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Methodology for economic impact estimation : prepared for Los Alamos National Laboratory by Center for Economic Development Research, College of Business Administration, University of South Florida

University of South Florida. Center for Economic Development Research

Los Alamos National Laboratory

Methodology for Economic Impact Estimation

Prepared for
Los Alamos National Laboratory

by
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Preface

Los Alamos National Laboratory (LANL) has been conducting a comprehensive evaluation of the Nation's critical infrastructures for more than a decade. Although this evaluation has focused primarily on national security concerns, these critical infrastructures are an integral component of the Nation's economic activity and whose vulnerabilities have economic impacts that are important to understand. As an outgrowth of their research, LANL has developed a model of the natural gas pipeline system and electric power grid for the Tampa Bay region that is resolved to a very detailed level of description. Using this model to simulate outages of electric power and natural gas, LANL commissioned the Center for Economic Development Research (CEDR) to estimate the economic impacts of specified outage areas in the seven-county Tampa Bay region. To estimate the economic impacts CEDR used the REMI^{TM} Policy Insight model. CEDR provided its findings of economic impact to LANL in the report titled "Electric Power and Natural Gas Outage Study," dated March 2003.

Subsequently, LANL commissioned CEDR to investigate a methodology, compatible with LANL outage simulation software and not requiring the use of a proprietary model, for estimating the economic impacts of outages using output tables and multipliers. This document is a report of the investigation.

The Center for Economic Development Research initiates and conducts innovative research on economic development. The Center's education programs are designed to cultivate excellence in regional development. Our information system serves to enhance development efforts at the University of South Florida, its College of Business, and throughout the Tampa Bay region.

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Introduction

The objective of this task is to investigate a methodology, compatible with LANL outage simulation software and not requiring the use of a proprietary model, for estimating the economic impacts of outages using output tables and multipliers.

Our methodology is unique in that we seek to directly estimate the economic impact of an interruption of electrical power or natural gas within specific outage areas. Using geographic information system (GIS) software, we merge detailed establishment databases with outage areas generated by a Los Alamos National Laboratory (LANL) simulation model to identify with precision which establishments are affected by a given outage. Incorporating establishment data with output tables and multipliers, we are then able to estimate measures of impact that consider the specific industry mix and density within the outage area. This approach provides a greater understanding of how hypothetical outages may impact specific areas than previous studies, which rely upon simple linear trends of aggregate or survey data.

Definition of Impacts

Direct Impacts – Direct effects of a policy change or event. For the purposes of this study, the direct effect is the reduction in output (or value-added) due to a temporary electricity or natural gas interruption.

Secondary Impacts – The inter-industry, or "ripple," effects caused by the direct impacts.

Total Impact – The sum of the direct and secondary impacts.

General Method

The method previously employed to determine the economic impact of a business interruption due to an outage of electricity or natural gas is a multi-step procedure requiring the integration of several distinct processes.[1] First, simulated outages were generated using a variant of LANL's Energy Interdependence Simulation (EISIMS) model developed for the Tampa Bay region.[2] Geographical Information System (GIS) shape files are then created to delineate the areas affected by the outage. The shape files and duration for each outage were then sent to the Center for Economic Development Research (CEDR) to estimate the economic impact.

[1] Colie, D. and D. Hughes, "Electric Power and Natural Gas Outage Study," prepared for Los Alamos National Laboratory, 2003.
[2] Unal, C., B. Bush, K. Werley, and P. Giguere, "Modeling of Interdependent Infrastructures," Los Alamos National Laboratory Report #LA-UR 02-0856. Los Alamos, New Mexico, 2002.

Once CEDR received simulated outage area shape files from LANL, the shape fields were integrated into the front-end database and direct economic impacts were determined. We then formatted the results from this process for input into the multiplier table, which estimated the total economic impacts. Total impacts are the primary effects, i.e. direct impacts plus the secondary effects as the direct impacts ripple through the economy.

We now propose in this paper how the previous method can be integrated into the EISIMS.

GIS Overlays (*Front-end Database*)

The foundation of our previous analysis was the creation of the front-end database, a geographical model of the seven county Tampa Bay region comprised of several linked geographical overlays and databases. Using the Environmental Systems Research Institute's (ESRI) ArcView 3.2 GIS software, linked geographic overlays were created for the census tracts, counties, and zip codes in the Tampa Bay study area. These overlays were integrated with comprehensive street maps of the region.

Linking the spatial overlays with comprehensive street maps allows for the geo-coding of individual establishments by street address to the combined GIS project area. The geo-coding process is the identification and addition of point locations to an existing geographical overlay. Typically, as in this case, the point locations are linked to databases that contain additional characteristic data that are associated with the point locations.

Databases including street address, employment, and industry group as defined by the 3-digit Standard Industry Classification (SIC) code of all business and educational establishments in the Tampa Bay region were geo-coded to the project area to complete the front-end database.

