

The application of big data and AI in the upstream supply chain

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1. Introduction

The use of Big Data has grown in popularity in organisations to exploit the purpose of their primary data to enhance their competitiveness (Saban et al., 2017). In conjunction with the increased use of Big Data, there has also been a growth in the use of Artificial Intelligence (AI) (Hokey, 2008) to analyse the vast amounts of data generated and provide a mechanism for locating and constructing useable patterns that organisations can incorporate in their supply chain strategy programme. As these organisations embrace the use of technology and embed this in their supply chain strategy, there are questions as to how this may affect their upstream supply chains especially with regards to how SME's may be able to cope with the potential changes. There exists the opportunity to conduct further research into this area, mainly focusing on three key industry sectors of aerospace, rail and automotive supply chains.

2. Big Data and AI in the Supply Chain

The term 'Big Data' was first used by NASA in 1997 by researchers to refer to the visualisation challenge for the computer systems with large amounts of data (Benabdellah et al., 2016). One of the sectors that have benefited from the technological and methodological advancements in the use of Big Data has been the logistics sector. Organisations such as DHL (Germany), UPS (United States) and Maersk (Denmark) have successfully used the Big Data field to enhance their competitiveness (Benabdellah et al., 2016).

As the supply chain becomes more global, there is an increase in the amount of valuable information generated. This information requires analysing to be useful in the establishment of an effective supply chain management strategy, and this introduces the notion of Big Data. This is where organisations are getting smarter and learning to collect and turn the large-scale quantities of data into a competitive advantage. They will use this data to forecast market demand, identification of radical customisation of services and, develop new business models to exploit their previously untapped data (Benabdellah et al., 2016). By applying the use of analytics to extract this valuable information, it can be used to enhanced decision making, and support informed decision making.

Richey et al. (2016) introduced the concept that as the Global Supply Chain Management (GSCM) includes many geographically dispersed companies that the Big Data generated is unstructured, of a wide variety and requires very speedy processing. This, therefore, becomes a critical issue in how to maximise the benefit of the data. As the data is very complex, decentralised and dynamic, the system of systems

theory would fit well in the management of GSC's and the use of the Big Data. A system of systems (SoS) refers to a large-scale distributed system in which its components are complex and independent systems themselves (Choi, 2016).

Choi (2016) further explores the implementation of SoS in GSCM by indicating that this requires the use of information technology as Big Data related technologies such as Radio Frequency Identification (RFID) devices, sensors, data storage processing and interconnected networks play a critical role in modern Global Supply Chain Management. Choi (2016) also suggests that several technological advances and applications have contributed to SoS and GSCM strategy.

These include;

- Information Technology for the integration of communication networks and unified communications
- Enterprise Resource Planning (ERP) to support the major business processes within the organisation and cases where the organisations ERP system formed part of an interconnected system and has been linked with the ERP systems of individual supply chain partners
- Cloud Computing application tools such as cloud storage for large amounts of data and the sharing of common platforms such as Cloud-ERP
- Internet of Things (IoT) which can help establish a virtual linkage between businesses so that the critical parts are all connected by devices. Modern technologies in this area relating to Big Data include Industry 4.0.

As previous stated, Supply Chain Management (SCM) is becoming more information intensive and, in some cases, has substituted of other assets such as inventory, warehouses and transportation equipment (Min, 2010). Supply Chain professionals must explore ways to manage better and leverage the information to make better business decisions. This is where the use of Artificial Intelligence (AI), which has existed for decades, is growing in SCM.

Merriam-Webster online dictionary defines AI as "A branch of computer science dealing with the simulation of intelligent behaviour...." and "the capability of a machine to imitate intelligent human behaviour." So, put differently, AI is the imitation and simulation of human intelligence by machines, particularly computer systems (Nakamki, 2018). The problem with present AI systems is that they can handle large amounts of data but are limited in their ability to use analytical and independent self-awareness which will be the key to building future intelligence. They are either reactive or have limited memory. Nakamki (2018) theories that "Future Event Artificial Intelligence" will not only understand consciousness but have



it based on Theory of Mind which refers to the understanding that others have beliefs, desires and intentions that impact the decisions they make and, Self-Awareness where the AI system has a sense of self and consciousness. This type of AI does not yet exist (The Conversation, November 14, 2016)

3. Use of Big Data

However, the use of AI is starting to increase in several global organisations. In a recent project, Llamasoft's AI platform was used to review and improve the efficiency of Schneider Electric's global supply chain. (Bharadwaj, 2019).

