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BIG DATA IN SUPPLY CHAIN MANAGEMENT: AN EXPLORATORY STUDY

Exploratory Study

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Abstract

The objective of this paper is to set a framework for examining the conditions under which the big data can create long-term profitability through developing dynamic operations and digital supply networks in supply chain. We investigate the extent to which big data analytics has the power to change the competitive landscape of industries that could offer operational, strategic and competitive advantages. This paper is based upon a qualitative study of the convergence of predictive analytics and big data in the field of supply chain management. Our findings indicate a need for manufacturers to introduce analytics tools, real-time data, and more flexible production techniques to improve their productivity in line with the new business model. By gathering and analysing vast volumes of data, analytics tools help companies to resource allocation and capital spends more effectively based on risk assessment. Finally, implications and directions for future research are discussed.

Introduction

In today's volatile and increasingly digital global business environment, companies need to create long-term profitability through developing dynamic operations and digital supply networks. Digital technologies, such as social networks, mobile, analytics and cloud, have enabled companies to collect massive amounts of data and can disrupt supply chain operations. For example, it can come from point-of-sale (POS) systems, Global Positioning System (GPS) data, Facebook, call centres or radio-frequency identification (RFID). Facebook processed more than 500 TB of information every day (Howe, 2008). Companies are also capturing exponentially growing volumes of transactional data about their customers, suppliers, and their operations. Therefore, they need more powerful techniques to explore that data. Big data refers to large data sets whose size is so large that exceeds the memory of computer used for processing by a company with limited hardware resources. In other words, the storage and processing capability of a single mainframe computer system become inadequate. This data can be captured, stored, communicated, aggregated, and analysed and the parallel computing capacity can improve the efficiency of acquisition and analysing big data (cloud computing). Data is cumulated and includes all kinds of data from every possible sources – structured or unstructured. The gains from big data are a combination of the size of current data sets coupled with rapidly increasing processing capability and improved predictive algorithms.

The supply chain for a product is the network of companies and activities involved in its production and distribution. Every product bought by the final customer represents the cumulative effort of multiple organizations. Thus, supply chain activities cover everything from product development, production, and logistics to maximize customer value and achieve a sustainable competitive advantage.

This research is focused on the supply chain management and how big data can help companies from supply chain to reduce cycle time, cross-functional views, improving decision making, and optimized supply chain performance. Companies should focus their limited time and resources on supply chain operations by reducing operation costs, lower cash requirements, and boost agility. For example, a manufacturer ordered more than was really needed to avoid supply shortage. In addition, its suppliers ordered more from their suppliers. As a result, inventories started to increase across the value chain. Thus, with better demand forecasting, companies can meet customers' demands in a much more agile way. However, relatively little research has addressed the impact of big data on supply chain management and what is its role in transforming supply chains. Also, there are difficulties to apply big data solutions.

Many companies don't understand how to apply analytics techniques to drive higher supply chain performance. For example, the cost of hiring skilled employees and the complexity of connecting nodes across an extended supply-chain network represents a significant barrier for big data using in companies.

This paper makes three contributions to literature. First, we investigate the convergence of predictive analytics and big data in the field of supply chain management. Big data analytics is embedded into key supply chain process. We also identify the factors that can support the supply chain value transformation and optimization to predict customer behaviour and deliver more value to them by using big data algorithms for predictive analysis. Second, the research offers a deeper understanding of barriers to implementation of big data in supply chain. We surveyed some students from the master's program to get their thoughts and perceptions on the importance of big data analytics tools in their companies and supply chains. Third, we investigate how unlocking value in supply chain processes and operations through identifying the critical path of value changes.

The remainder of this article is structured as below. The next section reviews literature relevant to this study. The research model for this study is then introduced, followed by the research methodology. In the next section, we present the research results, findings, and discussion. The last section provides our conclusion and recommendations for future research.

Theoretical Framework

The research began by a systematic literature review of the potential value that big data can create for companies from supply chain and how these can capture it. Supply chain management consists of internal operations, within a firm, and external operations, which cross organizational boundaries to integrate a firm with its customers and suppliers (Ragu-Nathan, 2006). The literature on supply chain integration suggests that companies should strengthen their internal integration before integrate with suppliers and customers.

