Supply Chain Analytics: Big Data, Predictive Modeling, and Prescriptive Decision Optimization

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ABSTRACT

This paper uses big data, machine learning and optimization techniques to study how supply chain analytics changes decisions. From descriptive analysis and diagnostic analysis to predictive analysis, prescriptive analysis and self-discipline decision-making, it is used for supply chain visualization, demand prediction, supplier risk prediction, predictive maintenance, network optimization, transportation route determination and supplement. This article emphasizes how real-time data and advanced analysis can improve efficiency, responsiveness and decision-making quality, and supply chain experts will be transformed into exception management and more strategic roles.

Keywords: Supply Chain Analytics; Big Data; Predictive Analytics; Prescriptive Analytics; Machine Learning; Optimization; Digital Twin; Decision Intelligence

1. INTRODUCTION

Supply chain analytics--- In order to make the action of supply chain better, we carefully use data analysis, statistical modeling, mechanical learning and optimization to think. There are sensor data, cloud computing and awesome machine learning algorithm everywhere. So far, it is too complicated or too much data to form the growth stage of supply chain's analysis -- operations management's Describe (what happened?), diagnosis (why did it happen? What will happen? What should we do?)-Tell us the difficult stage of analysis and the framework for understanding the business value it generates.

2. DESCRIPTIVE AND DIAGNOSTIC ANALYTICS

2.1 Supply Chain Visibility Platforms

Supply chain visibility platforms are immediate data of ERP systems, transportation carriers, IoT devices, port authorities and weather services, such as FourKites, project44, FourKites and Descartes allow us to see what various means of transportation, freight, are like now. Resilinc and riskmethods check whether customers' factories will break down. Elementum and E2Open collect the data of supply chain of many companies and make a platform to understand the whole network. Due to the popularity of COVID-19, the number of companies using supply chain visibility platforms has increased dramatically. Because I found that PPE and semiconductors are not enough, there are many invisible parts of supply chain, but it can't be solved well with the data equipment so far.

2.2 Root Cause Analysis

Diagnostic analytics-- Understand why the performance of supply chain is biased because there are data (what happened, where and when) and there are many complicated factors in the data of supply chain process mining-- Analyze the event logs of ERP and supply chain system and reproduce the actual process. Compared with the original design, it can solve the problems of supply chain process deviation, bottleneck, overall performance, compliance, etc. When Celonis, Minit and UiPath Process Mining process the purchase-to-pay and order-to-cash processes, about 15~30% of the transactions are not standard.

Table 1. Supply chain analytics maturity levels: questions answered and applications.

Analytics Type	Question Answered	Supply Chain Application
Descriptive	What happened?	KPI dashboards; delivery performance reports; inventory reports
Diagnostic	Why did it happen?	Root cause analysis; process mining; variance analysis
Predictive	What will happen?	Demand forecasting; supplier risk prediction; ETA prediction
Prescriptive	What should we do?	Network optimization; replenishment optimization; routing optimization
Autonomous	Act without human approval	Auto-replenishment triggers; dynamic pricing; exception management

3. PREDICTIVE ANALYTICS APPLICATIONS

It is understood that the performance of machine learning predictive analysis of supply chain management has been greatly improved in many applications.

Demand forecast: when neural networks and gradient boosting models are used in academic competitions (M4, M5) and companies, they always have 15~30% better MAPE values than the previous time series methods. Google, Amazon and Alibaba have spent a lot of money on their own forecasting models used in their supply chain plans.

Supplier risk prediction: The natural language processing model, which is learned from news, economic and regulatory data, can predict supplier failures and operational risks several weeks in advance and provide supply chain management.

Predictive maintenance: Using IoT sensor data attached to factory machines, the probability of failure of mechanical learning model can be predicted. Because maintenance can be arranged according to the state, the unexpected stop time will be reduced by 20~40%.

4. PRESCRIPTIVE OPTIMIZATION

Prescriptive analytics is a model to find the best solution according to the current state and expected state, and it is the most valuable stage in supply chain analytics.

Supply chain network optimization is to minimize the overall cost while maintaining the established service quality, and to determine the optimal number, location, inventory placement mode and transportation process of facilities, compared with the way that people adjust one by one in sequence.

Real-time transportation optimization is an algorithm that uses traffic jams and delivery failures to calculate the bus route in real time according to new orders. Compared with the method of using the same route, the efficiency of the route is 10~20%.

Autonomous replenishment systems is an algorithm to automatically place an order without human approval according to the inventory status, demand forecast and delivery time. It is used in most SKUs of large retail stores, and the person in charge of planning should deal with exceptions and strategies.

5. CONCLUSION

Supply chain analytics has developed from regular management reports to continuous decision intelligence. Now, it is fast and good to combine the real-time data of the whole supply chain with the prediction and optimization suggestions of machine learning, and the way of making the same supply chain decision analysis can always be changed from descriptive dashboard through prescriptive optimization to autonomous decision-making. This is a huge change in the management mode of supply chain. In the past, people judged by data, but now, with data as the center, people begin to make exceptional things and strategic decisions. The next research should investigate the impact of analysis-centered supply chain management on the organization. When the algorithm makes daily decisions, what will happen to the role of supply chain experts? What kind of ability does the organization of supply chain need to have to manage the supply chain system of the algorithm well?

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