Digital Twins, Stress Tests, and the Need for Resilient Supply Chains

Ronak R. Tiwari
National Institute of Techcnology, Calicut, India

Vishnu C. R.
Xavier Institute of Management and Entrepreneurship, Kochi, India

R. Sridharan
https://orcid.org/0000-0002-0186-6442
National Institute of Techcnology, Calicut, India

P. N. Ram Kumar
Indian Institute of Management, Kozhikode, India

INTRODUCTION

The human civilization has evolved from the invention of the wheel to self-driving cars. While technology has made our lives easier, it has also made the world around us more complex to maintain. For instance, the scope of developing a new automobile now, is not only to make it functional, but also to make it safer, appealing, and cost effective at the same time. **D**ata, **I**nternet-of-Things (IoT), **S**ensors, **Co**mputers (DISCO) form a set of essential tools which can help us maintain and better manage this complexity. Industry 4.0 is a term given to indicate the direction in which the future of the industry lies. It essentially stresses on use of DISCO to build a world that is more sustainable, resilient and agile.

The focus of this article is on Supply Chains (SCs). SCs undoubtedly form an integral part of the modern economies. Last two decades have particularly tested the SCs in every aspect. Issues like Climate change have become more evident with frequent natural disasters persistently occurring in different parts of the world. With SCs getting more global, diverse, and interdependent they have become prone to disruption risks from all over the globe. The challenge for modern SCs is therefore to be able to recover from a disruption, back to its original state, with least impact possible. This ability is defined as resilience in SCs (Christopher & Peck, 2004). The word resilience is borrowed from ecology, which refers to a system's capacity to resist damage and recover after a perturbation or disruption (Peck, 2005). The audience from material science/engineering background may find acquaintance with the term too, where it is described as a material's property to absorb some amount of energy and return back to its original form. It could be argued that incorporating resilience aspects in new supply network is probably easier compared to altering the existing network which is already complex, and a result of years of relationship and trust built with suppliers. Hence, the bigger question that organizations are looking an answer for is, how to build resilience in existing SC networks? Or for that matter how to asses an organization's current state of resilience?

DOI: 10.4018/978-1-7998-9220-5.ch180

One of the key ideas promulgated in risk management, after the 2008 financial crisis, was the notion of 'Stress Tests' (Bank Stress Test, 2021). Stress tests in banking imply that the banks are exposed to a standard set of extreme scenarios, and the banks are assessed on their ability to withstand these events. The banks which fail the stress test are accordingly guided to shape their strategy. The practice of stress tests which originated with banks has been adapted and used in many different fields. After the Covid outbreak especially, many governments are considering stress testing their critical SCs (Tausche, 2021). The motivation for stress testing a SC is not to build an invincible SC, but to point out the weak links in the existing network. Identification of such vulnerabilities using stress tests and strengthening those weak links could be an important step towards SC resilience. For example, the disruptions like natural disasters, or pandemics are extremely difficult to predict, but these events can severely impair the recoverability of a SC. Fortifying each node with additional inventory, or multiple backup sources can kill the efficiency of the business, and therefore, an imperative is to use data to continually monitor potential threats in the network using stress-testing. Hence, Stress-testing can push the momentum towards data-driven and proactive risk management.

An easy way to conduct a stress test for SCs is to simulate the behavior of the SC under a set of extreme disruption scenarios. But, to be even capable of doing that, an organization would probably first need to collect a lot of data about the existing supply network configuration. For instance, the data needed to build a simulation model could be: the inventory levels at each echelon, the ordering frequencies and quantities, the location of supplier facilities, the lead times between echelons, etc. The obvious limitation which surfaces here, is that an SC is dynamic in nature. The lead times, inventory levels, demand, capacity, and other aspects that build SC, keep changing with time. It is very much possible that the stress test conducted for one instance of data could be absolutely non-value adding for other instances. The imperative therefore, is to think of a digital model of a SC which can be updated in real time using data collected from sensors, servers, IoT devices, etc. This digital model is referred to as a 'Digital Twin' of a SC. A digital twin of a SC, coupled with computing infrastructure can provide invaluable insights about the SC network and its state of resilience. It can serve as a great tool to make better and timely decisions in the times of disruptions.

The objective of this article is to introduce the terms, problems, and solutions keeping students and learners in mind, which very few studies consider. This article will act as a good start for students, early-stage researchers and professionals who are interested in understanding the need for digitalization in SCs. Funding on the wide literature, this chapter attempts to answer five important questions:

1. Why SCs need to be resilient?
2. How digital transformation can enable SCs to become resilient?
3. What are digital twins in SC context and how do they look like?
4. How to use digital twins of SCs for resilience building?
5. How to measure SC resilience?

This article is divided into 5 sections. The following section provides a broad background on current state of industry resilience, and the rush for digitalization. With supply chain resilience at the center of discussion, the next section describes in detail, the concept of a 'Digital Twin' and 'Stress Test'. Building on the ideas developed in the previous section, the third section attempts to demonstrate through three simple and short examples (a) an Arena based application of performance analysis in SC digital twin, and (b) ways to stress test a supply chain (c) recent metrics for measuring supply chain resilience. The last two sections summarize the article, present some new research directions, and finally provide some concluding remarks.