We propose that that LANL develop a front-end database similar in scope and detail to the front-end database used by CEDR in the previous study. The database should include employment information obtained from the appropriate agency (in Florida, the Agency for Workforce Innovation supplied the employment data). Other locally available sources (school board, business rankings) can be used to supplement the front-end database. This front-end database will provide the direct effects (employment) of a business interruption needed for input into the multiplier tables.

Measuring Economic Impact with RIMS II Multipliers

To estimate the total economic impact of an outage of electricity or natural gas through total impacts, i.e. direct and secondary impacts, first measure the direct impacts as the number of establishments and employees of those establishments immediately affected by the outage. In our model, we use the front-end database to estimate these direct impacts.

Then, using the Regional Input-Output Modeling System (RIMS II) multipliers, estimate the total impacts. Total impact is the sum of the direct and secondary effects. We measure total impact by the value of lost production caused by the outage.

RIMS II is based on an accounting framework called an I-O table. For each industry, an I-O table shows the industrial distribution of inputs purchased and outputs sold. A typical I-O table in RIMS II is derived mainly from two data sources: The Bureau of Economic Analysis's (BEA's) national I-O table, which shows the input and output structure of nearly 500 U.S. industries, and the BEA's regional economic accounts, which are used to adjust the national I-O table to show a region's industrial structure and trading patterns.

Using RIMS II multipliers, the value of lost production is the sum of annual output for each industry group uniformly scaled to the duration of the outage. This lost production includes both the production of industries directly affected by the business interruption and the production lost through the "ripple effect" as the flow of goods and services is momentarily slowed down or halted through the economy.

To effectively use the multipliers for impact analysis, users must provide geographically and industrially detailed information on the initial changes in output, earnings, or employment that are associated with the project or program under study. Our proposed methodology uses employment by industry that is obtained from the front-end database and shape files. The multipliers are used to estimate the total impact of the project or program on regional output, earnings, and employment.

The BEA sells RIMS II multipliers for any region composed of one or more counties, and these multipliers can be ordered via fax or email.[3] For each region ordered, RIMS II provides several sets of multipliers: final-demand multipliers for output, employment, and earnings, as well as direct-effect multipliers for employment and earnings. Typically, RIMS II users start with a defined change in final demand to determine the effect on industry output, but manipulation of the other RIMS II multipliers can calculate a change in associated with a change in employment. For the purposes of this study, the front-end database previously described determines the direct impacts, measured by employment per industry. In order to determine the total economic impact of an outage of electricity or natural gas through industry group employment data, first divide the final-demand multiplier for employment by the direct-effect multiplier for employment, yielding the change in employment per million-dollar change in final demand (equation 1). Next, divide the initial change in employment (as determined by the front-end database) by the change in employment per million-dollar change in final demand, yielding the million-dollar change in final demand (equation 2). The change in final demand is then multiplied by the final-demand multiplier, yielding the million-dollar impact on output (equation 3). Our previous study measured the total impact by value-added, not output. Later in this paper, we present a discussion of the differences between these measurements.

[3] http://www.bea.gov/bea/regional/rims/order.cfm

This method is outlined in **Figure 1**. **Green** text signifies RIMS II data elements. These calculations and the RIMS II tables would need to be integrated into the EISIMS model, and updated periodically.

(1)	**Final-Demand Multiplier for Employment** / **Direct-Effect Multiplier for Employment**	=	Change in Employment / Change per $1M of Final Demand
(2)	Change in Employment / Change in Employment / Change per $1M of Final Demand	=	Estimate of Direct Impact on Employment / (Equation 1)
(3)	(Equation 2) X (**Final Demand Output Multiplier**)	=	$1M Change in Output

Figure 1. Estimating Output with RIMS II Multipliers

In order to further illustrate this process, we present the following example: A business interruption in the Kansas City, MO-KS Economic Area results in the displacement of 45 jobs in the construction industry. Using the following RIMS II multipliers[4], what is the change in total output from this interruption?

RIMS II Variables	
Industry Aggregation	Construction
Final-Demand Multiplier for Employment	34.4
Direct-Effect Multiplier for Employment	2.397
Final Demand Output Multiplier	2.3270

First, divide the Final-Demand Multiplier for Employment (34.4) by the Direct-Effect Multiplier for Employment (2.397) to estimate the change in employment per million-dollar change in final demand (14.3513 jobs/$1M). Divide this number into the number of jobs displaced due to the business interruption (45) to yield the total million-dollar change in final demand ($3.1356 million). Multiply this amount by the Final Demand Output Multiplier (2.3270) to yield the total change in output due to the business interruption – $7.2965 million.

