BIG DATA AND SUPPLY CHAIN MANAGEMENT:

APPROACHES TO IMPLEMENTATION

Approved: Mary R. Bartling Date: 5/10/19

Professor Mary Bartling

Seminar Paper Advisor

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Jane J. Yune

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Jane J. Yune

Under the Supervision of Professor Mary Bartling

Statement of the Problem

The application of Big Data technology to supply chain has the potential to offer a competitive advantage to firms of all sizes and industries. While there is plenty of research on Big Data as a category, its application within the context of supply chain is scarce. As a result, it is difficult for supply chain professionals to understand the potential benefits of the technology.

Furthermore, challenges that surround Big Data integration within a supply chain create apprehension from professionals attempting to adopt. These include concerns over data quality, a lack of vision at the executive level, and a talent pipeline lacking experience in Big Data.

The purpose of this analysis is to demystify the concept of Big Data within supply chain by consolidating numerous voices into a blueprint that can be used as a jumping off point. Within this work, various implementation pathways are analyzed for commonalties and themes that have led to successful adoption of Big Data within supply chain.

Methods and Procedures

Various works on the topic were obtained from academic and industry publications in order to review the various strategies used to implement Big Data within a supply chain. The research methodologies used in the literature ranged from multistage academic studies with interviews, surveys, and case studies, to first-hand experiences and observational reports. The information gathered was analyzed and compared to identify commonalities and themes that have led to successful implementation and adoption.

Summary of Results

Supply chain professionals and business leaders should create a plan that is unique to their organization and take a step-by-step approach to Big Data implementation. First, consolidate the data to assess the current state within the supply chain organization. This step is critical to managing expectations and helping create a vision of the future. Second, create an implementation strategy that aligns with the values of the business and resonates with the executive leadership team. Next, start small with a pilot program that can tackle the low hanging fruit. The goal is to gain momentum with quick, visible results and win the support of internal champions. Finally, harness the momentum from the quick data wins and deploy advanced analytics that can address more complex challenges. Remember, implementing Big Data within a supply chain is a marathon not a sprint – take incremental steps and commit to a continuous improvement process.

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Introduction

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In the era of the Internet of Things, data capture has become easier and more efficient with advances in Big Data technologies. Improvements in data storage, processing, modeling, visualization, analytics, and algorithms have allowed companies to make better decisions by making use of enormous amounts of information digitally collected from their customers, suppliers, and operations. The global Big Data market was estimated to be worth $100 billion in 2010 with 10% growth per year (Weng and Weng, 2013). The demand for all things Big Data has been fueled by success stories of companies such as Walmart, Amazon, and UPS that have been able to link their supply chains to analytic applications. Walmart is known to collect more than 1 million customer data transactions per hour, contributing to its 2.5 petabytes database ("Data, data everywhere", 2010), and through use of data analytics has uncovered fascinating information on customer behaviors and preferences (Sanders, 2016). Learning more about its customers through data collection and processing provided Walmart the ability to make decisions on where, and when to stock which products by working with its suppliers and coordinating supporting activities along its supply chain. The company used the quantifiable behavior of its customers to leverage better pricing and distribution from its more than 17,400 suppliers among 80 countries (Sanders, 2016).

There are many potential opportunities on the topic of Big Data. They are fueled by technological advances such as increased supply chain data, decreased storage cost, enhanced processing power, optimized mobile data connection, improved data analysis tools, and advanced visualization techniques and tools to tell a visual story (Deloitte & MHI, 2014; Zhong et al., 2016). Such enhancements to Big Data have opened the door to many possible opportunities in

all parts of the supply chain function. For example, procurement can benefit from Big Data which can act as enablers that improve the buying process by arming buyers with added insights that can be used to negotiate with contract manufacturers, as well as increasing the accuracy of future demand. One opportunity in inventory management is that Big Data can facilitate more accurate inventory levels by providing real time capacity levels and giving faster response. There are opportunities in optimization of logistics activities that provide positive outcomes through cost reduction, supply chain performance, and increased customer satisfaction and retention (Russo, 2015). To put it simply, the opportunities apply to all that is relevant to supply chain management. "A supply chain digital transformation, then, is about establishing a vision for how digital applications can improve service, cost, agility, and inventory levels while implementing process and organizational changes to drive operational excellence" (Gezgin, Huang, Samal, & Silva, 2017, p. 3).

