Artificial Intelligence and Supply Chain Management−Applications and Challenges

ABSTRACT

Organizations that successfully integrate AI into their supply chains can increase their operational efficiency, make decisions that are more informed, and create higher value at the enterprise level as AI can augment existing processes and skills. AI can provide a platform for enhanced demand, logistics, transportation, and supplier management, making key functions more predictive and valuable than before. However, challenges remain to realizing these benefits. AI can face resistance, be costly, need skilled personnel that may be difficult to find and retain for all but the industry giants. More importantly, making a business case for AI, including determining return on investment, may not be easy especially for smaller supply chain actors. To overcome some of these challenges requires organizations to have a clear AI strategy, build top management support and a trusting environment around AI to dampen any resistance to a technology that is at times controversial. Starting AI integration slowly with modest goals and readily measurable outcomes within some function or department, before an enterprise wide adoption may provide a learning opportunity and increase the chances of its success. AI should become a source of competitive advantage to merit the investment in people and resources that it requires.

KEYWORDS: Artificial intelligence, machine learning, supply chain management, technology integration, disruptive technology

1. Artificial intelligence (AI) as a digital disruptor

The late acclaimed theoretical physicist Stephen Hawking said "Every aspect of our lives will be transformed by artificial intelligence," and AI could be "the biggest event in the history of our civilization." While we must await the fullness of time to see if developments will indeed prove Hawking right, it is generally accepted today that AI has become one of the most disruptive digital technologies of our time. AI encompasses the wide-ranging tools that enable people to rethink how we integrate information, analyze data, and use the resulting insights to improve decision-making (West and Allen, 2018). An AI system combines, and utilizes mainly machine learning and other types of data analytics methods to achieve artificial intelligence capabilities (van Duin and Bakhshi, 2017).

A 2017 McKinsey Global Report on AI noted that AI "is poised to unleash the next wave of digital disruption" and companies should prepare for it, since early adopters have achieved higher profit margins and the gap with non-adopters is expected to widen (Bughin et. al 2017). The McKinsey Report estimated that tech giants such as Google and Baidu spent some US$20 to US$30 billion on AI in 2017, of which 90 per cent was on research and development and the rest on acquisitions of intellectual properties or companies. A project undertaken by Price Waterhouse Coopers (2017) estimated that "artificial intelligence technologies could increase global GDP by $15.7 trillion, and a full 14%, by 2030." Global giants such as Amazon, Siemens, Alibaba and Apple are already integrating elements of AI into their products. These early indicators notwithstanding, universal adoption of AI seems to be lagging behind the promise. For example, a study by Deloitte showed that when 1,500 senior business leaders in the United States in 2017 were asked about AI, only 17 percent said they were familiar with it. A number of them were not sure what it was or how it would affect their particular companies. Although the executives

understood there was considerable potential for AI to alter business processes, they still were not clear how AI could be deployed within their own organizations (Davenport, Loucks and Schatsky, 2017). In general, AI use in business appears to be rather low for good reason: by now, executives are used to hearing about the next big hype that fizzles when the reality fails to match the hype. AI may sound esoteric to all but the tech-savvy executive, and some companies may not be aware of its benefits at this time. More importantly, established companies are generally slow or reluctant to adopt new, disruptive technologies (Christensen, 1995).

Despite any misgivings, executives would do well to take a serious look at AI considering its immense potential. One area where AI may be particularly useful is in the area of supply chain management (SCM). We focus on AI use in SCM in this paper because the available preliminary research indicates that SCM, specifically retail and logistics are one of the most important areas where AI can create value (McKinsey, 2017; Chui et al. 2018a). For example, Chui et al. (2018) report that AI can improve performance beyond that provided by other analytical techniques in 89% of cases in transport and logistics and in 87% of cases in retail. The authors report that AI has the potential to create $400-$500 billion in retail, about the same value in transport and logistics, noting that AI has the potential to improve forecasting accuracy by 10 to 20 percent, which translates into a potential 5 percent reduction in inventory costs and revenue increases of 2 to 3 percent. Clearly, AI has the potential for value creation when integrated into SCM. The low rate of AI adoption in SCM may be, in part, because executives do not yet know much about its potential to create value in SCM. More importantly, AI integration into SCM has challenges that organizations need to overcome. Building a knowledge base of these and related issues may be helpful and this paper fills some of the existing gap. The paper is organized as follows: The next section presents the promise of AI. This is followed by the section on the challenges of AI

integration. The section after that presents some guidelines and the final section presents some concluding remarks.

AI has the potential to increase value creation in demand forecasting, management, customer service, and inter-partner coordination to mention a few. However, there are key challenges that organizations need to overcome if the benefits of AI integration into SCM is to be realized. Some key challenges include how to integrate AI into existing systems and processes, understanding the complex technology of AI and the technical and economic resources required to acquire the technology. For example, Ng (2017) reports that despite a promising future, adoption of artificial intelligence (AI) in consumer goods manufacturing and supply chain management has been much slower than in the technology, retailing and financial services sectors due to a lack of data for analytic tools to work on. We explore these and related issues and offer some guidelines for firms desirous of integrating AI into their supply chains in the sections that follow.

2. Artificial Intelligence: A Definition

It is not always easy to define a concept as broadly used as AI. Yet, this is may be one time where a clear definition would help. AI is a poorly understood concept with opinion surveys showing that even top business leaders lack a detailed sense of AI resulting people confusing AI with super-powered robots or hyper-intelligent devices. According to West and Allen (2018), the lack of clarity around the term enables technology pessimists to warn AI will conquer humans, suppress individual freedom, and destroy personal privacy.