Measuring Economic Impact with IMPLAN Multipliers

As an alternative to using the RIMS II multipliers, one can use IMPLAN's data sets to build a multiplier table linking changes in industry group employment to changes in output. IMPLAN is a proprietary economic impact assessment software system which, according to its developers, the Minnesota IMPLAN Group, Inc. (MIG, Inc.) is a traditional Input-Output model. IMPLAN is static in nature in that can analyze changes in a regional economy at a particular point in time.

IMPLAN provides multiplier tables for employment and total value-added. The employment multipliers estimate the direct change in employment per million dollar

[4] The RIMS II multipliers used in this example are taken from the RIMS II User Handbook, Third Edition, U.S. Department of Commerce, 1997. Available at http://www.bea.gov/bea/regional/rims/

change in final demand, and the total-value added multipliers estimate the change in value-added per million dollar change in final demand.

Starting with the initial changes in employment per industry group due to an outage of electricity or natural gas, divide these changes by the IMPLAN direct effect employment multiplier, yielding the million-dollar change in final demand (equation 4). Multiply the million-dollar change in final demand by the appropriate industry group's total value-added multiplier to yield the change in total value-added (equation 5). These calculations and the IMPLAN tables would need to be integrated into the EISIMS model, and updated periodically. Additionally, total output multipliers can substitute for the total value-added multipliers to determine the change in output per million dollar change in final demand. This annual figure can then be scaled to fit the duration of the electricity or natural gas outage. This method is outlined in **Figure 2**. **Blue** text signifies IMPLAN data elements.

(4) $\frac{\text{Change in Industry Group Employment}}{\textbf{Employment Direct Effect Multiplier}}$ = $1M Change in Final Demand

(5) ($1M Change in Final Demand) X (**Total Value-Added Multiplier**) = Total Value-Added ($1M)

Figure 2. Estimating Value Added with IMPLAN Multipliers

RIMS II vs. IMPLAN

RIMS II multipliers can be estimated for any region composed of one or more counties and for any industry, or group of industries, in the national I-O table. The accessibility of the main data sources for RIMS II keeps the cost of estimating regional multipliers relatively low. Empirical tests show that estimates based on relatively expensive surveys (i.e. proprietary models such as IMPLAN) and RIMS II-based estimates are similar in magnitude.[5]

An issue to consider when comparing RIMS II versus IMPLAN is the measurement of the effect of the business interruption. RIMS II measures the effect by output. Output is defined as the dollar amount of goods or services produced or sold and is further subdivided into two components: final demand (sales to final consumers) and intermediate sales (sales to other industrial sectors). IMPLAN can calculate either output or value-added. Value-added is the sum of total income and indirect business taxes. Value -added is a component output, and it avoids double counting of intermediate sales and captures only the "value-added" by the region to final products. We believe that value-added is the appropriate measure of a regional economic impact due to business interruption.

[5] See U.S. Department of Commerce, Regional Input-Output Modeling System (RIMS II), chapter 5. Also see Brucker, S., S. Hastings, and W. Latham, "The Variation of Estimated Impacts from Five Regional Input-Output Models," International Regional Science Review 13 (1990): 119-39.

Cost is also a consideration when comparing RIMS II to IMPLAN. RIMS II prices start at $275 per region, with county-level data comprising the smallest regions. There are 3,142 counties (or county equivalents) in the United States, so RIMS II coverage would cost $864,050 for the entire United States. Additionally, this coverage would not accommodate inter-county relationships with respect to jobs, earnings, or output. Outage areas involving more than one county would require the purchase of tables for a region composed of those counties, at additional cost, in order to correctly apply the RIMS II multipliers.

IMPLAN data sets are also available for purchase, with county-level data comprising the smallest region. Total cost for all IMPLAN data files is $30,000, with an additional $450 required to purchase the IMPLAN software.

Conclusions

We have proposed two methodologies for integrating CEDR's previous methodology into the EISIMS. Both methodologies would require the use of a front-end database similar in scope and detail to the database constructed by CEDR. The front-end database would then estimate the direct impacts (measured by employment) of a business interruption. Using this employment data in conjunction with either the RIMS-II or IMPLAN multiplier tables, the total impacts of a business interruption could then be estimated. Both the front-end database and the multiplier tables would require updating in order to provide accurate estimates.

Due to the certainty of price, and flexibility in measuring economic impacts, the IMPLAN model appears superior to the RIMS II multiplier tables. For limited outage areas, RIMS II is not as expensive as IMPLAN, but if nationwide coverage is desired, the RIMS II cost quickly escalates past the $30,000 cost of IMPLAN. Furthermore, IMPLAN provides multiple measurements for describing the economic impact of a business interruption: output and value-added.

Although IMPLAN is a proprietary model, and thus non-conforming to the specifications of our research task, we recommend that LANL integrate IMPLAN multiplier tables into its EISIMS software.