The problem supply chain management face is that while industry giants like Walmart, Amazon, and UPS set a high standard and tell a compelling story for Big Data utilization, there is a general lack of penetration across all business sectors. Gezgin et al. concluded that the average supply chain has the lowest digitization level out of five business areas that they reviewed, even though aggressive digitization can boost annual growth of earnings and revenue (2017). The lag in Big Data adoption is not just reserved for supply chain. While business intelligence penetration rates are on the rise for companies in general, rates of adoption are suppressed in low- to medium-sized companies compared to their larger counterparts (Columbus, 2017). This helps explain the low level of Big Data penetration in supply chains. The sluggish rate at which supply chain management has embraced data transformation is represented in the availability of research on the topic. There is a genuine lack of empirical research on the benefits

of Big Data on supply chains (Kache & Seuring, 2017; Waller & Fawcett, 2013; Russo, Confente, & Borghesi, 2015) and "limited knowledge and data statistics" on this topic (Zhong et al., 2016, p. 585). In an in-depth analysis of the role of Big Data analytics in supply chain management since 2010, the topic of Big Data in supply chain management begins to appear in research and industry literature starting in 2012 (Tiwari, Wee, & Daryanto, 2018). Since then, a significant improvement has been seen in the volume of research materials on the convergence of the Big Data and supply chain management starting in 2015 (Tiwari et al., 2018).

The challenges to successfully integrating Big Data may shed light on the apparent apprehension. While the prognosis of Big Data is excellent, data collection methods, transmission, storage, processing technologies, decision-making models, and interpretation and application are riddled with challenges (Zhong et al., 2016). Businesses report shared difficulties that overlap corporate and supply chain levels in the areas of integration and collaboration, IT capabilities and infrastructure, and information and cyber security (Kache & Seuring, 2015). One of the biggest sources of uneasiness is around the quality of data input and output. As the adage "garbage in, garbage out" highlights, the output of any analysis is only as good as the quality of the data available. The Dresner Advisory Service's 2018 Wisdom of Crowds ® Business Intelligence Market Study reported that most companies have great concerns over input data quality and decision-making outputs from poor-quality data (Columbus, 2018). A 2011 survey of procurement professionals reported that although 95% said data quality was crucial to achieving the procurement objectives, 50% felt their data was of low quality or they could not measure its standards. The same survey found that data problems hinder 37% of procurement professionals from realizing the savings and efficiencies that spend management can deliver (Zoetmulder, 2014). The quandary of wanting to use high quality data to support supply chain

goals but being encumbered by questions surrounding the quality of data available is troubling for supply chain management professionals and business leaders alike.

Another challenge centers on leadership and people. The lack of executive support to initiate and champion data transformation in supply chains is reflected in the level of senior leadership roles responsible for data analysis across industries. Fewer than 15% of the respondent organizations in the Dresner Market Study have a Chief Data Officer, and only about 10% have a Chief Analytics Officer (Columbus, 2018). Effective use of huge amounts of data is viewed as a high priority for most companies, but the actual importance placed on data is low based on the number of companies that have data or analytics officers. The low level of Big Data representation in the C-suite makes it difficult for all business areas in a company to gain support and pursue the transformative potential of Big Data, particularly for supply chain organizations that have the lowest digitization level. Equally troubling is the shortage of data savvy professionals equipped to fill the current void and meet that of future demand. In 2011, McKinsey Global Institute claimed a shortage of 140,000 to 150,000 workers, and approximately 1.5 million managers and analysts to analyze and take action on data outputs (Manyika et al., 2011). The shortage of data literate professionals of all backgrounds and the demand it created to educate and deploy a new wave of workforce equipped to manage, interpret, and act strategically can be seen in social media advertisements such as LinkedIn and Facebook. The marketing is geared toward post-secondary learners and highlights a distance learning method that can be completed in a short amount of time, that is focused on data management and analytics.

Supply chains comprise a system of linked parts can benefit from efficient uses of large amounts of data generated by the network. In order for Big Data to serve the interconnectedness

of supply chains efficiently, application development should connect the entire chain, implementation should be done systematically, and the entire chain should access and utilize the same Big Data technologies to avoid fragmented implementation and use (Sanders, 2016; Gezgin et al., 2017). Large amounts of analyzed data should flow back-and-forth quickly and efficiently in a coordinated manner, visible to all employees that can stand to benefit from added insights - from raw material producers all the way to sales associates on the floor. The result is an improvement in customer service, product cost, distribution speed, and sales. Compared to other parts of a business that can focus Big Data initiatives to their single functional area, supply chains have an added challenge of integrating systems of all nodes to allow for information to travel freely and to be used in a variety of ways. There is a great deal of coordination and collaboration required to implement Big Data initiatives in supply chains in a manner that capitalizes on their benefits. Organizations can address these challenges by carefully considering variables specific to their firm prior to initiating Big Data integration projects into their supply chains and creating a long-term goal to realize the full potential of Big Data.

Purpose of the Research

The primary purpose of this research is to inform supply chain management and business professionals of multi-dimensional and non-technical elements that should be considered when implementing Big Data into their supply chain organization. Supply Chain professionals should consider the following questions:

- What are some approaches for capturing the transformative potential of Big Data specifically for supply chain management?
- How should they plan for Big Data as a marathon, not a sprint?

- How should supply chain management approach implementation of Big Data to maximize the opportunities and overcome the known challenges?

Through answering these questions, the secondary purpose of this research is to influence supply chain professionals to consider Big Data by sparking interest on the subject and providing an identifiable plan that may work for their organization. The aim is to examine the recommended pathways for using Big Data in the supply chain by exploring and comparing frameworks, plans, perspectives, priorities, and shared opportunities and challenges between stakeholders.