One significant dimension of supply chain is that it requires communication, collaboration, and integration with all supply chain members. In supply chain, companies may conduct inventory optimization, logistic optimization, and supplier coordination to reduce the difference between supply and demand (Kaynak, 2008). In the supply chain context, the analysis of data involves multiple

companies which are shared during business transactions between trading partners. Also, integrating these data to form a data view gives rise to the challenges of interoperability (Hofman, 2013). The average company in most industries in Europe has enough capacity to store and manipulate big data. Hadoop cluster with a lot of nodes can process hundreds PB data. The main existing architecture of real-time analysis is HANA from SAP. It is a memory-based computing platform.

The most potential to create value through the use of big data will be in the most developed economies. This potential is based on the big data characteristics: *volume* – the generation and collection of masses of data, *velocity* – data collection and analysis must be rapidly and timely conducted to capture the value of big data, *variety* – means the various types of data (structured, semi-structured and unstructured) and *value* – the huge value but very low density (Manyika,2011) . Different analytical architecture shall be considered for different application requirements.

Big data create new growth opportunities for companies from supply chain by having captured and analysed the valuable data about products and services, buyers and suppliers, customer performance and intent to buy. The investment to create the supply chain's big data capabilities provides companies possibilities to enhance their competitive advantages over the long term. Also, big data allow companies to improve market segmentation and customisation of products and services precisely to meet customers' needs by using the real-time microsegmentation of customers to target promotion and advertising (Chen, 2014). Some studies have found that companies from supply chain have the most to gain form big data implementation when they are symmetric in terms of their capacity and capabilities, depending on the kinds of supply chains – integrated or decentralized supply chain (Bernstein, 2007).

The possibilities of big data continue to evolve continuously by innovation in the platforms and analytic capabilities for processing data. Thus, big data offer transformational potential to create value and have implications in how companies create long-term relationships with their suppliers and how their suppliers may be involved in product development and quality improvement. Supplier's participation in product design improves organizational performance directly by cutting costs and quality improvement. Also, supply chain should facilitate frequent meetings with customers and business partners, encouragement of customer feedback and customer involvement in product design. For example, the success of Amazon has relied a lot on big data because it enables the storage and analysis of the large volume of data

about customers which provide the opportunity to gain competitive advantages (Silveira, 2001).

Companies in the supply chain can capture value from big data implementation only through innovation in operation and processes. The McKinsey report pointed out that the supply chain lacks competitive pressure which reduces the ability of companies to capture the potential value from using big data (Tien, 2013). A constraint on capturing value form big data is a shortage of talent and skills. Thus, people can use insights from big data to create value. In addition, this type of talent is difficult to produce (analytical skills). The McKinsey report pointed out that some managers lack the capability to see the value in big data as well as how to unlock this value (Tien, 2013). See figure 1 - The transformational potential of big data to create value in supply chain .

Based on the literature review, the transformational potential to create value in supply chain is depicted in Fig.1. It can be noted that barriers have the potential to create resistance to the implementation of big data solutions in companies and their supply chains. Thus, it can be seen that low competitive intensity, vision, investment in new technology (big data) a shortage of analytical skills, privacy, security, and intellectual property are the main factors which may inhibit the desire of companies to implement big data solutions.

Research Design

The overall goal of this research is to provide a better understanding of the strategic role of big data and how it affects the performance of each entity in the supply chain. We strive to determine how companies become interested in the high potential of big data because this technology helps companies to identify the hidden values in supply chain.

Research data for this paper were collected from multiple sources. The first sources are literature, documents, published reports, and observations. The second sources consist of personal interviews with some students from masters' programs which work at different companies and academic members from University "Politehnica" of Bucharest. This research was conducted on May, 2015. The academic members from sample mainly came from various faculties and have different academic degrees. All interviews were conducted on a one-to-one basis in order to capture their experiences, opinions and concerns.

The research method is participatory observation and it is based on the following features: investigation through inductive processes rather than hypotheses testing, and data analysis to sort the qualitative data and interpretations of meanings. Data and theory are constantly compared and

contrasted throughout the data collection and analysis process (Howell, 2013).

