Improving Transportation Planning Using Machine Learning

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INTRODUCTION

Companies can no longer rely on lack of dependencies and integrations with suppliers or customers. Companies that are successful are the ones that have a focus on supply chain (Anderson, Britt, & Favre, 2007). Will (2021) published an article in which supply chain is described as follows: "A supply chain is a network between a company and its suppliers to produce and distribute a specific product to the final buyer. This network includes different activities, people, entities, information, and resources. The supply chain also represents the steps it takes to get the product or service from its original state to the customer". Lummus and Vokurka (2001) provide definitions from different article and finally provide a summarized definition of supply chain as; "all the activities involved in delivering a product from raw material through to the customer including sourcing raw materials and parts, manufacturing and assembly, warehousing and inventory tracking, order entry and order management, distribution across all channels, delivery to the customer, and the information systems necessary to monitor all of these activities". Another term supply chain management (SCM) is key in understanding supply chains and their management. The Council of Supply Chain Management Professionals defines SCM as "encompasses the planning and management of all activities involved in sourcing and procurement, conversion, and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. In essence, supply chain management integrates supply and demand management within and across".

As per the definition of supply chain, product moving from raw material stage to final customer, is physical movement, but there is information/ data being transferred from systems at every stage of the supply chain. A study by Forrester Research suggests that U.S. manufacturers are benefiting from using information technology (IT) to improve supply chain agility, reduce cycle time, achieve higher efficiency, and deliver products to customers in a timely manner (Radjou, 2003). Wu, Yeniyurt, Kim, & Cavusgil (2006) discuss the importance and competitive advantage IT can create for supply chains. The authors also discuss IT related resources, IT advancement, IT alignment and the role of these in a supply chain or a company. With the use of IT systems to improve efficiencies in the supply chain, comes a very compelling biproduct, i.e., data.

Transportation is a very important part of the supply chain. Because of the globalization of supply chains, the transportation networks must connect more effectively across different regions to meet increase in customers' demands, such as ensuring on-time delivery. The global nature of transportation networks and competition among companies to serve customers better leads to increase in demands of

DOI: 10.4018/978-1-7998-9220-5.ch184

service and faster delivery times with cost efficiency. This adds greater complexity in transportation networks which results in vulnerability.

With massive amounts data being generated in supply chains (Schoenherr & Speier-Pero, 2015) it is very crucial that supply chain management professionals are using predictive analytics to improve supply chain performance and competitive advantage (Waller & Fawcett, 2013a). McAfee and Brynjolfsson (2012) note that use of predictive analytics has a potential for significant above-average returns. Predictive analytics is a quantitative and qualitative approach of using historical data to answer questions of the future. Predictive analytics is a positioned within the domain of data science (Schoenherr & Speier-Pero, 2015). Data Science (DS) is an art of using science to tell a story about the data that allows for better decision making (Van Der Aalst, 2016) and (Provost & Fawcett,).

The importance of supply chain management has encouraged modern researchers to explore predictive analytics techniques to solve complex problems (Dubey et al, 2018), (Seyedan & Mafakheri, 2020) and (Govindan, Cheng, Mishra, & Shukla, 2018). Some of the areas of recent focus are demand forecasting using machine learning (Feizabadi, 2022), predicting supply chain risks using machine learning (Baryannis, Dani, & Antoniou, 2019). There is a need for more researchers to solve traditional supply chain problems like forecasting, planning and risk mitigation with more modern predictive analytics techniques.

The major contributions of this paper are 1) bring forward the complexity of supply chains 2) discuss challenges of transportation planning 3) provide insights into data science techniques 4) solve a real-world transportation planning problem using data science techniques.

BACKGROUND

Because of the complexity and global nature of supply chains, providing visibility of where the product is in the supply chain is necessary for better planning. To increase this visibility, most companies use transportation management systems (TMS) and other tracking software. TMS in general use order information, cost of shipping, etc. to help plan shipments. TMS' also provide visibility into where the shipment is currently. The limitation of TMS and the tracking software is that they can only provide information of what has happened so far and where the shipment is currently, but not what can happen further to the shipment.

There are different techniques employed to help understand how a shipment would potentially move further down the supply chain. One such technique is building simulation models, here are some simulation software OpenTrack (Nash & Huerlimann, 2004) and Railsys (Radtke and Hauptmann, 2004). These simulation software work for intermodal shipments. Researchers have used event graphs (Goverde, 2010), activity graphs (Büker, & Seybold, 2012), and Petri nets (Zegordi & Davarzani, 2012) to predict delays in shipments. Markov chains designs have been used to solve delay predictions as queuing theory models. Some of the challenges of traditional methods are that they cannot account for all the complex relationships in real-world and only a simplified version of the problem can be solved (Balster, Hansen, Hanno, & Ludwig, 2020). Predicting delays in advance helps plan better as there is more visibility into the future. There are not many papers in literature for predicting delays within the transportation area using predictive analytics, but there are a few general delay prediction problems (Yaghini, Khoshraftar, & Seyedabadi, 2013) and (van Riessen, Negenborn, & Dekker, 2016)

Data science techniques have been used in literature for wider variety of transportation problems like smart transportation planning (Karami, & Kashef, 2020), choosing the correct travel mode (Hagenauer, & Helbich,2017) and a comprehensive survey on the using predictive analytics for international freight