Analyzing Inventory and Primary Resources in the Supply Chain: Integrating Supply Chain, Analytics, and Sustainability

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Inventory is recognized as an essential asset and a key driver in supply chain management. There are many other resources that also play significant roles in the supply chain. Coordination of inventory and other resources is a central activity for supply chain managers. Sustainability has also developed as a topic of interest along with the increased importance of analytics. The purpose of this paper is to discuss the need for further coverage of analytics and sustainability within supply chain academic programs. Some initial steps in one supply chain academic program will be presented.

INTRODUCTION

A recent web search for the job title "supply chain analyst" returned 6,990 results (Indeed.com, 2017). A similar search for "supply chain management" jobs returned 40,794 results nationwide (Indeed.com, 2017). The number of supply chain analyst postings is a significant percentage when compared to the more general supply chain management search. Businesses are relying on a wide range of data sources to guide decisions, which has elevated the importance of supply chain analyst among the various supply chain roles in many companies.

The basic job description for "supply chain analyst" from one online source reads as follows:

> Gathers data and conducts analysis with the goal of improving the organization's supply chain operations. Identifies underperforming areas in the supply chain and may suggest improvements or resolutions to problems. May assist in the negotiation of supplier contracts or service arrangements. Typically requires a bachelor's degree or equivalent and at least 3 years of experience in the field or in a related area. Familiar with a variety of the field's concepts, practices, and procedures. Relies on experience and judgment to plan and accomplish goals. Performs a variety of complicated tasks. A wide degree of creativity and latitude is expected. Typically reports to a manager or head of a unit/department. (Salary.com, 2017)

The main objective of supply chain management is to coordinate the flow of materials, information, and funds across the entire supply chain from supplier to manufacturer to wholesaler to distributer to retailer to final customer. The ultimate goal of the supply chain is to match supply with demand. Substantial amounts of inventory are required at different points in the supply chain to support operations at various partner facilities or to provide acceptable customer service levels. Many companies have significant amounts of money tied up in inventory throughout the supply chain. Given the importance of inventory, the study of supply chain management must include a thorough study of inventory management. But focusing on inventory alone is clearly inadequate coverage of the full spectrum of

supply chain activities and resources. A consideration of the broader range of resources must also address the topic of sustainability.

LITERATURE REVIEW

Two seminal articles are used here to represent the literature for supply chain management. The articles mentioned provide the foundation for many publications, including journal articles and textbooks. Johnson and Pyke (2000) provide course outlines from eight highly regarded universities at the leading edge of supply chain academic programs. The authors then develop their own framework for their vision of how supply chain management should be taught. Extracting the main supply chain resources from the Johnson and Pyke framework results in the following:

- Facilities (covered as "Location")
- Inventory
- Marketing and Distribution Channels
- Customers
- Suppliers
- Information and Information Technology

The second article, by Mentzer et al. (2001), is approaching 3,800 citations according to Google Scholar, indicating its importance within supply chain literature. Researchers have cited Mentzer et al. (2001) as an authoritative source for defining and describing supply chain. The working definition they offer is as follows:

> A **supply chain** is defined as *a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flows of products, services, finances, and/or information from a source to a customer*. (Mentzer et al, 2001)

And:

> **Supply chain management** is defined as *the systemic, strategic coordination of the traditional business functions and the tactics across these business functions within a particular company and across businesses within the supply chain, for the purposes of improving the long-term performance of the individual companies and the supply chain as a whole*. (Mentzer et al., 2001)

These definitions lend support to our earlier observation that coordinating inventory and other resources is a central responsibility of supply chain managers. The definitions also imply the use of data and the need for supply chain analytics to make business decisions and to assist supply chain coordination.

Beyond supply chain management, we look to literature on data analytics. Davenport (2006) provides a great overview of the use of analytics in a wide range of business applications. He also includes several supply chain examples and lists specific supply chain activities where analytics have been deployed. He provides a description of the methods: "Simulate and optimize supply chain flows; reduce inventory and stock-outs"— and identifies Dell, Wal-Mart, and Amazon as exemplar companies for analytics related to supply chain (Davenport, 2006).

