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Risk Management under Uncertainties
-- Risk/Risk Trade-off

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1. Climate Change and Uncertainties

The most important factor for analyzing climate change is its uncertainties. According to the fifth Assessment Report by the Intergovernmental Panel on Climate Change, human activities are mainly responsible for a temperature increase since the middle of the 20th century. A temperature increase comes through a chain of events: human activities (economic activities), greenhouse gas emission growth, a GHG concentration rise, (greater radioactive forcing), a temperature increase and climate damage. All these events are uncertain. Particularly uncertain are human economic activities, a temperature increase due to GHG concentration growth, and damage from the temperature increase. For example, economic activities follow a cycle that led to global GHG emission falls after the 1997 Asian monetary crisis and the 2008 Lehman Shock. On the other hand, China's rapid economic growth caused a substantial increase in GHG emissions in the 2000s.

Another uncertain factor is climate sensitivity that represents a temperature increase accompanying the doubled CO_2 concentration. The latest fifth IPCC report describes the temperature increase as a 1.5-4.5°C range. The upper limit of the range is triple the lower limit. The CO_2 concentration increased by 44% from 278 ppm before the industrialization to 400 ppm in 2015 and has been increasing at an annual rate of 2 ppm or more. Unless additional measures are taken, the concentration could reach 550 ppm within this century, doubling the pre-industrialization level. Depending on climate sensitivity, the target of limiting warming to "well below 2°C" could end up as a pipe dream. See Fig. 1.

As shown in the figure, INDCs (Intended Nationally Determined Contributions) under the Paris Accord are on track to limiting the temperature increase to below 2°C under a climate sensitivity of 2.5°C or less. Under a climate sensitivity of 3°C, however, the gap between the red and aqua lines indicates that it would be very difficult to achieve the temperature increase target. If the climate sensitivity exceeds 3°C, the attainment of the target may be hopeless. The climate sensitivity uncertainty also affects the so-called carbon budget (cumulative GHG emissions to attain the 2°C target). The budget changes depending on the climate sensitivity.

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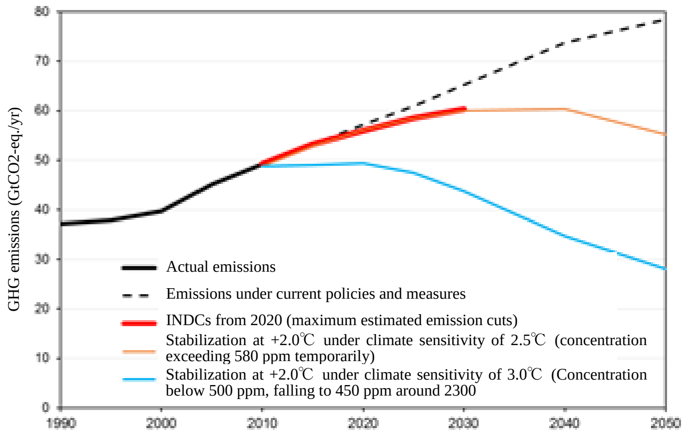
Fig. 1 Estimated Emission Pathways for Temperature Stabilization at 2°C under Different Climate Sensitivity Levels (through 2050)



Source: The figure is a simplified version of Fig. 1 in Kaya et al[1]. The black solid line shows actual GHG emissions. The red line shows total emissions under INDCs for the Paris Accord. The black dotted line shows the emissions pathway under current policies. The brown line shows the emissions pathway that limits the temperature increase to below 2°C under a climate sensitivity of 2.5°C. The aqua line shows the emissions pathway that limits the temperature increase to below 2°C under a climate sensitivity of 3°C.

Amid the great uncertainties, it is meaningful for countries in the world to set the 2°C target for 2100, see it as an aspirational and cooperate in attaining it. If the 2°C target is taken as a must, with serious efforts being made regardless of cost to fill the gap between INDCs and the 2°C emission trajectory for 2030, however, it may impede international cooperation. This point should be reconsidered.

Next, how about the relationship between the temperature increase and damage? The most famous diagram in this respect is titled “Reasons for Concern” in the IPCC report. The diagram, which is omitted here due to space constraint, shows the extents of risk growth accompanying the temperature increase for the five reasons of concern including biodiversity, extreme weather events and large-scale irreversible damage. Humans take measures to adapt to risk growth. This point is not taken into consideration. The diagram indicates the extents of risk growth instead of damage. As a matter of course, the monetary assessment of climate change’s damage to human lives or biodiversity is difficult. It is also difficult to identify damage from great disasters including substantial sea level rises accompanying the collapse of ice sheets in the western Antarctic Continent. The fifth IPCC Assessment Report estimates economic damage from a temperature increase of 2°C from the current level (a rise of 2.6°C since industrialization) at 0.2-2.0% of GDP (damage could be higher than this range), while describing the increase as uncertain. This means that damage from the temperature increase of 2°C since industrialization could be less than the estimate. How about the cost of measures to attain the 2℃ target? The fifth IPCC Assessment Report estimates the cost at 4.8% (2.9-11.4%) of global GDP for 2100. However, it notes that the