There is no universally accepted definition of AI. The Merriam-Webster defines artificial intelligence as (1) A branch of computer science dealing with the simulation of intelligent behavior in computers and (2) The capability of a machine to imitate intelligent human behavior. Marr (2018) observes that definitions of artificial intelligence begins to shift based upon the goals that

people are trying to be achieved with an AI system. For example, Amazon defines AI as "the field of computer science dedicated to solving cognitive problems commonly associated with human intelligence, such as learning, problem solving, and pattern recognition." Machine learning forms the basis of most AI, but it is not the same thing as AI. For example, as Marr (2018) observes, a machine-learning algorithms will never understand what it was trained to do: ML may be able to identify spam, but it will not know what spam is or understand why we want it to be identified. More importantly, unless someone (humans) re-trains the algorithm, it will probably not be able to identify if a new sort of spam emerges.

Marr (2018) observes that people generally invest in AI development for one of these three objectives: (1) Build systems that think exactly like humans do ("strong AI"), (2) Just get systems to work without figuring out how human reasoning works ("weak AI") and (3) Use human reasoning as a model but not necessarily the end goal. According to Marr (2018), the bulk of the AI development happening today by industry leaders falls under the third objective and uses human reasoning as a guide to provide better services or create better products rather trying to achieve a perfect replica of the human mind. AI can be broken into two components: augmentation (AI, which assists humans with their day-to-day tasks, personally or commercially without having complete control of the output) and automation (AI, which works completely autonomously in any field without the need for any human intervention e.g. robots performing key process steps in manufacturing plants). A distinction is sometimes made between narrow, general and super AI. According to Van Duin and Bakhshi (2017) virtually all current AI falls in the narrow category, meaning it can only do what it is designed to do. This means that for every problem, a specific algorithm needs to be designed to solve it. Narrow AIs are mostly much better than humans at the task they were made for: for example look at face recognition, chess computers, calculus, and

translation. Google Assistant, Google Translate, Siri and other natural language processing tools are examples of Narrow AI. While useful, these systems lack the self-awareness, consciousness, and genuine intelligence to match human intelligence. In other words, they cannot think for themselves. The most useful AI is a general AI, a single system that can learn and then solve any problem people present it. Super AI is associated with machines that are an order of magnitude smarter than humans are (Jajal, 2018).

West and Allen (2018) suggest that three qualities of AI, their capacity to operate in an intentional, intelligent, and adaptive manner makes them useful to industry. First, AI algorithms are designed to make decisions, often using real-time data, going up and above what passive machines giving mechanical or predetermined responses can do. AI uses sensors, digital data, or remote inputs and combine information from a variety of different sources, analyze the material instantly, and act on the insights derived from those data. Combining improvements in storage systems, processing speeds, and analytic techniques, AI are capable of tremendous sophistication in analysis and decision-making. Second, AI combines machine learning and data analytics. As long as the data are sufficiently robust that algorithms can discern useful patterns, machine learning can take the data and look for underlying trends, no matter whether the data comes in the form of digital information, satellite imagery, visual information, text, or unstructured data. If AI spots something that is relevant for a practical problem, software designers can take that knowledge and use it to analyze specific issues. Finally, AI systems have the ability to learn and adapt as they make decisions. Semi-autonomous vehicles may be a good example of AI's capacity to adapt. SAVs can take advantage of the experience of other vehicles on the road, without human involvement, and the entire corpus of their achieved "experience" is immediately and fully

transferable to other similarly configured vehicles. In the case of fully autonomous vehicles, advanced systems can completely control the car or truck, and make all the navigational decisions.

3. The promise of AI for supply chain management

Supply chains have become the backbone of the global economy partly accounting for the rapid growth of such giant conglomerates like Walmart and Amazon, to name just a few (Van der Vegt et al. 2015). Despite their importance, supply chains are subject to disruption, face substantial risk, and their management has not always been easy (Christopher and Peck 2004). Developing robust and resilient supply chains is one way of enhancing supply chain performance (Sheffi, 2007) and AI, including machine learning, may play an important role in this respect. This section of the paper explores some specific areas where AI can create value in SCM.

3.1. Streamlining procurement

The process of procurement involves buying raw materials or finished goods and shipping the materials or goods to the desired demand location. The procurement process involves several levels of complexities such as agreeing and delivering on the product or raw material or service, including consideration of the price, quantity, quality, and delivery time. Procurement within supply chain focuses on agreeing on terms and conditions with a third party on the acquisition of goods and services.

Procurement is a strategic function in organizations because organizations spend substantially on purchasing of goods and services (Presutti, 2003). However, traditional procurement systems are known to be complex and inefficient. Lee et al. (2009) argued that the drawbacks of current procurement practices include a lack of coordination and proactivity between buyers and suppliers. In addition, the lack of automation and intelligent advice tools makes the

procurement of suitable suppliers and assessing supplier performance in a timely manner difficult. Some of the most popular tools currently used for procurement are Enterprise Resource Planning (ERP) systems such as System Application Product (SAP) and E-Procure systems. While these systems provide some level of flexibility and solution, their biggest drawback is the lack of transferability and the need for developing a customized edition for each supply chain entity that needs to use it. Organizations may be moving to using technology to overcome some of the existing challenges. For example, some organizations have used Intelligent Agent Technology for managing the procurement process. Agents were able to track demand, reduce the bullwhip effect, discover complex scenarios, and adapt to the fluctuation of the supply chain environment (Kimbrough et al., 2002). Advanced technology, specifically AI, an improvement on intelligent systems, can assist human purchasers in identifying suppliers, search materials, and prepare purchase orders. AI overcomes the transferability problem with current systems because it provides a quicker and more efficient way for searching for data, uses improved algorithms for faster computations, provide unique set of data computations, and a quicker adaptability window with data transfer from one system to the other (Emil and Mărăcine, 2015).

