Effects of Population Redistribution on Greenhouse Gas Emissions

A case study of South Korea

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Motivation

- South Korea has been recognized as the 9th biggest GHG emitter in the world
- Excessive centralization around Seoul area causes various problems; air & water pollutions, traffic congestions, overheated real estate market, social conflict by unbalanced development and so on
- To address the two distinct problems, the government is aiming to achieve a 30% reduction in GHG emissions by 2020 and is executing a comprehensive decentralization strategy that expects to redistribute population throughout the country
  - E.g., Construction of *Sejong City and transfer of 118 gov. institutes from Seoul to 11 non-Seoul regions
  - The government anticipates that 877,000 population will migrates by the decentralization plans

Research Objectives

- Analyze how population redistribution affect national GHG emissions holding total population the same
- Find a population redistribution scheme to minimize adverse effect or on GHG emissions

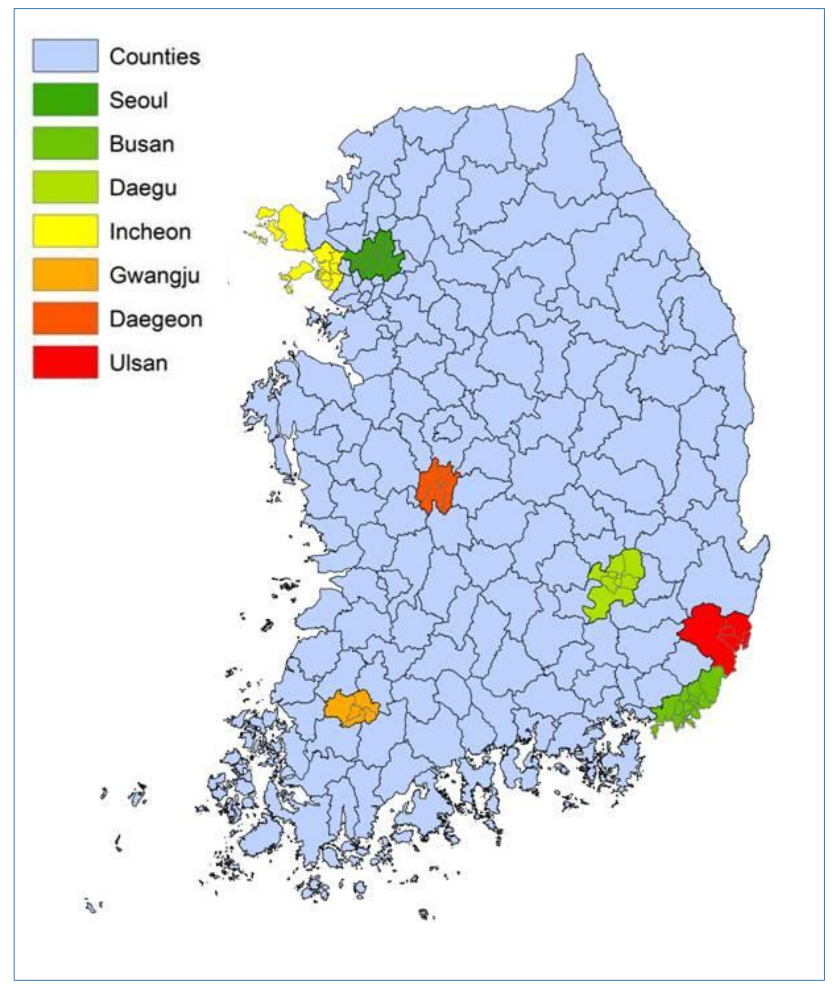
Two Conflicting Views

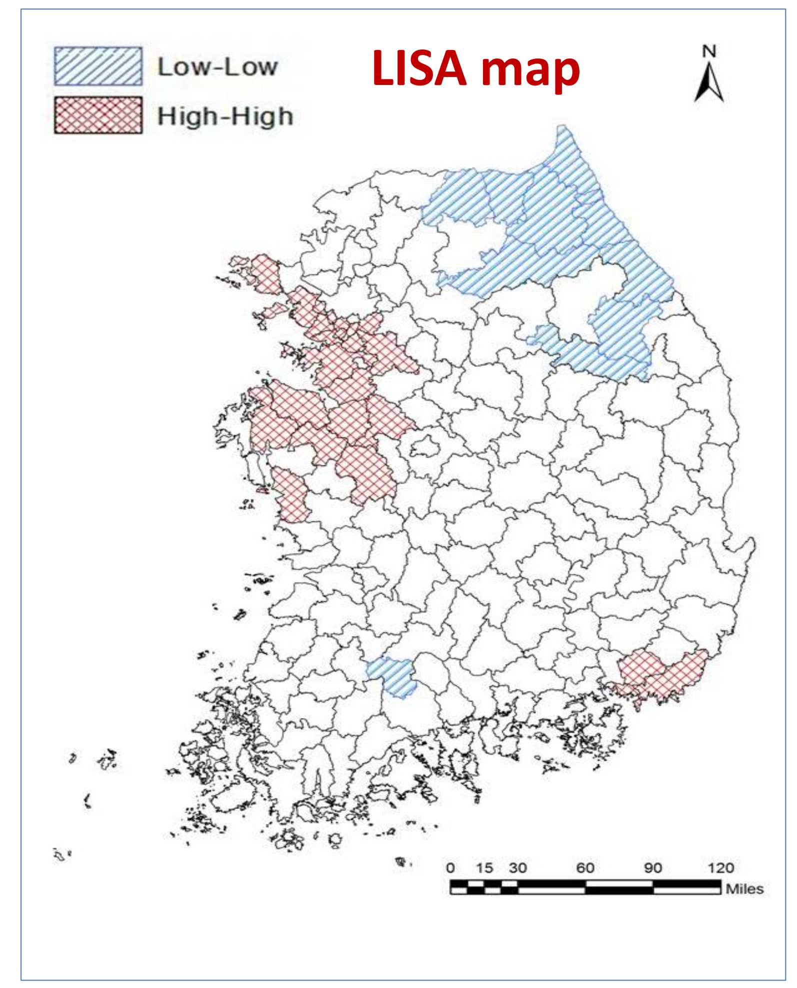
- Malthusian view
  - Positive relationship between population density and per capita emissions
  - Exploitation of lower quality resources
  - More energy consumption per unit of value added
- Bosrupian view
  - Negative relationship between population density and per capita emissions
  - Proximity and agglomeration in population density area provide energy efficiency

