Analyzing Critical Infrastructure Dependencies: Security and Survivability Effects in the Service Sectors

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Abstract

Discussions about survivability require systemwide comparisons and interdisciplinary approaches. Our consideration of survivability focuses on large-scale economic implications of attacks or vulnerabilities on major infrastructure sectors as defined by the Department of Commerce. We explore the critical connections between core service infrastructure sectors (e.g. telecom, electricity, and pipelines) using a total supply chain analysis model originally developed to estimate environmental and energy effects of production in the U.S.

Introduction

With the increasing focus and attention in the United States on national security, there have been many stories and agendas put forth that note holes or vulnerabilities in our systems. The resulting legislative push towards spending money to fill these holes has created many resource allocation issues. While there are many apparent problems, there is no obvious socially acceptable way to choose which vulnerabilities should be addressed first.

Some of the systems that are mentioned when speaking about 'Critical Infrastructure' are the telecommunications, transportation, and energy sectors. There is much discussion in the popular press and in defense warfare theory about the interconnectedness of these infrastructures. As a result, it is difficult to point at a single infrastructure vulnerability and not see systemwide impacts. For example, a vulnerability in the U.S. electric power grid has far-reaching effects in not only other infrastructures and economic sectors, but in geographically distant regions, including other countries.

Many researchers in the area have recognized the dependencies inherent to the complexity of our nation's infrastructures. Some have even attempted to visualize these interdependencies by showing our critical infrastructures and the ways in which they depend on each other. Others are looking for specific or tangible vulnerabilities between systems. However, there has been no quantitative assessment of either the degree to which these infrastructures depend upon each other, or the changes to the economy that result from these interdependencies.

We propose to use publicly available data from the Department of Commerce's Bureau of Economic Analysis to show the actual economic dependencies between critical infrastructures, and the service economy sectors in general. The input-output tables of the U.S. economy detail the economic purchases that result between all 500 sectors. Specifically, the 'make and use' tables show how much output is MADE by each of the sectors, and which other sectors USE the output from each sector. For example, the use table would show not only which sectors use electricity - which is of course all of them - but also how much dollar value of electricity is used to produce goods or services in that sector. This data are real and tangible representations of how dependent sectors are to other sectors. Of course, the sectors of most interest to us when discussing vulnerabilities are our critical infrastructures.

Using the data as mentioned above allows us to answer a wide range of potential policy questions. For example, we could consider which infrastructure sector should be given budget priority for upgrading security. We could look at the economic dependencies of all other sectors in the economy to see, for example, which of the infrastructure sectors lead to the most value added in the economy. Thus, making investments for security upgrades in that sector would have the largest preventative 'bang for the buck' when considering the degree to which potential negative economic shocks could be avoided.

Other analyses are possible with the type of model described above. Input-output data in the U.S. has been collected for over 50 years. We can analyze how dependencies on critical infrastructures have changed over time, and also study the speed at which new technology adoption has led to further infrastructure changes. At the sector level, we can see which sectors have moved from being 'casual' to 'primary' users of infrastructure and potentially identify previously unseen vulnerabilities.

One primary mechanism that will be used to complete this research project will be the Economic Input-Output Life Cycle Assessment (EIO-LCA) model, developed over the past decade at Carnegie Mellon (and available on the Internet at www.eiolca.net). This model, originally developed to trace out the energy and environmental supply chain impacts of production changes in the economy, is driven by the input-output data referenced above. However, instead of considering the environmental implications of decisions, we will be using the tool to consider survivability and dependability issues associated with national security.

Part of the 'transitional' utility of the model has already been tested. We recently added employment data to the model. This data shows us the average amount of employment needed in each sector of the economy needed to support output in another sector. Had a user performed such an analysis on the air transportation sector last summer, they would have seen that the supply chain of air transportation depended upon employment in the fuel, passenger transportation, and related sectors. This same result considered 'in reverse' notes which sectors

would feel the most pain as a result of a 15% drop in commercial airline revenue as a result of terrorist attacks and business travel reductions resulting from an economic slowdown.

A similar analysis across all infrastructure and service sectors would show the amount of 'pain' other sectors would feel due to a technological or economic shock to national infrastructure. Benchmarks of 'pain' in this case could be reduced product lead times from disrupted Just-in-Time inventory models, energy price increases, etc.

This type of tool could also be used to benchmark the service sectors against each other to check their relative dependencies on infrastructure, and thus lead to insights into where sector or industry-level initiatives should begin to address these vulnerabilities. At the firm level, a financial services company could compare its own infrastructure vulnerabilities with other firms in their sector to guarantee that emergency response plans and corporate disaster training fully incorporate the range of vulnerabilities that exist.

Addressing national security where the rubber meets the road is inevitably a resource allocation problem. Many challenges exist, and many security holes need to be addressed. In the absence of obvious social preferences to direct our national efforts, we need to move expeditiously to see how our economy is affected by these interdependencies. We can use economic measures of dependency as proxies for our social preferences to help guide our efforts to improving the security of our nation's critical infrastructures. This plan guarantees that we protect the welfare of our society by maintaining economic security.