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Los Alamos National Laboratory Economic Analysis Capability Overview

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Los Alamos National Laboratory has developed two types of models to compute the economic impact of infrastructure disruptions. FastEcon is a fast running model that estimates first-order economic impacts of large scale events such as hurricanes and floods and can be used to identify the amount of economic activity that occurs in a specific area. LANL's Computable General Equilibrium (CGE) model estimates more comprehensive static and dynamic economic impacts of a broader array of events and captures the interactions between sectors and industries when estimating economic impacts.

LANL Computable General Equilibrium (CGE) Model

Los Alamos National Laboratory (LANL) is developing economic modeling tools that contribute to the evaluation of cascading effects of all hazards. The purpose of this project is to improve LANL's ability to evaluate the downstream economic impacts (e.g., from sector-to-sector or industry-to-industry, etc.) to the economy resulting from all-hazards events.

The LANL infrastructure analysis team provides essential economic analysis support to the majority of the team's infrastructure analysis projects. LANL is developing a Computable General Equilibrium (CGE) model to capture the interaction of buyers and sellers in markets in calculations of economic impacts. The CGE model also incorporates the activities of nonmarket institutions, such as a government sector, that tax firms and households that make and receive payment for goods and services.

The following flow diagram captures how different sectors of the economy are represented in the LANL CGE model.

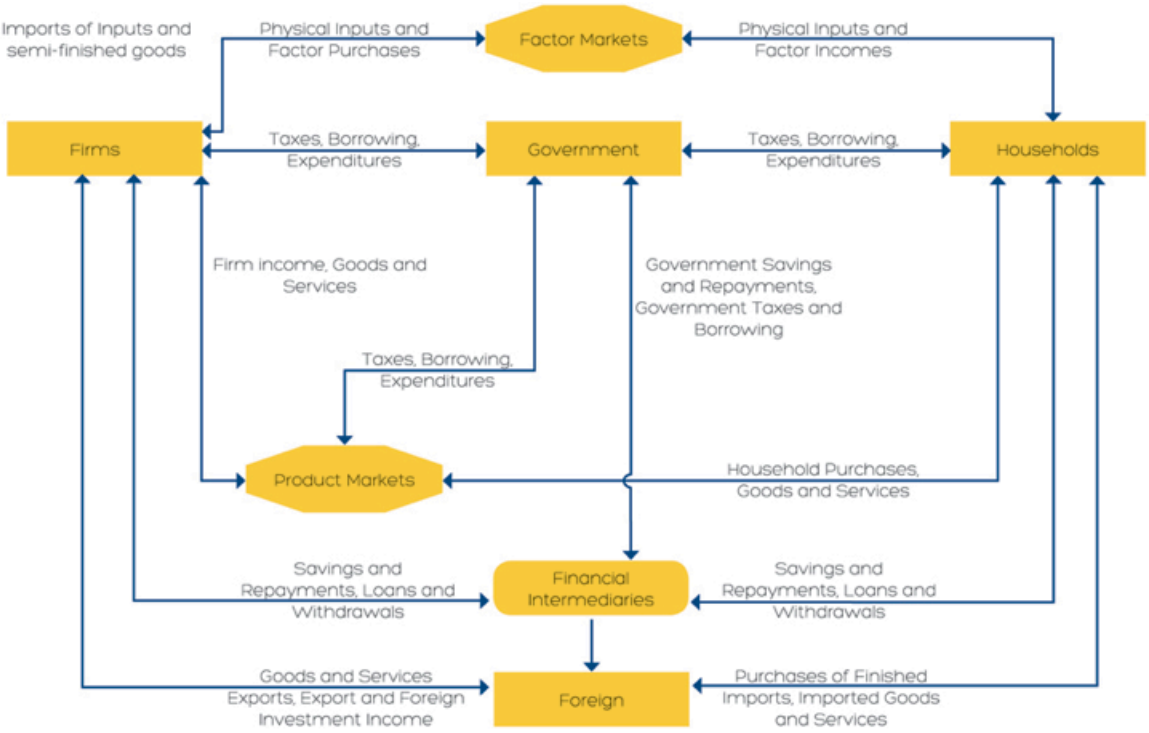

Figure 1. CGE Economy Flow Diagram

Data

The CGE model requires data input (see Table 1) to construct a Social Accounting Matrix (SAM) table for a given region or regions of interest. The SAM is a snapshot of the regional (or national) economy that shows the flows of resources between sectors (businesses, households, government, etc.) and industries in the economy and forms the core of every CGE model. The populated SAM is the input into the CGE model, which then estimates the initial baseline (pre-event) state of the economy and calibrates the model exactly to the data representing the regional or national economy. Models may be created for virtually any region, e.g., multiple states can be combined into a larger regional economy, an individual state can be divided into smaller sub-state regions, and (given sufficient data) models of other countries can be created.

