ESRI Japan Economic Model for the Long-Term Outlook Using System Dynamics and AI

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○We simulated the future outlook of the Japan economy from now to 2100. The conclusion is summarized as bellow.

○The total population of Japan is estimated to be 130 million(upper) to 40 million(lower) in 2100, compared to the current 120 million.

○Japan's GDP could reach $20.0 trillion(upper) to $3.0 trillion(lower) by 2100, compared to $4.4 trillion today.

○As a result of calculations, it is estimated that the well-being in Japan may be 4.0(upper) to 0.2(lower) in 2100 if the current situation is 1.0.

○With this model, we can envision a variety of future perspectives.
The key of this project is to identify the key factors that would lead us to these different visions.

○The various future visions are a large amount of information, so to speak, that has been simulated by generating 20,000 scenarios for each issue.
We let AI analyze this large amount of information. In this way, we will be able to confirm the characteristics of each of the future visions.

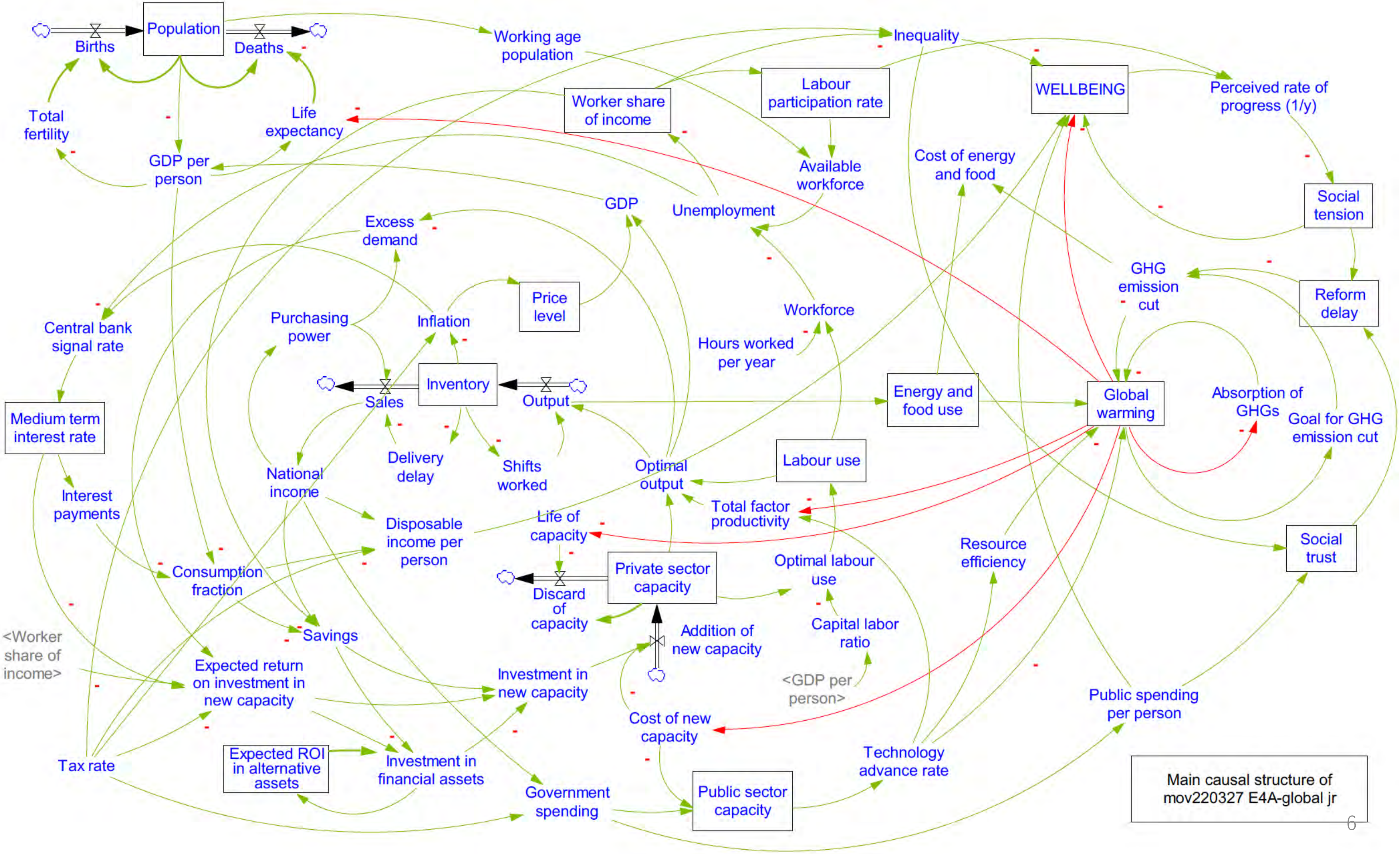
○As a result, the importance of income distribution to young people, the importance of accepting foreigners, the need to expand and domestically produce renewable energy as soon as possible, and the importance of expanding trade with the Global South are confirmed.

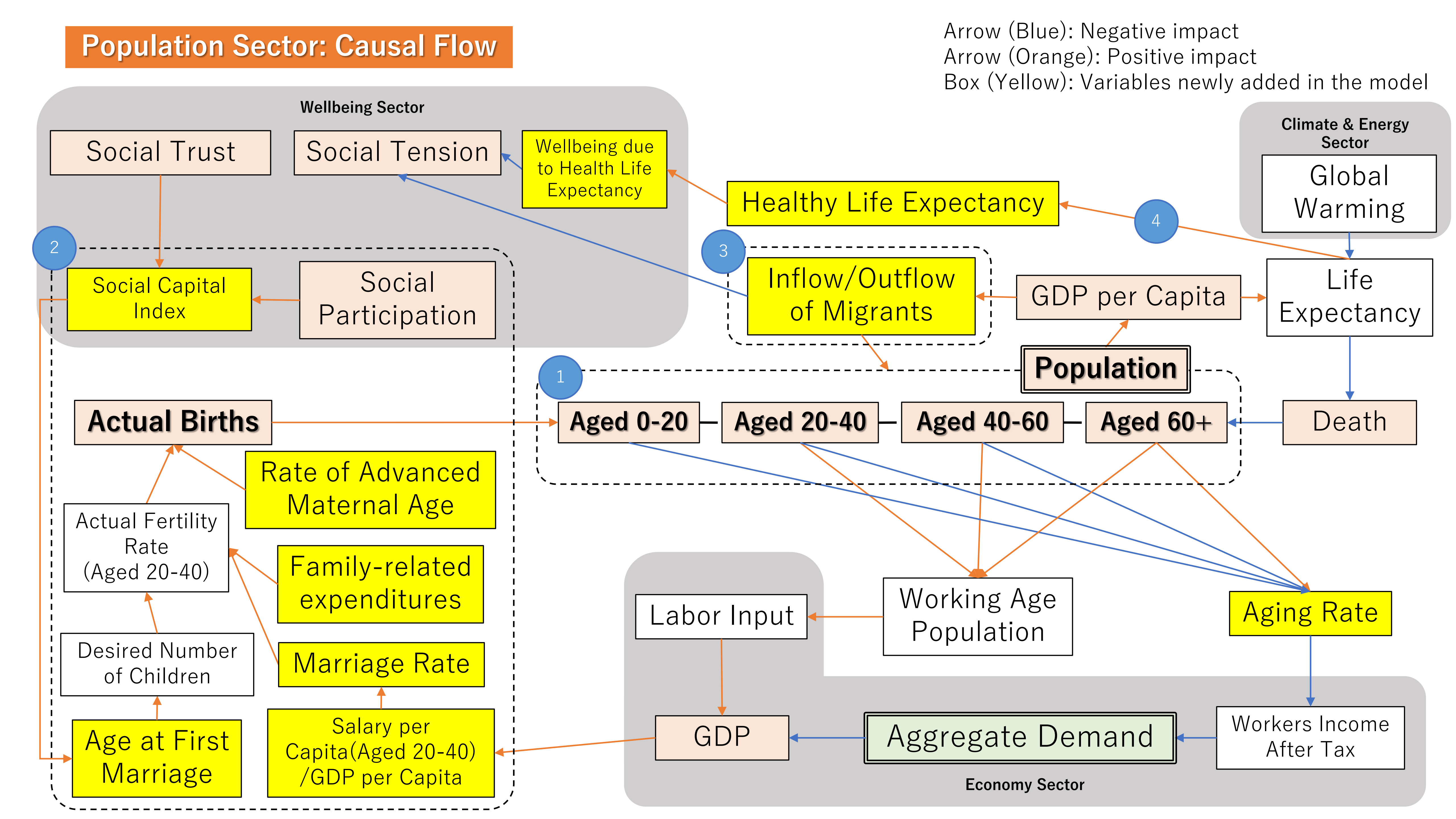
Overview of the Model

〇The model is a system dynamic AI model, based on the “Earth4All model” (global model; by the Club of Rome), modified and replaced by Japanese data to analyze Japan’s characteristic issues – low birthrate, aging population, budget deficit, friction between the US and China, etc.

〇The model consists of 11 blocks: population, production, demand, inventory, public, finance, international economy, energy and environment, labor, social issues, and wellbeing. There are 767 causal flows and 1,146 variables.

〇The model is constructed using a system dynamics approach. The coefficients that define the relationships among variables are basically calculated by regression analysis of actual values from 2000 to 2022. The equations in the model are connected with a number of feedback loops, including equations that vary linearly, vary by a logarithmic function and use delays.


