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Flood risks and impacts: A case study of Thailand's floods in 2011 and research questions for supply chain decision making

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ABSTRACT

This paper investigates the impact of floods on the global economy through supply chains, and proposes measures for the related supply chain risk. We examine Thailand's 2011 flood since it is a notable example of the impact of floods both on industries and the whole economy. The protracted floods affected the primary industrial sectors in Thailand, i.e., the automotive and electronics industries, with a devastating impact on the whole economy. The impact of natural hazards on the global supply chain is increasing. However, the impact on each firm that is exposed is different depending on how well they are prepared and how they respond to the risks. Designing supply chains in a more resilient way will ultimately reduce risks to the economy. Comparing different supply chains and industries' structure in Thailand, this study identifies the factors in private investment decision- making, such as *locations of facilities, alternate locations of production, the diversified sources of procurement, emergent assistance from other partner companies in the same supply chain,* and *degree of the recovery of customers* and proposes a hypothesis and related questions for future research.

1. Introduction

Floods on one side of the earth affect the economy on the other side of the earth through global supply chain networks. Today's global supply chain has achieved cost reduction by reducing inventory, shortening transportation timelines, and streamlining production systems. However, with lean and complex supply chains, there is much more susceptibility to systemic risk, a financial term used to describe a risk originating from one node of a financial network which then harms the entire financial market. This notion of risk is applicable to supply chains. While a more efficient production and transportation system is more capital intensive and cost efficient, in the event of a natural disaster, the entire system may suffer disruption and break down. The Economist [1] reported that while death rates from natural disasters have been falling, their economic cost continues to increase drastically. This cost includes place based impacts and supply chain impacts. However, the latter have not been systematically reported or broken out.

According to Bolgar, [2] Accenture, a global management consulting firm, revealed that 93% of the companies studied consider supply chains as their top priority. Further, 30% of the companies attributed 5% of their lost revenue to the disruption of their supply chains. Supply chains are important, not only for a company but also for a nation. For instance, in January 2012, the Obama administration released the National Strategy for Global Supply Chain Security, which focuses on energy, container shipment, and cyber networks. For both companies and governments, weather-related hazards are one of the

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biggest sources of risk to the supply chain. A studied carried out by Zurich Financial Services Group and Business Continuity Institute [3] revealed that 51% of supply chains were affected by adverse weather over the past year. 49% of businesses lost productivity from such disruption, while their cost increased by 38% and their revenue decreased by 32%.

In this paper we (i) investigate the impacts of floods on supply chains using the case of Thailand's 2011 flooding focusing on automobile and electronics industries; and (ii) propose components that should be considered in measuring supply chain risk by proposing future research questions.

2. Reviews of important concepts and indices

In this section, we review some concepts to provide a context for an analysis of the Thailand floods of 2011 and other cases related to the impact of floods on supply chain networks.

2.1. Direct and indirect damages

There are a number of definitions of damage caused by disasters (See for example, Rose [4]). Yet, Table 1 is the common understanding among existing studies [5]. In this study, direct damage refers to the physical damage by natural hazards to facilities or equipment while indirect damage refers to the damage which is not physically damaged by natural hazards to facilities or equipment but is caused by ripple effects.

Table 1
Different aspects of flood damages.
Source: Jonkman, et al. [5].

	Tangible and priced	Intangible and unpriced
Direct damage	• Residences • Capital assets and inventory • Business interruption (inside the flooded area) • Vehicles • Agricultural land and cattle • Roads, utility and communication infrastructure • Evacuation and rescue operations • Reconstruction of flood defenses • Clean up costs	• Fatalities • Injuries • Inconvenience and moral damages • Utilities and communication • Historical and cultural losses • Environmental losses
Indirect damage	• Damage for companies outside the flooded area • Adjustments in production and consumption patterns • Temporary housing of evacuees	• Societal disruption • Psychological Traumas • Undermined trust in public authorities

2.2. Time to recovery and financial impact

Second, the performance indices that measure the impact of a disaster on supply chains are reviewed. Simchi -Levi [6] proposes the Risk Exposure Index, which assesses a cost induced by a potential disruption based on the Time to Recovery (TTR) for each level or node, and the resulting Financial Impact (FI). Those individual risk components are then summed up to obtain a comprehensive FI for the entire supply chain. There are several aspects of TTR. For example, time to resume operations, even partly, if a facility has been stopped, is a major indicator of resiliency that has frequently gained attention in the real business world. Time to return to the "pre-disaster" level of production can also be an important indicator in terms of the real impact of disruption. In the real world, Cisco Systems, Inc. has already adopted this notion of TTR, which is "…based on the longest recovery time for any critical capability within a node, and is a measure of the time required to restore 100% output at that node following a disruption [7]. " Thus, to measure resiliency of supply chains or impacts of floods to supply networks, this paper will focus on TTR, the time needed for both part and full restoration.

Regarding the financial impact of the floods, the operational profits from the financial statements of a company as affected by the amount of extraordinary losses caused by disasters are of particular interest. This approach, that examines financial performance to see resiliency and robustness of supply chains, is similar to the trends in businesses. For example, Gartner, which is the leading information technology research company, have annually published Supply Chain Top 25 ranking since 2005. In 2012, Gartner attempted to measure resiliency of supply chain. The company assumed that companies with good and steady financial performance are more likely to manage supply chain than companies with unstable performance, though they did not examine TTR [8].[1]

2.3. Perspectives for analyzing supply chain resiliency and robustness

Third, the concepts that are needed to analyze product and process features are introduced. We use the four perspectives proposed by Fujimoto [9]: *dependence*, *visibility*, *substitutability*, and *portability*. The first perspective is dependence on suppliers. Extreme dependence on one supplier's product can make the supply network vulnerable. The second is *visibility of supply chains*. If the downstream companies in supply chains are unaware of a serious bottleneck in a supply network, there is a greater chance that the network cannot respond to the disruption quickly. The third is *design information substitutability*. If a product uses a specific design for a particular product, especially when the supplier uniquely controls design resources and processing of the product, then in a crisis, such products will be extremely difficult to replace by

[1] Hofman and Aronow [8] uses three-year average of return on asset (ROA) and revenue growth and standard deviations of these two financial indicators to calculate resiliency of supply chains.

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