Significance and Implications

The significance of this research lies in consolidating many different voices that prescribe a data transformation plan to discover commonalities and themes. Academic and management literature will be reviewed to highlight supply chain topics that will aid in Big Data planning, implementation, and acceptance. This research will attempt to develop a data transformation approach that is general, yet multi-faceted and well-rounded, and that can be considered when adopting Big Data initiatives in the context of supply chain. This research will contribute to the ongoing discovery of the potential impact of Big Data to supply chains – and will hopefully act as a catalyst to nudge the reader into considering data transformation within their organization.

The implication of this research is that Big Data has and will transform the global economy. Therefore, supply chain and corporate leaders should take steps in the same direction by creating and executing an implementation roadmap that is unique to the organizations and attempts to capture the potential opportunities of Big Data. The rate at which a large quantity of data are generated, or the demand for decision-making from quick and accurate interpretation of them, will continue to grow. In recent years, a wide interest and an expanded use of Big Data

created a high demand for cost-effective technologies that companies can plug and play with ease. The business intelligence boom of the current decade has put advanced data visualization and analysis tools within reach of most organizations (Carey, McCauley, & Clark, 2018) and this trend will continue to grow. Gartner (2017) forecasted that the global business intelligence (BI) and analytics software market could further grow to $22.8 billion by 2022. This implies that the supply chain of most companies will be impacted by increased demands from customers who now expect the same seamless performance they have grown accustomed to from industry giants that have masterfully applied BI and benefitted with a tremendous success. Supply chains should be brought up to speed on processing and using enormous amounts of data to keep up with other business areas. It is a critical component of harnessing the transformative potential of Big Data for the entire business organization.

Methodology

The methodology for this research consisted of desk-based study using various types of literatures, including scientific papers, scholarly journal articles, industry articles, magazines, and conference publications. Information specific to the impact of Big Data in supply chain management was obtained from academic research and conference publications published in 2010 or later to present timely materials. Further information and statistics were obtained from articles published in industrial journals such as *Computers & Industrial Engineering, International Journal of Production Research, and Journal of Transport and Supply Chain Management*. It is important to note that many scholars agree there is a lack of empirical research on the use of Big Data in SCM (Sanders, 2016; Kache & Seuring, 2015; Waller & Fawcett, 2013; Russo, Confente & Borghesi, 2015). Therefore, this research was supplemented

by other literature and research retrieved from business reports from data analytics marketers, management consulting firms' publications, and business management journals.

Assumptions

The research materials cited in this paper are assumed to share the common definitions for the following words as subjectively defined by data technology and solutions industries and leading researchers:

- Big Data is generally known as "a very large volume of data, both with or without structure" ("Big Data. What is it and why it matters"), that the traditional data processing software cannot manage (Manyika et al., 2011).
- Supply chain analytics are technology tools and techniques that capture and use data from a variety of internal and external sources to produce valuable insights that can help supply chains increase operational agility and service quality while decreasing costs and risks (Deloitte & MHI, 2014).
- Business intelligence (BI) "leverages software and services to transform data into actionable intelligence that informs an organization's strategic and tactical business decisions" (Pratt, 2017).

The author assumes that the readers of this research paper have a working knowledge of supply chain management, and a general understanding of Big Data and related technologies. Therefore, definitions to industry specific words have not been defined unless the author felt that it was necessary to clarify the context. It was also assumed that words such as Big Data, Big Data analytics, and business intelligence found in the author's research material can be used interchangeably to answer the question posed in the Purpose of the Research statement. These and other related terms had specific purposes in the literature used as research materials for this

paper, but the use of these terms to discuss Big Data in each source was similar as they were presented under the theme of Big Data.

Delimitations of the Research

The author chose the topic of research to uncover useful approaches and considerations to take when implementing Big Data initiatives in the context of supply chains. The subject of Big Data, particularly its opportunities and challenges, has become ubiquitous in management and industry journals yet research on Big Data in supply chains is scarce. Because of limited coverage on the subject, there is an even bigger deficiency in the research on what should be considered and addressed during the strategy building part of the Big Data journey. The aim of this paper is to provide a contribution to the industrial and academic conversations on the subject of Big Data in supply chains by informing the readers of another dimension of the topic that is qualitative in nature. Whereas observational writings and pieces regarding Big Data are abundant, those that were not specific to supply chain were not chosen because of interest and relevance to the study at hand.

The research is limited to frameworks, plans, perspectives, shared opportunities and challenges between stakeholders, and priorities of implementing Big Data analysis in the supply chain. Big Data technologies and services will be mentioned as part of the discussion within the context of aforementioned delimitations. The focus of this research on Big Data will be limited to elements applicable to supply chains, leaving out specifics of choosing which technology to hire versus outsource. There are many pieces written by marketers of tools that speak only to the technology side of Big Data implementation. These works are left out of this discussion as the technical implementation of Big Data requires considerable knowledge and know-how best left to IT professionals.

