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IMPACT OF ANALYTICS AND DIGITAL TECHNOLOGIES ON SUPPLY CHAIN PERFORMANCE

Dr. Debasish Roy
Sr DGM, Head Central Purchase , IT and Communication, Corporate Infrastructure and Services, Powai, Larsen & Toubro

Abstract : The quest for improved business performance is driving most manufacturers, retailers and third party logistics players, cutting across industries, to reinvent their supply chain models, using the latest digital technologies and management thinking. Companies are embracing analytics to innovate and transform supply chains and change the way they understand and react to changing market trends. Companies are hoping to discover better opportunities to connect with customer and have closer relationships with suppliers, by leveraging Digital technologies in the supply chain. However, analytics and Digital technologies in itself is not leading to improvement in supply chain performance, leading to 'Productivity paradox'. This paper proposes that Business process reengineering termed as the "Extended Supply Chain" and "IS capability" and a suite of "Digital technologies" may be needed to harness the insights of improved analytics.

Key Words: Analytics, Supply Chain, Digital Transformation, Digital technologies, Business Process Reengineering, Extended Supply chain, IS capability

Introduction

Most Manufacturers and Retailers, cutting across industries, are using analytics and big data to forge better opportunities to connect with customer and have closer relationships with vendors (suppliers). Companies are leveraging digital technologies to innovate and transform supply chain models. The nature of supply, demand and product management are evolving.

A select group of digital technologies are maturing and being adopted. However their impact on the supply chain efficiency, hinges on the supply chain's ability to support digital business.

The Chief Executive Officer & Chief Supply Chain Officer, supported by the Chief Information Officer, is exploring what are the facilitators to improve effectiveness of analytics, big data and digital technologies in the supply chain.

What is this digital reality in business and effects on supply chains?

- Companies are garnering big Data from customer interaction and processes
- Internet of Things provides visibility of assets and resources.
- Advances in 3D printing has potential to offer higher responsiveness to supply chain.
- Drones are disrupting the delivery models.

Analytics is working on all above areas to provide insights for better decision making. However readiness of the ecosystem to adopt analytics needs to be probed. The facilitators and the barriers to improve supply chain performance need to be identified.

The Scope of research is

- To study the impact of big data and analytics on extended supply chain, including flow between firms and its customers, suppliers and partners

- Exploring the theories which can be mobilized for studying adoption of analytics and big data in extended supply chain

The paper takes a two pronged approach. We list down use cases in traditional supply chain functions and provide how analytics can be useful there. On the other level we also study the impact of the digital technologies which the industry is adopting in coming times.

Literature survey

Literature survey was done to help understand the terms Analytics and Big Data with reference to supply chain. The understanding is presented.

Analytics in Supply Chain. Analytics can be defined as tools and techniques that are dedicated to harnessing external and internal data to produce breakthrough insights that can help supply chains reduce costs and risks whilst improving operational agility and service quality (Deloitte & MHI, 2014). Some of the impacts analytics may have on supply chain are:

- *Sense Before Responding* As digital marketing programs become digital business, organizations are seeking to listen cross-functionally to customer sentiment and use advanced analytics to test and learn the market response. Similarly supply chain leaders are effectively listening to social data and use it cross-functionally to understand customer sentiment.
- *Cognitive Learning: Adapt to Change* Companies realize that sole reliance on order and shipment data increases the latency and delays the time to respond to market shifts thus putting the supply chain on the back foot. Leaders are turning to new forms of predictive analytics, new forms of pattern recognition, optimization, and learning systems to improve the ability for the organization to improve the response.

Hahn & Packowski (2015) described four types of use cases of analytics in supply chain (i) monitor and navigate (ii) sense and respond (iii) predict and act (iv) plan and optimize. Business analytics may help in increasing organization efficiency, using different analytical methods to forecasting trends of market and reduce the operating cost and increase the profits by using mature supply chain systems (Hoole, 2005 ; Hedgebeth, 2007).

For measuring the function of Business analytics in Supply chain performance, the framework used for analysis and insights is SCOR model (Jamehshooran et al, 2015). SCOR model provides a systematic approach to identifying, evaluating and monitoring supply chain performance, covering the four core supply chain processes of *Plan, Source, Make and Deliver*. (Stephens, 2001), In *Plan* data is analysed to forecast the market trends for the products and services (Azvine et al, 2005). In *Source* agent based information system that include evaluation, search, selection and price negotiation (Lee et al , 2009; Trkman et al , 2007). In *Make* production should be within specification and on time, (Ranjan, 2008). In *Deliver* analytics is used in logistics management to reach products on time (Reyes, 2005). Trkman et al, (2010) used the SCOR model to study Supply chain performance and introduced *Process Orientation* and *Information Systems* as moderators.

