

Economic Impact Modeling and Analysis with Input-Output Models
Peter Gordon, James Moore, II, and Harry Richardson, University of Southern California
pgordon@usc.edu, jmoore@usc.edu, hrichard@usc.edu

Quantifying the economic impacts associated with various plausible terrorist attacks is the first task 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 eventually require computationally efficient means of modeling alternative system states so that the policy space can be searched and choices made.

Our research efforts have focused on developing models that estimate such impacts. We have also identified relevant scenarios to test our models.

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). 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 from the U.S. Commodity Flow Survey.

NIEMO is a flexible tool that can be applied to study and explore the details and implications of a variety of actual and hypothetical disruptions. We have developed, tested and applied demand-side versions of NIEMO that elaborate the effects of declining purchases and supply-side versions that elaborate the effects of declining sales.

Applications of NIEMO have permitted us to computationally simulate different attacks on major seaports and theme parks. We have also applied NIEMO to the study of the state-by-state impacts of Hurricane Katrina. These applications have involved demand-side and supply-side versions of the model. The former capture the economic effects of declining sales opportunities (such as from reduced exports); The latter capture the economic effects of declining supplies (such as from reduced imports).

We have also refined and applied the Southern California Planning Model (SCPM), an integrated highway network-economic-spatial allocation model of the Los Angeles metropolitan area. The current version, updated in 2005, includes 47 economic sectors (the same "USC Sectors") the 3,191 TAZs of the greater Los Angeles five-county area, and 89,356 highway links. The latter include 647 HOV lane-miles. The model evaluates the spatial, sectoral, and economic consequences of local terrorist threat scenarios affecting the Southern California economy. It can be replicated and applied for any large metropolitan area with data that are commonly available to regional planning agencies.

We have applied SCPM to studies of attacks on the Los Angeles-Long Beach ports and on the central business district of Los Angeles.

We seek to aid policy makers by advancing economic analysis to gain a better understanding of short-term economic impacts. We also hope to develop models appropriate for incorporation into larger decision support mechanisms.

"This research was supported by the United States Department of Homeland Security through the Center for Risk and Economic Analysis of Terrorism Events (CREATE) under grant number 2007-ST-061-000001. However, any opinions, findings, and conclusions or recommendations in this document are those of the authors and do not necessarily reflect views of the United States Department of Homeland Security."

The costs of counter-measures are usually known, but the benefits are the costs avoided. Can these potential losses be estimated and accounted for in policy choices and resource allocation decisions? Our studies develop methods to estimate local impacts.

Terror prevention occurs at all levels of government. National efforts rest on local support. Mitigation efforts include economic stimuli, and national aggregates my obscure important positive and negative local effects -- which appear to cancel out via aggregation. Further, intense losses may be highly localized, and the importance of these impacts are obscured if the losses are averaged over larger regions.

Our work addresses both of these issues. NIEMO provides impact estimates for the States of the U.S. as well as for various economic sectors. SCPM-style tools provide the similar sectoral information for small sub-metropolitan areas.

Both efforts required that we develop a sectoral classification system that is compatible with the other systems that are widely used by the various agencies and groups that develop and report economic data. We label this 47-sector classification the “USC sectors.” Our system is compatible with the Standard Industrial Classification (SIC), the North American Industrial Classification System (NAICS), the Standard Classification of Transported Goods (SCTG), Harmonized System Codes (HS) for Commodity Classification and various other agency and commercial systems. This permits us to translate data from one system into any other with generally good accuracy.

Having developed the USC sectors, we can combine input-output data with the information from the U.S. Commodity Flow Survey and other sources. NIEMO is operational and useful because of these data processing successes.

Demand-side and supply-side versions of NIEMO have been tested and applied. Most input-output exercises are demand driven, but this standard approach no always relevant. In our work on port closures, flows of imports and exports are temporarily interrupted. Loss of export opportunities can be treated by conventional demand side approaches, but the activity constraints imposed by a loss of import capacity must be handled by fundamentally reformulating the input-output model from a supply-side perspective. The two NIEMO formulations that result are used in concert to estimate both-demand side and supply-side impacts.

Our research group tested attack scenarios for various hypothetical targets (e.g., ports, theme parks, downtowns, livestock, sports stadia). We also applied our models to estimate the state and sectoral economic impacts of Hurricane Katrina. We worked closely and collaboratively with a Battelle team, supporting their work on a multi-stage project to model the economic impacts of possible terrorist attacks for the Nation Biodefense Analysis and Countermeasures Center.

In a separate effort undertaken at the request of the US Department of the Treasury, our group estimated losses that might be generated by international border closures in response to an avian flu pandemic (whether natural or manmade).

Some of our major findings are summarized in the following table

We note that attack scenarios for the Los Angeles-Long Beach ports have been studied. Estimated losses are in the range of \$23-\$45 billion. Most losses are in California, but significant costs accrue to other states as well.

Attacks on other targets (e.g. theme parks, downtowns, livestock, and sports stadia) generate losses of similar magnitudes and incidence.

