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An Overview of the Utility of Big Data Analytics in a Contemporary Supply Chain Network

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Abstract:- Contemporarily, the volume and speed of the transit and exchange of data is very high and is driven by Big Data and Internet of Things. This has affected all the functional areas of the management of a business organization, including the management of the Supply Chain Network. This paper lists the ways in which Big Data Analytics positively impacts the efficiency of the Supply Chain Network of an organization.

Keywords:- *Supply Chain Management, Big Data Analytics, Supply Chain Network, Internet of Things.*

I. INTRODUCTION

Big Data (BD) are the information assets generated by input devices such as CCTV footage, Radio Frequency Identification Devises (RFID) readers and from Internet of Things (IoT). With speedily evolving data analytic tools, such a large and varied volume of data (much of which is real-time) is bound to impact all facets of any business organization. E.g.: Walmart successfully met the surge of demand for Pop Tarts during a hurricane; Amazon reminds customers of their preferences before they actually fill the cart; EBay modifies its Web Design to yield more sales.(1)

Also, technological advances drove the Supply Chain (SC) to evolve into a complex structure of interdependence and connections, thereby increasing the efficiency of an SC Network and creating an emergent Supply Chain Management (SCM). This paper identifies ways in which Big Data Analytics (BDA) enhances the efficiency of an SC Network.

II. OBJECTIVE AND METHODOLOGY

Objective: To identify the ways in which the use of BDA positively affects impacts the efficiency of an SCNetwork.

Methodology: The research is based on observations compiled from a set of available literature. Each observation is noted and discussed and the findings are presented thereafter.

III. REVIEW OF LITERATURE

A. The Supply Chain

SC encompasses all activities concerning procurement, collaboration with channel partners (suppliers, intermediaries and customers) and management of logistics thus linking major business functions, even across companies, to form a cohesive and high-performing model. SCM controls the upstream and downstream flow of all resources (man-material-man-hours-money-method) to realize an end-product as per consumer needs with maximum efficiency related to the said resources. Effective SCM grants a company a definitive competitive edge. (2), (3)

SC Network has been created by the evolution of SC alongside technological advances and is a complex network involving companies, suppliers, intermediaries and consumers, and a value-added exchange of goods and information. The typical SC Network has five key areas: External Suppliers, Production Centers, Distribution Centers, Demand Zones, and Transportation Assets. Standards like the GS1 Global Standards guide the SC Network to perform and respond real time with continued inputs, thus increasing its efficiency. Management Information Systems (MIS) aiding the management of SC Networks include: Order Management Systems, Warehouse Management System, Replenishment System, SC Visibility, Optimization Tools (4)

B. Big Data Analytics and the Internet of Things

Advancement of technology has ensured that input of data is from very many sources, mostly live and live-streamed, resulting in BD. BD is of a rather large volume and if efficiently filtered and processed, can provide with accurate, real time analytics which guide business decisions and management, including SC Networks. BD is characterized by the 4Vs: Volume (largeness of data and increased potential insights, Variety (BD takes forms such as audio, video, text, and graphics), Velocity (BD is processed as high speed and is real-time), Veracity (the quality of captured data may include noise and affect analytical efficiency). (5)

The advancement of technology has ensured that smart devices are available for almost all personal and organizational activities and are affordable as well. Such devices get connected on the Internet forming a network: the Internet of Things (IoT), wherein data is exchanged,

creating a situation where the entities of the physical world get linked using computer-based systems. Enterprise IoT (EIoT) refers to the network within IoT, wherein the information-traffic is between enterprises. It is estimated that there will be 30 billion devices by 2020. (6)

Discussion: IoT ensures and enhances otherwise available BD, contributing real-time data and analytic output to mitigate risk, increase efficiency in a paperless manner, increase responsiveness and thus improve quality of an SC.