Big Data - Companies have been capturing data for years and conducting analysis to gain market intelligence – So what exactly is different? Three characterises of big data - volume, velocity and variety are what make big data different.

- *Volume* Data is being collected all along the supply chain. This includes data from POS, GPS and RFID Data, to data emitted by equipment sensors to social media feeds.
- *Velocity* Data is being collected with increasing granularity and frequency. Personal information is being attached to these transactions.
- *Variety Data* is being collected in form of structured data that we are familiar but also as unstructured data such as text and voice messages, social network feeds and blogs.

To add to this, companies are increasingly harnessing unstructured data (garnered from social feeds) and using analytics cross-functionally to understand the external sentiment. Garmaki et al (2016) defined Big data analytics as a holistic process to manage process and analyse the Vs in order to create actionable insights for sustained competitive advantage.

However various studies (Irani, 2010; Roach et al 1987; Sharif & Irani, 2006) have argued that Information systems (IS) investments have not resulted in business value. Studies in IS and business value have concluded that the results may be mediated by a number of intermediate variables (Mooney et al, 1996). Researchers have also proposed that multi-dimensional perspective of business value need to be studied to understand the impact of IS capabilities (Bharadwaj, 2000; Bhatt & Grover, 2005; Santhanam & Hartono, 2003).

This paper proposes to expand these learnings and bring in a number of intermediaries i.e. Digital Technologies, Information system capability and Extended supply chain to have a broader and more multidimensional view of impact of Analytics on Supply chain performance.

Digital Technologies In any modern day supply chain, not only analytics but Digital Technologies are being adopted and hence there is a need to study the statistical moderating effect when studying the impact of analytics on Supply chain performance. Some of the Digital technologies relevant to supply chain are *Additive manufacturing (3D Printing), Internet of things* (Machine to machine communication between devices that belong to different systems, including public infrastructure) and *Drone technology*. IoT through use of Big Data and analytics has led to supply chain innovations (Li & Li, 2017), servitization (Fichman et al 2014) and Multimodal delivery (Ganesan et al, 2016). Additive Manufacturing is disrupting the Supply chain models by a dramatic reduction in transportation volumes and bringing manufacturing closer to the customer (Chen, 2016; Mohr & Khan, 2015). Autonomous vehicles or drone technology is a supply chain design inflection point (Fawcett & Waller, 2014).

Information System (IS) Capability Pervious studies (Lin, 2007; Lu & Ramamurthy, 2011; Chen et al, 2014) have also brought a positive relationship between IS capability and firms performance. Wamba et al (2016) and Kim et al (2012) in their research have further refined IS capability and concluded that Business Data Analytics infrastructure capability, management capability and personnel capability have an impact on Supply chain performance.

Extended supply chain: Business Process Reengineering (BPR) involves the analysis and redesign of companies' processes and workflows to achieve sustainable improvements in quality of response and cost competitiveness (Jha et al, 2016). Extended supply chain is the BPR initiative, which assists in maximizing the impact of analytics in supply chain. Extended supply chain proposes a close integration with other lines of business units that are key

players in the supply chain such as product development, manufacturing, sales, and operations. The priority is to evolve agile cross-functional teams, thereby make vertical department structures, operation silos less relevant, and at the same time retain the functional expertise of departments. The inclusion of cross-functional business processes may be needed to exploit the advantages of analytics based supply chain planning. Also with the advent of unstructured data, organizations need to redesign business processes to be able to extract actionable insights from unstructured data. The extended supply chain is not only an intra company BPR initiative but calls for collaboration with all the stakeholders. Supply chain visibility across the extended supply chain is a core issue involving interaction of people, processes, technologies and information flow. (Hearney, 2013).

Kiron et al (2013) reported that, i) respondents who agree that analytics is helping their organizations innovate are much more likely to say they collaborate with partners and suppliers through use of analytics (ii) are reaching beyond their own data to feed their analytics process. Studies have highlighted the importance of achieving a high level of inter and intra organizational processes and information systems (Wamba & Akter, 2015).

Research Framework

The Theoretical Framework uses the well-established SCOR Model, covering the four core supply chain processes of Plan, Source, Make and Deliver. The framework developed, to explore the use of analytics on the four SCOR processes and the impact on the supply chain performance, is given as follows:

