Temporal and spatial distribution of global mitigation costs: INDC role and generation equity

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In the working group three of the fifth IPCC assessment report, there are numbers of scenarios corresponding to 450ppm CO2 equivalent concentration stabilization, which is generally known as what we call 2 degree target. RCP (Representative Concentration Pathways) 2.6 is one of them and the summation of all countriesâ€™ emissions submitted as INDC (Intended Nationally Determined Contributions) is expected to be larger than RCP2.6 in 2030. To achieve the 2 degree target, additional emission reduction is needed to fill the gap between them after 2030. Such mitigation scenario consistent with INDC and achieving the 2 degree target would have different mitigation costs spatially and temporally, and influence on the generation equity both in intra- and inter-generations. Here, we have the three research questions, namely 1) for inter-generation equity, does INDC cause more harm to the future generation comparing with RCP2.6? 2) For intra-generation equity, if we follow INDC pledges, would we gain more intra-generation equity? 3) Would it help to improve generation equity regarding mitigation costs if we could have more stringent reduction target than INDC?
This study answers these questions using the AIM/CGE (Asia-Pacific Integrated Model/ Computable General Equilibrium) model, which is a recursive dynamic general equilibrium model that covers all regions of the world. GTAP and energy balance table are used as a basis of the SAM and energy balance table and reconciled them with other international statistics such as national accounts. The data in the year 2005 is used as the base year calibration data. GHG emissions are calibrated to EDGAR4.2.
The following four scenarios were analyzed: BAU, 26W, 26W_INDC and 26W_S_INDC. The BAU entails no emissions constraints and follows current trends in energy technologies. The 26W scenario has emissions constraints that approximately meet the emission target in RCP 2.6. It uses a uniform global carbon price to achieve the emission target. 26W_INDC scenario also meets the radiative forcing target approximately achieves 2.8 W/m2 in 2100 (not 2.6 but it is close enough considering temperature changes) and INDC pledges are satisfied before 2030 and a uniform global carbon price is assumed thereafter. 26W_S_INDC scenario is similar to 26W_INDC scenario except that each countryâ€™s INDC emission target increases by 10 percent compared to 26W_INDC. The socioeconomic assumptions behind of all three scenarios follow SSP2 socioeconomic assumptions. The target period of assessment is 2020 to 2100.
To make current and future mitigation costs comparable, we introduce discount rate. The discount rates are decided using the following function (a). Î´ is the pure rate of time preference for the present. g(t,r) is the GDP growth rate in region r and time t. Î·(r) represents inequality aversion in region r. Previous studies often assign a value ranging from 1 to 2 for inequality aversion. Ï•(t,r) is the discount rate in time t for region r.

$$Ï•(t,r)=Î´+Î·(r) * g(t,r) \quad (a)$$

We get GDP loss results as mitigation costs in the above scenarios from AIM/CGE model. To analyze inter-generation equity, we divide the year 2020 to 2100 into two generations. Current generation is 2020 to 2060. Future generation is 2060 to 2100. Then, we compared NPV (Net Present Value) of GDP losses in the scenarios. For intra-generation equity analysis, we focused on the relationship between the GDP loss rate and GDP per capita across regions in different years as well as using NPV of GDP loss rate as average values.
The results show that 26W_INDC has low mitigation cost in the former period, but high in the latter period comparing with 26W. Therefore, if we use ordinal number 2.0 as the inequality aversion parameter, 26W shows better inter-generation than 26W_INDC. More than 2.66 in the inequality

aversion parameter makes 26W_INDC a better one. More stringent emissions reduction than INDC in 26W_S_INDC scenario could give us better inter-generation equity. Regarding intra-generation equity, 26W_INDC is better than 26W in average. It is because INDCs tend to have stronger reduction targets in high income countries which would have higher mitigation costs than low income countries. The different yearsâ€™ results for intra-generation equity show that INDC improves intra-generation equity before 2055. But after 2055, INDC has slightly negative impacts on intra-generation equity.

From the results of this study, we suggest that to improve inter-generation equity, each country should commit more emission reduction target before 2030. Furthermore, to improve intra-generation equity, we should have continuous consideration for low-income countries in global climate change cooperation after INDC.