Literature Review

To achieve a successful integration of Big Data in supply chain, the digital transformation plan should include many steps that are typical of system implementation – setting goals, assessing the current situation, and laying out a plan. While reviewing differing strategies for approaching digital transformation, one thing became clear: to successfully implement Big Data in supply chain, one must have an approach clearly defined from the beginning. The approaches found in literature are organized and arranged to address competing needs within and among functional areas of the supply chain. The long-term goal of fully maximizing the power of Big Data in supply chain management can be initiated through a careful selection and successful execution of high impact, easy to implement projects, supported by a commitment to continuous improvement to further develop capabilities. Supply chains can maximize the transformative potential of Big Data by fully learning and understanding from theoretical and practical perspectives.

It appears that the best practices of Big Data implementation in supply chain are as unique as the supply chain's connected network of several functional nodes. Unlike typical technology implementations that end with a go-live and a sign-off, Big Data implementation along the supply chain and technology capability build are done incrementally with a vision in mind. In a multistage academic study consisting of exploratory interviews, surveys, and case studies of leading companies, Sanders (2016) discussed the common barriers and characteristics of successful Big Data analytics implementation in supply chains. The author observes that the companies that achieved the transformational potential of Big Data in the realm of supply chain management had three things in common in their approaches. First, the companies defined competitive priorities and operational requirements in each segment of the supply chain to

identify different objectives to support. Second, Big Data applications were integrated horizontally among all internal and external supply chain functions to share intelligence efficiently and to avoid fragmentation. Finally, performances were rigorously measured and driven by strategically developed metrics and the feedback loops were monitored to identify areas to make incremental improvements in a continuous fashion.

Sanders (2016) emphasized that technology and Big Data analytics should be thought of as tools in achieving competitive advantage through Big Data adoption. Selection of analytics applications should follow and support decisions at each step of the implementation. To build technological capability, Sanders (2016) discussed a process of maturation in four stages. The first stage involves structuring data by scrubbing and organizing it to ensure quality. The second stage is making data available to everyone when they need it. The next stage is using standardized and basic descriptive analytics to interpret the data. The final stage of maturity is applying advanced analytics to generate radical new business insight. The author suggested that experimenting with Big Data in small projects in a few high potential pilots is an important lesson in digital transformation and execution (Sanders, 2016). This enables learning, creates value, allows a secure IT infrastructure to be built concurrently (Sanders, 2016), and allows for staged implementation. Combining the pilot projects with the four stages to maturation can fully leverage the power of Big Data to supply chains. Progressing through the maturity map in stages can afford cohesive implementation among many functional areas of supply chain, thus ensuring more fluid transfer and analysis of data by using a common tool and data set shared along the chain.

Industry practitioners have different perspectives than the academic researchers on how to approach Big Data implementation in supply chain due to different motivating factors behind

their research. Choosing the correct technology and managing the updates to operations take priority for industrial practitioners. In contrast, academic researchers generally focus on moving through Big Data adoption phases and reviewing differing priorities of many functional areas of the supply chain. The industry practitioners seem to focus on topics that can deliver value-added services in technology implementation, such as developing a talent strategy and organizational restructuring plan to support the big shift to capturing Big Data's potentials.

In research that draws from the experiences providing supply chain solution consulting services, Gezgin et al. (2017) of the Boston Consulting Group asserted that the correct approach to digitizing a supply chain is to select the right leading-edge technologies and to revamp operations at the same time. The aim of research conducted by Gezgin et al. was to present a framework for supply chain digital transformation that outlines three distinct steps, while addressing the need for collaborative and coordinated work among functions with different performance objectives. The three steps are to plan an effective digital transformation based on a vision for the future state of supply chain, assess the current performance state, and develop a transformation road map that looks to the future. There is no "one size fits all" approach that would work for every company, and the authors encourage the reader to think whether the operations and technology solutions are integrated sufficiently at each step (Gezgin et al., 2017). The three steps will need to be pitched against specific internal and external pressures, trends, and goals to be refined further to fit the requirements of an individual organization.

Gezgin et al. (2017) also emphasized that a plan that develops a talent strategy and establishes an organizational structure that fosters innovation and continuous improvement, should be included in the ongoing operational capability development part of the data transformation process. A quick launch to digital transformation can be established through

capturing the low-hanging fruit – an opportunity high in value and easy to implement – by employing one of the latest off-the shelf technologies that are uncomplicated to integrate with existing ERPs. Gezgin et al. (2017) pointed out that the approaches to digital transformation discussed in their research can evolve as the potential areas of change are organized into a long-term road map. However, the importance of early wins is emphasized as they can positively affect the improvements to supply chain operations and set the stage for future digital transformation activities in the pipeline. It appears that the approaches to capture the transformational potential of Big Data are logically placed in order. So far, they are described in terms of a beginning, a middle, and an end. Or, another way to interpret the stages is good, better, and best. Regardless of how the implementation approaches are described, the steps need to be taken in order (Sanders, 2016; Gezgin et al., 2017).