For analysis of domestic United States regions, the SAM is populated with publically available data from the BEA, available data from the BEA, BLS, and ITC.

Table 1 summarizes the data used to populate the SAM.

Table 1—Data Sources for Populating Social Accounting Matrix

SAM Table Component	Data Source	Frequency and Industry Detail
Input-Output Make, Use, and Total Requirements Tables	U.S. Bureau of Economic Analysis	Annual data from 1998 to 2014, 2- and 3-digit North American Industry Classification System (NAICS) industry categories
National Level Consumer Price Index (CPI)	U.S. Bureau of Labor Statistics	Annual and quarterly from 1998 to 2014
Government Current Receipts and Expenditures (Federal and State and Local)	U.S. Bureau of Economic Analysis, National Income and Product Accounts	Annual and quarterly, 1998 to 2014
General Import Tariffs	U.S. International Trade Commission	Annual and quarterly data from 1998 to 2014, 2- and 3-digit NAICS industry categories
Employment and Wages	U.S. NAICS Bureau of Labor Statistics, Quarterly Census of Employment and Wages	Annual and quarterly data from 1998 to 2014, 2- and 3-digit NAICS industry categories

Capabilities and Applications

The approach to estimating the economic impacts with the LANL CGE model is to first characterize the event in terms of direct physical impacts to either assets or inputs such as capital or labor, or to changes in prices. These changes are mapped to specific LANL CGE model variables, model input changes are then determined, and the CGE model is then solved for a new equilibrium solution. The estimated impacts are differences between simulation and baseline values of specific measures of economic activity such as Gross Domestic Product (GDP), prices, and other variables.

The model inputs changes for impacts to assets or economic inputs are determined in several ways. Physical infrastructure models may be used to, e.g., estimate electric power outages and interruptions or damage to assets resulting from hazards such as peak ground acceleration of an earthquake event or water depth from a flood event. Real-world data may also be used to estimate these disruptions. In other cases, model input changes have to be determined judgmentally or with the application of other external models. For example, a pandemic influenza would not cause physical damage to assets, but would increase worker absenteeism, so an epidemiological model would have to first be used and those results would be translated into reductions in labor input in the model. As another example, an oil

supply shock would influence an economy through price changes rather than through damage to specific physical assets.

The model can estimate impacts over time, so longer-term impacts of events that cause longer-lasting damage to assets are estimable. The model can also be used to estimate inter-regional economic impacts for those events whose direct effects cross states or other regional boundaries. Moreover, the model can estimate full regional trade impacts for each industry, losses in exports experienced in one region and industry-specific trade flow impacts amongst regions.

Finally, the model can be adapted to virtually any user-defined region, including regions comprising multiple states or FEMA regions, regions comprising multiple parts of one state (e.g., northern versus southern California), and when data permits models can be create for foreign countries or specific regions outside the United States.

Recent applications of the Los Alamos CGE model include:

- Analysis of weapons of mass effects (WME) events
- Analysis of economic impacts of hurricanes
- Analysis of economic impacts of earthquake/tsunami event

LANL FastEcon Model

FastEcon provides direct, indirect, and induced gross domestic product (GDP) at current prices at the spatial level of the 10 Federal Emergency Management Agency regions and individual states.

FastEcon uses the most recent available data (currently 2014) for 20 industries corresponding to the North American Industry Classification System (NAICS) 2-digits industrial specification.

FastEcon estimates GDP values based on three components:

1) Number of jobs,

2) Direct GDP per job, and

3) The multiplier that computes total GDP (i.e., the sum of direct, indirect and induced) per dollar of direct GDP.

The workflow is explained in detail below. Figure 1 provides a diagram of the FastEcon workflow and inputs.

