Economic Modeling for Risk Analysis of Disasters: Spatial and Temporal Extensions

May 22, 2008

JiYoung Park

Assistant Professor,
Department of Urban and Regional Planning,
University at Buffalo, State University of New York
Contents

- Introduction: Modeling and Risk Analysis
- Traditional I-O Models and Expansions
- Contributions
- Extensions
- An Example
- NIEMO Coefficients
- NIEMO Accuracy
- Further Research
- Examples of Empirical Application
- Examples: FlexNIEMO vs NIEMO
- Possible Research for Korea
Introduction: Modeling and Risk Analysis

- Macro-economic models, e.g. Input-Output (I-O) or Computable General Equilibrium (CGE) model as tools estimating socioeconomic impacts resulted from man-made or natural disasters.

- Application of input-output analysis to the study of economic impacts (actual and hypothetical) has led us to a number of discoveries and innovations.
Introduction: Modeling and Risk Analysis (Continued)
Introduction: Modeling and Risk Analysis (Continued)

Traditional One-Region I-O Approach

- No Spatial Information
- No Resilience and No Input Substitutions

Why?

- Data Problems
- Difficulties in Methodology and Application
Introduction: Modeling and Risk Analysis  (Continued)

• Data Problems
  
i. Industrial classification incompatibilities.
  
ii. Incomplete commodity trade flow data between states.
  
iii. No information on service trade flows.
Introduction: Modeling and Risk Analysis (Continued)

- Difficulties in Methodology and Application
  
i. Multiregional or Interregional Input-Output Model (MRIO or IRIO).

ii. Theoretical weakness using supply-driven approach (to examine forward-effects).

iii. No operational models on temporal extensions.
Traditional U.S. I-O and Expansions

Figure 1. Four Types of U.S. Input-Output Systems
Contributions

1. Data Problems
   - Develop conversion bridges between various U.S. industry code systems.
   - Develop two methodologies to complete trade flows between states for non-service and service sectors.

2. Difficulties in Methodology Application
   - Economic theory of applicability of supply-driven approach and construction of supply-driven type I-O models.
   - Develop a method combining price-elasticities for I-O model: Price-sensitive supply I-O models.
   - Construction of temporally extended I-O model: FlexIO and FlexNIEMO.
Figure 2-1. Extensions of Traditional Input-Output Model: Space, Time, and Supply-Driven IO.
Extensions
(continued)

Figure 2-2. Newly Developed Input-Output Models with Suggested Methodologies.
Figure 3.
NIEMO Modeling and Development process
Figure 4. Inverse Matrix of NIEMO: Technical Coefficients
NIEMO Accuracy

Figure 3. Overall estimated errors resulting from various types of IO models
NIEMO Accuracy *(continued)*

- With respect to estimation of overall model accuracy, I found that there are only relatively small errors when comparing the aggregates of all sectors and also only minor errors on an individual sector-by-sector comparison basis.

- The sectoral aggregation required to go from IMPLAN to NIEMO imparts only minor errors.

- Because spatial aggregation adds more severe aggregation errors than sectoral aggregation, it is necessary to consider MRIO-type models, especially in the case of economically robust and specialized subregions.

- NIEMO, containing approximately six-million multipliers, can be constructed at low cost and small accuracy loss --given that IMPLAN’s outputs are plausible.
Further Research

- Elaborations of NIEMO
  i. Complete and update service trade flows for NIEMO.
  ii. Construct a closed version of NIEMO.
  iii. Combine NIEMO with other countries’ I-O models, e.g. Inter-Countries Economic Model of Asian Pacific Rim (ICEMAP).
  iv. Advancement of FlexNIEMO and structural analysis of the model.
  v. Empirical applications to various possible disasters.
Further Research *(Continued)*

- TransNIEMO
  
  i. NIEMO+Transportation System

  ii. Currently, TransNIEMO includes highway system, but will ultimately include seaports and air networks.

  iii. TransNIEMO will contribute to the identification of effective transportation policy and land-use planning.

  iv. Major bridge disruptions and consequent economic impacts.
Further Research (Continued)

- HAZUS-NIEMO
  
i. HAZUS software + NIEMO; HAZUS developed by FEMA, provides direct economic impacts for natural disasters such as earthquakes, hurricanes, and floods.

  ii. This is first attempt to remedy economic limitation in HAZUS.

  iii. Some research papers are prepared and will be submitted to major journals.

  iv. For empirical application to analyze the economic impacts of a disaster, HAZUS-NIEMO will be tested this August.
Further Research (Continued)