Of course, these are well-known examples for most faculty in the operations and supply chain field. But analytics is not only important for giant corporations such as Wal-Mart. Analytics can provide valuable insights and needs to be more accessible for all types of businesses. Training in analytics is needed for a broader audience of students who will lead small and medium firms.

SUPPLY CHAIN ANALYTICS

The term data analytics (or business analytics) has very different meanings for different people from different functional backgrounds. Customer data tends to be the dominant focus of many business intelligence and data analytics endeavors. While the customer is clearly important in supply chain management, there are many other aspects that need to be analyzed.

One leading business analytics textbook (Camm et al., 2014) does not include "inventory" in the index for the book, and none of the examples or problems address "inventory" explicitly. The only closely related topic is a linear programming example and subsequent problems that address production, demand requirements, and departmental capacity constraints. This is not unexpected since the book's coverage of "business analytics" was not intended to provide a thorough coverage of "supply chain analytics."

The following sections highlight the efforts in two courses—Operations Management and Supply Chain Management—to incorporate supply chain analytics topics. A third course on supply chain analytics, offered as a special topic course, also provides an excellent opportunity to deliver supply chain analytics material. This initial effort has attempted to provide broad coverage of analytics for different supply chain elements.

Inventory

The following topics are introduced in Operations Management and covered more extensively in the Supply Chain Management course:

- Economic order quantity (EOQ)
- Reorder point and safety stock calculations
- Cycle service level
- Inventory costs
    - Carrying costs
    - Average inventory costs
    - Ordering costs (or setup costs)
- Inventory value and ABC analysis
- Linkages between supply chain partners
    - Supplier
    - Manufacturer
    - Distributer
    - Retailer
- Bullwhip effect

These topics are presented in a variety of formats including lecture, quizzes, problem sets, exercises, and case studies. In Supply Chain Management, greater emphasis is placed on the cost and performance impacts of decisions such as safety inventory policies.

Primary Resources

The Supply Chain Management and special topic course afford the opportunity to incorporate analytics that focus on primary resources such as facilities (factories and distribution centers), suppliers, company fleet vehicles, the workforce, and others. There are a limited number of examples and problem sets in some of the textbooks currently available. In every case, the books have not been written with "supply chain analytics" as the main topic, so the instructor must be persistent to develop or find good supplemental materials.

Essentials of Business Analytics by Camm et al. (2014) is the textbook used for the special topics course on supply chain analytics. Using this book requires careful selection of the materials and problems to be assigned. Ten out of 12 chapters from the book are used and supplemental materials are included from several sources. The main topics covered are as follows:

- Descriptive Statistics
- Data Visualization
- Linear Regression
- Time Series and Forecasting (with emphasis on Seasonal)
- Data Mining

- Linear Optimization
- Decision Analysis (uncertainty, risk, and tree diagrams)

The supplemental materials include an overview of data science and additional material on machine learning and data mining. Provost and Fawcett (2013) is a primary supplemental source. Future offerings of this course will incorporate more supplemental materials to sharpen the focus on supply chain analytics.

Sustainability

Another related topic which provides further motivation for this paper is an increased emphasis on sustainability. The interest in sustainability is prevalent throughout a variety of national and international organizations, special interest groups, and corporations. The expectations regarding sustainable business practices, and more specifically for this paper, sustainable supply chain practices are becoming a worldwide standard. Supply chain analytics needs to interface with corporate sustainability initiatives. A widely cited definition of sustainability is attributed to the United Nations Brundtland Commission: "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987; Christopher, 2011).

The business school accrediting organization, AACSB, has supported a more recent United Nations initiative known as Principles for Responsible Management Education (PRME, 2017). This initiative establishes a set of six principles for educational institutions to follow when providing courses and programs on the topic of sustainability.