AI can help in the early detection of supply chain disruption and awareness, help compliance issues, and manage quality challenges. In a recent study by Gartner, usage of AI tools in procurement assisted in alerting the enterprise and suppliers to supply chain disruption by approximately 44%, recognizing and flagging supplier compliance issues by 39%, and quickly identifying instances of fraud by 37% (McCrea, 2018). Some of the specific AI tools that can assist in this include cognitive procurement advisors (CPAs), virtual personal assistants (VPAs), the use of natural-language processing (NLP) and natural-language generation (NLG) to increase the speed of procurement and ease of doing business. Agents were able to track demand, reduce the

bullwhip effect, discover complex scenarios, and adapt to the fluctuation of the supply chain environment (Kimbrough et al. 2002).

Smith (2016) suggest that AI powered Chabots (A chatbot also known as a talkbot is a computer program which conducts a conversation via auditory or textual methods) can play an important role in procurement. According to Smith (2016), the impact of Chabots on the world of procurement would be important as their use will take away many of the mundane, routine parts of the job and leave the interesting strategic bits that humans are uniquely equipped to deal with. Bots will handle low value transactions and handle the paperwork, sending orders, chasing orders, dealing with invoices and payments. In other cases, bots enabled information will flow to the buyer so that if raw materials prices fall, the bot will inform the buyer and start the conversation with the supplier for a change in pricing and bots running e-auctions on a regular basis with little or no human interaction can handle all pricing issues. Smith (2016) suggests that an organization and supplier bots can handle most of these transactions without human interaction leading to lower costs both internally and with supplier firms. Some firms are already using AI for procurement. For example, the Hyatt Regency Riverfront in Jacksonville, FL, USA, is a pioneer adopter of AI. The hotel is now able to forecast the demand for food and beverage and to generate spontaneous staffing schedules with superhuman accuracy. The Pan Pacific in San Francisco, CA, was on track to save an estimated 4 per cent of labor cost during the first year of AI implementation. The hotel achieved a daily overall average restaurant accuracy of 90 per cent, with a similar accuracy being achieved for room service and banquet forecasting, allowing the hotel to staff appropriately and reduce costs (Hotel News Wire, 2018). Organizations such as Walmart, Amazon, Google and other strategic buying companies are also currently using AI procurement tools to modernize their procurement process (Turban et al. 2017).

3.2. Supply chain planning

Effective structures and planning tools for demand and supply chain planning (DSCP) are basic requirements for coordinating thousands of individual decisions in supply chain and customer management (Hubner, Kuhn and Sternbeck, 2013). A failure to align demand and supply plans leads to logistical issues. For example, the increasing competitive retail business requires ever-greater customer orientation and operational efficiencies and demand/supply planning is becoming more critical as consumer expectations rise, and competition increases. Accurate forecasting, supply flexibility, and efficient inventory stockpiling are all parts of demand and supply planning. Forecasting and inventory management pose key challenges to supply chains. In supply chains, each member (i) forecasts the demand of its customer, the supply chain member (i+1) that follows it, who, in time, forecasts the demand of member (i+2) and so on until reaching the forecast of the demand of the final link, the final customer. Forecasting is not an exact science, but rather a combination of mathematical calculations based on past observations and judgement from the decision maker. Qualitative forecasting is based on an expert's judgment or group decision-making while in quantitative forecasting, the decision maker uses different methods to assign weights to past observations. Clearly, it is not easy to coordinate forecasting across the supply chain, as errors in forecasting in the supply chain will be magnified, a phenomenon known as the bullwhip effect.

Technology such as decision support systems (DSSs) have been used for individual planning problems. However, the clear focus lies on isolated planning issues rather than on an integrated planning perspective that takes into account interdependencies between individual problems (Fisher and Raman, 2010). Tools that foster better coordination between strategic partners and help forecasting would therefore be useful and this is where AI comes in. AI can help in demand and supply planning in several ways. First, machine learning can help with forecasting

inventory, demand and supply. If integrated with SCM tools, ML could revolutionize the agility and optimization of supply chain decision-making (Kodiak Rating Community, 2017). Second, AI helps in big data analysis as forecasting engines with machine learning can look to see which combination of algorithms and data streams has the most predictive power for different forecasting hierarches (Forbes, 2017). Finally, AI can enable forecasting based on the underlying casual drivers of demand rather than on the more traditional, and less trusted inputs based on previous outcomes, thereby improving forecasting accuracy by 10-20 %, which translates into a 5% reduction in inventory costs and revenue increases of 2-3% (Chui et al. 2018). One example of the utilization of AI for forecasting is what happens in the Ann Arbor-based firm, Llamasoft. The company uses Demand Guru, a form of machine learning to identify hidden patterns such as seasonal demand, and Data Cube, a program that uses a collection of curated weather and economic time-series databases to recognize cause and effect relationships for predicting future demand (www.llamasoft.com). Another example of AI application in SCM is Aera Technology that uses a platform for supply chain demand planning in collaboration with Merck pharmaceuticals (Castellanos, 2018). Other notable applications of AI technology helping in customer demand management already exist. For example, Netflix uses AI to provide highly accurate predictive technology based on customers' reactions to films. Amazon.com uses Amazons' transactional A.I. to predict what customers are interested in.

