# ABSTRACT

Zhang, Pengcheng. Doctor of Philosophy, Purdue University, December, 2008. A Generalized Modeling Framework to Analyze Interdependencies among Infrastructure Systems. Major Professor: Srinivas Peeta.

Extreme events over the past decade in the USA, ranging from the 9/11 terror attacks to the 2003 Northeast power blackout to the 2005 hurricanes, have highlighted the urgent need to understand the security and economic implications of the interdependencies among civil infrastructure systems. The need is further highlighted by the challenges arising in the context of urbanization and the needs to renew ageing infrastructure. This motivates a new generation of models that can incorporate multiple infrastructure systems in a single framework, capture their interdependencies, and conduct decision-making analysis for more efficient, effective, robust and resilient infrastructure systems.

This dissertation proposes a generalized modeling framework that combines a multilayer network concept with market-based economic approach to capture the interdependencies among the various infrastructure systems with disparate physical and operational characteristics. Thereby, the systems are modeled as individual networks connected through flows representing market interactions, and the different types of infrastructure interdependencies are captured through supply-demand mechanisms.

Based on a multilayer infrastructure network (MIN) concept, the modeling framework uses the computable general equilibrium (CGE) theory and its spatial extension (SCGE) to formulate the equilibrium and disequilibrium problems. Fundamental introduction and comprehensive literature review are conducted on the related topics. Key modeling issues for the mathematical formulation are discussed, followed by the description of static equilibrium models. The equivalent variational inequality (VI) formulation is also proposed to analyze the mathematical properties such as the existence and uniqueness of solution. The dynamics issues are then discussed, followed by the description of the dynamic planning, equilibrium-tending and disequilibrium models. Numerical experiments are conducted to illustrate the characteristics of the models and their capability to capture the various types of interdependencies. Implementation issues are then discussed, and potential application domains of the framework are demonstrated through numerical examples to provide insights on the importance of infrastructure interdependencies in real-world problems.