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Improving Supply Chain Visibility With Artificial Neural Networks

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Abstract

The vulnerability of supply chains has been increasing and to properly respond to disruptions, visibility across the supply chain is required. This paper addresses these challenges by relying on the use of artificial neural networks to predict the capacity of a simulated supply chain to fulfil incoming orders and to anticipate which supply chain nodes will receive an order for the next period. To assess the effectiveness of the approach two experiments were conducted. The findings contribute to the understanding of on how artificial neural networks can be applied to reduce the vulnerability of supply chains.

1. Introduction

The vulnerability of supply chains has been increasing in the last years, not only because of the necessity to reduce costs but also because of the permanent focus on increasing efficiency rather than effectiveness [1]. The negative consequences of supply chain disruptions are diverse. Additionally, to financial losses, a damage of reputation can occur. To increase competitiveness, companies are more and more focused on lessening the impact of disruptions. Therefore, predicting stock outs brings reliability and stability to companies, giving managers the ability to accurately manage their supply chain (SC) operations. This control is crucial for keeping customer's satisfaction.

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Furthermore, it increases competitiveness, not only for the company itself but also for their upstream and downstream business partners. The capacity to anticipate events empowers companies to act proactively and reduce risks, which induces higher levels of competitiveness.

Many risk mitigation strategies have been identified and presented in the literature, for example, by selecting reliable suppliers [2], enhancing the security system [3], increasing the diversification of products and suppliers [4] and creating redundancies to cope with disruptions [5]. However, there are other sources of uncertainty that, based on historical data, can be extrapolated and by enhancing the visibility through the SC, an increase in resilience can be achieved.

Supply chains are exposed to a variety of risk sources that are hard to foresee. Moreover, the combination of all those risk sources is hard to cope with. That is why monitoring the actions and being conscious of what happens from upstream, downstream and, eventually from other entities non-directly connected with the SC is crucial. Moreover, being aware of others actor's behavior can give precious hints on how to adjust and redesign the SC regarding problematic hotspots. That would allow SC managers to predict events that could negatively affect the SC performance, assisting the companies in the decision-making processes, cope with uncertainty and reduce the impact of future disruptions. However, many companies still suffer from a lack of visibility, and despite extensive research, the quantification methods to increase SC visibility are still ambiguous [6].

This paper addresses this problem by combining a SC simulation model with an artificial neural network. The methodology begins by setting up a multi-echelon SC in a simulator to generate data to feed the artificial neural network. That data is used to teach the artificial network and give it the ability to recognize and extrapolate to future events based on new and untrained data. The effectiveness of the approach, in terms of recognition rate, is assessed performing two experiments.

This paper comprises 5 sections. In section 2 it is stated the literature related to SC management. Section 3 covers the methodology implemented on the proposed approach, and the results are presented in section 4. Conclusions are presented in section 5.

2. Literature Review

The SC concept has been discussed intensively among practitioners and within the scientific community since the mid-eighties. Since markets are in constant change, decisions such as managing inventory levels, transportation, production scheduling and lot sizing are more and more challenging decisions. However, there are some risks that are taken consciously, acknowledged as "calculated risks" [7]. These risks are taken whilst making important decisions regarding costs, security and performance, whence it is important to establish the levels which represent the "manageable" risks the company is willing to take.

Considering these sources of uncertainty and by enhancing the visibility through the SC, it has the potential to reduce the adverse effects of a SC disruption [8] and to improve SC resilience [9]. Visibility, in terms of identifying and understanding inventory and demand levels across the SC [10] improves an organization's capability to process information. Specifically, visibility allows to access useful information around the products' movement. Greater visibility, created through improved knowledge and understanding of inventory and demand levels, allows organizations to proactively manage potential risks in their SC.

Some organizations cope better with risks than others, mostly because they have resilient supply chains. Resilience can be defined as "the ability to proactively plan and design the SC network for anticipating unexpected disruptive (negative) events (…) and transcending to a post-event robust state of operations, if possible, more favorable than the one prior to the event, thus gaining competitive advantage" [11]. This definition shows that resilience in supply chains can be assessed in four aspects: (1) preparation for a disruptive event, (2) response to an event, (3) recovery from the event and (4) growth/competitive advantage after the event [12]. Moreover, companies ought to control and regulate their supply chains on a regular basis to adjust it to the constant environment variations to avoid the negative outcomes [13].

Several strategies have the aim to improve supply chains resilience and have been presented in literature. A recent review analyzed 91 papers and presents a list of 24 resilience strategies categorized as proactive or reactive [12]. The implementation of some of those strategies implies strengthening the SC visibility to anticipate the occurrence of a disruptive event. Moreover, the ability to receive in time the warnings about potential disruptions will grant the