3.3. AI and warehouse management

The effectiveness of supply chain planning depends a lot on proper warehouse and inventory-based management (Kodiak Rating Community, 2017). Warehousing, the temporary storage of goods, was estimated to cost $126 billons in 2012, accounting for 15% of the overall cost of transportation in the US (Jacob and Chase, 2018). The use of AI can bring efficiency and cost

savings to warehouse management in several respects. First, AI can help the development of lean warehousing (Jacob and Chase, 2018). The use of machine learning and AI can help reduce waste by optimizing material retrieving, minimizing shipping errors, and a reduction in shipping defective material by early detection in the retrieval process. Robots can help with routing, consolidating, cross-docking, redirecting shipments, and optimizing warehouse management decisions. Second, ML and forecasting engines are able to use algorithms and data streams to make predictions, which helps warehouse management (Marr, 2017). Machine learning allows organizations to collect data on inventory – origins, transit routes, times when inventory is scanned or its location and status by applying RF (Radio Frequency) tags (Marr, 2017). Third, AI can greatly enhance customer support within the warehouse environment. The industry research firm, Gartner, predicts that by 2020, the majority of commercial interactions will take place between customers and virtual agents (www.gartner.com). The use of chatbots and other virtual agents can be highly effective for automating low-level customer service inquiries. Autodesk, a global leader in computer aided design and engineering software, has been immensely successful in this endeavor. Using the IBM Watson Conversation service, the company built the Autodesk Virtual Agent (AVA) which is able to answer 40 unique low-level queries at a rate of 30,000 interactions per month and cuts response time to customer inquiries from 1.5 days to 5 minutes, or just about a 99% reduction (Gesing, Peterson and Michelsen, 2018). Finally, AI has enabled automated guided vehicles (AGVs) to use automated material handling across traditional manufacturing boundaries by moving between buildings. Today's AGVs have the potential of being made relatively more autonomous by integrating them with data from existing warehouse management and control systems through a connecting software layer called warehouse execution systems (Bharadwaj, 2018). Several organizations are already using AI to enhance their warehouse

operations. For example, Procter and Gamble, Pfizer, and Wal-Mart are using Warehouse Management Systems (WMS) with state of the art technologies that include voice-activated receiving and packaging instructions. The Gap is using technology provided by Kindred AI to speed up assembly of e-commerce orders with robots using reinforcement learning and deep learning (Vanian, 2017). De Jesus (2018) reports that European retailers are using AI software across three applications: inventory management, visual search and sales. AI can seamlessly connect supply, demand, storage and transportation of materials, with high speed and high efficiency, leading to low cost advantages for the players.

3.4. Logistics and Shipping

Transportation and logistics are essential functional areas for any organization that stores goods and moves these goods from one location (source) to the other (destination). While transportation is concerned with the movement of goods from a source to a destination location, logistics refers to all the entities that are involved in transporting goods and services as well as the physical facilities such as the warehouses, distribution centers, and other outlets that store these goods and services.

Apart from purchasing, transportation is the next most substantial cost component in supply chain management. For example in 2014, the total cost of US logistics was estimated at $1.449 trillion and 62.6% of that spending was transportation-related costs (Gilmore, 2015). This situation is likely to worsen considering the rise in fuel prices and supply chain actors often employ any cost-saving strategies they can use to reduce cost. Organizations typically use distance measurement as a way of determining the most efficient routes. AI improves on distance measurement methods and thereby saves costs. In AI transportation application, very advanced techniques are used for transportation distance calculations. Using specialized algorithms called the Linked Chain Method; AI systems are able to minimize the distance traveled and transportation costs (Tokgoz et al. 2015).

Active RFIDs (Radio-frequency identification) use AI techniques in helping to track transportation routes and distances. For example, Walmart uses Active RFID tags to determine the locations of their trucks, giving the firm the ability to provide real time feedback to its retail outlets, as well as the ability to forecast for, fulfil any Vendor Managed Inventory (VMI) agreement with suppliers, and be on top of their Collaborative Forecasting, Planning and Replenishment (CFPR) strategies. Eventually autonomous driving vehicles may become a usable technology, overcoming human weaknesses and making deliveries.

3.5. Managing supplier selection and coordination

Supplier selection is the process of selecting a supplier to acquire the necessary materials (typically raw materials, maintenance repair and supplies) to support the processing of product outputs for organizations. Selection of the best and/or the most suitable supplier is based on assessing supplier capabilities (Shih et al. 2007). Supplier coordination on the other hand looks at streamlining all the flow of such as raw materials, finished goods, information, communication and financials across the supply chain (Chang et al. 2006). In a typical supplier selection and coordinating environment, firms decide to choose the right supplier by going through a list of guidelines that includes, but not limited to price lists, value for money, quality, reliability, service Ting and Cho (2008). The ability to weigh up the priorities of such importance is one of the topmost priority lists for most strategic buyers. However, there are complexities and challenges associated with the supplier selection process. Some of these challenges include determining the optimal selection criteria, replication of good supplier selection process, building a creative and effective team to manage the process, etc. These challenges are sometimes difficult to manage through regular quantitative and qualitative techniques (Deswal and Garg, 2015). AI can use Fuzzy Logic and other advanced forms of data gathering through conventional and unconventional means