Schneider's existing supply chain flows across 240 manufacturing facilities and 110 distribution centres around the world. They wanted to reduce the costs and analyse potential opportunities as they acquire new business units and how they can assimilate them into their supply chain. Schneider contacted Llamasoft and charged them with creating a supply chain predictive model which would automatically devise the best routing options for their large number of raw materials which includes circuit breakers that could fit on a warehouse shelf to transformers that are the size of a room. In conjunction with this, the supply chain data (such as transportation rates, data regarding shipping routes, etc.) resided on some 27 legacy ERP system from several new acquisitions and the company's existing supply chain data.

Data engineers at Schneider first built a data extraction tool that could collect the enterprise data from all the ERP systems, verify and 'clean' the data to be input to the Llamasoft platform. Llamasoft has made claims that their model needs around 2-4 hours to analyze some 200,000 transportation policy data points, 130,000 flow and routing constraints, and more than 150 initial scenarios (Data provided by Schneider) and could identify \$9.32 million (8 million Euros) in annual savings for Schneider which could potentially be obtained by altering product flow in the supply chain. This could potentially be achieved by, re-routing certain shipments directly from the manufacturing plants rather than through one of their distribution centres to save on material handling and inventory storage costs.

This case study indicates how the supply chain of just one global organisation creates vast amounts of data (Big Data) and that by using the power of IT and AI that improvements can be made that can lead to a good level of cost savings.

The University of Melbourne carried out global research in collaboration with the Chartered Institute of Procurement and Supply (CIPS) to gather intelligence on the level of understanding of the supply chain digitalisation (including the use of Big Data and AI) and what this means for procurement and the wider business community (Fig 1). This collaboration primarily aimed at understanding the nature of digitalisation technologies managers have applied or intend to apply across their firm's supply chain practice, motivations and benefits behind pursuing a digitalisation strategy and challenges facing managers towards implementing supply chain digitalisation. This global survey was conducted in mid-2018 with over 700 managers in more than 20 different industries from 55 different countries taking part in the study. Findings have revealed significant insights on how digitalisation is shaping the future of procurement and supply chain management

(Fig 2) with several organisations either having or planning to have the use of Big Data and AI in place in the next 2-3 years.

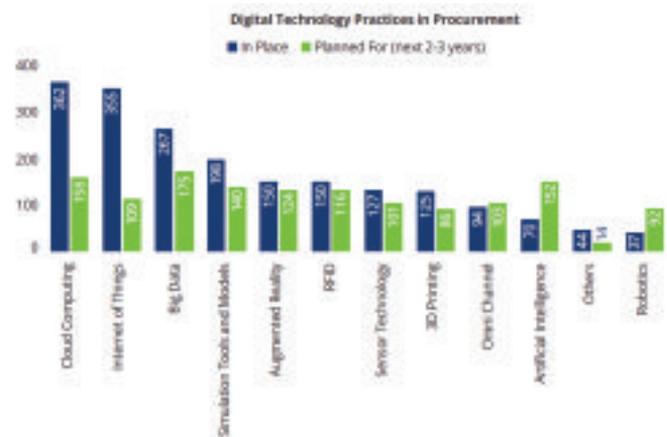


Fig 1. Digital Enablers in Procurement (University of Melbourne)

4. Supply Chain Development

Organisations are increasingly replacing their traditional supply chains with extended supply chains (Saban et al., 2017) which requires the suppliers of the organisation to collaborate, both upstream and downstream (Fig 2) to create value-laden products to the customer (Davis & Spekman, 2004). For organisations to achieve this, they require a high degree of supply chain collaboration (SCC) between the partners in the supply chain. According to Saban et al. (2017), to achieve SCC, organisations are turning towards using the latest decision support systems and technologies to

improve the organisation's agility, reduce cycle times, achieve higher efficiencies and, achieve the delivery of the value-laden products to their customers.