Much larger losses were found in the MANPADS air attack study, but these are the result of multi-year impacts that affect all regions of the U.S.

The highest losses of all might be generated by border closures in response to an avian flu or other pandemic. The largest component of these economic impacts follows from the loss of international trade. Labor impacts are relatively minor by comparison.

We have begun to develop FlexNIEMO, an empirically-based approach that tracks impact multiplier adjustments after the event. Early findings corroborate the idea that resilience can mitigate many losses. Elaborating these opportunities will improve our ability to meaningfully model the responses of large economic systems, and is a research priority.

Policy makers are increasingly looking to DHS funded research to support resource allocation decisions and evaluate trade-offs. Our work aids policy makers by creating new tools to advance economic analysis and gain a better understanding of short-term economic impacts. Longer term impacts are more difficult to model because they involve a larger set of technical and institutional adjustments.

Terror prevention occurs at all levels of government. National efforts rest on local political and financial support. Also, national aggregates may obscure important local economic effects -- which appear to cancel out via spatial aggregation. In addition, the costs of counter-measures are usually known, but the benefits of deploying such options are the costs avoided. Can these potential losses be estimated and accounted for in policy choices and resource allocation decisions? Our studies develop methods to estimate local impacts and express these in sectoral detail. This provides an essential link to risk management, and allows resource allocation decisions to be formulated as constrained optimization problems. At present, these formulations remain intractable, but progress can be made by applying heuristic algorithms.

Major disruptions of activities in large US metropolitan areas have never occurred at the scale of Hurricane Katrina. The economic disruptions associated with this event provided a unique opportunity to calibrate our methods against empirical benchmarks by estimating to the state-level and sectoral economic impacts of the Hurricane.

We also organized and hosted CREATE Economics Symposia in August 2006 and 2007. The 2006 event was devoted to papers that analyzed the economic impacts, aftermath, and responses to Hurricane Katrina. This symposium examined some of the issues arising from the Hurricane Katrina disaster. Scholars from many fields such as decision analysis, risk management, economics, engineering, transportation, urban planning and sociology explore some of the more important policy issues resulting from Katrina such as insurance, flood control and rebuilding the levees, housing, tourism, evacuation and relocation, utility lifelines recovery and resilience, the racial implications of the disruption of life in New Orleans, and interregional economic impacts of the disaster. The focus was less on what happened in the past but on how to deal with future risks, not only in New Orleans but in other locations threatened by disaster.

The 2007 meeting focused on international business and the terrorist threat. The 2007 Symposium addressed the international business implications of terrorisms, and was jointly funded by the USC Center of International Business Education and Research. Thirteen prominent researchers addressed various aspects of the topics. Both symposia will produce edited volumes published by Edward Elgar. The 2005 conference produced a third edited book in the CREATE series, the galley proofs of which are currently with the publisher, Edward Elgar.

CREATE Economic Impacts Studies: Major Findings

Nature of Disruption	Targets	Reason for Economic Impact	Total Economic Impacts		Base year, Duration, and Model	Citations	Notes
			Output (\$ Millions)	Jobs (Persons per year)			
Explosives	LA/LB, Houston, and NY/NW	Ports shut-down	23,258	Not Computed	2001, one-month, and demand-driven NIEMO	Park, J.Y., P. Gordon, J. E. Moore II, and H. W. Richardson, L. Wang, 2007, "Simulating The State-by-State Effects of Terrorist Attacks on Three Major U.S. Ports: Applying NIEMO (National Interstate Economic Model)"p.208-234, in H.W. Richardson, P. Gordon and J.E. Moore II, eds., The Economic Costs and Consequences of Terrorism. Cheltenham: Edward Elgar.	Direct/Indirect state-by-state impacts
Dirty Bomb	LA/LB	Ports shut-down	26,905	Not Computed	2001, one-month, and supply-driven NIEMO	Park, J.Y., 2007, "The Economic Impacts of a Dirty- Bomb Attack on the Los Angeles and Long Beach Port: Applying Supply-driven NIEMO", is being reviewed at Journal of Homeland Security and Emergency Management.	Direct/Indirect state-by-state impacts
Conventional Bomb	Terminal Island	Bridge closures	45,000	280,000	2001, 120 days, and SCPM (Ver.2003)	Gordon, P., J. E. Moore, II, H. W. Richardson, and Q. Pan., 2006, "The Costs of a Terrorist Attack on Terminal Island at the Twin Ports of Los Angeles and Long Beach," p.71-90, in J. D. Haveman and H. J. Shatz, eds., Protecting the Nation's Seaports: Balancing Security and Cost, San Francisco: Public Policy Institute of California.	Direct/Indirect/ Induced impacts of Southern California
Dirty-bomb	LA/LB	Ports shut-down	34,071	212,165	2001, 120 days, and SCPM (Ver.2003)	Gordon P., J. E. Moore, II, H. W. Richardson, and Q. Pan, 2005, "The Economic Impact of a Terrorist Attack on the Twin Ports of Los Angeles and Long Beach", in H.W. Richardson, P. Gordon and J.E. Moore II, eds., The Economic Impacts of a Terrorist Attack, Cheltenham: Edward Elgar.	Direct/Indirect/ Induced impacts of Southern California
Dirty-bomb	Downtown LA	Business interruption	4,968	33,157	2001, Inner zone - one year, outer zone – one month; and SCPM (Ver. 2005)	Richardson, H.W., P. Gordon, J.E. Moore, II and Q. Pan "The Economic Impacts of a Terrorist Attack on the Downtown Los Angeles Financial District" Publication pending.	Direct/Indirect/ Induced impacts of Southern California (Hybrid Scenario)
MANPADS	U.S. Airlines	Losses of air-passenger service	214,347 ~420,455	Not Computed	Sep. 2001 ~ Aug. 2003, 2 years, and IMPLAN IO model	Gordon, P., J.E. Moore, II, J.Y. Park, and H.W. Richardson, 2007, "The Economic Impacts of a Terrorist Attack on the U.S. Commercial Aviation System," Risk Analysis (forthcoming)	Direct/Indirect/ Induced impacts of U.S.
Mad-cow-Disease	U.S. Bovine Animals	Foreign exports shut down	13,681	Not Computed	Dec. 2003 ~ Apr. 2005, 15 months, and demand-driven NIEMO	Park, J.Y., C.K. Park, and P. Gordon, 2007, "The State-by-State Economic Impacts of Mad Cow Disease on the United States," revised to resubmit to Journal of Agricultural and Resource Economics.	Direct/Indirect state-by-state impacts