Empirical Analysis

In this section we outline the role of big data in supply chain taking into account the potential to help companies to manage their operating environment and risk profile. In this respect, we collect data from all respondents and the most interesting opinions, observations, or assessments will be presented in a systematic way further. The questionnaire used in this research included the following questions: (1) *what role will big data play in transforming the business processes from company? (2) How will big data affect the knowledge sharing and collaboration into the supply chain? What business performance drives the adoption of big data technology? How can big data change the existing business model? How will big data build transparency and connection into the supply chain?*

The investigation indicates many aspects of the process by which big data contributes to performance growth for each company in the supply chain. From the interviews, we obtained substantial evidence for the transformational potential of big data to create value in supply chain. Several students which work in transport companies mentioned the importance of logistic optimization using the applications of Internet of Things and Big Data. For example, they stressed that GPS, wireless and sensors can track vehicles positions any time. In addition, the optimal delivery routes contribute to reduce operating costs in the supply chain.

As Professor C (Faculty of Entrepreneurship, Business Engineering and Management) pointed out, *"… based on my experience I noted that big data enables development capabilities along the entire chain to meet dynamic customer needs through customization, agility, cost efficiency and market orientation, but many companies do not have experience, digital information technologies and sufficient technical talent in-house to implement big data solutions ... "*. Similarly, many respondents considered that *" ...big data analytics can help companies in the supply chain to reduce the number of warehouse and build transparency and connections into the supply chain and reducing operating costs.."*. This suggests that supply chain members using big data analytics can simplify the complexity in supply chain to sustain productivity and profitability growth. By using big data a company has the ability to find good suppliers and customers quickly and accurately. However, lack vision about the potential of big data and the low degree of supply chain integration prevent effective cross-organizational use of analytics tools.

Most respondents noted that supply chain may include multiple silos of disparate data preventing the use of big data analytics to predict demand, production capacity and customer preference. For example, Professor M (Faculty of Automatic Control and Computer Science) believes that *"… the end-to-end visibility of supply chain and the real-time analytics can be used to inventory optimization and enable logistic companies to act rapidly and effective..."*. Thus, with the right data, supply chain members can more accurately forecast inventory, demand, and capacity. By using big data analytics, companies in the supply chain can reduce operating costs and increase profit margins to improve long-term profitability.

Many respondents have related that a shortage of talent and analytic skills can reduce the potential to translate business needs into analytics solutions. Knowledge sharing and collaboration using big data analytics facilitates better decision making in supply chain and value creation. Some respondents stated that *"…we have a lot of engineers, economists, statisticians and computer scientists in the country, but their skills are limited to their area of specialization. We need professionals who can use big data analytics to bring competitive advantage for their companies..."*. Based on this statement it is found that poor data quality and lack in talent and skilled employees prevent collection and analysis of data using big data analytics tools.

Some respondents assert that big data analytics is disruptive technology in supply chain. This means that supply chain members need more than new tools, skills and technologies, they need to rethink business processes and change the way they operate. In addition, budget constraints of companies in the supply chain and operational risk related to big data analytics severely limits the investment in these assets.

Many respondents said that they don't think their companies have analytics capabilities to use big data. Manufacturers could capture a significant big data opportunity to create more value using real-time data, and advanced analytics tools. The greater is integration across supply chain, the more supply chain and profitability. However, security concerns can prevent the implementation of big data solutions because of their velocity, volume, and variety of big data.

Using data generated through interviewing of academic members and the results of other studies presented in the first part of this research, we can determine the main role of big data in supply chain taking into account the potential to help companies to manage their operating environment and risk profile. Thus, the key factors which support the transforming supply chain and the main barriers to the implementation of big data in companies are summarized in Table 1 (The summary of the

transforming supply chain and barriers to implementation big data).

Using advanced big data analytics tools allows companies in the supply chain to increase the degree of integration across the supply chain. By gathering and analysing vast volumes of data companies can improve long-term profitability and decision quality. Nevertheless, there are some individual companies which do not share data, the value they can obtain forms big data depending on the degree to which they can pool data across supply chains.

Low visibility in supply chain may induce loss of confidence among members of chain and business disruption because they are highly specialized. Risk assessment is a collaborative effort that depends on data quality, the configuration of the business network and the degree of supply chain integration.