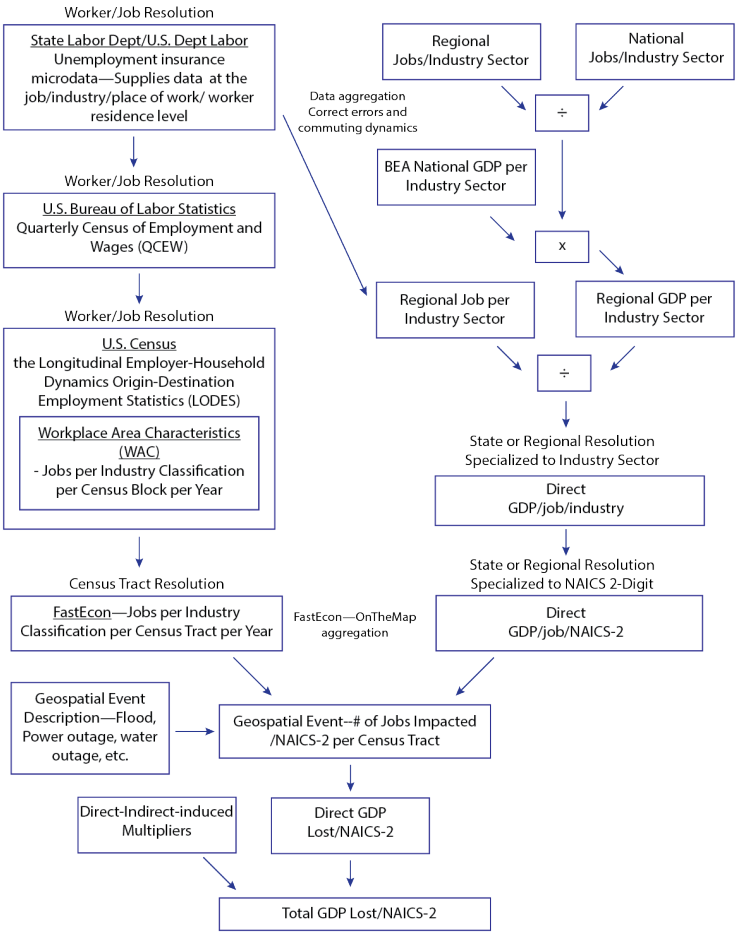

Figure 2. FastEcon workflow and inputs

The Workplace Area Characteristics (WAC) data provide jobs quantities by sector. These data are contained in the Longitudinal Employer-Household Dynamics Origin-Destination Employment Statistics (LODES), published by the U.S. Census.[1] LODES data are derived from the Quarterly Census of Employment and Wages (QCEW) published by the Bureau of Labor Statistics, QCEW data are built on unemployment insurance micro data collected by state labor departments and validated by U.S. Department of Labor. These original microdata contain individual information for jobs, including the industry, establishment of work, and residence for each employee. QCEW data may be from 3% to 5% incomplete. The Census developed the LODES product to aggregate information about commuting dynamics and to fix small errors in the QCEW data by means of an algorithm that assigns employees with incomplete information to establishments that are spatially close within the state. The WAC dataset contains the number of jobs in a period and industry classification for each establishment. WAC data are estimated at the Census block level. FastEcon uses the Census Bureau's OnTheMap web service to aggregate data at the Census tract level.[2] The jobs reflected in the dataset are full or part time.

[1] Longitudinal Employer-Household Dynamics, U.S. Census, http://lehd.ces.census.gov/data/.
[2] U.S. Census Bureau, "OnTheMap," http://onthemap.ces.census.gov/.

Direct GDP per job by industry is computed by dividing regional GDP by the number of jobs. Regional GDP by industry is derived by distributing Bureau of Economic Analysis (BEA) national GDP values to regions by multiplying national GDP by the ratio between the regional and national number of jobs by industry. The regional GDP values are at the BEA sector-level for 65 industries. These data are then aggregated at the NAICS 2-digits level. FastEcon estimates of direct GDP per job vary across regions because of regional industrial specialization.

Economic multipliers that provide direct, indirect, and induced GDP per dollar of GDP, are estimated using the standard procedure based on the Leontief inverse as it has been developed in the input-output literature and modeling approach.[3] LANL has developed regional input-output tables at the U.S. county level that simultaneously account for regional differences in both supply (as observed in QCEW data) and domestic trade flows (as estimated by transportation models and surveys).[4] FastEcon multipliers vary at the regional level because of differences in local economies and due to economic interdependencies within the nation.

Understanding the results: Direct GDP impacts result from an event. For example, if the event is a disruption of the electric grid, the direct GDP impact equals the consequent loss of production in the firms affected by the disruption. Indirect impacts are result from impacts along the supply chains of directly impacted firms. Induced impacts result from a loss of remuneration to production factors. In the previous example, direct impacts propagate to suppliers of directly affected firms, and iteratively to the suppliers of suppliers (indirect impacts are the sum of all these effects). Directly and indirectly affected firms then will have to reduce wages and dividends because of the production loss experienced. As a result, consumers will have to reduce their consumption levels, which will represent a further loss of production for firms and that will iteratively propagate along supply chains (the impacts induced by loss in consumption constitute induced impacts).

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[3] The literature on input-output modeling is extensive. One source is Ronald E. Miller and Peter D. Blair, *Input-Output Analysis Foundations and Extensions*, Cambridge University Press, 2009.

[4] For example, *Computable General Equilibrium Model Fiscal Year 2014 Capability Development Report*, National Protection and Programs Directorate, Office of Cyber and Infrastructure Analysis, US Department of Homeland Security, May 2015, and *Computable General Equilibrium Model Fiscal Year 2013 Capability Development Report*, National Protection and Programs Directorate, Office of Cyber and Infrastructure Analysis, US Department of Homeland Security, April 2014.