Economic Impact Analysis

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1. Executive Summary

We have continued our current program of research, which involves applying spatially disaggregate economic models to estimate the losses following various hypothetical terrorist attacks. Towards this end, we have developed and tested the National Interstate Economic Model (NIEMO), the only operational multi-regional input-output model of the 50 states and the District of Columbia (DC). In addition, the group has invested considerable attention in identifying meaningful, computationally tractable means of representing the details of the national economy in a way that articulates with the national highway network, and spent the past year operationalizing the following applications and extensions.

i. TransNIEMO is the first operational model to combine representations of economic and highway network equilibria.

ii. FlexNIEMO is an approach that tests the stability of economic multipliers, including intra- and interstate effects.

In addition, we responded to requests from DHS to collaborate with other centers of excellence in response the H1N1 threat by providing estimates of economic losses associated with closure of the national borders between Canada and Mexico.

2. Research Accomplishments

We have maintained and extended our initial program of research, which has involved quantifying the economic impacts associated with various plausible terrorist attacks. This is the first step when assessing the costs and benefits of various programs of mitigation. These impacts should be identified at a spatially disaggregated level. There are three reasons for this. First, spatial aggregation obscures important details. Second, much political decision-making in a federal system is decentralized, and outcomes affecting local populations must be compared. And third, effective decision support for resource will

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eventually require computationally efficient means of modeling alternative system states so that the policy space can be searched and choices made.

2.1. TransNIEMO

For the past few years we have developed, refined, and applied the National Interstate Economic Model (NIEMO), the only operational multi-regional input-output model of the 50 states and the District of Columbia (DC). NIEMO develops results for 47 economic sectors (the “USC Sectors,” easily translated to other U.S. industrial and commodity codes), and is developed with data from the Minnesota Implan Group’s IMPLAN software (the best known and most widely used commercial input-output data source) and the U.S. Commodity Flow Survey.

Having successfully modeled interstate commodity trade, the next logical step is to assign trade flows to the infrastructure that supports them, and we have done so during the past year. The elaboration of NIEMO that accomplishes this step is called “TransNIEMO.” Results (summarized below) were presented at the 3rd National Urban Freight conference in October of 2009 and at the 55th and 56th Annual Meetings of the North American Regional Science Council in November of 2008 and 2009. We report on the nationwide economic impacts of a major disruption of freight shipments across the lower Mississippi River. See Figure 1.

This application of TransNIEMO involves two steps:

i. Estimation of increased transportation costs due to loss of key links (in this case bridges) the constructed highway network system, and

ii. State-by-state economic impact analysis of resulting reductions in household expenditures via applications and extensions of NIEMO.

The first major step in developing this model is to allocate commodity trade flows to the highway network, which accommodates approximately 73 percent of total trade flows. The National Highway Planning Network (NHPN) has about 452,000 miles of roads, of which the Freight Analysis Framework (FAF) contains 245,500 miles. This includes 46,380 miles of Interstate Highways, 162,000 miles of National Highway System (NHS) roads, 35,000 miles of other national roads, and 2,125 miles of urban streets and rural minor arterials. The network also includes thousands of bridges and tunnels. Major facilities are potential bottlenecks that may be
targets of attack. The value of each of these facilities cannot be determined without the application of a model that has TransNIEMO’s capabilities.

Figure 2 shows the framework for our research model. Combining the FHWA FAF network with NIEMO to create TransNIEMO involved many data management challenges, because the FAF network was compiled from multiple State-level sources. In addition, modeling transportation flows on a national network connecting urban centers includes requirements not associated with metropolitan level models. In particular, the national network is very complex. Economic space must be represented in a more aggregate way, making procedures for allocating
Network nodes: 10% sample of intersection nodes within buffer miles

Buffer miles boundary surrounding network node points

Labor proportion in truck mode

Select intersection nodes from the selected highways

Select Interstate and State highways

Cascade points from MSAs and remainder areas

Baseline NIEMO trade flows for 29 of 47 USC Sectors

Share of total cost paid for truck services by State, 509 sectors

Freight origin-destination flows for the truck mode

Freight shipping expenditures by origin State, 509 sectors

Freight shipping expenditures by origin State, 29 USC sectors

Calculate proportion of shortest path time change by state O-D pairs

Apply shortest path algorithm by a selected scenario and aggregate by states

Calculate changed shipping costs by states and by 29 sectors

Scenario 1

Scenario i

Scenario N

Figure 2 TransNIEMO: Data and Modeling Process
freight demand to physical facilities much less obvious than in the metropolitan case. We rely on economic centroids we identify for the 114 Freight Analysis Framework (FAF) zones. To capture realistic freight flows among these zones, 1,872 network nodes are identified in the vicinity of the economic centroids. See Figure 3.