to aid decision-making during supplier selection. AI improves on the selection process because it is capable of using advanced levels of abstractions, larger and more complex data models, more complex algorithms and lots more data to feed the system. Algorithms can learn from the data itself to improve the results and even uncover opportunities for the company. Both Nestle and Unilever have adopted this method in dealing with their supplier selection. According to Smith (2016), chatbot can find suppliers for you by doing market research, asking questions of the suppliers and build a shortlist, and monitoring their performance management. This selection should be easy as bots will run and score tenders and all managers have to do is approve the selections. In addition, AI will help evaluate whether the organization is reaching its targets using Key Performance Indicators (KPIs). KPIs are measurable values that demonstrates how effectively a company is achieving key business objectives. AI will then highlight performance issues to the relevant staff. Logistics companies depend on networks that must function well with high volumes and time-sensitive deadlines and AI offers logistics companies the ability to optimize network orchestration to degrees of efficiency that cannot be achieved with human thinking alone (Gesing, Peterson and Michelsen, 2018).

4. Challenges of AI use in supply chain management

AI is a complex technology and therefore its integration can pose several challenges. Exploring these challenges can give us some clues on how to implement AI to realize its promise and existing research on new technology adoption can help our understanding of some of these challenges.

4.1. Stakeholder resistance to AI integration

The fear that machines will replace human labor has been with us from the time of the Luddites (textiles workers who protested against automation) in the early 19th century. Such fears may be genuine and

organizations cannot underestimate possible resistance to AI introduction from some internal stakeholders as "innovation assassins" may be lurking everywhere. Covert and overt legitimate resistance to the introduction of new technology may be a fact of organizational life. In fact, stakeholder resistance to new technology is a well-known phenomenon (Howell and Higgins, 1990). This is especially likely to be the case with AI as there are legitimate, but perhaps exaggerated, fears that AI may replace people. For example, an Oxford University study predicted 47% of jobs could be automated by 2033 and the 2017 McKinsey's research estimated AI-driven job losses at 5%". According to Leonard-Burton and Kraus (1985), resistance to a new technology often arises because of stakeholder perception that the technology is either not for their benefit or for fear of loss of position with the introduction of a new technology. Resistance can either be benign or grow into sabotage, often taking the technology sponsors by surprise. These challenges may exist for AI integration for a number of reasons.

First, employees may resist AI because of the fear that they will lose their positions. There is little doubt that AI will lead to some job losses. However, history teaches us that fears and concerns regarding AI and automation are understandable, but may be ultimately unwarranted. Technological change may eliminate specific jobs, but it has always created more in the process. (McClelland, 2018). AI and automation can eliminate drudgery and free people to pursue careers that give them a greater sense of meaning, and greater job satisfaction. In the end, AI may create more jobs than it causes us to lose (McClelland, 2018). More importantly, if the past is any predictor of the future, we know that machines will not completely replace humans and the dire predictions today will prove unfounded just like those of the Luddites during the Industrial Revolution. Indeed, AI may actually open up new vistas for industrialization. Second, resistance may come because of the fear that AI will lead to a loss of control that some people have. For

example, chatbots may render customer service personnel, including their supervisors, less useful and that could cause resentment in some cases. Finally, people may look at the technology and decide that it does not give them any direct benefits, even if it allows the organization to create value. The potential benefits and rewards of AI may not be readily apparent to everyone in the organization. The fact is AI may actually eliminate some positions, reduce visibility of others and yet create greater value for the organization overall.

4.2. The challenge of building a trusting environment

Introducing a new technology involves behavior change and change implementation is unlikely to succeed unless internal stakeholders support the initiative, therefore building a trusting environment is important. In a collaborative study by DHL and IBM on the use of AI in logistics, Gesing, Peterson and Michelsen, (2018) note that it is very important for organizations introducing AI to build trust within the organization. According to the authors, a deep understanding of organizational attitudes towards AI is necessary especially because of fear over potential job loss through automation. The potential impact of AI on society has generated significant debate and there may be legitimate fears on the part of some employees that AI will replace them. Indeed, even some notable proponents of AI themselves have expressed reservations about the potential negative consequences of AI. Voices of caution include that of Stephen Hawking who is reported to have said that the "development of full artificial intelligence could spell the end of the human race." Elon Musk, CEO of Tesla, despite already integrating AI into his firm's cars is another voice of caution. There are also some positive voices. Amazon CEO Jeff Bezos is positive on AI, observing that "We are now solving problems with machine learning and artificial intelligence that were … in the realm of science fiction for the last several decades." It is important for organizational leaders to explain what the promise of AI

is. Demonstrating that in the final analysis AI will augment, not eliminate jobs, will offer some assurance to employees.

4.3. Managing the cost and securing resources for AI

Talent, data and money may be the holy grails of AI use in SCM. AI requires financial, physical, human resources, which may not be readily available in organizations especially smaller supply chain firms, and there presently exists a big skills gap in AI. As Gartner's Andy Roswell-Jones puts it, AI is hard to implement because of the need for new skills, some of which are hard to find. Individuals with the top skillsets and those that are able to understand AI, its use and how to apply it are inadequate for several reasons. First, AI requires advanced skill sets in data science and information management. One of the biggest challenges facing AI adoption is the lack of technical expertise within organizations. Some (2018) notes that the deployment of AI applications in business enterprises require specialists who have a deep understanding of the current AI technologies, its limitations and the current advancements and the skills gap may be hindering AI adoption. Second, even where they are available, such experts are expensive to hire and retain. Data scientists, data engineers and subject matter experts in today's market are rare and expensive, and smaller organizations may not have the resources to acquire such expensive talent. Third, AI requires hardware including processors that have much advanced processing power that many organizations do not have now. While using cloud computing and massively parallel processing systems can be an interim solutions, the problem is as data volumes continue to grow, and deep learning brings more algorithms that are complex into existence, the challenges grow. Fourth, data acquisition and storage is another challenge in AI implementation. Industrial AI systems depend