Population
Births
Deaths
Total fertility
Life expectancy
GDP per person
Working age population
Inequality
Worker share of income
Labour participation rate
WELLBEING
Perceived rate of progress (1/y)
Available workforce
Cost of energy and food
Social tension
GDP
Unemployment
Excess demand
Price level
Inflation
Purchasing power
Workforce
Hours worked per year
GHG emission cut
Reform delay
Central bank signal rate
Inventory
Sales
Output
Energy and food use
Global warming
Absorption of GHGs
Goal for GHG emission cut
Medium term interest rate
Delivery delay
Shifts worked
Optimal output
Labour use
National income
Interest payments
Life of capacity
Total factor productivity
Disposable income per person
Consumption fraction
Discard of capacity
Private sector capacity
Optimal labour use
Resource efficiency
Social trust
<Worker share of income>
Savings
Addition of new capacity
Capital labor ratio
Expected return on investment in new capacity
Investment in new capacity
<GDP per person>
Public spending per person
Cost of new capacity
Tax rate
Expected ROI in alternative assets
Investment in financial assets
Technology advance rate
Government spending
Public sector capacity
Main causal structure of mov220327 E4A-global jr



Population Sector: Causal Flow
Arrow (Blue): Negative impact
Arrow (Orange): Positive impact
Box (Yellow): Variables newly added in the model
Wellbeing Sector
Social Trust
Social Tension
Wellbeing due to Health Life Expectancy
Healthy Life Expectancy
Climate & Energy Sector
Global Warming
2
Social Capital Index
Social Participation
3
Inflow/Outflow of Migrants
GDP per Capita
Life Expectancy
4
1
Population
Actual Births
Aged 0-20
Aged 20-40
Aged 40-60
Aged 60+
Death
Rate of Advanced Maternal Age
Actual Fertility Rate (Aged 20-40)
Family-related expenditures
Labor Input
Working Age Population
Aging Rate
Desired Number of Children
Marriage Rate
Age at First Marriage
Salary per Capita(Aged 20-40) /GDP per Capita
GDP
Aggregate Demand
Workers Income After Tax
Economy Sector

1 Generational transitions due to births, deaths and aging

- Population by generation (0-20, 20-40, 40-60, and 60+) is determined by population changes associated with births, deaths and aging, as well as international population movements (immigration outflows and inflows), which is newly added in the model.

$$Population\ of\ Age\ Group\ X_t = Population\ of\ Age\ Group\ X_{t-1} + Net\ Change\ by\ Aging_t + Inflow/Outflow\ of\ Migrants_t$$

$*\ Add\ Births_t\ for\ Age\ Group\ 20-$、$subtract\ Deaths_t\ for\ Age\ Group\ 60+.$

2 Fertility Rate and Desired Number of Children

- The number of **births** is determined by **(1) desired number of children** and **(2) percentage of desired number of children realized**.
- **"(1) Desired number of children"** is calculated by the **age at first marriage**, which varies according to the social capital index.
  "(2) Percentage of desired number of children realized" is calculated by **"(3) marriage rate"**, which varies with income distribution among young people, **"(4) percentage of married households achieving desired number of children"**, which varies with family-related expenditures share of GDP, and **"(5) percentage of children born out of wedlock"**.

$$Fertility\ Rate_t = ①Desired\ Number\ of\ Children_{t-1} \times ②Percentage\ of\ Desired\ Number\ of\ Children\ Realized_t$$

$$① Desired\ Number\ of\ Children_t = -0.09 \times Age\ at\ First\ Marriage_t$$
$$= -0.09 \times (-3.2 \times Social\ Capital\ Index/10)$$

$$② Percentage\ of\ Desired\ Number\ of\ Children\ Realized_t =$$
$$③Marriage\ Rate \times ④Percentage\ of\ married\ households\ achieving\ desired\ number\ of\ children_t \times ⑤Percentage\ of\ children\ born\ out\ of\ wedlock$$

$$= ③\{0.037 \times Labor\ Share\ of\ Young\ People + (-1.28) \times Employment\ Rate\ of\ Age\ Group\ 20-40\}$$
$$\times ④\{20.5 \times Family-related\ Expenditures\ Share\ of\ GDP\} \times ⑤Percentage\ of\ children\ born\ out\ of\ wedlock$$

3 Changes in the number of foreign residents in Japan

- (**Net**) **inflow of foreign residents** are calculated based on the past relationship between GDP per capita and the number of inflow and outflow. Age structure is assumed to be constant, and inflow of foreign residents is distributed to each age group based on the age structure of 2022.

- $Net\ Inflow\ of\ Foreign\ Residents_t \quad *\ Stops\ increasing\ when\ GDP\ per\ capita\ reaches\ 7{,}000USD$

$$= Net\ Inflow\ from\ Low/Middle\ Income\ Countries_{2022}$$
$$+ \left(GDP\ per\ Capita\ of\ Low/Middle\ Income\ Countries_t - GDP\ per\ Capita\ of\ Low/Middle\ Income\ Countries_{2022}\right)$$
$$\times 1.15$$

4 Impact of changes in healthy life expectancy on wellbeing

- Added a path where **global warming**, etc. drives down **life expectancy**, which drives down **healthy life expectancy**.
- For additional wellbeing indicator, ratio of healthy citizens to the entire population (calculated by **life expectancy**) is adopted.

$$Life\ Expectancy_t = 76 \times 0.839 \times e^{(-0.025\times(GDP\ per\ Capita_t - GDP\ per\ Capita_{1980}))}$$
$$\times Effect\ of\ Global\ Warming_t \times Effect\ of\ Family-related\ Expenditures_t - 1.1$$

$$Healthy\ Life\ Expectancy_t = Ratio\ of\ Healthy\ Life\ Expectancy\ per\ Life\ Expectancy_t \times Life\ Expectancy_t$$

$$Wellbeing\ due\ to\ Healthy\ Life\ Expectancy_t$$
$$= 1 - \left(Population\ over\ 60_t \times \frac{Life\ Expectancy_t - Healthy\ Life\ Expectancy_t}{Healthy\ Life\ Expectancy_t - 60}\right) / Population_t$$

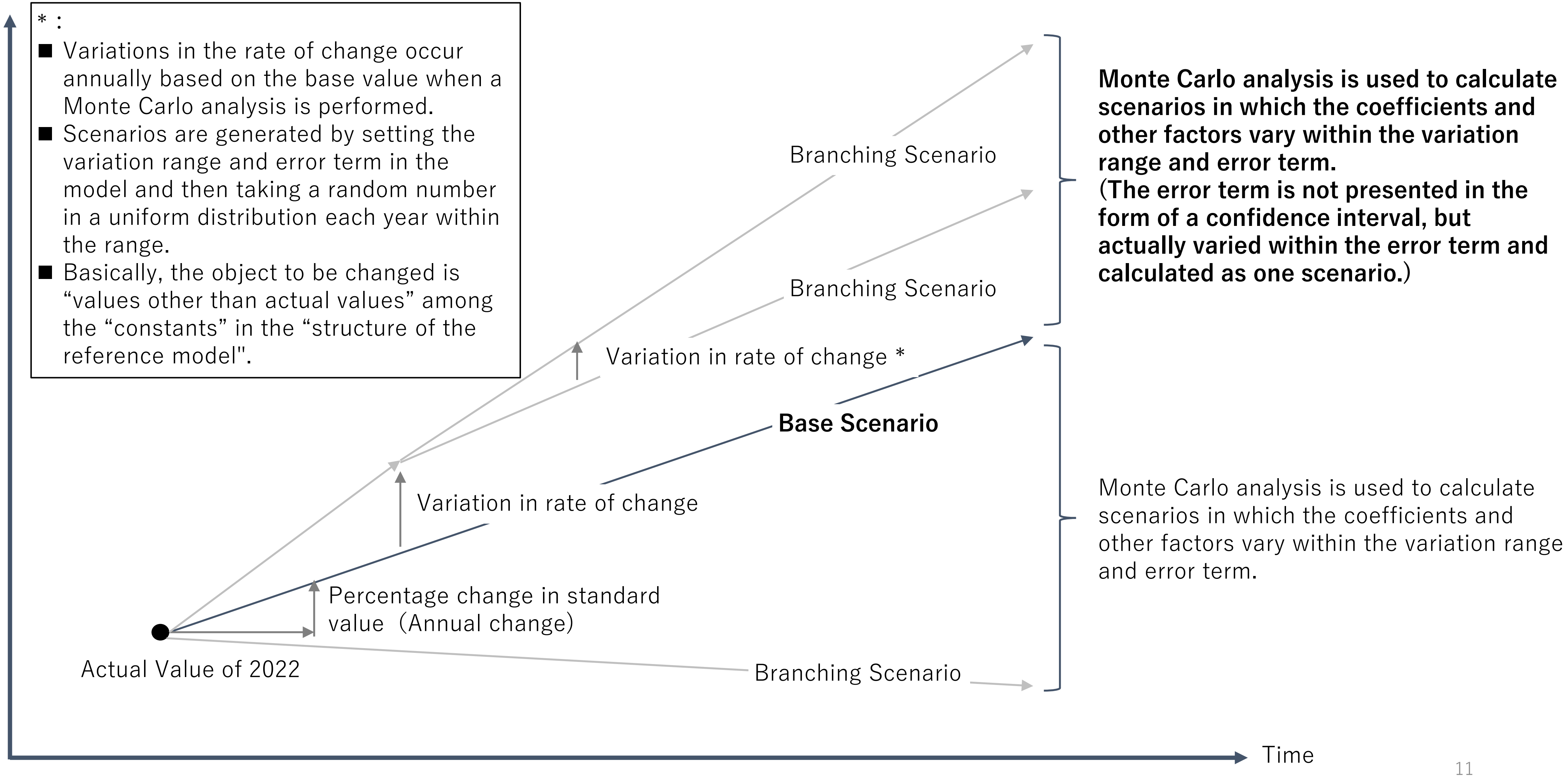
〇Using Monte Carlo methods, all variables affecting the primary outcome are shaken (including zero shaking range. Most of them oscillate within upper and lower bounds. Some are completely random) and a wide range of scenarios is generated (20,000).

