CO2 emissions recuction potential from passenger vehicles in road network complexity in Japan

Topic: Input-Output Analysis: Energy Policies
Author: Chisato HOSOSHIMA
Co-Authors: Shigemi KAGAWA

The Intergovernmental Panel on Climate Change (IPCC) reported that greenhouse gas (GHG) emissions should be reduced by 43% in 2030 and 84% in 2050, compared to 2019 levels in order to limit average temperature increase to 1.5 degrees Celsius. Japan ranks fifth in the world in GHG emissions in 2019, therefore a decarbonization policy in Japan could have a significant impact in limiting the average temperature increase. The Japanese government has pledged to reduce GHG emissions by 46% from 2013 levels by 2030 and to achieve carbon neutrality by 2050.

In particular, the transportation sector accounts for 17.7% of Japanâ€™s total CO2 emissions in FY2020, with 45.7% of these emissions from private passenger cars. Therefore, emissions from passenger cars cannot be ignored. In order to realize decarbonization, it is essential to understand the relationship between urban structure, transportation, and CO2 emissions. Urban structure affects urban transportation, and that urban transportation causes transportation-related CO2 emissions. However, there has been no detailed CO2 emissions analysis of urban transportation in Japan as a whole, considering the difference characteristics of urban structures in different regions, nor have there been rigorous estimates of CO2 emissions from Japanâ€™s road network at the city level.

To the best of our knowledge, this study is the first attempt to not only estimate CO2 emissions from passenger vehicles in road network complexity in Japan in 2015 but also forecast the vehicle emissions in 2030. Specially, we complied a comprehensive cities database in Japan in 2015 including urban agglomeration (i.e., population density in persons per km2), transportation infrastructure development (i.e., number of bus stops per capita), aging structure (i.e., percentage of households with household members aged 65 years old and over), job opportunity (i.e., percentage of people working in its own city), urban economy (i.e., average price of residential land in JPY per m2), and urban traffic (i.e., traffic volume of passenger vehicles in road network complexity in a city). Based on the dataset covering 1523 cities of Japan, we conducted a cross-sectional regression analysis and estimated the impact of urban structure (urban agglomeration, transportation infrastructure development, aging structure, worker environment, and urban economy) on urban traffic at city level.

The traffic volume of a specific city estimated by the specified regression model was further used to estimate CO2 emissions caused by driving passenger cars as well as idling i.e., when the engine is running while the car is stopped. In estimating the vehicle emissions in a city, we considered the differences in the penetration of next-generation vehicles (i.e., hybrid vehicles, plug-in hybrid vehicles, electric vehicles, and fuel cell vehicles) and conventional gasoline vehicles) and traffic congestions across cities. It should be noted that the fuel efficiency differs across the vehicle types. In addition, we considered different fuel efficiencies of driving on general roads and highways, respectively.

For transportation-related CO2 reduction policies of each city by 2030, we set the following three scenarios: (I) reducing not only CO2 emission factor for power generation by 48 to 69% but also reducing CO2 emission factor for hydrogen refining by 71%, (II) increasing fuel efficiencies in km per liter of all vehicle types by 32%, and (III) increasing the penetrations of hybrid vehicles, plug-in hybrid vehicles, electric vehicles, and fuel cell vehicles by 40%, 7%, 20%, and 3%, respectively. The

Embodied Energy and Emissions Intensity Data for Japan Using Input-Output Tables (3EID) was used to estimate the additional CO2 emissions induced by the next-generation vehicles promotion policy in each city.

The results from the scenario (I) shows that the CO2 emission intensity reduction targets of power generation and hydrogen refining under the current penetrations of the next-generation vehicles would have a small effect of 1.6% decrease in the total vehicle emissions in the Japanese cities in 2030. On the other hand, we found that the vehicle emissions would considerably be reduced by 37% under the scenario (III) of promoting the use of next-generation vehicles by 2030. Furthermore, the results show that by implementing all the three policies (I), (II), and (III), CO2 emissions from passenger cars are expected to be reduced by 55.5% from 2015 to 2030. This indicates that although the spread of next-generation vehicles is the most effective in reducing CO2 emissions in the road networks, technological improvements such as improved fuel efficiency of vehicles are also essential in obtaining the additional CO2 reductions. The detailed city level results show that if the above three scenarios are attained in the Japanese cities in 2030, the passenger vehicle emissions could be reduced by 46% from 2013 levels by 2030.