on sensor data as its input. The large amount of sensor data collected for AI validation may present noisy datasets that are difficult to store and analyze. Finally, because AI technologies are expensive, all but the large organizations such as Facebook, Apple, Microsoft, Google, and Amazon have separate budget allocations for AI implementation while small, and mid-size enterprises are bound to struggle to implement AI solutions in their business processes (Some, 2018). As Faggella (2018) points out, at this point in the technology's development, artificial intelligence is not easy to "do" in business. The science is hard, the math is hard, and the level of data infrastructure and subject matter expertise needed to derive real value from AI in business are rare. Those seeking expertise outside need to be careful not to be defrauded. According to Faggella, companies seeking to choose AI vendors can look at three things before making the choice: (1) AI expertise in leadership (2) The use of AI in marketing language (3) Assessing a company's investors. Following these guidelines should reduce the possibilities of choosing vendors who may not be equipped for delivering on a successful project.

4.4 AI and the risks of hacking and cyber attacks

Although AI can usher in a period of unprecedented growth in supply chain development and management, the potential for great damage when this system either gets into the wrong hands or is abused needs to be taken seriously. In fact, AI can help reduce cyber fraud (Vasudevan, 2018). At the same time, AI use in SCM can expose organizations to cyber fraud. The malicious use of AI to sabotage the supply chain is a challenge because AI is dual-use by nature, and many of the malicious uses of AI have related legitimate uses as well. In some cases, the difference between legitimate and illegitimate uses of AI could be one of degree and ensuring appropriate safeguards against malicious use is a challenge (Brundage, Avin, Clark et al. 2018). A recent report on the malicious use of AI highlights a range of security threats, from sophisticated automation of

hacking to hyper-personalized political disinformation campaigns (Brundage, Avin, Clark et al. 2018). The authors note that as AI capabilities become more powerful and widespread, the growing use of AI systems leads to increasing threats in at least three ways: (1) Expansion of existing threats. The set of actors who can carry out particular attacks, the rate at which they can carry out these attacks and the set of potential targets may increase. (2) Introduction of new threats. New attacks may arise with AI systems to complete tasks that would be otherwise impractical for humans. In addition, malicious actors may exploit the vulnerabilities of AI systems deployed by defenders. (3) Change to the typical character of threats. The growing use of AI may allow attacks to be especially effective, finely targeted, difficult to attribute, and likely to exploit vulnerabilities in AI systems. Particular areas of vulnerability that were identified in Brundage, Avin and Clark, (2018) include: (1) digital security. There may be an increase labor-intensive cyberattacks (such as spear phishing) attacks that exploit human vulnerabilities (e.g. with speech synthesis for impersonation), existing software vulnerabilities (e.g. through automated hacking), or the vulnerabilities of AI systems (e.g. through adversarial examples and data poisoning. (2) Physical security including novel attacks that subvert cyber physical systems (e.g. causing autonomous vehicles to crash) or involve physical systems that it would be infeasible to direct remotely (e.g. a swarm of thousands of micro-drones). (3). Political security. The use of AI to automate tasks involved in surveillance (e.g. analyzing mass-collected data), persuasion (e.g. creating targeted propaganda), and deception (e.g. manipulating videos) may expand threats associated with privacy invasion and social manipulation. Planning for this level of security is a challenge.

5.0 Recommendations

The promise of AI in SCM is only achievable when organizations plan for, and overcome these and other challenges discussed in this paper. Organizations can do much to ensure that the promise of AI is realized, and we offer some guidelines next.

5.1.Build a business case for AI

It is easier to get stakeholder support when a clear business case can be made for AI integration into SCM. According to a recent Gartner survey, 37% of organizations are still looking to define their AI strategies, while 35% are struggling to identify suitable use cases. Building a business case requires an analysis of the expected benefits and costs associated with a project. The problem of AI is this may not be as easy as AI projects can appear costly without any immediate gains — particularly for loosely bound scenarios and in organizations that are not used to setting aside budget to develop and deploy solutions for new business scenarios (Pettey, 2018). Pettey (2018) observes that making a business case for AI is difficult because there is no such thing as an AI business case. Instead, the business case will be for a particular business scenario, problem or use that employs AI methods and techniques as part of the overall solution. Pettey (2018) suggests that focusing on four questions will help define an AI project. These are (1) why are you doing this project? (2) For whom are you trying to deliver this solution? (3).What solution and technology framework will you employ and (4) how will you deliver this project? Moutusi Sau, principal research analyst at Gartner (https://www.gartner.com) notes that business cases for AI projects are complex to develop as the costs and benefits are harder to predict than for most other IT projects because there are additional layers of complexity, opaqueness and unpredictability that are not found in other standard technology. Be as it may, demonstrating value for the organization from AI integration is a precondition for building legitimacy and support for it.