〇For Population analysis, variables affecting population and GDP per capita are variable.
For environmental analysis, variables affecting the amount of CO2 and carbon capture are variable.
For international economic analysis, variables affecting economic growth and export volumes are variable.

〇Group 20,000 results into several groups by K-means method.

〇The AI's work process then takes on the task of deciphering the key factors that characterize each group.

The variation range of coefficients and error terms are calculated as a wide range of scenarios by changing values within a set range in a Monte Carlo simulation, which starts from a reference value.

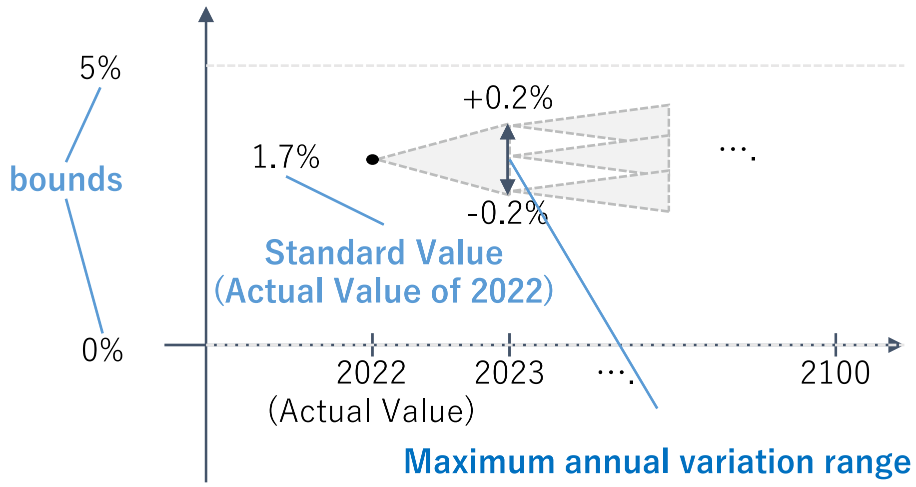


Using the Monte Carlo method, all parameters affecting the objective variable are varied within upper and lower bounds to obtain 20,000 possible combinations (simulation results).

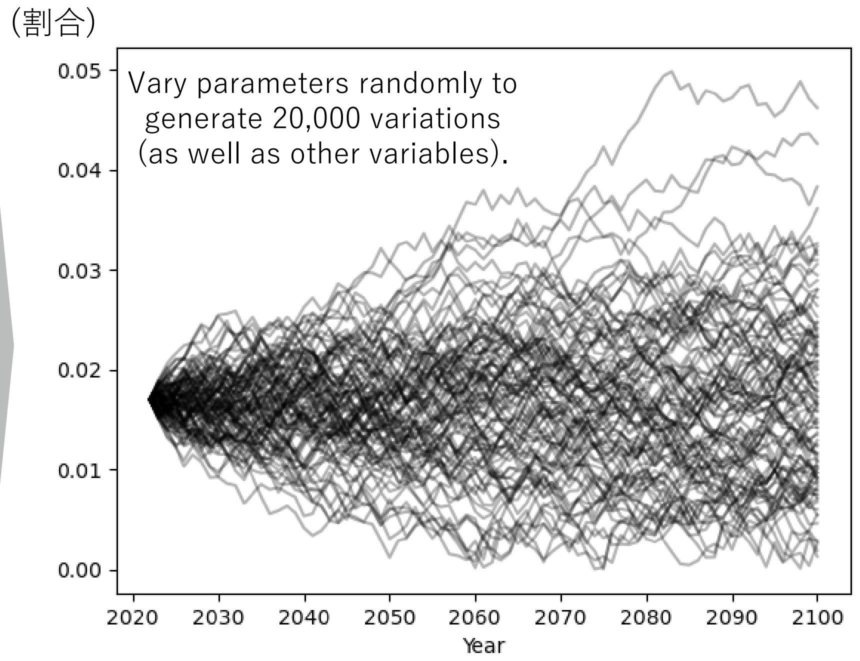
Method

- Random annual variation of all parameters affecting the objective variable within a pre-determined **upper and lower limit** within a **maximum annual variation range**.

e.g. Method of variation
*In case of Family-related expenditure's share of GDP



Family-related expenditure's share of GDP

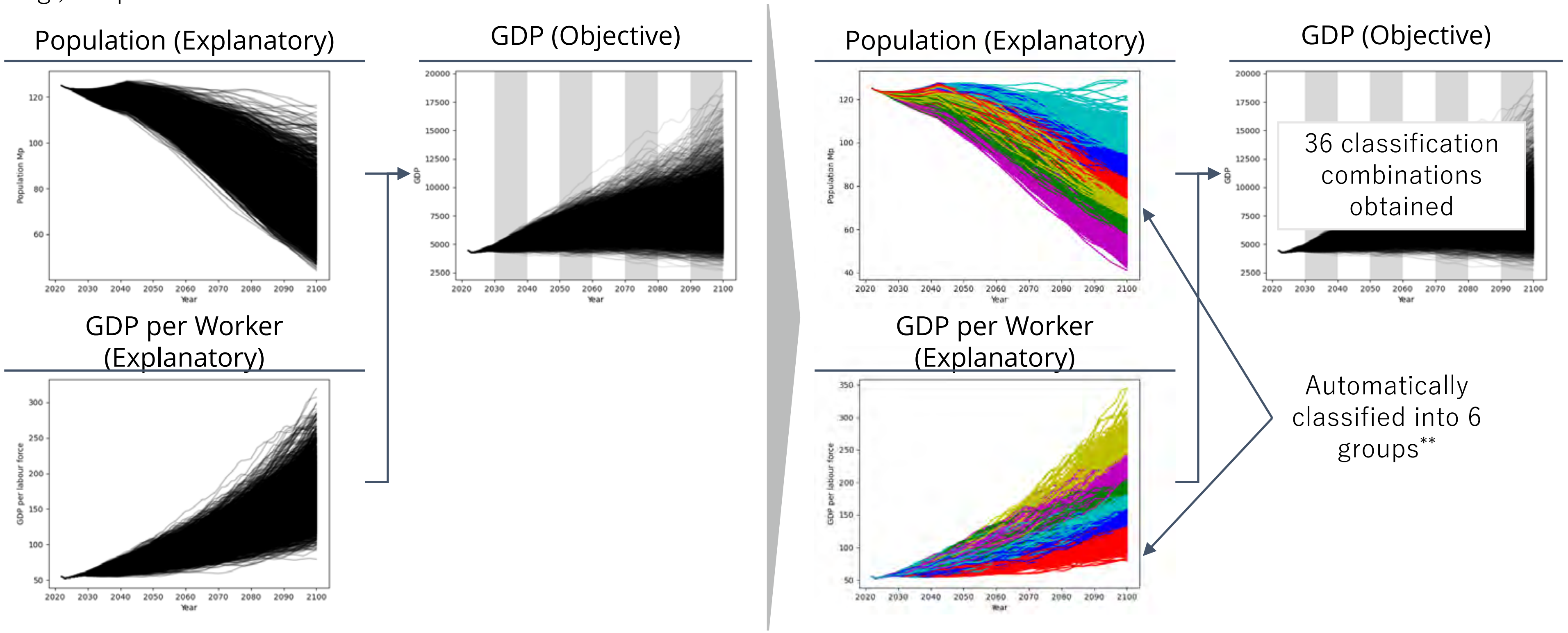


Eliminate human arbitrariness and mechanically classify explanatory variables.

Method

■ Classify time series data of explanatory variables to calculate the objective variable for each sector into groups of similar scenarios using K-means (DTW*) with reference to the degree of similarity.

e.g.) Population Sector



*: A method for measuring the similarity between two time series data. Allows for expansion and contraction along the time axis, allowing for robust comparisons against slight temporal deviations. **: For the number of classifications, the "elbow method" and actual classification results were checked, and the minimum value that was significantly classified was adopted.

Reclassification of classified results of the obtained explanatory variables by hand.

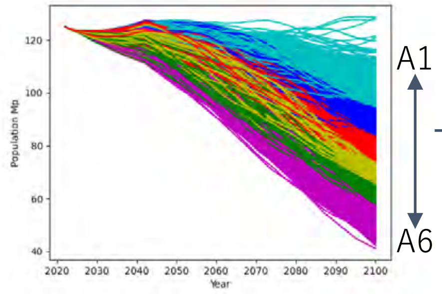
Method

- Reclassifying classified results of the obtained explanatory variables by hand, with reference to the values of 2100.