A research that that extols the virtues of step-by-step approach is provided by Ganeriwalla et al. (2016). Through observations made from working on supply chain digital transformation with dozens of companies, Ganeriwalla et al. (2016) have found that leading companies applied three strategies to achieve digital supply chain technologies success. First, a company must fix performance gaps by using digital technologies to remedy straightforward problems in supply chain that are too big to be solved by existing approaches. Second, they should innovate their business process by using digital supply chain technologies to solve more complex problems. Third, the company can strive to disrupt their supply chain by using technologies to grow their revenue and margins. This is done by redeveloping operating models and go-to-market approaches.

The authors prescribed a step-by-step approach to put the strategies into practice (Ganeriwalla et al., 2016). Supply chain practitioners should actively immerse themselves in the digital supply chain management landscape to collect innovative ideas and envision opportunities. Then they should prioritize digital application that can provide the most value for the business and shrink the performance gaps. Finally, deploy pilot programs in high-priority areas to execute and to learn from lessons gained from the pilot before implementing a full-scale rollout throughout the supply chain organization to each functional area. The step-by-step approach is designed to provide a solid foundation to Big Data success in supply chain by actively engaging the participants, selectively applying digital transformation to areas in supply chain that show immediate improvements, and carefully scaling up the implementation activities to impact the entire supply chain organization.

It is agreed that the fragmented application of Big Data in the supply chain is considered to be a shortsighted use of the potential transformative power of data (Sanders, 2016; Gezgin et al., 2017). Therefore, the implementation of Big Data in supply chains should take into account the objectives of all functional areas being integrated, including unique challenges and opportunities in Big Data specific to each area. Most literature on the implementation strategies of Big Data in supply chains are written in general terms that are appropriate for use across the entire supply chain system. However, some literature provides Big Data applications specifically geared to procurement, which may have tremendous potential for growth within a digital transformation.

Through their work as industry practitioners, Spiller, Reinecke, Ungerman, and Teixeira (2014) found that procurement organizations have to expand technological capabilities in many areas of supply chain to harness the opportunities of Big Data. It is up to leadership of the Chief

Procurement Office to define an agenda for capturing value from Big Data by assessing where the greatest value can be discovered, both in the near future and as a long-term plan. The authors prescribed a two-phase approach to capturing the transformative potential of Big Data in procurement. First, lay down a foundation by developing an analytical talent pipeline, then building on the foundation by sourcing or developing technical solutions to analyze Big Data. Second, analytics experts can gain credibility by sharing the insights generated from Big Data analysis, initiating a pilot program and learning lessons to promote future experiments, and creating value by expanding the pilot program. Prior to launching the two-phase approach to Big Data in procurement, it is imperative to develop a baseline by making the organization's spend data as transparent as possible, build management systems, and establish meaningful KPIs. Therefore, Big Data implementation in supply chain management should be far reaching, mandated by the top leader, and carried out in phases to establish a solid foundation to set the stage thoroughly.

The McKinsey insiders (Spiller et al., 2014) pointed out that it is essential to recognize that expanding capabilities to harness the Big Data transformation involves folding in many elements. One element is the challenge of securing participation of many different stakeholders (talent acquisition, IT, legal, suppliers, various supply chain functional areas etc.) to come up with competing goals to reconcile. Another element is the hurdle of proving the value of Big Data through showcasing easy and early wins to demonstrate possibilities. Big Data approaches should include other elements such as the acquisition of additional tools and processes during scale up, the assessment on performance to make improvements, and the analysis of the quality of insights generated. Though the authors presented their approach in the procurement context,

the two-phase approach and the need to balance soft skills and management skills with technical and procurement knowledge have a wider application to other parts of the supply chain.

Note that not all research that discussed the procurement function of supply chain in the Big Data implementation context shared the general approach. Zoetmulder (2014) outlined the implication of Big Data on the procurement node of the supply chain. The author revealed that the use of Big Data technologies has a "transformational quality to turn spending into savings" (p. 8) and emphasized that the value of good data is critical in procurement. He asserted that the key to realizing the full potential of Big Data in procurement is to continuously improve data quality. The solutions to getting good data are centered on functionalities of spend management technologies. Zoetmulder argued that the way to better data is through sequential undertaking of three solutions: improved management of supplier data, enhanced online shopping experience for procurement professionals, and standardization of multi-source data through data analytics solutions. Even though the approach is specific to procurement and a particular type of application, the approach of improving data quality as a way to capture the transformative potential of Big Data can be applied to other areas of the supply chain.

Although Spiller et al. (2014) and Zoetmulder (2014) presented Big Data implications and approaches specific to procurement, the prescribed ways to harness the opportunities of Big Data can be applied to other parts of the supply chain. Zoetmulder (2014) advised the use of specific functionalities of a procurement management tool as a way to get clean, organized, and pertinent data. Whereas, Spiller et al. (2014) focused on elements related to change management in Big Data adoption.