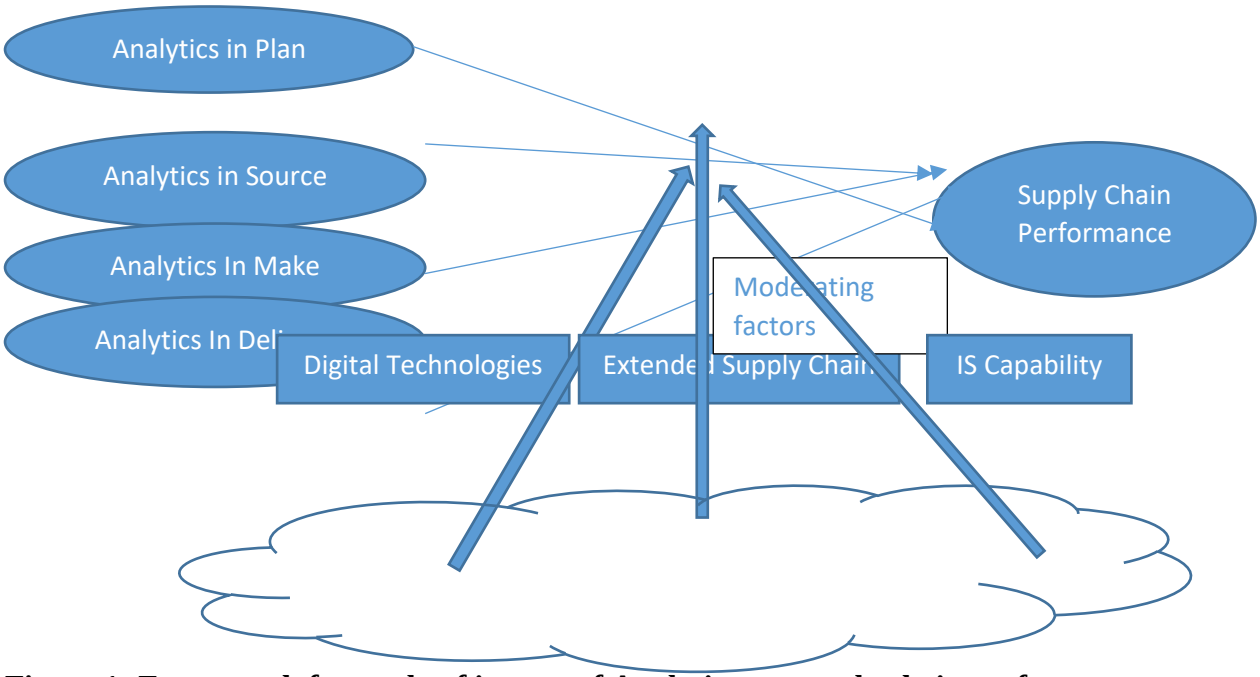

Figure 1: Framework for study of impact of Analytics on supply chain performance
Source: Developed for this research

Definition of constructs:

Analytics in Plan: Analysis used in predicting market trends and automating demand planning

Analytics in Source: Analysis used in vendor relation management and procurement decisions

Analytics in Make: Analysis used in production planning and inventory management

Analytics in Deliver: Analysis used in order fulfilment and logistics management

The statistical *moderating factors* (i.e. Digital technologies, Extended supply chain, IS Capability) acts as facilitators to increase impact of analytics on supply chain performance. Absence of these factors may present barriers to realizing the potential benefits of analytics on supply chain performance.

Based on this understanding, a structured questionnaire was developed. Stakeholders across manufacturing, infrastructure, consumer goods, ecommerce and third party logistics industries, were interviewed. The feedback from fourteen Chief Executive officers, thirty-five Chief Supply chain officers and eighteen Chief Information officers from companies of various sizes across India, was compiled. The results are discussed to derive conclusions on impact of adoption of analytics in supply chain. The feedback of the respondents on use cases of analytics in the SCOR processes of Plan, Make, Source and Deliver are presented. Their insights on the facilitating influence of Digital Technologies, Extended supply chain and IS capability are compiled.

Findings

Supply chain analytics is leading to optimization of inventory within the supply chain, minimizing the carbon footprint and minimizing operating costs, such as manufacturing, and distribution costs. Large amounts of data and the associated analytics are enabling the establishment of norms and events outside norms (outliers). Supply chain practitioners are doing 'Social listening' to predict and have contingency planning to prepare for 'black swans' (i.e. low probability events which can disrupt supply chains). Companies are adopting new forms of predictive analytics, new forms of pattern recognition, optimization and learning systems to help organizations improve quality of response, discarding the earlier dependence on order and shipment data for planning, which often could not take into account changes in market conditions. The collaborative supply chain, with exchange and sharing of data across the extended enterprise is increasing transparency, mitigating the bullwhip effect and smoothing out flow throughout the supply chain.

