Environmental Externalities and Health Expenditures: 
A Cross-Country Analysis of Health Expenditure Determinates

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Introduction

• Poor environmental quality is responsible for many health damages. Air, water, and soil pollution can increase risks of illnesses.

• Main sources of environmental degradation and damages are:
  – greenhouse gases (in the form of carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), Chlorofluorocarbon CFCs, HCFCs),
  – local air pollutants (CO, NOx, SOx, PM10,...),
  – Water pollution (BOD, COD),
  – soil pollution

• Kalkstein (1990) presents a long list of different effects of heating due to climate change, and older literature presents many evidences about each pollutant and its damages to health.
Review of literature: How to estimate economic effects of environmental degradation?

• There are several methods for estimating the economic effects:
  – Dose-response approach which is a long-run impact assessment method, the most important example for this method is ExternE Project (Eyre et al., 1999), which is a source for calculating the amount of damage to health and then its associated economic health costs. Rabl and Spadaro (2000) estimate the annual years of life lost due to air pollution (as much as 8000 people per year) in France by using the ExternE dose-response functions.
  – Problems: complexity of non linear functions, need for comprehensive and expensive long run data.
- Enumerative method: measures welfare impacts and estimates all the negative externalities linked to physical changes obtained from different studies of the health effects of environmental degradation. For instance Nordhaus (1994) uses this method to estimate the welfare effects of climate change equal to 4% decline in GDP.

- Statistical long run approach: analyses the effect of an environmental factor on the production level, or health expenditure of a special region. Statistical method seems to estimate more robust results as the outcome covers the reactions of all elements of the system when an environment effect occurs.

Statistical models have immunity toward biases created by extrapolations which come from the summation of separate effects.
– General equilibrium models: it covers many area of multidisciplinary work, but it is built based on many assumptions. For this reason, much research has been focused on small elements of environmental quality change, rather than drawing a general image of the problem. Bergman (2011), Jorgenson and Wilcoxen (2012), Conrad (2001), Bosello and Roson and Tol (2006), and Wiedmann et al. (2007),... provide empirical models with this approach.

– Cost of illness (COI) models, value transfer, WTP and Contingent Valuation Method (CVM),... are other common methods for this reason.
Statistical method; estimating determinants of health expenditure

• Income: Newhouse (1977) applies the statistical method and uses per capita income and per capita health expenditure in a model, to describe the amount of national output of each country that is allocated to health sector. Many other research afterward try to find determinants of the health expenditure. (Murthy and Ukpolo 1995, Hansen and King, 1996; Matteo and Matteo, 1998; Gerdtham and Lothgren, 2000; Freeman, 2003;...)

• Environment: quality of air, water, soil are important determinant of health costs and as Jerrett et al. (2003) show that providing environmental infrastructure and protection policies can reduce health care costs.
• Jerrett et al. (2003), studied pollution emissions, public environmental protection budget, and health care expenditures in 49 Canada counties with a cross-sectional model. Results shows:
  – a significant correlation between level of pollution and the per capita health expenditures.
  – Counties with more environmental budget, significantly pay lower health expenditures (offset effect).
• Narayan and Narayan (2007) study a cointegration model of 8 OECD countries and find that there is a significant and positive relationship between level of air pollution and health expenditure.
Vulnerability: different vulnerability factors can affect the health expenditures. Matteo and Matteo (1998) consider people above 65 (as more vulnerable), per capita income, federal costs as determinants of per capita Health Care Expenditures (HCE) in provincial level in Canada. Result of the study shows that:

- Like other studies, per capita income has a positive and significant correlation with HCE.
- Age, as a vulnerability variable, has a significant and positive effect on HCE.
- Federal program funding has a significant and negative effect on per capita HCE.
Model

A model of Newhouse (1977) is used and new determinants are added:

\[
\ln \text{Healthexp}_{it} = \ln \text{GDP}_{it} + \ln \text{Nox}_{it} + \ln \text{Methane}_{it} + \\
\ln \text{PM10}_{it} + \ln \text{BOD}_{it} + \ln \text{Envexp}_{it} + \ln \text{Vulner}_{it} + \varepsilon_{it}
\]

Where:
Variables

Dependent variable is log of:
- Health expenditure per capita (constant 2005 ppp dollar)

Independent variables are logs of:
- GDP per capita (constant 2005 ppp dollar),
- Several environmental determinants:
  - NOx: Industrial Nitrous Oxide emission (per capita ton of \( \text{CO}_2 \) eq.)
  - PM10: PM10 country level (microgram cubic meter)
  - Methane: Methane (per capita ton of \( \text{CO}_2 \) eq.)
  - Bod: Organic water pollutant (BOD kg per worker)
  - Envexp: Terrestrial and marine protected area (% of country area)
- vulnerability variable: vulner, is share of population above 65 and below 14 (% of total population)
Data