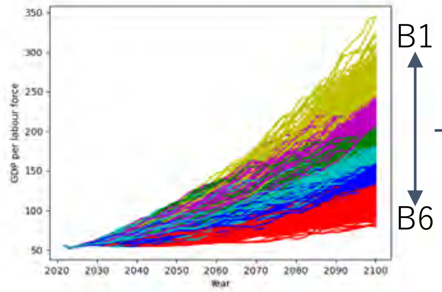
e.g.) Population Sector

Automatically classified into 6 groups**

Population (Explanatory)

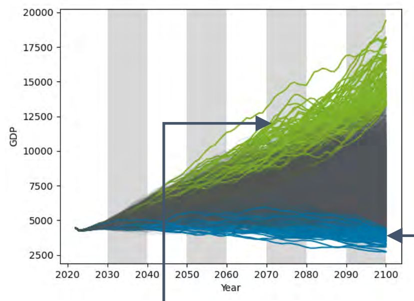


GDP per Worker (Explanatory)



GDP per worker (Compared to 2022)		Population (billion)					
		A1 >1.0	A2 >0.9	A3 >0.8	A4 >0.7	A5 >0.6	A6 >0.5
	B1 >x5	**High**	**High**	**High**	Med.	Med.	Med.
	B2 >x4	**High**	**High**	Med.	Med.	Med.	Med.
	B3 >x3.5	**High**	Med.	Med.	Med.	Med.	Med.
	B4 >x3	Med.	Med.	Med.	Med.	Med.	Med.
	B5 >x2	Med.	Med.	Med.	Med.	Med.	**Low**
	B6 <X2	Med.	Med.	Med.	Med.	Med.	**Low**

GDP (Objective)



High-level Economic Growth Scenario

Low-level Economic Growth Scenario

Check the transition of explanatory variables (percentiles*) in each scenario group to identify the points and factors that diverge to other scenario groups.

Method

- Check the transition (percentiles) of the explanatory variables for each scenario group.
  - Using 5%, 50%, and 95% percentile (p5, p50, p95).
- Identifies points (calculated within a certain range) and branching factors that lead to other scenario groups.

e.g.) Population Factor *Group A3 (0.80-0.90 billion in 2100) and A4 (70-80 million in 2100)

Identify points and factors by tracing back explanatory variables.

Age at First Marriage

Division point exists

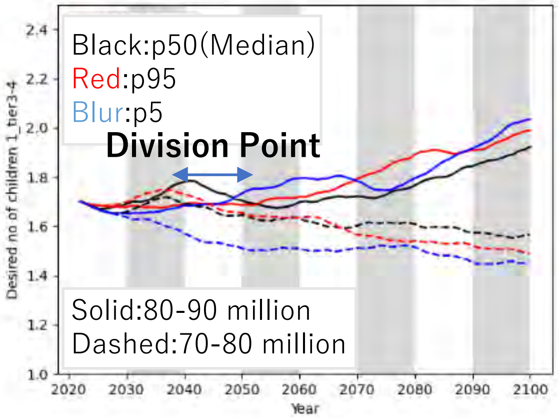
Social Trust

Division point exists

Social Participation

Division point does not exist

Desired number of children (Division factor)



Percentage of desired number of children achieved

Division point does not exist

Fertility Rate

Division point exists

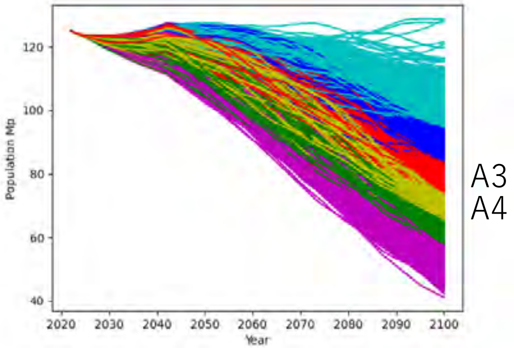
Life Expectancy

Division point does not exist

Foreign residents

Division point does not exist

Population



【Required Information】
Division point of A3,A4 is year 20XX, division factor is XXX

⋮

*： X percentile refers to the value that is in the Xth percentile of the total when the data are sorted in decreasing order, counting from the beginning.

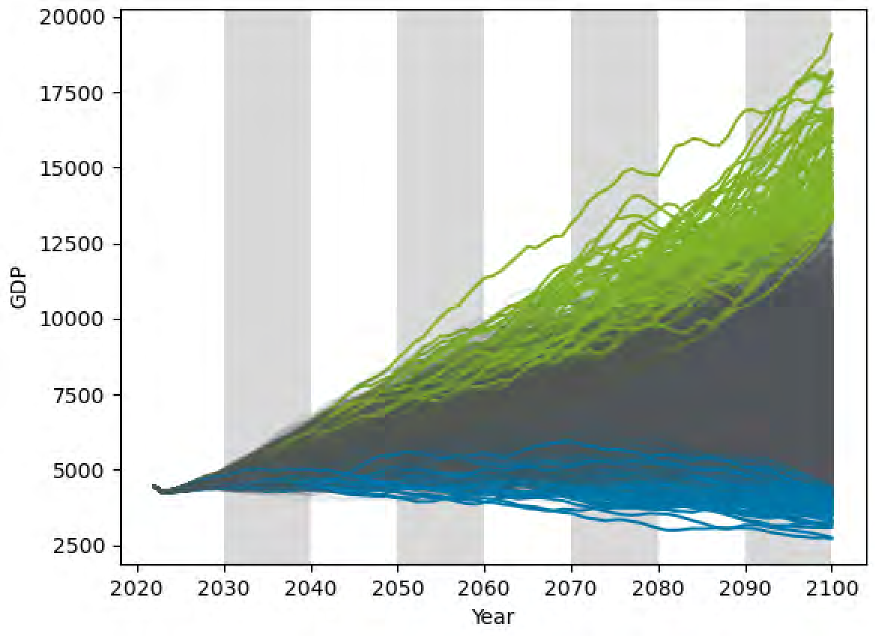
Population

Mechanically classified the results of 20,000 different simulations on GDP.

② Mechanically classify scenarios using K-means

- Explanatory variables of "GDP" such as "population" and "GDP per worker" are mechanically classified by K-means.
- Based on the results, classified GDP into high/low economic growth scenarios

GDP



A **High-level Economic Growth Scenario**

GDP: More than 3 times higher than 2022 at 2100

A growth scenario that is comparable to the future GDP growth multiples of OECD countries. Two patterns exist.

- **A-1. Slight decline in population but increase in GDP**
- **A-2. Population decline but increase in GDP**

B **Low-level Economic Growth Scenario**

GDP: Less than 2022 at 2100

A scenario in which GDP stagnates or declines, which could occur if various indicators decline to a certain level due to irregular events such as contingencies or natural disasters.

GDP will increase by accepting a certain number of foreign residents, maintaining the birth rate, and promoting technological development and capital investment on a large scale.

	GDP (USD)	Population	Life Expectancy	Fertility Rate	Foreign residents	GDP per worker (USD)	Investment in technology (USD)	Investment in capital (USD)
2022	• 4,4trl.	• 124 million	• 84	• 1.24	• 3mil.	• 54,000	• 275bil.	• 123bil.
					Rapid Increase			
2040					• **8mil.**		1.3% increase (annually)	2.6% increase (annually)
2050	• 5,0-8,0trl.	• 110-120mil.	• 86-88	• **1.1-1.4**	• **10-12mil.**	• 60,000-100,000	• **400bil. (annually)**	• **250bil. (annually)**
2060							1.8-4.1% increase (annually)	1.8-3.6% increase (annually)
2100	• 12.0-16.0trl.	• 110-120mil.	• 92-94	• **1.1-1.3**	• **7-14mil.**	• 170,000-250,000	• **1,000-3,000bil. (annually)/ 44,400bil. (total)**	• **600-1,500bil. (annually)/ 265,00bil. (total)**

<Japan in 2100>

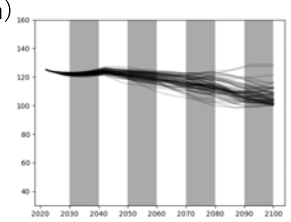
■ GDP：**3 times higher** than 2022

■ Population: more than **100 million**

■ GDP per worker: **3.5 times higher** than 2022

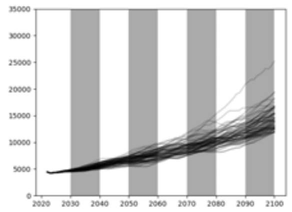
Population

(million)



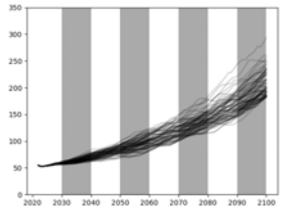
GDP

(billion)



GDP per worker

(thousand)



Fertility rate can be maintained by increasing marriage rates and desired number of children.

	Fertility Rate	Marriage Rate	Labor share among young people	Desired no of children	Age at First Marriage	Social Participation	Social trust	Desired no of children achieved	Family-related expenditure (share of GDP)
2022	1.24	74%	11%	1.7	30	0.37	0.34	0.92	1.7%
2040			11-12%						
2050	**1.1-1.4**	**70-75%**		**1.5-1.7**	**31**	**0.28-0.32**	0.30-0.38	1.0-1.2	3.0%
2060			10%						
2100	**1.1-1.3**	**75-85%**	12-13%	**1.4-1.8**	**30**	**0.32-0.36**	0.30-0.38	1.0-1.4	2.0-3.5%

GDP per capita growth is lower than G20 and purchasing power is lower, but disposable income is growing and wellbeing is increasing.