Figure 5. NIEMO and Its Future
## Examples of Empirical Application

<table>
<thead>
<tr>
<th>Researchers</th>
<th>Title</th>
<th>Demand-driven NIEMO</th>
<th>Supply-driven NIEMO</th>
<th>Price sensitive supply-driven USIO</th>
<th>Supply-driven FlexNIEMO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Park et al. (2006)</td>
<td>The State-by-State Economic Impacts of Mad Cow Disease on the United States</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Park (2008a)</td>
<td>The Economic Impacts of a Dirty-Bomb Attack on the Los Angeles and Long Beach Port: Applying Supply-driven NIEMO</td>
<td></td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Park (2008b)</td>
<td>Application of a Price-Sensitive Supply-Side Input-Output Model to an Examination of the Economic Impacts of Hurricane Katrina and Rita Disruptions of the U.S. Oil-Industry</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Park et al. (2007b)</td>
<td>Simulating The State-by-State Effects of Terrorist Attacks on Three Major U.S. Ports: Applying NIEMO (National Interstate Economic Model)</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Richardson et al. (2007)</td>
<td>Tourism and Terrorism: The National and Interregional Economic Impacts of Attacks on Major U.S. Theme Parks</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Researchers</td>
<td>Title</td>
<td>Demand-driven NIEMO</td>
<td>Supply-driven NIEMO</td>
<td>Price sensitive supply-driven USIO</td>
<td>Supply-driven FlexNIEMO</td>
</tr>
<tr>
<td>----------------------</td>
<td>----------------------------------------------------------------------</td>
<td>----------------------</td>
<td>---------------------</td>
<td>-----------------------------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Park et al. (2007c)</td>
<td>Estimating the State-by-State Economic Impacts of Hurricane Katrina</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lee et al. (2007)</td>
<td>Estimating the State-by-State Economic Impacts of Bio-terrors: The Case Study of FMD</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gordon et al. (2008)</td>
<td>U.S. Border Closing Economic Impact Simulations</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Park et al. (2007d)</td>
<td>The Regional Economic Impacts of Hurricanes Katrina and Rita on Oil and Gas Refinery Operations in the Gulf of Mexico: Applying a Flexible Multi-regional Input-Output Model</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
</tbody>
</table>
Examples: FlexNIEMO vs NIEMO

The state-by-state economic impacts of Customs District of Louisiana: Application of NIEMO

Figure 6-1. The state-by-state economic impacts of Customs District of Louisiana: Application of NIEMO, Direct losses of foreign exports in USC sector 10 (Coal and petroleum products), Total Impacts between Aug. 05 and Mar. 06
Examples: FlexNIEMO vs NIEMO (Continued)

The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO

Figure 6-2. The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, Direct losses of foreign exports in USC sector 10 (Coal and petroleum products), Total Impacts between Aug. 05 and Mar. 06
**Examples: FlexNIEMO vs NIEMO (Continued)**

The state-by-state economic impacts of Customs District of Louisiana:
Application of FlexNIEMO, August 2005

Figure 6-3. The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, Direct losses of foreign exports in USC sector 10 (Coal and petroleum products), August 2005
The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, September 2005

Figure 6-4. The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, Direct losses of foreign exports in USC sector 10 (Coal and petroleum products), September 2005
Examples: FlexNIEMO vs NIEMO (Continued)

The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, October 2005

Legend
OCT._05: As Percent of Total
- <0.001%
- <0.01%
- <0.1%
- <1%
- >=1%

Figure 6-5. The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, Direct losses of foreign exports in USC sector 10 (Coal and petroleum products), October 2005
Examples: FlexNIEMO vs NIEMO (Continued)

The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, November 2005

Figure 6-6. The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, Direct losses of foreign exports in USC sector 10 (Coal and petroleum products), November 2005
Examples: FlexNIEMO vs NIEMO (Continued)

The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, December 2005

Figure 6-7. The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, Direct losses of foreign exports in USC sector 10 (Coal and petroleum products), December 2005
Examples: FlexNIEMO vs NIEMO (Continued)

The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, January 2006

Figure 6-8. The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, Direct losses of foreign exports in USC sector 10 (Coal and petroleum products), January 2006
Examples: FlexNIEMO vs NIEMO (Continued)

The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, February 2006

Figure 6-9. The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, Direct losses of foreign exports in USC sector 10 (Coal and petroleum products), February 2006
Examples: FlexNIEMO vs NIEMO (Continued)

The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, March 2006

Figure 6-10. The state-by-state economic impacts of Customs District of Louisiana: Application of FlexNIEMO, Direct losses of foreign exports in USC sector 10 (Coal and petroleum products), March 2006
Possible Research for Korea

- Korean Interregional Input Output (KIRIO)
  
i. Source: Bank of Korea.


iii. Region: 6 regions.

iv. Sector: 78 industries.

v. It is critical to construct a disaggregate regional model, e.g. at the si-do level.

vi. Trial constructing a MRIO model with 28 industries and 16 regions is on-going.
Possible Research for Korea (Continued)

• Application using the Korean Interregional Input Output (KIRIO)
  i. Economic impacts analysis from the Sandstorm.


  ii. Possible research.

- .

  iii. Other economic effects analyses from government investment.

- .
Possible Research for Korea (Continued)

• Application using the Inter-Countries Economic Model of Asian Pacific Rim (ICEMAP).
  i. Economic impacts analysis on Northeast Asia from the Sandstorm.
  ii. әә FTA, әә FTA, әә FTA әә әә әә
  iii.әә әә әә әә әә әә.