All data is from the World bank Database, 2001 – 2012,

• For four groups of countries :
  – High income OECD Countries
  – High income non-OECD Countries
  – Above Medium Income Countries
  – Below Medium income Countries

• Data is average 12 year of time series from 2001 to 2012
### Summary of Statistics, OECD Countries
#### 12 year average (2001-2012)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Obs</th>
<th>Mean</th>
<th>Std. Dev.</th>
<th>Min</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO2 (kg per capita, kgpc)</td>
<td>31</td>
<td>9.8394</td>
<td>3.8345</td>
<td>3.8345</td>
<td>21.9980</td>
</tr>
<tr>
<td>INOx cap (kgpc)</td>
<td>27</td>
<td>0.0982</td>
<td>0.0937</td>
<td>0.01591</td>
<td>0.4323</td>
</tr>
<tr>
<td>Methane cap (tpc)</td>
<td>31</td>
<td>1.6982</td>
<td>1.4659</td>
<td>0.33499</td>
<td>6.5897</td>
</tr>
<tr>
<td>PM10 (microgram/m3)</td>
<td>31</td>
<td>23.4995</td>
<td>9.8070</td>
<td>11.6503</td>
<td>53.0242</td>
</tr>
<tr>
<td>BOD (kg/day/worker)</td>
<td>28</td>
<td>0.1613</td>
<td>0.0300</td>
<td>0.1186</td>
<td>0.24998</td>
</tr>
<tr>
<td>EnvExp (%)</td>
<td>31</td>
<td>13.8933</td>
<td>8.0141</td>
<td>0.9836</td>
<td>41.1525</td>
</tr>
<tr>
<td>Healthcap (2005 ppp$)</td>
<td>31</td>
<td>2877.91</td>
<td>1301.847</td>
<td>929.8987</td>
<td>6787.911</td>
</tr>
<tr>
<td>Vulner (%)</td>
<td>30</td>
<td>32.7164</td>
<td>2.0673</td>
<td>27.9498</td>
<td>37.8668</td>
</tr>
<tr>
<td>GDP cap (2005 ppp$)</td>
<td>31</td>
<td>30067.05</td>
<td>10401.11</td>
<td>13107.69</td>
<td>67183.3</td>
</tr>
</tbody>
</table>
Hypothesis

• For all groups, there are 4 main hypothesis:
  – Income positively affect health expenditure (HE)
  – Environmental protection offset health expenditure
  – Environmental pollutants increase health expenditure
  – Vulnerability increases health expenditure
Results

• A cross section model was applied for four groups of countries.
  – Income coefficient is positive and significant for all groups.
  – Coefficients of BOD, PM10, NOx, Methane are positive but not significant.
  – Coefficient of Environmental protection variable is negative but not significant.
  – Coefficient of Vulnerability is positive but not significant.
Recommendations for future study

• Change in data sources, specially Env. Quality data, Env. Quality ranking and indices can be used, data for environmental expenditures need to be replaced.

• Price index for health expenditure and many other determinants of health can be added.

• Country level Panel cointegration analysis.

• A state level model, which is now in the pipeline!
References:


Conrad, Klaus. Computable general equilibrium models in environmental and resource economics. No. 601. 2001


Thank you
### Annex 1- Test results for OECD countries

| Inhlthexp | Coef.     | Std. Err. | t     | P>|t| | [95% Conf. Interval] |
|-----------|-----------|-----------|-------|------|---------------------|
| lngdp     | 1.408851  | 0.1973111 | 7.14  | 0.000 | 0.9856611 - 1.832042 |
| lninoxcap | 0.0088719 | 0.055171  | 0.16  | 0.875 | -0.1094583 - 0.127202 |
| lnpm10    | 0.007976  | 0.1222429 | 0.07  | 0.949 | -0.254209 - 0.2701611 |
| lnbod     | 0.0461581 | 0.3140035 | 0.15  | 0.885 | -0.6273124 - 0.7196286 |
| lnenvexp  | 0.0555409 | 0.0542331 | 1.02  | 0.323 | -0.0607775 - 0.1718593 |
| Invulner  | 0.404226  | 0.7916012 | 0.51  | 0.618 | -1.29359 - 2.102042 |
| Inmethanecap | 0.0215397 | 0.091981  | 0.23  | 0.818 | -0.17574 - 0.2188194 |
| _cons     | -7.73298  | 2.597603  | -2.98 | 0.010 | -13.30428 - 2.161677 |

Adj R-squared = 0.8290, Prob > F = 0.0000