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Incorporating transportation network modeling tools within transportation economic impact studies of disasters

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Abstract: Transportation system disruption due to a disaster results in "ripple effects" throughout the entire transportation system of a metropolitan region. Many researchers have focused on the economic costs of transportation system disruptions in transportation-related industries, specifically within commerce and logistics, in the assessment of the regional economic costs. However, the foundation of an assessment of the regional economic costs of a disaster needs to include the evaluation of consumer surplus in addition to the direct cost for reconstruction of the regional transportation system. The objective of this study is to propose a method to estimate the regional consumer surplus based on indirect economic costs of a disaster on intermodal transportation systems in the context of diverting vehicles and trains. The computational methods used to assess the regional indirect economic costs sustained by the highway and railroad system can utilize readily available state departments of transportation (DOTs) and metropolitan planning organizations (MPOs) traffic models allowing prioritization of regional recovery plans after a disaster and strengthening of infrastructure before a disaster. Hurricane Katrina is one of the most devastating hurricanes in the history of the United States. Due to the significance of Hurricane Katrina, a case study is presented to evaluate consumer surplus in the Gulf Coast Region of Mississippi. Results from the case study indicate the costs of rerouting and congestion delays in the regional highway system and the rent costs of right-of-way in the regional railroad system are major factors of the indirect costs in the consumer surplus.

Key words: consumer surplus; intermodal transportation; economic impact; disaster relief; diverted traffic

1 Introduction

The United States has experienced multiple disasters in the past 10 years that have caused significant destruction to many types of infrastructure systems, resulting in immense economic impact to the affected

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region. These disasters range from flooding in the mid-west, tornados in Oklahoma, to two of the costliest hurricanes to hit the coastline. One infrastructure system that is highly susceptible to damage is the transportation system which is the foundation to society. According to the research of Kreis et al. (2006), state departments of transportation (DOTs) are interested in the economic impact of transportation projects to prepare infrastructure and to have emergency funds available. In addition, DOTs and metropolitan planning organizations (MPOs) can use the economic impact analysis of a disaster to support the best restoration plan to mitigate economic costs following a disaster and the use of pre-disaster funds to strengthen infrastructure and prepare for potential loss.

Determining the regional economic costs that result from a disaster may help minimize disaster related ripple effects throughout the transportation network. There are two types of economic costs associated with disruption to the transportation infrastructure, direct economic costs and indirect economic costs. The direct economic costs are the costs that relate to the restoration or reconstruction of the transportation system. These costs are pure calculations based on current construction costs, economic variables and standard growth rates. The indirect economic costs are the additional costs incurred by diverting vehicles and trains in the entire transportation system, also known as consumer surplus. Consumer surplus due to a disaster is represented by the grey shaded area *ABCD*, in Fig. 1 (Nicholson and Du 1997).

The indirect economic costs that are the basis for consumer surplus become a difficult computation because they are imbedded within the use of the infrastructure, such as costs of rerouting traffic, emissions, and congestion delays. Additionally, data needed to determine pre and post costs may be very difficult, if not impossible to collect after a disaster. Although there are many approaches for estimating the economic loss after a disaster, the challenges to any type of economic study of a disaster include the dynamics of travel demand in private and freight vehicles, the dynamics of traffic patterns and the dynamics of the transportation network. It is for these reasons that a methodology to estimate the indirect economic costs based on diverting vehicles and trains in a region due to a disaster is critical.

To demonstrate the capabilities of the research, a case study of the worst natural disaster in the history of the U. S., Hurricane Katrina, was reviewed specifically for the Gulf Coast Region of Mississippi where the highway and railroad facilities were the most heavily damaged (Zhang 2010) and that made the regional economy crippled.

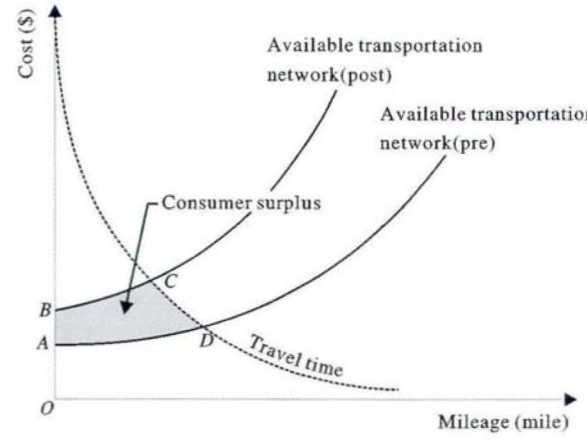

Fig. 1 Travel cost and travel mileage

2 Literature review

2.1 Transportation economic impact study

Input-Output (I-O) models are widely used in economic impact studies for transportation disruptions due to their ability to be manipulated for specific scope of use. Recent research includes three distinctly different methods to the use of an I-O model for specific goals. Hu (2008) developed a method for evaluating the economic impact of freight disruptions due to highway closures, applying these impacts to calculate the indirect costs incurred by a market as a whole. Kim et al. (2002) used a multiregional I-O model and a regional commodity flow model to estimate and evaluate the economic impacts of a catastrophic earthquake based on hypothetical scenarios. Seetharaman et al. (2003) utilized a demand-side I-O model to evaluate the economic benefits of a proposed freight policy for a six-county region in Illinois. Okuyama (2007) integrated I-O model with Social Accounting Matrix (SAM) analysis to analyze the correlations among transporta-