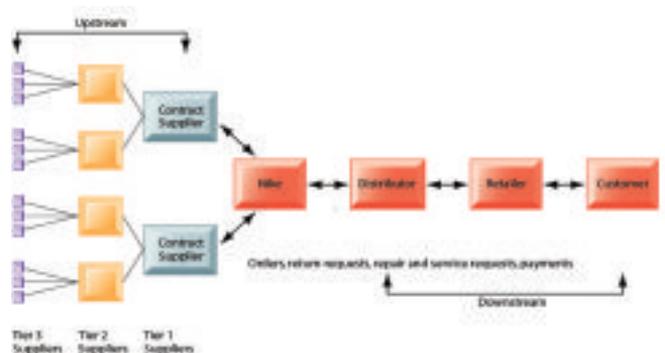


Fig 2. Nike Supply Chain

Benabdellah et al. (2016) state that competition is shifting from the "firm v firm" perspective to a "supply chain v supply chain" perspective. This changing perspective is making many organisations rethink the strategies that they will need to adopt in the future to remain competitive in the global marketplace. Procurement and supply chain are at the centre of how much of this data is processed and applied to the development of a competitive supply chain. There has been a growth in the term digitalisation (University of Melbourne, 2019) which could lead to increased transparency, flexibility,



agility and a customer-centric value-adding supply chains. With this change in mind, the ability to strive for excellence in the supply chain has driven the expansion in the use of structured and unstructured data which, can be classified as, Big Data (Ramen et al., 2018).

McCormack & Kasper (2002) define the extended supply chain as:

“Extending outward beyond company boundaries to your customers and suppliers and connecting with them through the use of digital technologies and integrating practices”.

This definition is relevant as the competition amongst organisations shifts from the “firm v firm” perspective to a “supply chain v supply chain” perspective (Benabdellah et al., 2016). According to Hult et al. (2004) to achieve and maintain this competitive edge, the sharing of information within a supply chain is vital due to the long-term benefits that can be delivered such as coordinated processes and enhanced planning.

The differing viewpoints bring into question how an organisation can develop a supply chain network that includes multi-directional links and interdependent activities amongst multiple tiers of the supply chain (Manuj and Shain, 2011). An extended supply chain network requires the collaboration of companies, both downstream and upstream, to cooperate to achieve supply chain collaboration (SCC) between them and deliver value-added products to customers (Saban et al. 2017).

Fawcett et al. (2012) argue that part of the reason why organisations cannot achieve high levels of SCC is that they will be constrained by inter-firm conflict, nonaligned goals and, the non-sharing of sensitive information. These constraints will inhibit the use of collaborative communication technologies such as Management Information Systems as argued by Saban et al. (2017) who also

coined the term ‘Technocentric thinking.’ They believe that SCC can be achieved by having the right technology in place which aids the development of a competitive and productive supply chain. This position is further supported by the research of Chopra and Meindl (2013) whose posit is that SCC is best achieved when separate autonomous organisations integrate, not only their resources such as people, processes and technology but, also their expertise and sensitive information at the right time to drive business success.

This approach is important as supply chains have increasingly become global in nature and the requirements of organisations to be able to rapidly respond to customer requirements is fundamental to business success. Coupling this with the macro-economic factors that require lean and agile supply chains drives the emerging trends in SCC. The emergence of SCC into a blueprint for the development of a well-integrated sales and operation planning (S&OP) system, supported by synchronised Management Information Systems, has made it possible for organisations to create and maintain strong customer relationships (Rokonuzzaman, 2018).