	Well-being (derive from purchasing power (compared to foreign countries))	GDP per capita (Japan, USD)	Well-being (derive from Health life expectancy)	Healthy life expectancy	Well-being (derive from disposable income)	Disposable income (USD)
2022	1	35,000	1	74	1	11,000
2050	0.75-0.8	55,000	0.92-1.035	70-77	1.5	15,000-18,000
2100	0.6-0.7	110,000-130,000	0.88-1.12	70-85	3.25-3.75	35,000-40,000

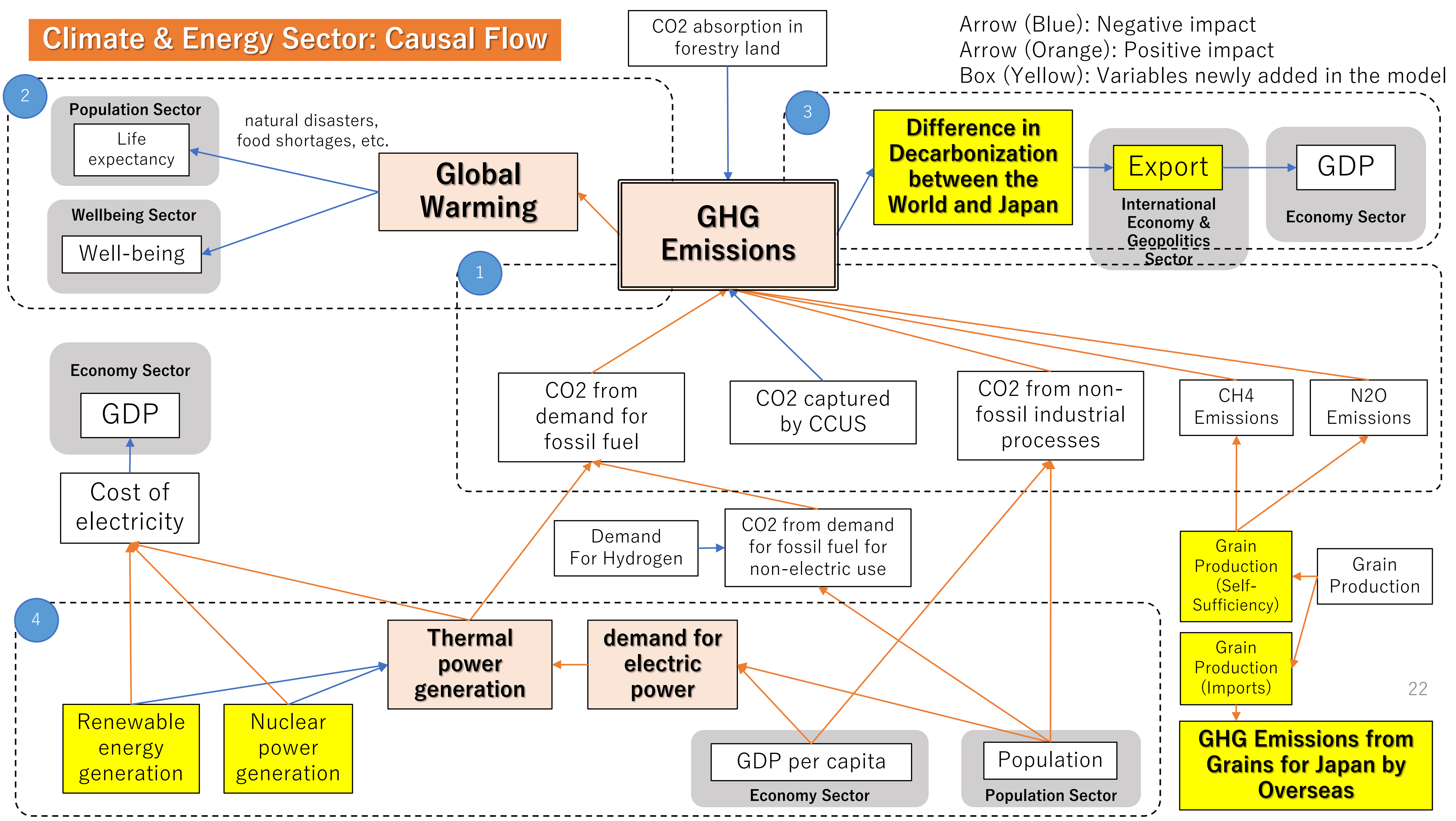
<Japan in 2100>

■ Well-being

- ➢ **Deriving from purchasing power: decreasing**
- ➢ **Deriving from Health life expectancy: level off**
- ➢ **Deriving from disposable income: Significantly improved**

Climate & Energy

Climate & Energy Sector: Causal Flow



1 Greenhouse gas (GHG) emissions are determined by CO2, N2O, and CH4 emissions

■ GHG emissions are calculated as the sum of CO2 emissions (from fossil/non-fossil fuels), N2O emissions and CH4 emissions. CO2 emissions from fossil fuels are composed of those from thermal power generation and others.

$$\boldsymbol{GHG\ emissions_t} = \text{CO2}\ \boldsymbol{emissions\ (from\ fossil\ fuels)_t} + \text{CO2}\ \boldsymbol{emissions\ (from\ non-fossil\ fuels)_t} + \boldsymbol{N2O\ emission_t} + \boldsymbol{CH4\ emission_t}$$

$$\text{CO2}\ \boldsymbol{emissions\ (from\ fossil\ fuels)_t} = \text{CO2}\ \boldsymbol{emissions\ (from\ thrmal\ power\ generation)_t} + \boldsymbol{CO2\ emissions\ from\ demand\ for\ fossil\ fuel\ for\ non-electric\ use\ _t} + \boldsymbol{CO2\ captured\ by\ CCUS\ _t}$$

2 Global Warming through GHG emissions lowers the Well-being and the Life Expectancy

$$\boldsymbol{Well-being_t = a.\cdot\cdot\cdot_t - b.Global\ Warming_t + c.\cdot\cdot\cdot_t + d.\cdot\cdot\cdot_t + \cdot\cdot\cdot}$$

$$\boldsymbol{Life\ Expectancy_t = \cdot\cdot\cdot_t - Impact\ of\ Global\ Warming\ on\ life\ expectancy_t + \cdot\cdot\cdot}$$

3 Delays in promoting decarbonization lower Exports and GDP

- If the gap in decarbonization efforts between Japan and the rest of the world widens, **Exports** could decrease by up to 3%, and **GDP** would also decline.

$$\boldsymbol{Export_t = Export_{t-1} - Difference\ in\ decarbonization\ between\ the\ World\ and\ Japan_{\ t} - U.S./China\ Decoupling\ effect\ on\ Export_t + Fluctuations\ in\ exports\ for\ the\ Global\ South_{\ t}}$$

4 "Energy Mix" fluctuates the amount of thermal power generation and energy costs

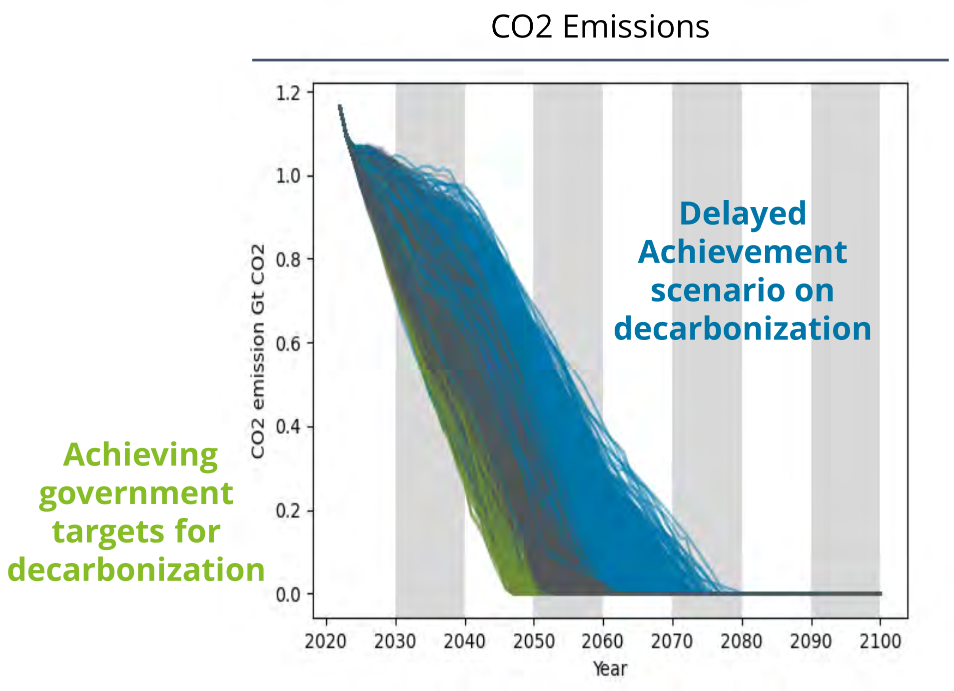
- The **CO2 emissions (from thermal power generation)** increase as the **thermal power generation** increase.
- The **Thermal power generation** is calculated from the **demand for electric power**, which varies with the population and the GDP per capita, minus the **renewable energy generation** and the **nuclear power generation**.

$$\boldsymbol{Thermal\ power\ generation_{\ t} = Demand\ for\ electric\ power_{\ t} - Renewable\ energy\ generation_{\ t} - Nuclear\ power\ generation_t}$$

- The **Electricity costs** fluctuate through **thermal, renewable, and nuclear power generation**, and the **Electricity costs** affect **GDP**.

Classified the results of 20,000 different simulations of CO_2 emissions

■ CO_2 emissions are classified into the scenario of "**Achieving government targets for decarbonization**"/ "**Delayed Achievement scenario on decarbonization**".

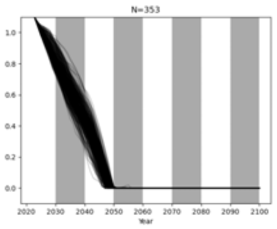


Ⓐ Achieving government targets for decarbonization	**Decarbonization achieved by 2050** A scenario in which carbon neutrality is achieved and overall greenhouse gas emissions are reduced to zero by 2050, the target set by the government.
Ⓑ Delayed Achievement scenario on decarbonization	**Decarbonization is achieved after 2061** A scenario in which decarbonization occurs after 2061, well behind government targets.

