Impacts on Greenhouse Gas Emissions from Population Migration and Substitution of Energy Sources Resulting from the Tohoku Earthquake

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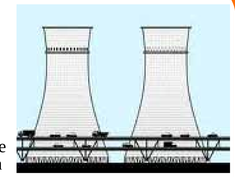


Introduction

The Tohoku earthquake:

- Japan experienced a devastating earthquake and tsunami off the Pacific coast of Tohoku in March 2011.
- About 16,000 people lost their lives, 220,000 houses were destroyed.
- Approximately 140,000 of the population within the 20 kilometer radius around Fukushima Daiichi were evacuated immediately after the events.

Consequences:

- The out-migration is expected to cause population increases in other regions of the country.
- The Japanese government shut down all existing nuclear power plants for safety concerns at least in the short term.
- Increased use of fossil fuel in the near future seems inevitable.

Objective

This study analyzes the effect of the migration and the nuclear power shutdown following the Tohoku earthquake on greenhouse gas (GHG) emissions in Japan.

- Hypothesis 1:Substituting fossil fuels for nuclear power results in increased total GHG emissions for Japan.
- Hypothesis 2: Displacement of population from low-density areas to high-density areas (referred to as "L→H migration") increased GHG emissions.
- Hypothesis 3: The combined effect of the migration and energy substitution vary spatially across the country.

Empirical Model

A spatial Durbin model (SDM) that accounts for spatial dependence in the dependent variable and explanatory variables is estimated using the prefecture-level data from 1990, 1995, 2000, 2005, and 2008:

$$y_{it} = \rho \sum_{j=1}^{N} w_{ij} y_{jt} + \alpha + X_{it}\beta + \sum_{j=1}^{N} w_{ij} X_{jt}\theta + u_i + \lambda_t + e_{it}; \quad i = 1,2,\dots,N; \; t = 1,2,\dots T$$

y_{it}: GHG emissions for prefecture i at time t

$\sum_{j=1}^{N} w_{ij} y_{jt}$: Spatial lag of GHG emissions

W_{ij} : i, j-th element of a spatial weight matrix

X_{it}: population, energy use from fossil fuel, energy use from nuclear power plants, energy use from hydro and other sources, and per capita vehicle ownership

Results

GHG emissions increases due to substitution of fossil fuels for nuclear power under 3 assumptions of 10% outmigration of Fukushima prefecture (207,556 population)*

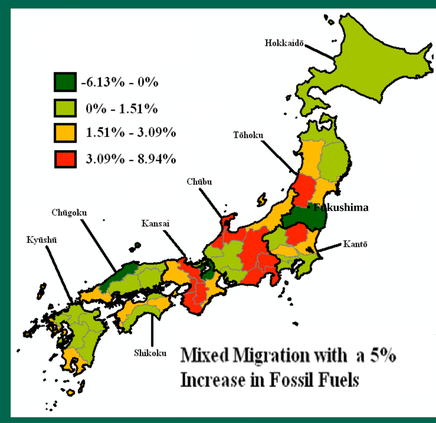
Migration Pattern**	Increase in Fossil Fuel	% Change in GHG from Baseline****
H→L migration	5%	1.755%
	10%	3.035%
	Max***	7.960%
Mixed Migration	5%	1.748%
	10%	3.028%
	Max***	7.951%
L→H migration	5%	1.745%
	10%	3.025%
	Max***	7.947%

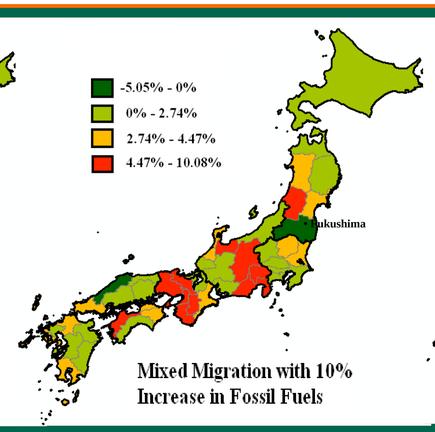
* 10% outmigration is hypothetical scenario based on current and future evacuations over the fear of radiation

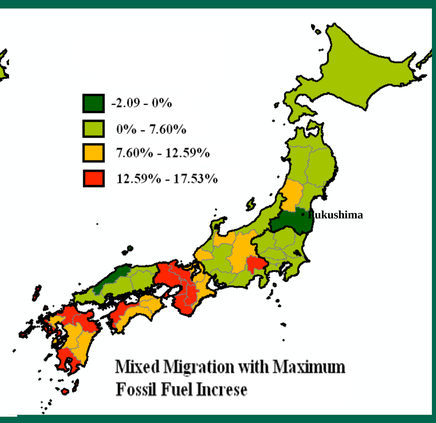
** Immigration is weighted by prefecture population

*** 100% substitution from nuclear power to fossil fuel

**** Baseline GHG emissions is 1.1 billion tons per year







Conclusion

- Substituting fossil fuels for nuclear power results in an increase in the total GHG emissions in Japan by up to 8%.
- The southwest regions (Kansai, Shikoku, and Kyushu regions) experience the largest increases because of their greater reliance on nuclear power than other regions.
- Migration patterns have a much smaller effect on the total GHG emission than energy sources.