Some use cases of Analytics in SCOR processes of supply chain are:

i. Analytics in Plan - Demand analytics (i.e. Real time tracking how forecast is comparing with actual sales down to stock keeping unit level, at point of sale and during promotional events, tracking of lost sales).
ii. Analytics in Make – Finished Inventory optimizations (Inventory carrying cost optimization, decreasing bullwhip effect, customized fulfilment level based on customer segmentation). A combination of analytics techniques and data visualization enhances decision making in make analytics.
iii. Analytics in Source – Achieve lowest landed cost and secure long term high quality supplier partners by scoring models for each potential partner and getting data from multiple sources. Sourcing had the least developed analytics but is the growing area being the largest expenditure item. Analytics to decrease Total cost of ownership and supplier negotiation are being adopted. Companies are creating online market tools that allows suppliers to enter key operational metrics, product specification and bidding information as part of the annual supplier scorecard and product sourcing process to reduce the elaborate 'Request for Quote' process and at the same time allow real-time benchmarking. Increasing supplier quality from supplier audit to inbound inspection, detecting and isolating quality problems upstream of suppliers faster than traditional methods are growing use cases of analytics. The medical

industry in particular is using analytics to monitor quality to minimize costly litigation (from failure of implanted devices like stents / pacemakers) and disruption of customer service (by creating backorders).

iv. Analytics in Deliver – Network planning and optimization, (Warehouse location, optimized flow paths to fulfil customer demand of various segments at least cost), Transport analytics (optimizing routes including back haul, shipment schedules). Micro segmentation represents one of the important assets analytics can provide. Another evolving use case which is being keenly tracked by decision makers is the use of hyper-scale, real-time matching in transportation (e.g. Uber/ Ola/ Didi Chuxing in personal transport). Manufacturing companies and logistics management companies are collaborating to implement analytics in their logistics model. Analytics has improved traceability of products from the source to end consumption, generating data for sustainability indexes like carbon footprint and water consumption as well as insights on life cycle costs.

In a hyper competitive world where the bar of business performance is being continuously raised, investment in Digital Technologies along with the adoption of analytics to improve supply chain performance is critical.

Digital technologies which are improving the impact of analytics in the Supply chain are:

i. Additive manufacturing (3 D printing) is enabling businesses to station local manufacturing centres closer to strategic markets. This along with insights from analytics is making supply chains become agile and able to cope with faster product design and production cycles.

ii. Internet of Things (IoT) information is being used to generate analytics across the value chain and reducing manual intervention, improving visibility and decision making. Objects moving through the value chain are producing unprecedented supply chain visibility. Stationary objects connected over the Internet of Things are monitoring the surrounding environment, reporting conditions, altering their state depending on predefined parameters, enabling companies to come closer to the customer.

iii. Drones and vehicle automation are disrupting the supply chain by enabling automation in the world of supply chain logistics and materials handling. The scope is enormous from Self driving trucks and cargo ships, loading / unloading of parcels, last mile delivery drones as being tested by UPS and Amazon.

Analytics can be, over time, copied by rivals eroding the competitive advantage. To sustain the competitive advantage of analytics adoption, realignment of business processes at both the strategic and tactical level is being undertaken.

Companies who have done the Business process reengineering of Extended supply chain agree that analytics help their organizations innovate. The supply chain visibility is helping them to collaborate with partners and suppliers through the use of analytics. However companies also agree that internal integration is a prerequisite for extended supply chain. In an extended supply chain, Information System readiness of all the stakeholders is a challenge in a developing country like India. An industry wide initiative is necessary to improve the Business analytics Information technology infrastructure, Personnel capability.

Conclusion:

The use of a Business Framework developed on the SCOR Model, has given an opportunity to do a structured inquiry on the state of affairs of analytics in the supply chain across industries and provide actionable insights to practitioners on how to improve supply chain performance. The study of the impact of statistical moderators, i.e. Digital Technologies , Extended supply chain and IS capability on supply chain performance, reemphasises that analytics in isolation will not have its intended benefits, if these facilitating conditions are absent. Digital Technologies Extended supply chain and IS capability will have an increasing cause and effect relationship on performance as companies mature in their use of analytics in the supply chain.

Interviews have also revealed various barriers to the adoption of analytics in the supply chain. Implementing analytics initiatives needs data science skill sets with deep domain knowledge of supply chain functions. Companies, particularly the resource constrained ones, are struggling to grow and retain these capabilities, which may inhibit companies from exploring the full potential of analytics. However, the beneficial impact of the adoption of analytics on the supply chain performance has come out very strongly and emphatically in the research. It is crucial that companies have the facilitating factors (i.e. Digital technologies Extended supply chain and IS capability) to reap the full potential of analytics in supply chain performance.

Limitations and Future scope of the study

This research model does not include Top Management support as an enabler of use of analytics to improve supply chain performance. However anecdotal evidences from Industry experts are emerging that say that Top Management involvement has a key role to play. Research evidence may suggest that an additional moderator Top Management involvement may make the model more comprehensive.

The respondents of the survey are from India. However most modern day supply chain involves multi national operations. A much broad based survey may improve the insights on this research initiative.

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