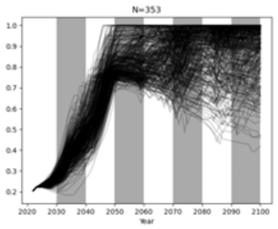
Decarbonization can be achieved by 2050 by increasing the ratio of low-carbon energy and the proportion of electrification, and by absorbing a certain amount of CO2 through CCUS

	CO2 Emissions	From the electricity demand	From the non-electricity demand	From non-fossil industrial processes	Captured by CCUS	Proportion of electrification (Starting from 2022)	Renewable energy ratio
2022年	1.16 Gt	0.36 Gt	0.78 Gt	0.06 Gt	0.0006 Gt	0%	20%
2050年	**0 Gt**	**Almost zero (less than 0.05 Gt)**	**Less than 0.15 Gt**	**0.05 Gt approx.**	**0.1 Gt or more**	**60% or more**	**70% or more**
2100年	0 Gt	0 Gt	0-0.1 Gt	0.03-0.05 Gt	0.15 Gt	70%	60-100%

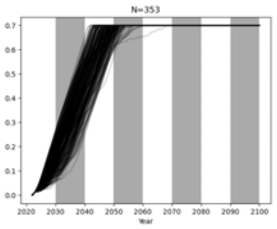
CO2 Emissions



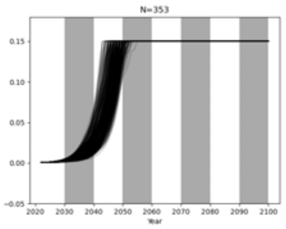
Renewable energy ratio



Proportion of electrification



CO2 captured by CCUS

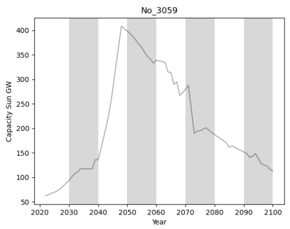


In most of the scenarios for achieving government targets for decarbonization, the share of renewable energy will increase, mainly solar (household) and offshore wind power.

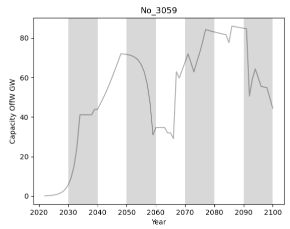
	Solar power generation capacity (Business)	Solar power generation capacity (Household)	Biomass power generation capacity	Offshore Wind power generation Capacity	Onshore wind power generation capacity	Hydroelectric power generation capacity
2022年	62.2 GW	7 GW	6.9 GW	0.09 GW	4.61 GW	44.7 GW
	Approx. 4-fold increase			Approximately 700-fold increase		
2050年	**399 GW**	**45.9 GW**	**32.5 GW**	**71.6 GW**	**9.86 GW**	**44.8 GW**
2100年	130 GW	14 GW	12 GW	45 GW	3.5 GW	45 GW

Power generation capacity is declining due to population decline and energy efficiency improvements

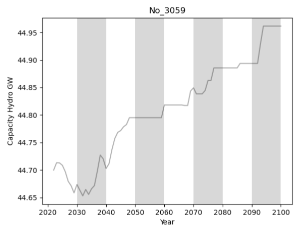
Solar power generation capacity (Business)



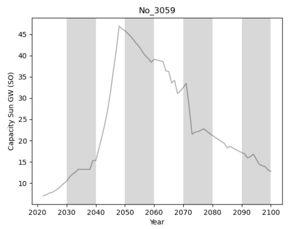
Offshore Wind power generation Capacity



Biomass power generation capacity

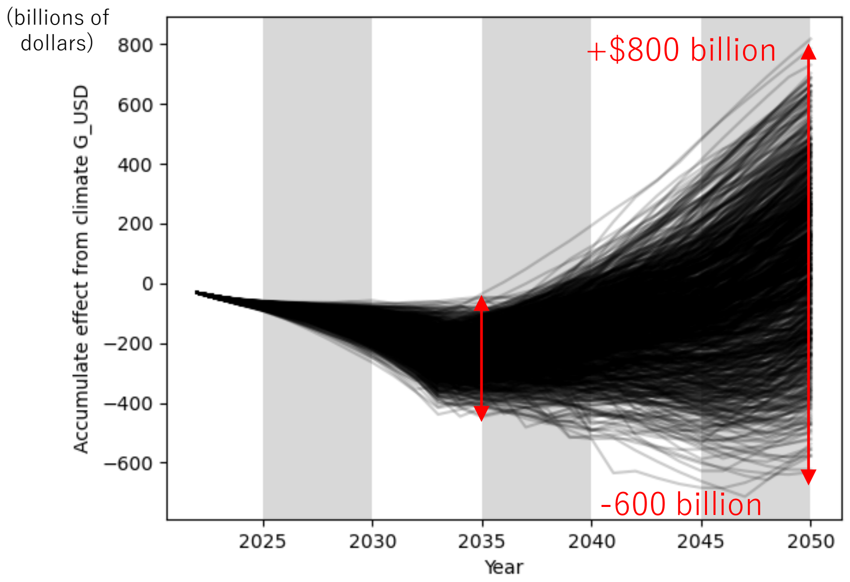


Solar power generation capacity (Business)



While achieving government targets on decarbonization requires allowing for negative short-term impacts on GDP, there are a number of scenarios with a cumulative positive impact on GDP as of 2050

Cumulative impact on GDP from renewable energy deployment and energy costs*.



■ What can be said from the simulation

- ➢ To achieve government targets on decarbonization, a certain amount of negative GDP impact (up to a cumulative maximum of about **-$400 billion** in 2035) must be allowed for.
- ➢ The cumulative GDP impact from the environmental domain will be in the range of **-$600~+800 billion** in 2050.

■ Background of the simulation

- ➢ When introducing renewable energy, a high domestic procurement rate will have a positive impact on GDP, vice versa.
- ➢ A 10% increase in energy costs will decrease GDP by 0.15%**, whereas a decrease in energy costs will increase economic activity and positively affect GDP.

* : It shows the entire scenario, not just "scenarios for achieving government targets on decarbonization."
** : [How energy prices shape OECD economic growth: Panel evidence from multiple decades - ScienceDirect]

It is important to push down energy costs and reduce the amount of energy while continuously investing in renewable energy-related facilities.

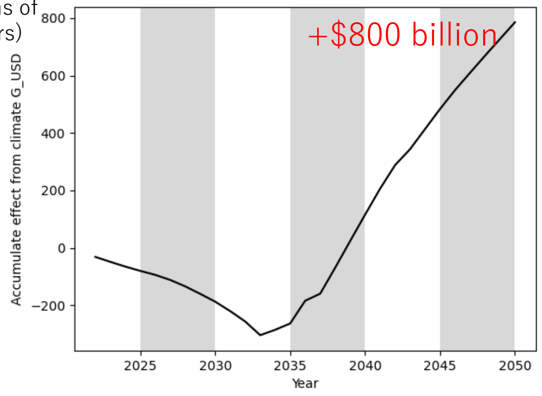
【Results】

■ Cumulative impact of renewable energy deployment and energy costs on GDP will start to rise after 2035, reaching **+$800 billion** by 2050

- ➢ CAPEX of renewable energy will increase to more than **$40 billion per year** between 2030 and 2045.
- ➢ GDP impact from energy costs turns upward after 2035-2040, reaching **$30 billion** in 2050.
- ➢ Energy imports are reduced to **almost zero after 2035-2040**.

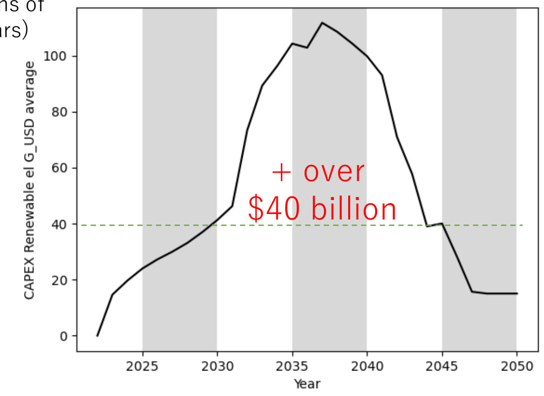
Cumulative impact on GDP from renewable energy deployment and energy costs

(billions of dollars)



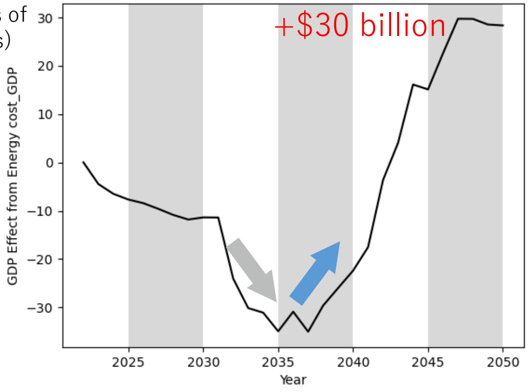
CAPEX of renewable energy (10-year average)

(billions of dollars)



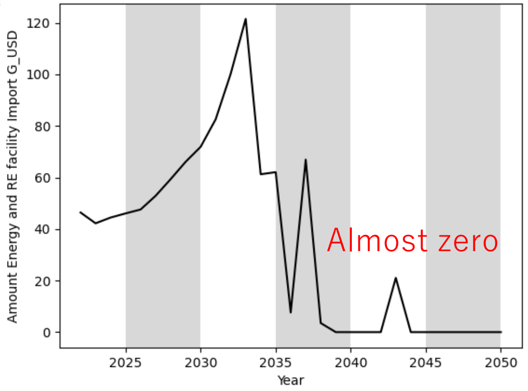
GDP Impact of Energy Costs

(billions of dollars)