Another suggestion for instructors and practitioners is to use the SCOR® Model from the Supply Chain Council as a framework for sustainability evaluations. The five terms used in the SCOR® Model are Plan, Source, Make, Deliver, and Return. This sequence follows the logical order of events that occur in a supply chain (Monroe, 2013). The following discussion and outline demonstrates how the SCOR® Model can be used as a framework for sustainability initiative evaluations and possible analytics applications.

Plan

Are the principles of sustainability used as a guide in the planning stage for the company's supply chain? By "plan" we refer to many different activities including new product development, selection of materials for products, new process development, planning capacity, selecting transportation modes, deciding to outsource logistics to a third party, and many others. The full range of environmental, economic, and social issues should be included for consideration during this stage.

Source

Are the principles of sustainability guiding the company's choices when making sourcing decisions? These decisions include selection of suppliers, insourcing vs. outsourcing, developing a supplier as a strategic partner, choosing local vs. distance suppliers, and many other supplier-related decisions. Two other questions help to describe intent: Is the company selecting suppliers that are also committed to following the sustainability principles? Is there another option in any given sourcing decision that meets the company's sustainability requirements better than the original option? The triple bottom line (TBL) should be considered explicitly in making these decisions.

Make

All of the common sustainability statements regarding manufacturing apply here. Reducing, reusing, and recycling materials used in the manufacturing process are primary approaches for using these resources in a responsible manner consistent with sustainability. Again, the focus should include environmental, economic, and social considerations, and explicit company positions must be developed.

Deliver

Throughout the entire global supply chain there are multiple transportation elements and multiple handoffs from one entity to another (Russell and Saldanha, 2003). Transportation is a major concern in regard to emissions and the related environmental impact. The terms Plan, Source, Make, Deliver, and Return used across the SCOR® model reinforce the idea that a material/product will be transported multiple times.

An example in the Deliver segment is intermodal transportation, which translates to benefits in each area of the triple bottom line. Tyssen (2011) describes two case studies where decisions involving intermodal terminals result in benefits that are seen in each category—economic, environmental, and social.

Transportation choices have a major effect on the carbon footprint of companies. The decision to utilize intermodal rail for a significant portion of the transportation of products will have a very favorable impact on the company's environmental compliance, carbon footprint, or other environmental metric. Intermodal also provides an economic benefit when compared to greater utilization of truck deliveries.

Return

This stage of the supply chain may refer to the product, used component parts, packaging, or even reusable or recyclable shipping materials. The economic benefits here will manifest as cost savings and in some cases new revenue streams. While environmental and economic benefits are at the forefront, additional probing should be used to identify social benefits as well.

Across all five stages of the SCOR® Model there is an abundance of data that must be analyzed. In fact, the SCOR® Model can serve as a very effective framework for supply chain analytics in general. When the concept of sustainability is incorporated with the SCOR® Model elements, the application of analytics becomes more relevant and critical to today's students and corporations.

SUMMARY

This paper has discussed the growing demand for supply chain analysts as the motivation for incorporating more explicit supply chain analytics topics in existing supply chain academic programs. A very brief outline of analytic topics covered in two regular curriculum courses and one special topic course are also presented.

One proposition of this paper is that the major shortcoming of business analytics is the myopic focus on customer data. Supply chain analytics should certainly include customer data, but many other resources must also be analyzed to enhance supply chain performance. Inventory is a significant resource to be included, along with other supply chain resources such as facilities, suppliers, distributors, vehicle fleets, employees, and many others. Many of these same resources (such as emissions, fuel usage, material recycled) are also of interest when analyzing sustainability initiatives.

This paper is a beginning step along the path to a more thorough coverage of supply chain analytics. Future steps will include developing supply chain cases and data sets that are tailored to allow students to practice analytics across all phases of the supply chain. Applying analytics to more practical data sets about sustainability initiatives is another planned enhancement for the future.

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