Comparison of urban energy use and carbon emission in Tokyo, Beijing, Seoul and Shanghai

Shinji Kaneko, Hiroshima University
Shobhakar Dhakal, Global Carbon Project
Goals through comparative study

- To understand dynamic relationships among urbanization, economic development, industrial structure changes, *total* direct CO2 emissions and indirect CO2 emissions.

- To distinguish unintentional factors such as income effects, economic structure effects accompanied by urban development process from the intentional factors which try to utilize the advantages of cities (concentration, economy of scale, economy of agglomeration).
Contents

- Urbanization and *direct* per capita CO2 emission
  - Cities and CO2 emissions
  - Economic development, urbanization and per capita CO2 emission

- Urban development process and energy, CO2 in Tokyo, Beijing, Seoul and Shanghai
  - Flying geese pattern of development
  - Economic structure and external dependency
  - Energy structure

- Embodied CO2 emissions
  - Carbon budget analysis (Tokyo, Beijing, Shanghai)
  - Regional comparisons in Japan
  - Future works
Gap of per capita CO2 between city and country

Tokyo

Seoul

Beijing and Shanghai
City and CO2 emission

- Urbanizing world
  - World: 32.75% (1960) => 48.77% (2005) => 60% (2030)
  - Developing East Asia and the Pacific: 16.76% (1960) => 41.45% (2005)

- If per capita CO2 emission in cities is twice larger than that in national average, then cities contributes 66% of CO2 emissions under current level of urbanization.

- Better understanding of the gap in per capita CO2 between city and national would be good start to have overall contribution of cities to global carbon emissions.
Urbanization, GDP and per capita CO2 emission

Dependent Variable:
CO2 emission (metric tons per capita)

Independent Variable:
Urban population (% of total)
Manufacture, value added (% of GDP)
GDP per capita (constant 2000 US$)

Period: 1960-2006
Countries: 163 countries
Observations: 3,396
Data Sources: World Development Indicator 2007
Model: Random Effect Tobit Regression model
Urbanization, GDP and per capita CO2 emission

By eliminating lower income countries and refining the sample with higher income countries, elasticity of urbanization to per capita CO2 emission changes. In the range of per capita GDP between 21,000 and 22,000, the elasticity turns to be negative.
<table>
<thead>
<tr>
<th></th>
<th>2004 GRDP billion 2000 $, PPP</th>
<th>2000 $, exchange</th>
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<tbody>
<tr>
<td>Tokyo</td>
<td>625</td>
<td>879</td>
</tr>
<tr>
<td>Seoul</td>
<td>213</td>
<td>143</td>
</tr>
<tr>
<td>Beijing</td>
<td>191</td>
<td>46</td>
</tr>
<tr>
<td>Shanghai</td>
<td>332</td>
<td>80</td>
</tr>
<tr>
<td>Total</td>
<td>1,360</td>
<td>1,148</td>
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<tr>
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<th>2004 GDP</th>
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<tbody>
<tr>
<td>Brazil (9, 10)</td>
<td>1,362</td>
</tr>
<tr>
<td>Italy (8, 7)</td>
<td>1,488</td>
</tr>
<tr>
<td>France (7, 6)</td>
<td>1,626</td>
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</tbody>
</table>
Urban development pattern of East Asian mega-cities
(Passenger vehicle ownership)

- Tokyo Olympic (1964)
- Seoul Olympic (1988)
- Beijing Olympic (2008)
- Shanghai Expo (2010)
Phase of economic development and industrial transformation

GDP/GRP Growth

-2.0% 0.0% 2.0% 4.0% 6.0% 8.0% 10.0% 12.0% 14.0% 16.0%


Economic growth rate (%)

China growth ratio Beijing Growth ratio Shanghai Growth

Industrial Structure Change

0% 10% 20% 30% 40% 50% 60% 70% 80% 90%


Industrial Share (%)

Beijing_Industry Beijing_Service Shanghai_Industry
Shanghai_Service Tokyo_Industry Tokyo_Service
Consumption vs Investment

Share of Private Final Consumption

Share of Gross Fixed Capital Formation

- China
- Japan
- Beijing
- Shanghai
- Tokyo
- Korea
Economic external dependency

**Import/Domestic Demand**

- China
- Japan
- Beijing
- Tokyo
- Shanghai

**Export/Total Production**

- China
- Japan
- Beijing
- Tokyo
- Shanghai
CO2 emissions from Tokyo, Beijing, Seoul and Shanghai
Methodology: carbon footprint analysis with regional input-output energy model

- Embodied energy and embodied CO2 emissions
- Indirect energy and CO2 emissions
**CO₂ Balance, million t-CO₂ (1)**

- **Japan 85-90-95**
  - Carbon footprint
    - 1.63 (1985)
    - 1.60 (1990)
    - 1.51 (1995)

- **China 92-97**
  - Carbon footprint
    - 1.09 (1992)
    - 1.23 (1997)
**CO₂ Balance, million t-CO₂ (2)**

- **Tokyo 85-90-95**
  - Carbon footprint
    - 5.81 (1985)
    - 6.55 (1990)
    - 4.44 (1995)

- **Beijing 92-97**
  - Carbon footprint
    - 1.95 (1992)
    - 1.99 (1997)
**CO₂ Balance, million t-CO₂ (3)**

- **Fukuoka 85-90-95**
  - Carbon footprint
    - 3.65 (1985)
    - 3.16 (1990)
    - 3.21 (1995)

- **Kitakyushu 85-90-95**
  - Carbon footprint
    - 1.43 (1985)
    - 1.71 (1990)
    - 1.71 (1995)
CO₂ emission (2000)

Direct CO₂ emission

Indirect CO₂ emission

(million t-CO₂)

60
40
20
10
n.a.
$CO_2$ emission per capita (2000)

Direct $CO_2$ emission per capita

Indirect $CO_2$ emission per capita
Comparison of annual growth rate from 1990 to 2000

<table>
<thead>
<tr>
<th></th>
<th>Direct CO₂ emission</th>
<th>Indirect CO₂ emission</th>
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<tbody>
<tr>
<td>Growth Rate (%)</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>-2</td>
<td>n.a.</td>
</tr>
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Legend:
- 4: Very High
- 2: High
- 1: Moderate
- 0: Low
- -2: Very Low
- n.a.: Not Available
Net virtual inflow of carbon
Indirect - Export CO₂ emission (2000)
Indirect and Export CO₂ Emission per Direct CO2 (2000)

Indirect / Direct CO₂ Emission

Export / Direct CO₂ Emission
(Direct + Indirect) CO$_2$ emission per capita (2000)
(Direct + Indirect - Export) CO\textsubscript{2} emission (2000)
Concluding remarks

- Gap of per capita CO2 between city and national average vary from city to city, to have better understanding some distribution pattern of the gaps across different scale and income level of cities would help to understand overall urban contribution to global carbon emissions.

- With higher income group, urbanization would positively contribute to improve per capita CO2 emission at the country, while urbanization in middle income countries would negatively contribute.

- Industrial structure and its changes are one of the dominant factors to determine the level and changes of both total CO2 emissions of cities, directly and indirectly.

- In order to evaluate the real performance of cities’ climate mitigation policies, we need study more on the contributions of unintentional factors.