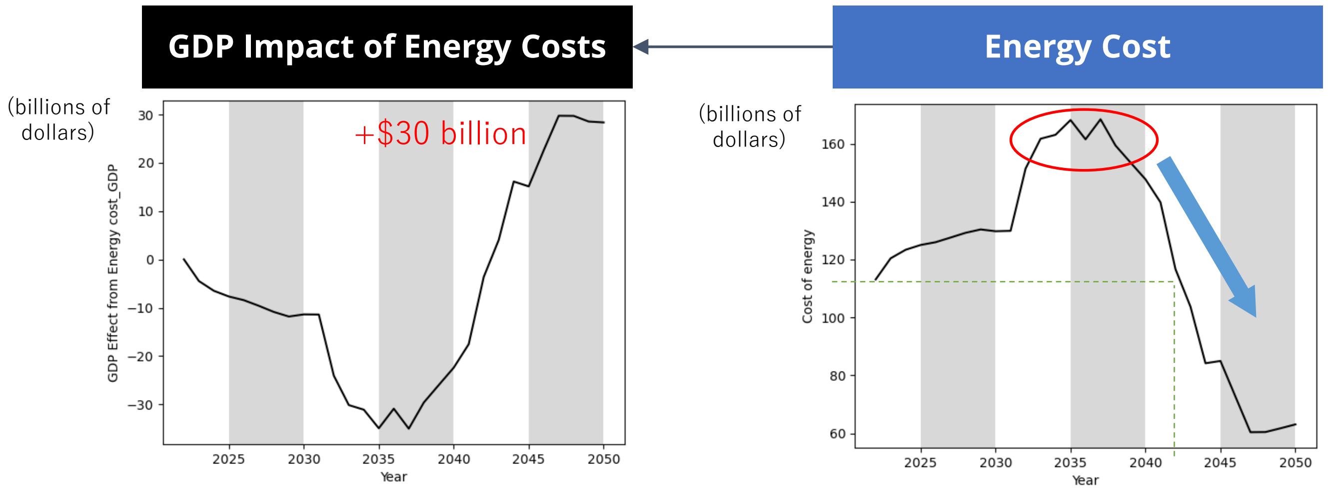


Energy imports

(billions of dollars)



How quickly energy costs rise due to the introduction of renewable energy will determine the impact on the economy (GDP).



【Results】

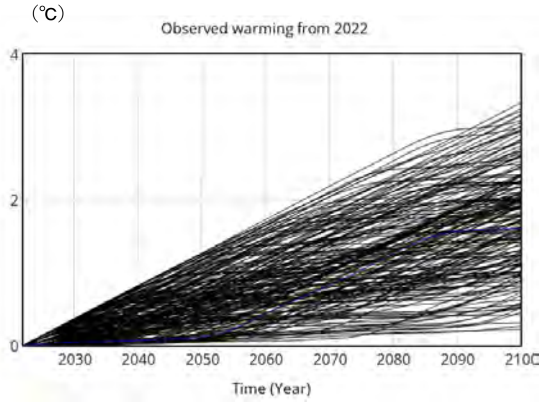
■ Energy costs peak at around **$160 billion** in 2035, when renewable energy substitution becomes more active.

■ **After 2035, the replacement with renewable energy is completed** and energy costs are pushed down, reaching the 2022 level ($113 billion) in the decade 2035-2045.

■By 2050, the Energy Costs are reduced to about $60 billion, about half of the 2022 level, with a **GDP impact of +$30 billion**.

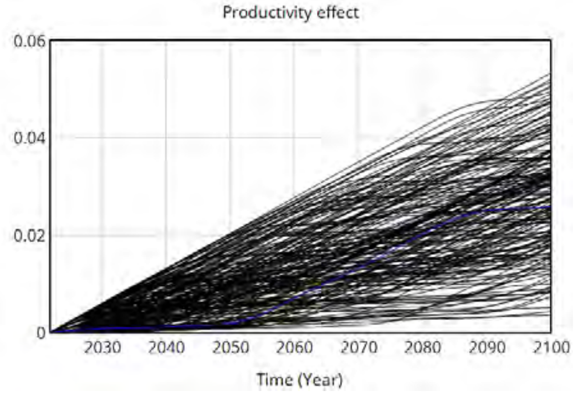
By updating function for selecting temperature scenarios, a wide range of temperature increases is calculated.

Temperature Rise from 2022
***Significant change observed**



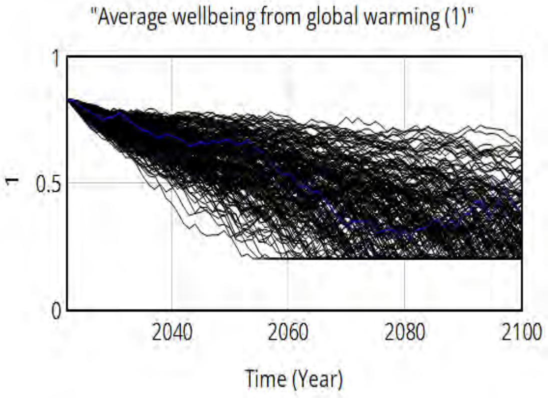
- **Temperature increase calculated in the range of +0.2~3.3 ℃.**
- **Covers most of the range shown in IPCC scenarios (+0.1~3.6 ℃ increase from 2022).**

Effect of temperature rise on productivity



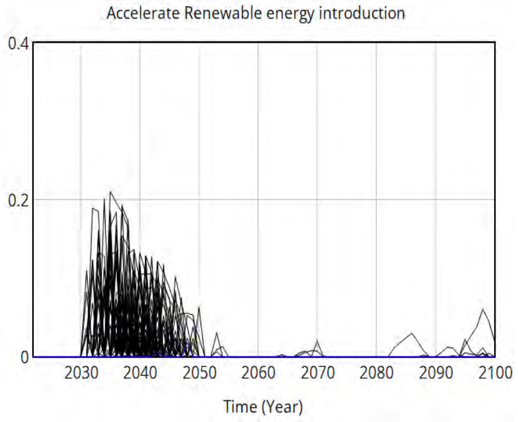
- **0.3%~5.3% decrease in labor productivity is projected.**

Change in Wellbeing due to temperature rise



- Range from 0.2 (lower limit) to approximately 0.7.

Increase in the rate of change in renewable energy introduction due to temperature rise



- Due to rising temperatures, **introduction of renewable energy facilities is accelerated by up to 20%.**

International Economy

Decoupling was modeled to occur due to relative changes in national power between the U.S. and China

Modeling method | Model Image

U.S.-China Bilateral Decoupling

- Calculating trade volume with the degree of proximity of U.S. and China's national power as explanatory variables
- The GDP forecast in purchasing power parity terms is used to calculate the degree of proximity in terms of national power.
- Cases in which trade decreases beyond a certain level are considered decoupling.

Proximity of U.S. and China's national power → US-China trade volume →

- U.S.-China partial decoupling (-1.7% per gross trade volume) ⇒Japan's exports up 1%
- U.S.-China full decoupling (-5.8% per gross trade volume) ⇒ Japan's exports up 2%

Between liberal/authoritarian camps decoupling

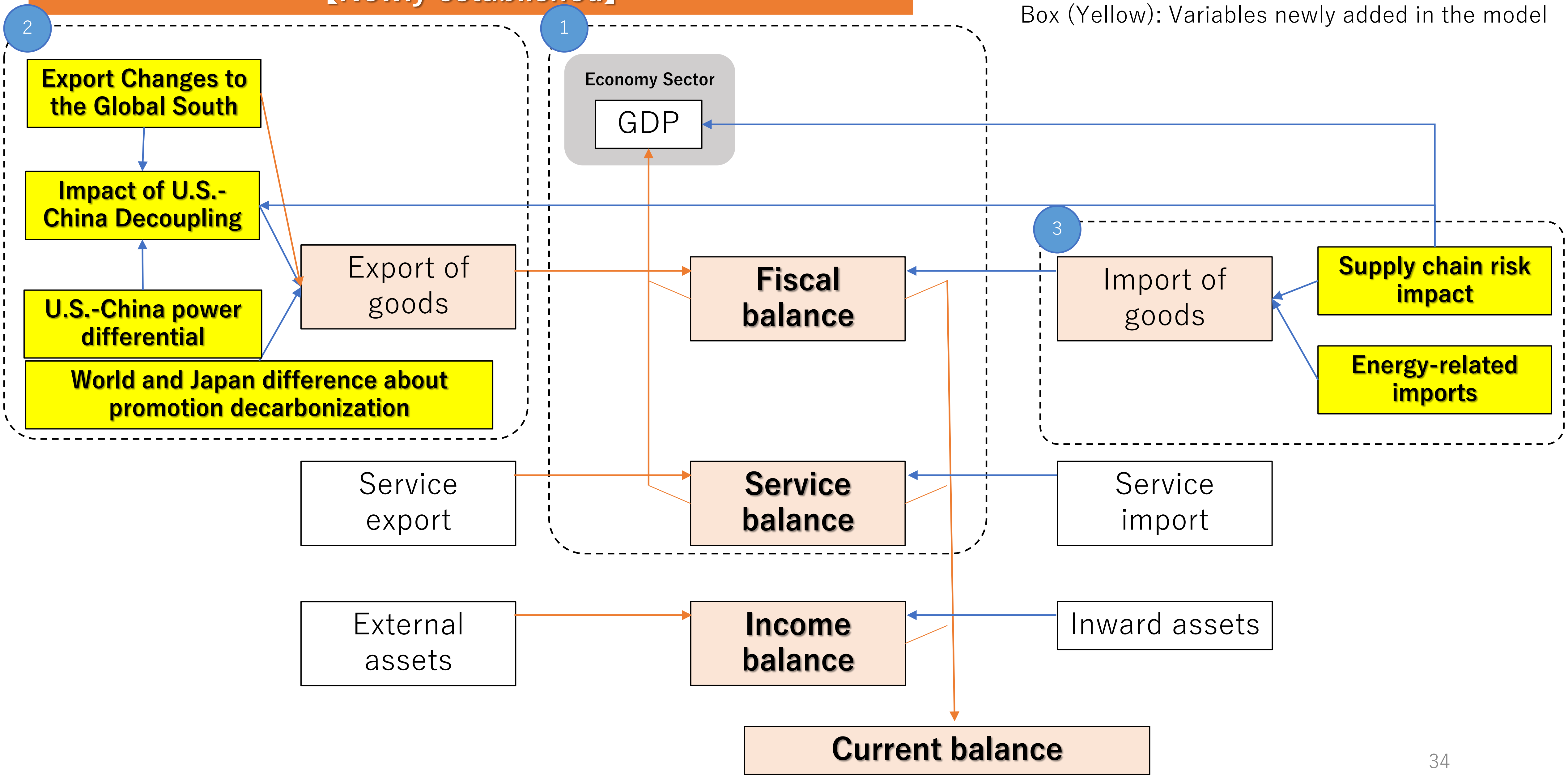
- Assumes that if bilateral decoupling occurs, Japan will be required to promptly participate
- Assumes that each decoupling occurs and then develop into inter-camp decoupling in 1 year