There are limited resources available outside the arena of management consulting service that discuss the specifics of approaching Big Data implementation in the supply chain context.

Through an overview of new technological developments that allow companies to make decisions based on data-driven insights, Ittman (2015) discussed Big Data in terms of data analytics and supply chain. The real-life analytics initiatives executed provide examples of application of Big Data tools and the results of various approaches employed. The range of problems to be solved in supply chains are vast, often interconnected with other parts of the supply chain, and require analytical tools that can provide prescriptive and predictive analytics. Ittman (2015) argued that realizing the value in what Big Data and advanced analytics can do and developing strategies to optimize many areas of the supply chain were key factors to successful application of Big Data in the supply chain. Thus, recognizing the opportunities in Big Data and creating an implementation strategy that is inclusive of joining many parts of the supply chain appear to be a part of the recommended approach.

Future studies that compare and contrast approaches between academic researchers and industry practitioners will add to the ongoing discovery of the impact of digital transformation in supply chain context. This may reveal that the two groups use distinctive tones to present what they believe to be the best path to Big Data success. Although limited research on the intersection of Big Data and supply chain management has started to change in the recent years (Tiwari et al., 2018), researchers lament that "the content is repetitive and rigorous scientific investigations into the topic have been absent" (Schoenherr & Speier-Pero, 2015). There is a scarcity of research on actual implementation approaches used and on data captured on efficiencies achieved from the Big Data adoption. Additional research comparing the implementation approaches to determine how to produce the fastest implementation, the biggest and the quickest ROI payoff, and the deepest level of integration among the supply chain functions will contribute greatly to the discussion.

A common approach to capturing the transformative potential of Big Data in supply chain management appears to be a combination that joins a long-term strategy based on a vision of the future with high-impact pilot projects to demonstrate the value of using large amounts of data collected. This balances out the need to concurrently build credibility to win the support for data transformation and sustain the initiative long enough to carry out the implementation in an orderly fashion that fosters development of complementary activities, such as IT infrastructure build-up and data management process plans. Although supply chain professionals have to rely on the expertise of IT professionals on the specifics of configuration and integration of the technologies, they should be knowledgeable about tools that can drive the supply chain. The knowledge about the technologies available can help initiate and engage in conversations with cross-functional teams to implement data technologies in the supply chain.

It is not enough to just plan and execute the data technologies to use the massive amounts of data that flow in and out of supply chain. Meeting challenges posed by Big Data with a strategy can increase the chances of maximizing the known opportunities. Plans to manage complementary elements, such as marrying technical capabilities with supply chain knowledge, overhauling operations to support the digital transformation, and changing the organizational structure that places importance on data, can yield a successful outcome. The generalness in which the approaches have been discussed have a wide application across supply chain. However, when strategizing data transformation specific to each functional area, it is worthwhile to seek out and test approaches that take specific objectives and challenges of each supply chain node into account to develop a plan of attack that is directly applicable. The complex nature of Big Data transformation in supply chain is a big challenge but the journey can be started with small wins to garner attention and create value propositions.

Discussion

The major steps discovered are to assess the need, envision the future, create a plan, start with small wins, and plan to spend ample time to reach the vision. These may be grossly oversimplified and generic answers to the questions posed to discover what should be taken into consideration when executing Big Data in supply chain management. However, the steps and stages suggested, and approaches discussed in the literature review revealed commonalities and variation among the major themes.

Starting off small (Sanders, 2016), reaching for early wins (Gezgin et al., 2017), and deploying pilot programs (Ganeriwalla et al., 2016; Spiller et al., 2014) all suggest that in the beginning stages of planning to execute the Big Data transformation, supply chain professionals should aim to solve an easy but high-impact data challenge with data technologies and techniques. The purpose of the small-scale quick-start is to learn (Sanders, 2016), create value (Ganeriwalla et al., 2016; Spiller et al.,2014), gain credibility (Spiller et al., 2014), and demonstrate opportunities (Spiller et al., 2014). Some of the first or early stage tasks are creating a vision for the future and assessing the current performance state (Gezgin et al., 2017), immersing in all things digital supply chain management to learn and envision opportunities (Ganeriwalla et al., 2016), realizing the value in what Big Data and analytics can do (Ittman, 2015), and defining an agenda for Big Data by the top-level management (Spiller et al., 2014). These strategic tasks aim toward creating a desired future state through learning about Big Data's transformational potentials and opportunities for supply chain (Ganeriwalla et al., 2016; Ittman, 2015), reflecting in the current state (Gezgin et al., 2017) and setting the path toward the vision for the supply chain organization (Spiller et al., 2014; Gezgin et al., 2017). The advice of working incrementally toward reaching the desired state that uses Big Data to its full potential

appears over and over again. Sanders (2016) listed the application of advanced analytics as the final step in the process of maturation in building technological capabilities and reported that companies that successfully adopt Big Data make incremental improvements in a continuous fashion. Ganeriwalla et al. (2016) suggested that a full-scale rollout of Big Data can be the final step only after initial pilot programs are launched and tested, in applying the three proven to be successful strategies used by leading companies that adopted supply chain digital transformation. Spiller et al. (2014) suggests expanding on the pilot program in their second of two-phase approaches to Big Data adoption in procurement.