➡ **Which is the case in South Korea?**

Spatial Dependence in GHG emissions

- Moran's Indices (significant 5%)
- Cluster map of the Local Indices of Spatial Association (LISA, Anselin 1995) shows significant spatial clustering of CO_2e
- Spatial dependence identified in the residuals of the aspatial model





Methodology

- STIRPAT (Dietz and Rosa 1994)

$$I_i = aP_i^b A_i^c T_i^d e_i$$

  - I: Environmental Impact (GHG)
  - P: Population
  - A: Affluence (GDP)
  - T: Technology (Social structure)

$$\ln(GHG_i) = \alpha_1 + \alpha_2 \ln(P_i) + \alpha_3 \ln(GDP_i) + \alpha_4 \ln(E_i) + \alpha_5 \ln(M_i) + \varepsilon_i$$

- Spatial Durbin model (Anselin 1988)

$$\ln(GHG_i) = \delta_1 + \rho_d \sum_{j=1}^{n} w_{i,j} \ln(GHG_i) + X_i \boldsymbol{\delta}_2 + \sum_{j=1}^{n} w_{i,j} X_i \boldsymbol{\delta}_3 + \upsilon_i$$

  - $w_{i,j}$ defines neighboring relationship between *i* and *j*
  - Direct and indirect effects can be obtained
  - Inclusion of spatially lagged dependent variable and independent variables enable to analyze the spillover effects among neighborhoods

* The government has planned to build Sejong City, a multifunctional administrative city that is projected to attract half a million people

Estimation Results

- Population and GDP have positive significant effects on GHG at 5%
- Estimated elasticity of GHG with respect to population is 0.86~0.89, i.e., inelastic
- In Spatial model, total effect (direct effect + indirect effect) of population on GHG is close to unit elasticity 0.94~.96

Hypothetical redistribution Scenarios

- Scenario (1) assumes that the entire 877,000 population migrates from the Seoul Area. (triggers population migration from outmigration locations of higher density to in-migration destinations of lower density (referred to as "H→L migration"))
- Scenario (2) assumes that 176,000 migrate from the Seoul Area to Sejong City and 133,000 migrate from the Seoul Area to the 11 cities, while the remainder of the migrating population (324,000 to Sejong City and 244,000 to the 11 cities) comes from other South Korean regions proportional to their 2005 populations. (triggers H→L migration of 731,000 of the 877,000 population (or 83%) and population migration from outmigration locations of lower density to in-migration destinations of higher density (reffered to as "L→H migration") of the rest of population (or 17%))
- Scenario (3) is the same as the scenario (2) except the 244,000 migrate from non-Seoul regions to the 11 cities in the ascending order of the populations within the provinces of the 11 destination cities. (triggers H→L migration of 570,000 of the 877,000 population (or 65%) and L→H migration of the rest of population (or 35%))

Simulation results under the Hypo. redistribution Scenarios

Weight Matrix	Baseline	Scenario 1 Total emission	Scenario 1 Change in emission	Scenario 2 Total emission	Scenario 2 Change in emission	Scenario 2 Total emission	Scenario 2 Change in emission
First-order Queen contiguity	298,709	303,843	5,134 (1.72%)	301,570	2,861 (0.96%)	292,374	-6,335 (-2.12%)
First-order Queen contiguity Hybrid	295,287	300,612	5,325 (1.80%)	298,225	2,938 (0.99%)	288,942	-6,345 (-2.15%)

Conclusions

- The results highlight a potential major cost of decentralization that has not yet been considered, increase in national GHG emissions.
- The contrast in the simulated effects of population redistribution between scenarios (1) to (3) suggests that the decentralization plan can be implemented to not only achieve the goal of decentralization but the goal of mitigating national GHG emissions.