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Supply chain analytics

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Abstract In this article, I describe the application of advanced analytics techniques to supply chain management. The applications are categorized in terms of descriptive, predictive, and prescriptive analytics and along the supply chain operations reference (SCOR) model domains plan, source, make, deliver, and return. Descriptive analytics applications center on the use of data from global positioning systems (GPSs), radio frequency identification (RFID) chips, and data-visualization tools to provide managers with real-time information regarding location and quantities of goods in the supply chain. Predictive analytics centers on demand forecasting at strategic, tactical, and operational levels, all of which drive the planning process in supply chains in terms of network design, capacity planning, production planning, and inventory management. Finally, prescriptive analytics focuses on the use of mathematical optimization and simulation techniques to provide decision-support tools built upon descriptive and predictive analytics models.

1. Why analytics in supply chain management?

The supply chain for a product is the network of firms and facilities involved in the transformation process from raw materials to a product and in the distribution of that product to customers. In a supply chain, there are physical, financial, and informational flows among different firms. Supply chain analytics focuses on the use of information and analytical tools to make better decisions regarding material flows in the supply chain. Put differently, supply chain analytics focuses on analytical approaches to make decisions that better match supply and demand.

Well-planned and implemented decisions contribute directly to the bottom line by lowering sourcing, transportation, storage, stockout, and disposal costs. As a result, analytics has historically played a significant role in supply chain management, starting with military operations during and after World War II—particularly with the development of the simplex method for solving linear programming by George Dantzig in the 1940s. Supply chain analytics became more ingrained in decision making with the advent of enterprise resource planning (ERP) systems in the 1990s and more recently with 'big data' applications, particularly in descriptive and predictive analytics, as I describe with some examples in this article.

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The Supply Chain Operations Reference (SCOR) model developed by the Supply Chain Council (www.supply-chain.org) provides a good framework for classifying the analytics applications in supply chain management. The SCOR model outlines four domains of supply chain activities: source, make, deliver, and return. A fifth domain of the SCOR model—plan—is behind all four activity domains. Furthermore, a key input of the supply chain planning process is demand forecasting at all time frames: long, mid, and short term with planning horizons of years, months, and days, respectively. Table 1 illustrates different decisions in each of the four SCOR domains that can be aided by analytics. These decisions are further classified into strategic, tactical, and operational according to their time frame.

Analytics techniques can be categorized into three types: descriptive, predictive, and prescriptive. Descriptive analytics derives information from significant amounts of data and answers the question of what is happening. Real-time information about the location and quantities of goods in the supply chain provides managers with tools to make adjustments to delivery schedules, place replenishment orders, place emergency orders, change transportation modes, and so forth. Traditional data sources include global positioning system (GPS) data on the location of trucks and ships that contain inventories, radio frequency identification (RFID) data originating from passive tags embedded in pallets (even at the product level), and transactions involving barcodes. Information is derived from the vast amounts of data collected from these sources through data visualization, often with the help of geospatial mapping systems. RFID is a significant improvement over barcodes because it does not require direct line of sight. Accurate inventory records are critical in supply chains as they trigger regular replenishment orders and emergency orders when inventory levels are too low. Although RFID technology helps in significantly reducing the frequency of manual inventory reviews, such reviews are still needed because of data inaccuracy due to, for example, inventory deterioration or damage or even tag-reading errors.

Predictive analytics in supply chains derives demand forecasts from past data and answers the question of what will be happening.

Prescriptive analytics derives decision recommendations based on descriptive and predictive analytics models and mathematical optimization models. It answers the question of what should be happening. Arguably, the bulk of academic research, software, and practitioner activity in supply chain analytics focuses on prescriptive analytics.

In Table 2, I provide a summary of analytics techniques—descriptive, predictive, and prescriptive—used in supply chains in terms of the four SCOR domains of source, make, deliver, and return. I elaborate on Table 1 and Table 2 in the next sections.

Table 1. SCOR model and examples of decisions at the three levels

SCOR Domain	Source	Make	Deliver	Return
Activities	Order and receive materials and products	Schedule and manufacture, repair, remanufacture, or recycle materials and products	Receive, schedule, pick, pack, and ship orders	Request, approve, and determine disposal of products and assets
Strategic (time frame: years)	• Strategic sourcing • Supply chain mapping	• Location of plants • Product line mix at plants	• Location of distribution centers • Fleet planning	• Location of return centers
Tactical (time frame: months)	• Tactical sourcing • Supply chain contracts	• Product line rationalization • Sales and operations planning	• Transportation and distribution planning • Inventory policies at locations	• Reverse distribution plan
Operational (time frame: days)	• Materials requirement planning and inventory replenishment orders	• Workforce scheduling • Manufacturing, order tracking, and scheduling	• Vehicle routing (for deliveries)	• Vehicle routing (for returns collection)
Plan	Demand forecasting (long term, mid term, and short term)			