![Figure 3 Economic Centroids for 114 Freight Analysis Framework Zones, 1,872 Network Nodes](image)

Network flows are computed by applying a static network equilibrium algorithm. Flows are computed twice, once to provide baseline values, and once to simulate flows following disruption. The differences between these two results identify changes in shipping costs. Changes in shipping costs drive changes in product costs. A price input-output model is applied to estimate these changes. Next, state-by-state economic impacts from changes in household consumption are estimated via NIEMO. See Figure 4.

![Figure 4 Summary of TransNIEMO Approach](image)

The loss of highway capacity inflicts costs, but traffic reallocations may favor some routes by eliminating some sources of demand for network access. Thus, a model that highlights state-level impacts can reveal economic winners as well as losers. These details would be lost if a national aggregate model is used for the same sort of analysis. In this scenario summarized here, 36 states experience negative impacts, while
15 states experience positive impacts. See Tables 1 to 3 for summary data for the most impacted states. Figure 5 identifies the states in each category.

### Table 1 Top Five Losing States

<table>
<thead>
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<th>State</th>
<th>Direct Impact</th>
<th>Indirect Impact</th>
<th>Total Impact</th>
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<tbody>
<tr>
<td>OH</td>
<td>-9.3608</td>
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<td>-16.9910</td>
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<tr>
<td>DE</td>
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<td>PA</td>
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### Table 2 Top Five Gaining States

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<th>State</th>
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<tr>
<td>AR</td>
<td>17.6380</td>
<td>12.1085</td>
<td>29.7465</td>
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<td>CO</td>
<td>7.7615</td>
<td>4.1128</td>
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<td>CA</td>
<td>6.7824</td>
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<td>AL</td>
<td>5.6410</td>
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<td>UT</td>
<td>4.2363</td>
<td>2.7134</td>
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### Table 3 National Totals

<table>
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<th>State</th>
<th>Direct Impact</th>
<th>Indirect Impact</th>
<th>Total Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Total</td>
<td>-59.7632</td>
<td>-63.9897</td>
<td>-123.7529</td>
</tr>
<tr>
<td>Rest of World</td>
<td>0.0000</td>
<td>-5.7642</td>
<td>-5.7642</td>
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Traditional impact models rely on fixed economic multipliers. The Flexible National Interstate Economic Model (FlexNIEMO) identifies detailed multiplier changes, possibly reflecting spatial economic resilience. The market economy moderates negative impacts by discovering and implementing efficient substitutions. These adjustments are not captured by conventional input-output approaches.

We ask how the coefficients of NIEMO might be perturbed in response to major economic shocks. Many procedures have been developed over the years to update and/or regionalize the coefficients of input-output models. This research extends similar procedures to a multi-regional IO model. This FlexNIEMO approach can provide an understanding of multi-period economic impacts of various events in spatial detail. Changes in technical coefficients over time reveal structural changes in interindustry and interregional trade relationships. A reasonably short-term perspective is needed to maintain plausible ceteris paribus assumptions.

We apply the FlexNIEMO approach to the events of 2001, including 2000-01 economic recession and the terrorist attacks of 9/11. In this case, the key question is whether the major adjustments and impacts stemming from the events of 2001 are among the trade coefficients or among the technical coefficients. This is tested by studying data for three states (NY, NJ, and CT). These data include:

i. consumer expenditures, available from IMPLAN, and

ii. GDP, available from the BEA.

The 2001 version of NIEMO was updated to 2002 and 2003 versions using the FlexNIEMO procedure to test the null hypothesis that the updated trade and technical coefficients (and multipliers) were subject to no statistically observable change in this interval. Findings from the application of FlexNIEMO to estimate post-impact changes in economic include:
i. the effects of 9/11 and the concurrent recession were limited, and

ii. changes in economic structure only occurred within each impacted state, while the trade coefficients are unchanged among the three states. See Figure 6.

