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CONCEPTUALIZING RESILIENCE IN SUPPLY CHAIN SIMULATION

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ABSTRACT

Supply chains (SCs) collaborate in production and consumption across the world. SC management techniques attempt to optimize and balance supply chain operations. SC simulation can help support this by exploring "what-if" scenarios across key performance indicators, particularly when SCs are subject to potentially disruptive events. Resilience is the capacity for an enterprise to survive, adapt, and grow in the face of turbulent change. Change engenders SC vulnerabilities and management control attempts to create SC capabilities to address them. We are investigating the feasibility of creating a generic SC Simulation framework that represents sources of vulnerability and resilience and allows decision makers to explore potential capabilities to address them. This article reports progress on the first step of this study towards the creation of a conceptual model of SC resilience.

1 INTRODUCTION

A supply chain (SC) is a network of business entities engaged in tasks from production to consumption involving forward and backwards flow of products, information, and monetary exchange. SC Management attempts to balance production and consumption across a SC that favors a global, holistic view in which business entities collaborate to optimize the whole rather than their own individual elements. SC Simulation is an attractive decision support technique that can accommodate complex, dynamic behavior, and can explore "what-if" scenarios across a range of key performance indicators (KPIs) and parameters (Mustafee et al. 2022). Resilience can be defined as the capacity for an enterprise to survive, adapt, and grow in the face of turbulent change (Fiksel 2006). Further, it is an ability to return to "normal" after turbulent change, or to transition to a "better" state after lessons are learnt. A better ability might be sustainability reflecting an enterprise's ability to be viable during its lifetime. Petit et al. (2019) present a theoretical basis for resilience in SCs that acknowledges changes engendering SC vulnerabilities and management control creating SC capabilities. This gives context for their qualitative SC Resilience Assessment and Management (SCRAM) tool.

We are investigating the feasibility of a generic simulation-centered framework to support SC management decision making with respect to resilience. The framework will help to establish the requirements for decision-support tools to provide actionable options for users, empowered by a deeper understanding of an SC's sources of fragility, both to mitigate vulnerabilities and to enhance overall resilience. Our work adds to the conceptualization of Fiksel (2006) by acknowledging that actions of resistance and adaptation can be anticipatory or reactive. The first step towards this goal is the creation of a conceptual model of resilience in supply chains; this also lays the foundation for developing the resilience

framework based on Many Objective Optimization (Li et al. 2015) and Option Awareness (Pfaff et al. 2013) to support informed decision making.

2 CONCEPTULIZING RESILIENCE: KEY QUESTIONS

Figure 1 presents a generic SC conceptual model. Its elements include one or more suppliers of raw materials, a manufacturer, a distributor, one or more retailers and many customers (other elements such as warehouses might also be there). Each element has one or more resilience-related vulnerabilities, here denoted Resilience Risks (RRs). SC operations may be further influenced by business climate, government directives, external logistics and resources, and other RRs (e.g., climate, geopolitical, pandemic, etc.). Each element can be detailed as part of the conceptual model. In addition, other elements such as regions and places are also being considered. For example, a region is a geographic area that may be subject to RRs; a place is within a region that may have its own RRs. A region might have a seasonally related RR (e.g., torrential rain) and a place might have a significant RR (e.g., a port with labor shortages). Regions and places therefore can help to represent RRs in more detail. Routes are also elements. A route can start and end at a place and go through several regions. In this way transportation resilience between SC elements can be represented in more detail and solutions may be planned to mitigate these.

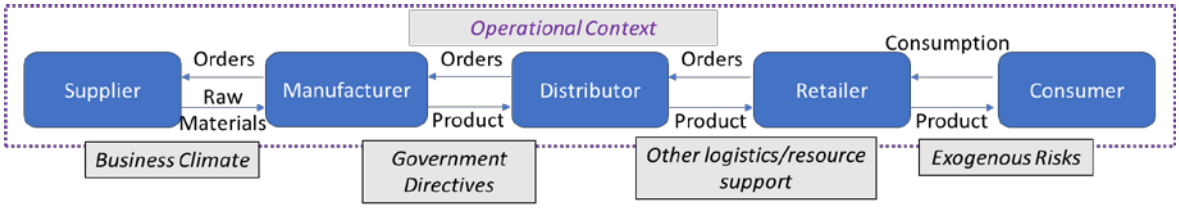

Figure 1. Generic Supply Chain.

We are investigating key questions to shape our conceptual model for SC resilience. These include: What are the generic RRs for all elements? Which RRs are specific to certain elements? What needs to be represented for "normal" supply chain behavior? What global RRs exist? What relevant resilience KPIs exist for each element in the supply chain (e.g., environment, ethical behavior, reliability, etc.)? What experimentation will need to be performed to investigate resilience capabilities is also being considered?

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