5. Information Flows

As mentioned previously, SCM is a series of members interconnected not only by the flow of physical items but also by information flows. The flow of physical items is, traditionally, sequential and linear as products flow from supplier to customer while information is simultaneous, especially through the use of electronic exchanges by all the supply chain partners (Bouhaddou and Benablehafid, 2015).

It is the flow of this information upstream through the supply chain and how this is influenced by the downstream organisations using Big Data and AI to develop their supply chain strategy that creates the question for this research. The changes in requirement patterns such as batch sizes, frequency of orders, changes in requirements, delivery locations, economic order sizes and late customer customisations (to name a few) can all affect the ability of SME’s to be able to cope with the changing demands of the downstream organisation’s requirements which are influenced by the results obtained by the use of Big Data and AI. Fig 3 shows an illustration of a supply chain for the provision of laptops. As the information flows through the supply chain. Changes in the information pattern by the laptop manufacturer which can be influenced by customer requirements, the external environment and the competitive nature of the marketplace



Fig 3. illustration of a supply chain for the provision of laptops

6. Research Originality

Early research has indicated that the use of Big Data and AI is limited in the sectors mentioned earlier of aerospace, rail and automotive. This is due to the fact to how many organisations are still competing on a “firm v firm” basis and that the dynamic complexity of a supply chain network (Fahhama et al., 2017) has restricted the ability of the supply chain to adapt to the “supply chain v supply chain” approach.

The research suggests that although organisations are aware of the existence of AI and Big Data, there are few that are actively investigating the potential use and benefits that could be realised by using adopting the use of these data and knowledge assets.

The emergence of new terms, such as Supply Chain Analytics (SCA), reflects a broad interest in leveraging the business value of supply chain data and harnessing the power of various analytical technologies and methods. Top performing companies are better at utilising their data for business planning, and execution and this has led to the increase in



supply chain integration and visibility. In general, academic research expects the benefits of analytics in supporting supply chain operations (Bongsug et al., 2013).

Thus, after reviewing studies and research papers on supply chain management, we have identified the research gap in supply chain management which requires technological changes along with better implementation to tackle the upcoming and the current issues subsequently.

7. Research Objective

As can be seen from figure 4 below the supply chain had a linear relationship between the suppliers, manufacturers, distributors and the consumers but now with the advent of e-commerce and rising customer demands the supply chain has become complex and hence the managers are finding it difficult to optimise the operations.

8. Practical Impact

To achieve and retain customer confidence and trust, organisations that use AI and Big Data need to be able to present the provenance and authenticity of the data and knowledge they use to make decisions.

Making effective use of collective intelligence and crowd-sourced data presents opportunities for organisations from all market sectors to better understand the facts and experiences to use AI to improve decision making, produce new options and ideas, and give better oversight and monitoring of the environment that they operate in.

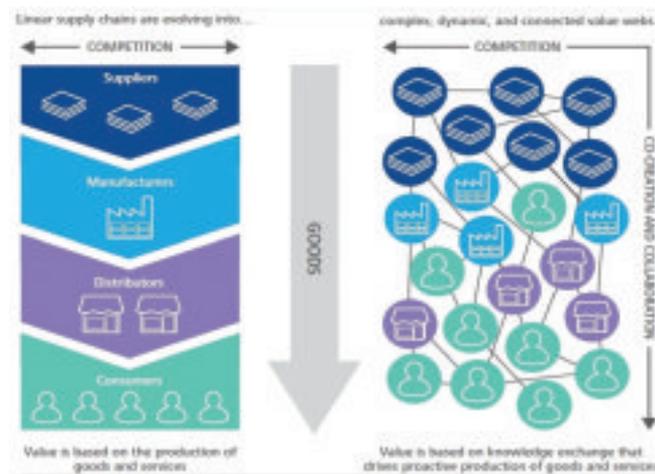


Fig.4. Supply Chain Evolve into value web

So the main objective of the research is to find a way to reduce the complexity of the supply chain by using Big Data Analytics and to identify the data sources that may be considered for decision-making purposes in each of the SCM levels: procurement, marketing, transportation, and warehouse operations.



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