C. Analytics in an SC Network

Data Analysts of Walmart studied the Point of Sale (POS) data during the time of hurricanes. One would imagine that predictive analytics would forecast enhanced sales of safety equipment. However, actual research showed that people tended to buy pop tarts during such a natural disaster. (7).

Discussion: The role of Data Analytics in increasing the SC Network appears significant.

Value creating data sources with respect to the SC Network include Core Transactional Data: CRM Transactional Data, Demand Forecasts; Internal Systems Data: On shelf Availability, ERP Transactional Data, Barcode Systems, Delivery Expedite Instances, Transportation Costs, Origination and Destination; Other data: RFID inputs, Global Positioning System (GPS) data, Intelligent Transport Systems, Call Logs, Email Records, Competitor Pricing, Claims Data. (1)

D. The SC Network: Vulnerability, Risk Mitigation and Resilience

The structure of an SCNetwork impacts its vulnerability. There should be a continued effort towards simplicity, reducing errors and waste of resources. BDA, may reveal insights from available inputs about the source of disruptions, thus guiding the restructuring of the SCNetwork. It may also reveal sources of redundancy. (8)

Discussion: BDA could guide SCM research identifying areas of improvement within the SCNetwork, reducing errors, waste and redundancy.

With rapidly progressing technology and changing circumstances, an SCNetwork has to be dynamic to be effective. The SCNetwork has to be designed keeping in mind uncertainties and changing situations and if circumstances so demand, a risk analysis of the SCNetwork needs to be undertaken. Uncertainties affecting the SCNetwork are both endogenous (wherein the origin of risk is within the SCNetwork; E.g.: deteriorating relationship between the organization and its suppliers) or exogenous (wherein the origin of risk is outside the SCNetwork; E.g.: Risks originating due to market conditions). Risks to SCNetwork may also be classified as continuous or discreet. Continuous risks may be addressed by BDA powered by EIoT inputs especially if they are endogenous. Howe ever the discreet variety of risk may be associated with specific incidents and could be affected by IoT and BDA to a certain extent only. Reverse SC network is created when a company gets involved in the disposal of its products as well as its actual products. Mobile telephone companies offer exchange of used and outdated telephones for new models at a discounted rate. (It has been seen that companies who have a Reverse SC Network benefit and profit more and have a more satisfied customer base) (4), (5), (6)

Also, SCNetworks are inherently complex and dynamic and cognitive human capacity limitations affect the performance of an SC contributing to endogenous risk. (8)

Resilience of an SC is the ability of the SC to adapt to change and resilient SCNetwork has them ability to adapt to and counter risks without affecting its productivity. Strategic resilience requires constant innovation with respect to product structures, processes and inter-corporate relations. (4), (3)

E. Logistics driven by Customer Needs

Increasing globalization has ensured a more aware customer with heightened access to products. Thus, the importance of product design with respect to generating demand in a limited market is significant. Product design affects the entire SCNetwork. Conversely, an efficient SCNetwork in turn affects positively the chances that the product design would be suited to customer expectations. (3) BDA enable an organization to better understand market trends and customer preferences. Data from range of market sales, social media, and demographic and direct data inputs from static and dynamic data points enable to predict and proactively plan SC activities. BDA can assess GPS data with traffic and weather data to plan and optimize delivery schedules. BDA enables a Sc to be proactive and increase responsiveness.(1)

Also, IoT apart from the Internet enables communication between all parties and so, a customer may be connected to a distributor. This would enable cost reduction and better collaboration. (3)

Zhong, Xu, Chen, & Huang, 2017 in their study analyze the utility of BDA for the conduct of Physical Internet based shop floors (by using RFID readers and wireless communication networks). A BDA framework is illustrated to make optimal use of available information to realize the logistics trajectory and to decide on the level of efficiency of logistic operators..(9)

F. Collaborating within the SC Network

An effective SC functions by extreme and complete collaboration within internal departments and between internal and external departments. Companies need to address social responsibility within the SCNetwork by heightened collaboration within the local partners and the entities within the SC. (8)