U.S.-China partial decoupling ⇒Japan's exports up 1.05% → After 1 year → Partial decoupling between camps ⇒Japan's export down 5%

U.S.-China full decoupling ⇒Japan's exports up 2.15% → After 1 year → Full decoupling between camps ⇒Japan's export down 15% ※Depending on the percentage of exports to the Global South.

International Economy & Geopolitics Sector: Causal Flow 【Newly established】

Arrow (Blue): Negative impact
Arrow (Orange): Positive impact
Box (Yellow): Variables newly added in the model



1 Newly establishment of an international economy and geopolitics part

■ A new pathway for changes in the **balance of goods and services** to affect GDP is added, and the **current balance** can also be calculated.

2 Factors affecting goods exports

■ **Goods exports** fluctuate due to the following factors

- ✓ Economic development of the Global South (+)
- ✓ World and Japan difference about promotion decarbonization (−)
- ✓ U.S.-China Decoupling (−)

3 Factors affecting goods imports

■ **Goods imports** vary depending on the following factors

- ✓ Supply chain risk manifestation (−)
- ✓ Increase in energy-related imports (+)

4 Decoupling impact varies depending on the U.S.-China power differential and the share of exports to the Global South

■ **The difference in GDP in purchasing power parity terms between the U.S. and China changes the volume of China's export to the U.S.**

Decoupling is judged to have occurred when the rate of decrease exceeds a certain level due to the same factors.

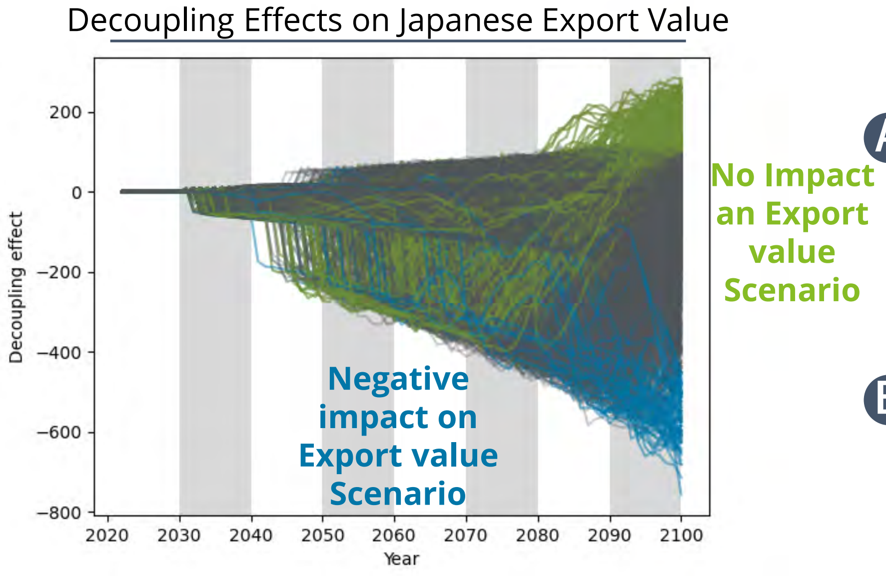
■ Impact of decoupling depends on **the ratio of exports to the Global South**

$$\underset{in\ China's\ exports\ to\ the\ US\ due\ to\ GDP\ differences\ _t}{\boldsymbol{Percentage\ change}} = -0.59 \times \left(\frac{China\ GDP_t}{U.S.GDP_t} - \frac{China\ \mathrm{GDP}_{2022}}{U.S.GDP_{2022}}\right)$$

Derive the status and bifurcation points of the no/negative impact scenario for export value due to DC* from the results of 20,000 simulation scenarios.

Derive status and bifurcation points for high/low scenarios

■Decoupling impact on Japan's export value is classified into two scenarios: "no impact on export value" scenario and "negative impact on export value" scenario.



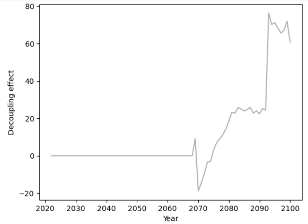
A	No impact on Export value Scenario	**<u>Decoupling has no effect on Japan's export value</u>** A scenario in which decoupling occurs between the U.S. and China or between the liberal and authoritarian camps, but export value is unaffected.
B	Negative impact on Export value Scenario	**<u>Decoupling has negative effects on Japan's export value</u>** A scenario in which decoupling occurs between the U.S. and China or between the liberal and authoritarian camps, with a negative impact on the value of export.

*：DC=Abbreviation for decoupling

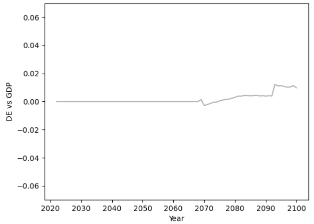
If decoupling between the camps is a late occurrence and there is a shift of exports to the Global South, the negative impact on export value will be minimal.

	Decoupling Impact (USD)	Decoupling Impact (GDP ratio)	Percentage of exports to the Global South	Nominal GDP(U.S.)(USD)	Nominal GDP(China)(USD)
2022			• 23%	• About 21tril.	• About 26tril.
2065～2070	• ±20bil.	• Less than ±1%	• Around 35%	• 60-70tril.	• 70-90tril.
	Small-scale decoupling between camps occurs				
2090～2100	• +70bil. *Slightly positive impact	• Less than ±1%	• Around 50%	• 105-125tril.	• 170~250tril.
	Large-scale decoupling between camps occurs				
2100	• +700bil. *Slightly positive impact	• Less than ±1%	• Around 50%	• About 125tril.	• About 250tril.

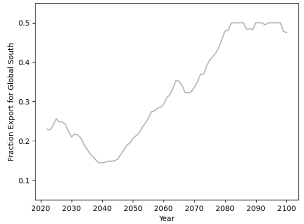
Decoupling Impact (USD)



Decoupling Impact (GDP ratio)



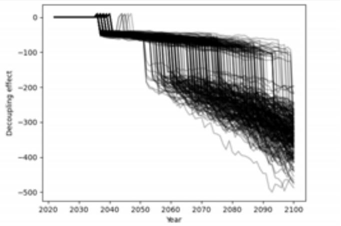
Percentage of exports to the Global South



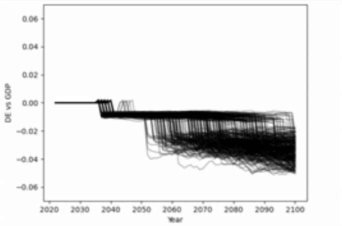
If decoupling between camps occurs early, the shift of exports to the Global South will not occur in time, which will have a negative impact on the value of exports.

	Decoupling Impact (USD)	Decoupling Impact (GDP ratio)	Percentage of exports to the Global South	Nominal GDP(U.S.)(USD)	Nominal GDP(China)(USD)
2022			23%	About 21tril.	About 26tril.
2035～2040	About 50bil.	About -1%	7-20%	25-30tril.	About 30-40tril.
	Small-scale decoupling between camps occurs				
2050～2100	-500bil. to -200bil.	About -5%	7-20%		
	Large-scale decoupling between camps occurs				
2100	-500bil. to -200bil.	About -5%	7-20%	30-120tril.	50~430tril.

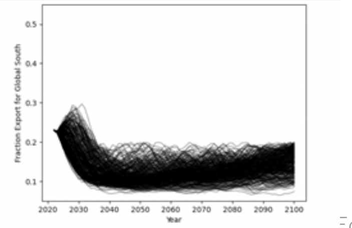
Decoupling Impact (USD)



Decoupling Impact (GDP ratio)



Percentage of exports to the Global South



Conclusion

〇Japan society is facing a rapidly declining population. Under such circumstances, what are the necessary conditions for maintaining a sustainable economy and society? The answer to this model was a combination of a generous income distribution to young people, increased family spending, community stability, and aggressive investment in technology development.

〇What are the conditions necessary to realize a decarbonized society? The answer to this model was to make a bold shift to renewable energy, invest in the development of CO2 capture and storage technologies, increase domestic energy self-sufficiency, and control energy costs.

〇What is Japan's desired response to the US-China decoupling? The answer this model leads to is that the most desirable thing is that decoupling does not occur. The second answer is that it should not lead to decoupling between factions. The third answer is to develop trade with the Global South.

Predicting the future using AI.

We would like to further pursue this possibility.

Thank you for your attention.