The major themes found in this research are important because they can break down an otherwise daunting task of administering Big Data in supply chain into steps, stages, processes, and solution tactics. While the research on the convergence of Big Data and supply chain is still developing, there are success cases that have been studied that can be imitated. The lack of penetration of Big Data in supply chains across all business industries, along with supply chain management having the lowest digitization level out of five business areas (Gezgin et al., 2017), spells trouble for businesses. Because Big Data has improved many performance metrics to better serve the internal and external customers of many large well-known organizations, it has established a strong presence that cannot be ignored by supply chains professionals. Perhaps this hesitancy to embrace the data revolution is due to the perception that planning and executing a highly technical and conceptual idea in a unique organization like supply chain seem out of reach. Supply chain as a networked body that connects many functional nodes that have different priorities and objectives requires a great deal of coordination and collaboration among stakeholders, as well as data science experience for the supply chain professionals that spearhead the data transformation. Taking on the implementation in stages and developing strategies to fit

the needs, resources, attitudes, and culture of each supply chain practitioner's business can alleviate the misperception that Big Data equals using advanced analytic tools and that a big jump in performance efficiencies can be expected and achieved from the get-go.

Another reason the findings in this research are important is that they address some of the challenges discussed in the earlier part of this paper. One of the biggest concerns supply chain professionals have about Big Data is around the quality of data input and output. Zoetmulder (2014) provided three solutions to getting better data in procurement, and they are functionalities found in spend management technology. This means that choosing the right technology can aid in improving the quality of data with minimal configuration to see the benefits. Gezgin et al. (2017) reported that selecting the right leading-edge technologies that can be purchased off-the-shelf with few customizations that are easy to integrate with existing ERPs can help capture early wins that promote digital transformation. In recent years, many cloud-based data analytics SaaS (software as a service) packages have become available with subscription models that are far less costly than what companies traditionally spent developing their own systems. A hypothetical implementation of a Big Data application project by Existek has an estimated a cost of approximately $698,000 (2018). Most off-the-shelf cloud-based solutions can be purchased based on per license subscription, which means that companies interested in improving their data quality can enter the Big Data arena by spending much less than what it would cost to develop a customized application. An added benefit of using a SaaS platform is that it can provide added scalability as companies grow and their data management and analytics needs expand. The quality of data can be improved as a part of the process of maturation in building technological capabilities in supply chain management (Sanders, 2016). Structuring data by scrubbing and organizing to ensure quality is the first stage in the maturation process (Sanders, 2016). The

quality of data will improve as the entire supply chain organization feeds data to the same application and extracts meaningful insights to act on. Maintaining the cycle of data input, output analysis, and act on insights gained to occur in a continuous fashion will populate and propagate the system with reliable and clean data that will yield higher quality data as the cycle continues.

Throughout the search for literature written on Big Data and implementation approaches specific to supply chain, a pattern among the findings appeared. First, there is far more literature written on methods to implement Big Data in supply chain written by industrial practitioners than academic practitioners. For example, Gezgin et al. (2017), Ganeriwalla et al. (2016), Zoetmulder (2014), and Spiller et al. (2014) are in the management consulting business. Therefore, it can be deduced that perhaps the industrial practitioners have more first-hand experience of developing plans and assisting in the execution of Big Data adoption in supply chains than the academic researchers who write on the topic by gathering secondary research or conducting an intensive primary research. Second, the need to show the value of Big Data appear along with delivering the early- and easy-wins in the form of pilot programs and small projects (Sanders, 2016; Gezgin et al., 2017; Ganeriwalla et al., 2016; Spiller et al., 2014). One reason for the need to demonstrate value to both internal and external supply chain audiences might be that Big Data can be seen as a costly endeavor with an unclear ROI. Thus, the need to show the value-creation potential of Big Data is imperative in the beginning stages of adoption. Showing immediate progress with minimal investment in time and resources wins the support of internal leadership and can go a long a way towards the long-term goal of broader implementation of the technology.