Summary

The original contribution of this study lies in some findings: first, it provides additional clarifications to the supply chain efficiency literature. Companies in the supply chain use massive amounts of data about their business processes to integrated monitor and control of transactions, logistic operations and inventory optimization. Our findings indicate that big data analytics capabilities can be applied to optimize all operations in the whole supply chain. Second, we have examined the potential value from using big data to increase supply chain efficiency and greater integration. Our findings indicate the key factors which support the transforming supply chain and the main barriers to the implementation of big data in companies.

To overcome complexity, a shortage of talent and analytical skills, insufficient IT capabilities, concern over costs and lack of vision about the potential of big data, companies in the supply chain need to improve visibility, knowledge sharing and collaboration, inventory and logistic optimization to build long-term competitive advantage. Our findings have highlighted companies in the supply chain that embed analytics into day-to-day operations and processes increasing profit margins for all chain members. Thus, the importance of investing in big data analytics is not only to increase the supply chain efficiency and it is vital for each chain member to remain competitive.

The limitations for this study arrive from the small number of respondents used in this research. Future research should investigate other potential variables. One very interesting opportunity for future research may be to explore how big data analytics can improve innovation in supply chain.

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Table 1

The summary of the transforming supply chain and barriers to implementation big data

| The potential value from using big data	Barriers to implementation big data	Supply chain management performance
Configuration the supply chain to adapted it to business needs	Fragmented supply chain prevent effective cross-organizational use of analytics tools (*vision about the potential of big data*)	Reducing the supply chain complexity to sustain productivity and profitability growth
Inventory and logistic optimization by using big data analytics	Companies in the supply chain may include multiple silos of disparate data prevent using of big data algorithms for predictive analysis to predict demand and customer preference and buying behaviour (*low competitive intensity*)	Reducing costs to improve long-term profitability through dynamics operations and digital supply networks
Knowledge sharing and collaboration using big data analytics	Poor data quality and lack in talent and skilled employees who can translate business needs into analytics solutions (*a shortage of talent and analytical skills*)	Better decision making in supply chain and value creation
Big data analytics is disruptive technology in supply chain	Budget constraints of companies in the supply chain and operational risk related to big data analytics severely limits the investment in these assets (*new technologies and analytical techniques*)	Efficient supply chain processes to generate competitive advantage
Supply chain visibility	Security concerns can prevent implement big data solutions because velocity, volume, and variety of big data (*privacy, security, and intellectual property*)	Increased supply chain efficiency and profitability, greater integration across the supply chain
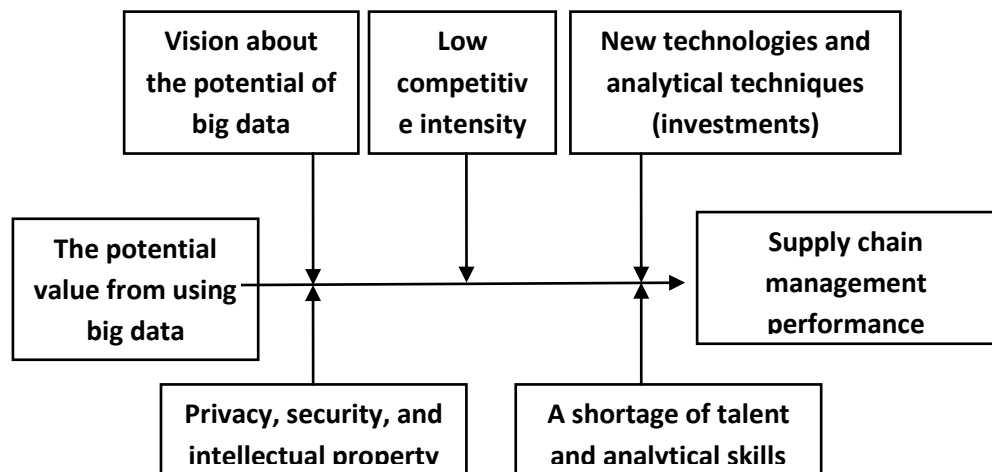
Figure no. 1 The transformational potential of big data to create value in supply chain