Nature of Disruption	Targets	Reason for Economic Impact	Total Economic Impacts		Base year, Duration, and Model	Citations	Notes
			Output (\$ Millions)	Jobs (Persons per year)			
Explosives	13 U.S. theme parks	Loss of visitors	20,747 ~ 24,921	Not Computed	2004, 18 months, and demand-driven NIEMO	Richardson, H. W., P. Gordon, J. E. Moore, II, S.J. Kim, J.Y. Park, and Q. Pan, 2007, "Tourism and Terrorism: The National and Interregional Economic Impacts of Attacks on Major U.S. Theme Parks," p.235-253, in H.W. Richardson, P. Gordon and J.E. Moore II, eds., The Economic Costs and Consequences of Terrorism. Cheltenham: Edward Elgar.	Direct/Indirect state-by-state impacts
Hurricanes Katrina and Rita	U.S. oil-refinery industries	U.S. oil price increase	1,537	Not Computed	2005, 4 months, and price-sensitive supply-driven USIO	Park, J.Y., 2007, "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," reviewed at Ecological Economics.	Direct/Indirect U.S. impacts
Hurricanes Katrina and Rita	PADD III region	Disruption of Oil-refinery industries	4,849	Not Computed	2005, 13 months, and supply-driven FlexNIEMO	Park, J.Y., P. Gordon, Y.K. Kim, J.E. Moore II, and H.W. Richardson, 2007, 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. Paper will be submitted to Journal of Economic Geography.	Direct/Indirect state-by-state and month-to-month impacts
International Avian Influenza Epidemic	Loss of air passengers, U.S. seaports closed, loss of cross-border shopping, loss of legal and illegal immigrants	U.S. border closures	1,734,075 ~5,408,796	Not Computed	2001, one-year, and demand- and supply-driven USIO and NIEMO.	Gordon, P., J.E. Moore II, J.Y. Park, and H.W. Richardson, 2008, "U.S. Border Closing Economic Impact Simulations," in H.W. Richardson, P. Gordon and J.E. Moore II, eds., Global Business and Terrorism. Cheltenham: Edward Elgar (Forthcoming).	Direct/Indirect state-by-state or U.S. impacts
Hurricanes Katrina and Rita	Louisiana customs district	Seaports shut-down	44,374	Not Computed	Aug. 2005 ~ Mar. 2006, 8 months, and demand- and supply-driven NIEMO.	Park, J. Y., P. Gordon, J. E. Moore II, and H. W. Richardson, 2007, "Estimating the State-by-State Economic Impacts of Hurricane Katrina," in H.W. Richardson, P. Gordon and J.E. Moore II, eds., The Socioeconomic Costs and Consequences of Hurricane Katrina. Cheltenham: Edward Elgar (Forthcoming).	Direct/Indirect state-by-state impacts
Foot and Mouth Disease	Feedlots in California	Closing of foreign exports and loss of household consumption	22,892 ~34,078	Not Computed	2001, one-year, and demand-driven NIEMO.	Lee, B., P. Gordon, J. E. Moore II, H. J. Y. Park, W. Richardson, 2007, "Estimating the State-by-State Economic Impacts of Bio-terrors: The Case Study of FMD", Paper will be submitted to Journal of Homeland Security and Emergency Management.	Direct/Indirect state-by-state impacts