5.2 Adopt a gradual approach to AI

Despite high levels of interest in AI technologies, current implementation remain at quite low levels. However, there is potential for strong growth as organizations begin piloting AI programs through a combination of buy, build and outsource efforts. The Gartner Group (Pettey, 2018b) makes four suggestions regarding the implementation of AI in organizations. First, it is important to aim low with AI adoption. Starting with a narrow project scope and purposes that are limited to improvements in areas of low-hanging fruit such as improving customer experience or enhancing a process may be preferable to a headlong plunge into AI integration. Setting low targets and aiming for soft outcomes will allow the organization to learn without betting everything. Second, AI should initially focus on augmenting not replace people, and used to help employees create higher value. Third, firms should plan for knowledge transfer. It will be prudent to grow in-house capabilities by planning to transfer knowledge and skills from external vendors. Finally, managers must be able to explain in simple terms how decisions and solutions are reached in AI by choosing transparent AI solutions.

5.3 Develop and implement a plan for AI integration

Organizations need to have a plan in place for integrating AI into their supply chains. AI can be used at several stages of the supply chain to create value. However, AI is costly and as mentioned elsewhere, making a case for it is important. Besides that, firms need a strategy for implementing AI or any new technology as firms often struggle with integrating new technology. Merely pitching the superiority of AI over existing technologies may not be enough to assure that managers and employees will readily accept the technology. Therefore, firms need to develop a strategy for implementing AI into their supply chains and they can do this in several ways.

First, it is important to decide how to acquire AI technology. The range of options includes building an in-house AI capability, outsourcing these capabilities, or leveraging AI-as-a-service offering from vendors (Chui et al. 2018). Stock and Tatikonda (2004) identify technological uncertainty, the lack of knowledge on how to acquire and implement new technology as one of the key factors influencing the technology integration process. According to the authors, the novelty of the technology to the recipient firm, the level of complexity in the technology and the tacitness of the technology and the degree to which it is physically embodied, codified and complete are what determines technological uncertainty. AI ranks high on all the three dimensions and therefore makes its integration more challenging. When an organization acquires the technology from outside, it must deal with managing the client-source relationship. It is important to build a collaborative relationship between the source and the client and frequent communication with the source from which it acquires the technology is important. The coordination of the processes of interaction as well as the willingness of the partners to cooperate are important to having a successful integration of new technology. Experience helps integration and firms who have had some experience in the past introducing new technology will have an easier time integrating AI into their supply chains (Stock and Tatikonda, 2004).

Second, firms need to determine the specific areas within the SCM function where AI application would be most beneficial. Chui et al. (2018) observe that SCM and related areas of retail and logistics stand out as the most important areas that will benefit from the application of AI. In consumer goods, supply-chain management is the key function that could benefit from AI deployment. Organizations need to determine the purposes for which they are acquiring the AI technology and end users of the AI technology should be able to see what problems the new technology can solve. Appointing an implementation team of managers would help the process.

One of the most important jobs for the implementation managers is to ensure that there is close cooperation between those who develop the AI technology and those who will be using it in the organization. According to Leonard-Barton and Kraus (1985) implementation managers should seek user involvement in the: (1) early identification and enhancement of the fit between a product and user needs, (2) preparation of the user organization to receive the innovation, and (3) shifting of "ownership" of the innovation to users. Prospective users should try out the technology early and organizations should not underestimate the scope and importance of preparations that would be necessary for AI integration.

Third, top management commitment and support to the new technology must be consistent. It is the job of top management to ensure that there is championing for the idea. There are those who will sit on the fence, be neutral to the new technology when it comes to supporting its implementation, what Leonard-Burton and Karus (1985) call "hedgers." These people are essentially opportunistic actors, taking credit when the new technology succeeds, and avoiding blame when it fails. According to the authors, sending signs of support from top management, making clear what the criteria is for judging the success or failure of the new technology, and demonstrating top management support for the new technology can reduce instances of hedging.

Finally, it is important to have a governance mechanism for data security to reduce malicious use of AI and cyber-attacks. While governments and policy makers have a big role in planning for cybersecurity, organizations for their part, can do some basic things to decrease the possibilities of malicious attacks on their AI systems. Prabuh (2018) proposed some useful guidelines that firms can use to guard against malicious attacks on their AI systems. First, organizations need make data security a top priority by ensuring that all team members/stakeholders have a basic understanding of security and privacy—things like data classification, data protection techniques,

authentication/authorization, privacy principles, applicable regulatory requirements, etc. must be well understood by all stakeholders. This is important because data and data management are at the heart of AI use in SCM. Ensuring that everyone uses the same terminology and understands the policy and standards would help. Having a good data governance structure in place that covers such issues as ownership and accountability should be helpful as data changes hands at different stages of each workflow. This is particularly important given the wide circulation of data required in machine learning and AI projects (Prahbu, 2018). Second, designing and activating diligent threat modeling of solutions—both at component level and from an end-to-end perspective will be helpful. This will ensure that security is 'built in' into the design and that applicable security requirements are met at every point in the end-to-end system. Organizations must ensure that all threats/risks identified during threat modeling and considered important enough to address are actually fixed by performing a combination of feature security testing and penetration assessments. Exercising good monitoring and security hygiene is important. Making sure all software components are at their latest security patch level, conducting periodic access reviews are all important parts of data security. Lastly, organizations must have a good incident response plan in place so they can deal with a calamity if one does happen.