[1] Kaya, Yamaguchi, Akimoto “The uncertainty of climate sensitivity and its implication for the Paris negotiation,” Sustainable Science, May 2016, Vol. 11, Issue 3, 515-518

cost would lower GDP growth only by 0.06 (0304-0.14) percentage points. Without carbon capture and storage measures, however, the cost is estimated to rise 2.4-fold. However, we here must pay attention to the fact that uniform carbon tax is assumed for all models. This assumption is ultimately unrealistic. An estimate based on Akimoto et al. [2] indicates that the total of countries' *minimum* costs to attain their respective INDC targets toward 2030 would be 6.5 times as much as that of a uniform carbon tax to attain the targets. The former cost is based on an assumption that countries will introduce their respective carbon tax to reduce GHG emissions. Given that this assumption is also unrealistic, it may be more realistic to view the global cost as an order of magnitude greater than 4.8% of GDP. Damage also has such great uncertainty. Given these points, it is questionable whether the 2°C target is justifiable from the cost-benefit viewpoint.

2. Risk Management under Uncertainties

Based on the abovementioned points, I advocated replacing the 2°C target with a long-term target of achieving net zero CO_2 emissions to stabilize the temperature in this column last year. Differing from the 2°C target, the long-term target has neither a temperature increase target nor a deadline. Under the long-term target, however, the temperature increase is very likely to exceed 2°C. What could be done in such case?

First, scientific research on climate change should be explored to reduce uncertainties. If the uncertainty of the climate sensitivity is reduced or if experts agree on the best estimate, for example, a temperature increase may be anticipated more accurately. If damage is clarified further as a result, the range of measures to prevent damage may be narrowed. Second, investment in research and development should be promoted along with international cooperation. Their promotion will help to clarify the extent to which a temperature increase could be technologically restricted. The reduction of uncertainties about the climate sensitivity and damage may decrease the uncertainty of costs of tackling climate change. Third, greater priority should be given to adaptation. This may reduce damage from the same temperature increase. Mitigation, or GHG emission reduction measures, though indispensable over a long term, will take much time to produce effects. In contrast, adaptation may produce effects more quickly. Particularly, adaptation is effective for developing countries vulnerable to direct damage from climate change.

Nevertheless, the risk of the temperature increase exceeding 3°C or 4°C should be ignored. Such magnitude of temperature increase could easily emerge depending on the climate sensitivity. One of the grounds for the United Kingdom's target of cutting GHG emissions by 80% by 2050 is that the probability of the global temperature rising by more than 4°C must be restricted to 1% or less. How would the risk be managed? Here comes geoengineering. A typical geoengineering approach is solar radiation management, known as SRM. Under the SRM approach, sulfur dioxide that can decrease the temperature would be massively released into the atmosphere. After the eruption of Mt. Pinatubo in the Philippines in 1991 released 20 million tons of SO_2, in fact, the

[2] Akimoto, Sano, Shoai, "The analyses on the economic costs for achieving the nationally determined contributions and the expected global emission pathways," Revolutionary and Institutional Economics Review, 14-1, 193-206

global temperature in the next year decreased by 0.5°C. Compared with other approaches, the SRM approach costs far less and produces effects more directly. However, it has the risk of unknown adverse effects. Then, the world would have to choose whether to tolerate new risks to reduce the climate change risk. Unless risks are quantified to some extent, which risk to accept, in other words, risk/risk trade-off, cannot be assessed. In the past, some people had rejected research on the SRM approach for the reason of unknown risks. If the temperature actually increases, however, the SRM option may have to be taken into account. In this sense, further research on SRM risks will be indispensable. This is the same case with bio-energy with carbon capture and storage, or BECCS, which uses bioenergy and stores emitted CO_2 underground, or with massive afforestation or reafforestation. In both cased, the issue is the extent to which the world should tolerate the risk of adverse effects on food security or ecosystems to avoid the climate change risk. In this sense, the climate change problem represents the problem of risk management under uncertainties.

CO_2 emissions grow as population increases. Given that, we may face the philosophical problem of how we should view the present situation in which human beings are the sole winner. I would like to leave readers to decide what to do in this regard.

Writer’s Profile

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Mr. Yamaguchi’s previous position include Visiting Professor/Project Professor, University of Tokyo (2006–2013) and Professor of Economics, Keio University (1996-2004). Prior to this, he was Senior General Manager at Tokio Marine & Fire Insurance Co., Ltd. He served in numerous positions on committees and councils related Climate change and Environmental issues such as a Lead Author of IPCC Working Group III.

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