Agribusinesses source raw materials from small farmers, who often fall prey to the activities and clutches of middlemen, affecting, the SCNetwork include the quality of product and process. *EIoT with BDA may put the small farmer directly in touch with the key entities within the SCNetwork (E.g.: Procurement)*(8)

Discussion: EIoT integrates all entities of the SCNetwork, whether internal or internal. The said input can generate and power BDA so that collaboration between all entities of the SCNetwork. EIoT may enable inputs regarding the status of social responsibility addressed by an SCNetwork.

G. Issues in streamlining the SCNetwork

SC Networks are regulated by local governments as well as global regulatory organizations.

Discussion: EIoT ensures that the company is aware of such regulations and EIoT input powered BDA enables regulatory authorities are aware of issues regarding the company, if any.
(4)

IV. FINDINGS

A. The Supply Chain

Typical Analytics Applications at an SC are: Supplier Risk, Product Characteristics, Sourcing Channel Options, Supplier Integration Level, and Supplier Negotiations (At Source); Inventory Optimization, Capacity Constraints, Facility Layout, Workforce Analytics (At Facility); Distribution and Logistics Optimization, Transportation Alternatives, Routing, Scheduling, Vehicle Maintenance (At Distribution); Location-based Marketing, In-store Behavior Analytics, Customer Micro Segmentation, Multi Channel Marketing, Assortment Optimization (At Sales). (10)

It may be noted that entities in an SC are outsourced to Third Party Service Providers. BDA enables the real-time generation of Third Party Data and report of performance. (11)

B. Big Data Analytics and the IoT

Attributes of BD that contribute towards effect SC Analytics are:

- Volume: Supplier: Product Design Data, Process Data; Manufacturing: Design Specifications, Production Planning, Purchase Data, Vendor Evaluation; Delivery: Demand data , lead time, delivery, shipping and routing , regional demographic data; Sales & Customer: Point of Sales (POS) data, order status, customer needs & desires, Returns
- Velocity: Real time Data
- Variety: Physical Documents, Emails, RFID Inputs, Audio-Visual Inputs
- Veracity: Multiple and often unreliable, unstructured data, creating noise

The value contributed by such data includes:

- Supplier; New product development, production planning and scheduling,
- Manufacturing: Optimal lot size and inventory planning, product decision, process selection, execution and control
- Delivery: Transportation and network planning, store planning
- Sales & Customer: Point Predictive demand modelling, customer analysis,

The difference that BDA has brought in SCM includes

- Real Time capture digital data has enabled the ability to understand human dialogue, thus in turn, generating a massive opportunity for enquiry
- Earlier data was collected to test a hypothesis. Now BD and its large volume of unstructured raw data has ensured that hypothesis get generated as every type of relationship between variables is captured without human intervention.
- BD, with IOT, has created the ability of conduct of large scale experiments on economic and social phenomena. (E.g.: LinkedIn turns granular data (both structured and unstructured) into quantification of member attitudes, by reading text. Full range of member reactions is quantified including “pain-points” and “member-delights”). (10)

C. Analytics in an SC Network

Applications of BD in SC Operations include Real time visibility of Inventory Levels, Demand and Supply Capacity resulting in better production and distribution schedules, Real time warehouse data enables identification and rectification of delivery mismatches, Accurate estimation of demand by assessing real-time marketing data, Monitoring of delivery routes and traffic data for re-routing and capacity and asset sharing, Accurate demand forecast data that eliminate under stocking and overstocking, Real time material-flow data optimizing complex distribution networks. (1)