![Figure 6 Changes in Technical and Trade Coefficients 2001 to 2003 for the 3-State Case: Technical Coefficients Appear in the Diagonal Matrices on the Horizontal Plane and Trade Coefficients Appear in the Off-Diagonal Matrices](image)

**2.3. H1N1 Border Closure**

Short-term border closings have been proposed as a means of forestalling the spread of pandemics to the U.S. The recent outbreak of H1N1 influenza in Mexico has prompted discussions of what the economic consequences of temporarily closing the U.S. border with Mexico might be. The World Health Organization declared the H1N1 outbreak a pandemic on June 12, 2009, and remains concerned over possible mutations of the virus.

In 2007, our group conducted a study of the effects of temporarily closing all U.S. borders in response to a worst-case avian flu outbreak. That work was published in *Global Business and the Terrorist Threat* (H.W. Richardson, P. Gordon, J.E. Moore II, eds.) Cheltenham: Edward Elgar (2009). We simulated the effects of five categories of border closure: 1) exports and imports; 2) air travel; 3) legal immigration; 4) illegal immigration; and 5) cross-border shopping. For some of these, alternate scenarios were examined. In this research, we followed similar procedures. We tested the short-term economic effects of closing the Mexican, the Canadian, and both borders.

The simulations use IMPLAN’s 2001 input-output model: The year for which we collected all input data is 2007. This approach assumes that only minor changes have occurred since 2001 in the technical
relationships between various sectors of the economy. These relationships are captured by the input-output model. However, relevant inputs have changed, and 2007 data are the most complete update available. We applied NIEMO to the only effects for which direct spatial impacts are known, disruptions in cross-border shopping. We applied the national version of USIO (a 47-sector aggregation of the national IMPLAN model) to account for the other four effects. Demand-side and supply-side versions of both models are available and were used.

We analyzed the border closure impacts for each case (Canada and Mexico) and reported the impact results for three cases of border closure, both countries (CASE 1) Mexico (CASE 2), and Canada (CASE 3).

In round numbers, the bottom line from the sum of our most optimistic scenarios is that a one-year dual border closing results in a $1 trillion total output loss. Dividing the output loss by an aggregate GDP multiplier of approximately 1.77 (computed from our results), we find an overall GDP loss of approximately $0.56 trillion, or approximately four percent of 2007 GDP ($13.75 trillion). All of the modeling results are for total output losses and can be converted to GDP losses via a similar calculation.

Our models are linear, so shorter closings would produce proportionately lower estimates of impacts. Model results for shorter closings are more plausible, because the model cannot simulate the large numbers of adjustments that come into play over time. Nevertheless, the nature of the disruption is obviously severe.

3. **Applied Relevance**

Our research agenda focuses almost exclusively on the development and application of models that provide detailed economic impacts. This permits the examination of events known to be relevant and expected to be relevant, and the evaluation of associated mitigation options.

4. **Research Products**

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### 4.1. Publications and Reports

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<td>Gordon, Peter; Richardson, Harry; Moore II, James - University of Southern California</td>
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4.2. Presentations – Conferences


4.3. Presentations - Outreach

2. Moore, II, J., “USC in the News” story featured research from CREATE, interview in The Washington Post, in a widely carried Associated Press story, quoted about an NTSB investigation finding that a signal system may have malfunctioned in a recent D.C. train crash, June 26, 2009
4.4. Models, Databases, and Software Tools and Products

Our work on TransNIEMO and FlexNIEMO is continuing

5. Education and Outreach Products

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<td># of visiting scholars involved (funded by other programs)</td>
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Research Assistants (names, degrees)
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SooHyun Cho, Doctoral student, Epstein Dept. of Industrial and Systems Engineering
Eunha Jun, Doctoral student, School of Policy, Planning, and Development
Sung-Ho Ryu, Doctoral student, School of Policy, Planning, and Development
Stephen Yoon, Master of Planning student, School of Policy, Planning, and Development

DHS Scholars & Fellows Summer Internship Program
Yonatan Moskowitz, Georgetown University

Internship Programs
Ha Seung-hung, Korea Aerospace University
Yeondo Lee, Korea Aerospace University

Visiting Scholars
Eunha Jun, Seoul National University
Heonsoo Park, Seoul National University
Kyoung Soo Lim, Sungkyul University