5.4 Champions and Cheerleaders for AI integration

Organizations integrating AI should anticipate resistance and plan for it by finding a champion for the idea. In a 1963 article, Schon described his experience battling organizational inertia and resistance to new ideas and technology, stating, "the idea either finds a champion or dies" (Schon 1963, p. 84). That challenge may be as relevant now as it was then. A champion is an individual who "recognizes a new technology or market opportunity as having significant potential; adopts a project as his or her own; commits personally to the project; generates support from other people

in the organization; and advocates vigorously for the project." Field and case studies of innovation highlight that individuals who informally emerge to promote innovations through the crucial organizational stages, are pivotal to the successful implementation of an innovation (Howell & Shea, 2001). Burgelman (1983, p. 238) reported that champions articulated a convincing master strategy for the idea and initially mobilized resources covertly by "acting as scavengers, reaching for hidden or forgotten resources to demonstrate feasibility and then, more overtly, by establishing and maintaining contact with top management, to keep them informed and enthusiastic about the project." Galbraith (1982) noted that champions engage in coalition building to secure organizational support for the innovation. In their study of champions' personality characteristics, influence tactics, and leadership behaviors, Howell and Higgins (1990) reported that champions could be distinguished from non-champions by communicating a clear vision of what the innovation could be or do, displaying enthusiasm about the innovation, demonstrating commitment to it, and involving others in supporting it. Leonard-Barton and Kraus (1985) recommend that for a new technology implementation to succeed, the implementation team must include the following: (1) A sponsor, usually a fairly high-level person who makes sure that the project receives financial and manpower resources and who is wise about the politics of the organization; (2) a champion, who is salesperson, diplomat, and problem solver for the innovation; (3) a project manager, who oversees administrative details; and (4) an integrator, who manages conflicting priorities and molds the group through communication skills. Finding champions for AI integration is an important maw for securing legitimacy and resources for the initiative.

5.5. Integrate people and technology

Whether AI and humans can co-exist is already a subject of considerable debate. However, we have shown that both AI and people are not mutually exclusive, but rather, AI can augment what

people do and improve SCM and efficiency. For example, Siri and Alexa have become intelligent digital assistants. Still, there are skeptics and so it is important to assure employees that both the technology and people are not mutually exclusive, but rather complement each other. The fact may be that while AI capabilities are growing rapidly, they still cannot accurately imitate humans. As machine learning helps to increase the system's intelligence, humans can ensure that the technology is used in the correct way and effort made to integrate AI into human performance. Pettey (2018) suggests that organizations using AI should focus on worker augmentation, not worker replacement even though AI's potential to reduce staff head count attracts the attention of senior business executives as a potential cost-saving initiative. A more informed expectation the author notes, however, would be for applications that help and improve human endeavors, as AI promises benefits far beyond automation and organizations that embrace this perspective are more likely to find workers eager to embrace AI.

Organizations using AI should aim for optimizing people and technology, and this issue has been extensively studied by work pioneered at the Tavistock Institute, and subsequent research, under the general rubric of socio-technical systems (Emery et al. 1960). Sociotechnical systems (STS) in organizational development is an approach to complex organizational work design that recognizes the interaction between people and technology in workplaces. Socio-technical theory therefore is about joint optimization, with a shared emphasis on achievement of both excellence in technical performance and quality in people's work lives (Wikipedia.com). Socio-technical systems design (STSD) methods are an approach to design that consider human, social and organizational factors, as well as technical factors in the design of organizational systems. A socio-technical systems approach to managing AI integration should force organizations to focus on both the technology and the user side of the equation. The outcome of

applying these methods is a better understanding of how human, social and organizational factors affect the ways that work is done and technical systems, including AI are used (Baxter and Sommerville, 2011).

6.0 Conclusions

Supply chains face a lot of turbulence (Sheffi, 2007) and organizations can use AI to develop the robustness and resiliency needed to overcome the vulnerabilities and risks associated with supply chains. We have shown in this paper that AI has potential in several areas of SCM. In fact, AI can help organizations create smart supply chains (Wu et al. 2015). AI applications across the supply chain can create new business value in the form of operational efficiencies, cost savings, and increased customer loyalty. Besides its planning and prediction capabilities, AI may allow supply chain actors to react much more quickly to disruptions than ever before. For example, AI empowered Airbus to solve a business problem more quickly and efficiently than prior approaches (such as root-cause analysis based on manual analysis of hundreds or thousands of cases). It is reported that when Airbus started to ramp up production of its new A350 aircraft, the company faced a multibillion-euro challenge. In the words of Matthew Evans, Vice President of digital transformation at the Toulouse, France-based Company, "Our plan was to increase the production rate of that aircraft faster than ever before. To do that, we needed to address issues like responding quickly to disruptions in the factory. Because they will happen." Airbus turned to artificial intelligence. It combined data from past production programs, continuing input from the A350 program, fuzzy matching, and a self-learning algorithm to identify patterns in production problems. In some areas, the system matches about 70% of the production disruptions to solutions used previously— in real time. Evans describes how AI enables the entire Airbus production line

to learn quickly and meet its business challenge (Ransbotham, Kiron, Gerbert and Reeves, 2017). US Industry giants such as Amazon, Facebook, and Netflix, Chinese giants Baidu and Tencent, and Airbus in Europe have all created important economic value with AI and the promise of AI for SCM is not in doubt. Navigating the key challenges discussed and the use of the guidelines point to the sort of things organizations can do to ensure that on balance, the benefits of adopting AI outweigh the possible dysfunctions. As Marr (2017) observes, big data-driven analysis such as machine learning will increasingly play a prominent role in supply chain optimization. While the present beneficiaries tend to be big, national and international networks due to the need for large volumes of up-to-the-minute data and the associated cost and complexity of pulling it all together, the possibilities of developing "as-a-service" and out-of-the-box analytical platforms, combined with new markets for purchasing external data, will open AI up to smaller scale operations.

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