The future of Data Analytics powering SC is depicted in Table 1

Type of Data	Useful for	Used by
Manufacturing Sensor Data	Real time monitoring of manufacturing equipment Basic/Activity data	Manufacturing Facility
	Design data, Forecasting data	
	Prod. Plan/ Schedule	
	Process data	
	Quality/ Reliability data	
	Maintenance records	
	Customer feedback data	
	Vendor data	
Supplier Data	Supplier Risk Management	Suppliers
	Coordination of Supplier Processes	
	Design data	
	Order status	
	Stock level	
	Schedule	
	Shipment and Routing	
RFID Data	Automated Inventory Replenishment Signal	Inventory Control
	Real time Inventory Data	
	Demand	
	Stock level	
GPS Data	Real time Inventory Locations Time	Warehousing
	Shipment and Routing	
	Order, Return	
	Reduction of Lead,	
Point-of-Sales Data	Real Time Demand Signal with Prices Information	Distributor
	Vendor Management	
	Product feedback	
	New product	
	Promotion	

Table 1

The evolution of the implementation of BD Analytics on SCM has four stages:

- Data Structuring: Data generated are clean, structured and can be used
- Making data available to all who need it and when they need it
- Application of basic, exploratory analytics to the data
- Continued application of advanced analytics, such as predictive analytics, real time data visualization and automated algorithms

D. The SC Network: Vulnerability, Risk Mitigation and Resilience

BDA has the ability to provide insights (in spite of the noise within the data and constantly fluctuating inputs). BDA thus will be able to mitigate the risks arising out of such endogenous sources to streamline functions along an SC.(8)

BDA coupled with EIoT may be able to stream real-time information to ensure a different endogenous risk is minimized. E.g.: A company may be alerted well in time regarding the deteriorating relationship between company and supplier by BDA used on input from EIoT so as to mitigate negative effect on the SCNetwork. It may be noted that such analytics powered by EIoT input would not have the similar effect on exogenous risk, as in this case the input may be from "external" IoT. Also, IoT can ensure inputs to the company regarding the use of their product and status of the same being up-to-date and thus prompt a company regarding the initiation of a Reverse SC network.

BDA powered by EIoT inputs (being real-time) will benefit strategic resilience of a SCNetwork. Being real-time, it may significantly increase strategic resilience. (13)

E. Logistics as per Customer Needs

Large amounts of structured and uncovered data reveal hidden patterns of useful insights BDA enable retail SCs to effectively monitor customer behavior and make accurate predictions of customer preferences. BDA, involving the continuous streaming of live data can give better customer insights than before, making it easier to predict customer reactions and trends, thus guiding how much stocks to order, when to order and answering similar queries and enabling enhance SC efficiency.. (1), (14)

BDA also ensures increased transparency for all activities from the warehouse, to the shop floor and transit. Transparency, enhanced by BDA, guides towards awareness of locations of resources and their utilization (15) Real time insights could be used to decide on the most profitable interconnected loads, real-time status of the market and profitable customers. (14)

Pre-defined Key Performance Indicators can indicate the optimal use of available information to drive efficiency in logistics management and can be used to create benchmarking. (9) A feedback loop should exist between metrics and be monitored continuously. The feedback should be used to edit the alignment as per requirement. (10)

V. CONCLUSIONS

BDA powered by EIoT and IoT contribute to strengthen a company's SCNetwork by harnessing the data available within the SC Network to address customer needs thus, enhancing logistic efficiency (by enhancing the collaborative nature of all key elements within the SCNetwork), ensuring risk mitigation especially for endogenous and continuous risks and reducing the vulnerability of the SC Network by

- Reducing wastage of resources
- Providing relevant cognizable insights in spite of the complexity in data

IoT driven BDA also ensures compliance of the SC Network with regulatory bodies.

V. SCOPE AND LIMITATIONS OF RESEARCH

The research can provide an insight into how BDA is powered by IoT to enhance the power of SCM research and resilience of the SCNetwork. However, the research is generalized and does not discuss the results with respect to different SC Models or even does not deal with analytics and data science tools that may specifically be used for related purposes. The research is also limited to the literature reviewed and may be built upon.

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