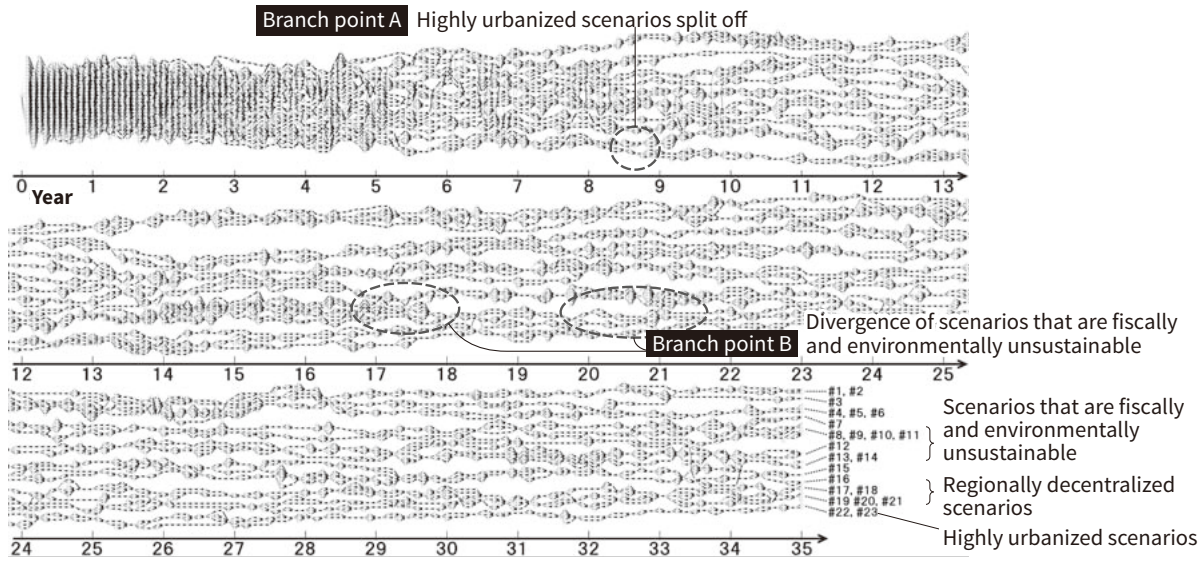


Table 1 — Results of Interpreting Scenarios

The different groups of scenarios in 2052 were evaluated in terms of eight of the societal indicators, namely population, fiscal position, regions, and environment and resources, employment, disparity, health, and happiness. Indicators that have improved or deteriorated relative to 2018 are indicated by up and down arrows (↑ and ↓) respectively, and those that are largely unchanged by a bar (—).

Scenario group	Population	Fiscal position	Regions	Environment and resources	Employment	Disparity	Health	Happiness	Interpretation
1	↑	—	↑	—	—	↑	—	↑	Delivers regional revitalization and is sustainable, but subject to risks regarding fiscal sustainability
2	—	—	—	—	—	—	—	—	Poor sustainability, low satisfaction
3	↑	—	—	—	—	↑	—	—	Sustainable in terms of population but low satisfaction
4	↑	—	↑	↓	—	↑	↑	↑	Not environmentally sustainable
5	↑	↓	↑	↑	—	↑	↑	—	Not fiscally sustainable
6	↓	↑	↓	↑	↑	↓	↓	↓	Highly urbanized, growing disparity, difficulty in sustaining population

3. 3
Strategy Selection Stage

In the final strategy selection stage, people (experts) interpret and make sense of the representative future scenarios chosen from among the scenarios produced by the options consideration stage. In this case, eight of the 149 societal indicators were chosen for analysis (see **Table 1**). These were made up of four indicators representing the performance of society (population, fiscal position, regions, and environment and resources) and four representing public satisfaction (employment, disparity, happiness, and health).

The results of the analysis, and the policy proposals based on these results, are listed below. Further details are provided in an accompanying release[(1)].

(1) The future scenarios for 2050 can be broadly grouped into those that are highly urbanized and those that offer a more decentralized future.

(2) The choice between an urbanized or decentralized future needs to be made within eight to 10 years and the necessary policies implemented.

(3) Ongoing policy implementation will be needed for the next 17 to 20 years or so if a sustainable and regionally decentralized scenario is to be realized.

4. Conclusions

This article has described a methodology for addressing the large and uncertain challenge posed by the sustainability of Japanese society in the year 2050, one that both draws on the depth of knowledge and thinking of people (experts) as a basis for modeling and the ability of a machine (AI) to comprehensively enumerate future scenarios and analyze the relationships between them.

In the future, Hitachi hopes to contribute to policy-making and to prevailing thinking by gathering widespread feedback from national and local government as well as the private sector, and by using AI to generate diverse future scenarios.

References

1) Hitachi News Release, "Utilizing AI to Propose Policies for Japan's Sustainable Future," (Sep. 2017), http://www.hitachi.co.jp/New/cnews/month/2017/09/0905.html in Japanese.
2) H. Simon, "Administrative Behavior: A Study of Decision-Making Processes in Administrative Organization," New York: Free Press (1976).

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