An unexpected research finding is the discovery that talent development to support the adoption of Big Data in supply chains is a critical focus point that should be included in the implementation approach. Gezgin et al. (2017) emphasized that an ongoing operational capability development should include a talent strategy to support the initiative. Spiller et al. (2014) built into the first approach of their two-phase approach that to build a solid foundation for Big Data it is necessary to develop an analytical talent pipeline. Talent as a key component in strategy to execute Big Data may have appeared because the low representation of data responsibilities in the C-suite (Columbus, 2018) mirror the fact that while the demand for people to process and analyze the data is great, there are not enough business professionals with data experience to fill the positions. The McKinsey Global Institute claims shortages of 140,000 to 150,000 workers and approximately 1.5 million managers and analysts to analyze and take action on data outputs (Manyika et al., 2011). According to Sayed, Gillela, and Venugopal (2013), Big Data has greatly stimulated the demand for specialists in information management. Schoenherr and Speier-Pero (2015) in their first large-scale academic survey on supply chain management predictive analytics argued that "educating scientists capable of mastering the challenges of predictive analytics is of utmost importance" (p. 126) and provided recommendations on how to train the next generation data scientists in the field of supply chain management. Waller and Fawcett (2013) also supported the notion that a data-scientific knowledge is crucial for supply chain leaders. Therefore, talent development should be given significant attention because without human resources to manage data, interpret the findings, and carry out the actions from insights gained, the effort to adopt Big Data in the supply chain will fail without realizing the full ROI potential.

Another surprising research finding is on the selection of technical tools. The expectation was to find frequent references to choosing the right tool. The author's assumption was to find many research instances that prescribe how to evaluate and select technological tools available, and that discuss what product development advances are being made at the moment to meet the demands of the marketplace. It is not too presumptive to assume and expect a fair amount of discussion on applications and tools when researching and studying Big Data for supply chains. It was surprising to discover that analytical technologies should be thought of as tools (Sanders, 2016). Whereas it was the expectation going into the literature research to find frequent and detailed discussions of currently available technologies that act as drivers of how Big Data gets implemented would. However, this was not the case. Sanders (2016) asserted that the selection of analytical applications should follow and support decisions at each step of the implementation, not the other way around. Choosing an application was mentioned in a similar fashion by Gezgin et al. (2017) as mere tools to achieve an early win through capturing the lowest hanging fruit in the beginning stages of implementation. Another significant find is that the use of specific applications and tools is not thought of as the starting point of Big Data adoption in the supply chain. Spiller et al. (2014) gave the topic more attention in the first phase of Big Data approach by recommending that sourcing or developing technical solutions be part of the first phase, but secondary to building a talent pipeline that can sustain the Big Data effort. Application selection gets a thoughtful mention as one of the elements that organizations need to consider as implementation is scaled up, that acquiring additional tools may be necessary (Spiller *et al.,* 2014). Ittman (2015) mentioned a major software vendor by its brand name, SAS, to discuss its components as a subset of business intelligence that fall in the category of analytics. But Ittman (2015) does not describe how to select an analytical software but uses the SAS

product to make a point that "there is a value to be obtained from the analysis of the data which can be achieved through analytics (pg. 5). The significance of this surprising finding is that one cannot expect to find a recommendation for a one-size fits all tool or method to evaluate and select a digital analytics tool in literatures aimed at organizational leaders each with varying needs and goals in Big Data adoption.

It is possible, contrary to the expectations and assumptions going into the research that selection of tools, especially a specific brand of tools, is a taboo topic. This is especially true for industrial practitioners like Gezgin et al. of the Boston Consulting Group and Spiller et al. of McKinsey & Company who are in the business of providing management consulting that delivers advice, creates strategies, and develops plans. Coming across as pushing a particular analytical technology or a specific brand of tool may seem to advocate a favored product for profit, as opposed to offering an objective review of available technologies and their functionalities in the form of pros and cons analysis. Since these industrial practitioners publish literature as a way to showcase their know-how, promoting branded tools may dilute the purpose behind the publication.

There are several potential limitations to this research. The availability of literature that intersects Big Data with supply chain is scarce, as previously mentioned. Furthermore, literature that explore different methods, paths, processes, and stages to implement Big Data in supply chain is hard to find. Another limitation is on the lack of deep-dives into successful implementations of Big Data in supply chains mentioned by the authors of the materials reviewed. The industrial practitioners may not be able to disclose companies they consulted to implement Big Data initiatives for confidential reasons. The same may apply to academic researchers who are privy to information that the public may not get as a part of their research.

The significance of the limitation is that with more material to review and compare, additional insights may be discovered to change the course of how the major findings are discussed and interpreted. While the limitations may pose additional questions by the readers, it is the author's hope that the questions that arise from reading this research can spur further inquiry by the reader and arrive at their own findings.

Conclusion

The value proposition of this research lies in consolidating different approaches found in researchers in academia and industry to provide common practices observed in firms that have successfully implemented Big Data in their supply chains. The major findings in this research are important as they can provide a starting point for supply chain professionals and business leaders to initiate the conversation within their organization about how to approach the topic of Big Data. Understanding different approaches to incorporate Big Data in supply chains can serve to be valuable information for supply chain practitioners interested in tapping into the massive potential that analyzing a large amount of data holds. The simplified reporting of the major findings discussed in this paper provides a broader understanding to the research problem that sets out to explore ways to direct supply chains to benefit from the transformative qualities of Big Data. Further research on Big Data implementation approaches and comparisons against the reported performance improvements can point to which approach, as a part or whole, is the best in terms of ROI. Further research can also be done by evaluating Big Data adoption approaches that employ professional services to provide a turn-key experience versus home grown applications of the technology.

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