Thesis Title:

Investigating the Impact of Big Data Analytics on Supply Chain Operations: Case Studies from the UK Private Sector

A thesis submitted for the degree of Doctor of Philosophy

By Ruaa Hasan

Brunel Business School

Brunel University London 2021

Abstract

In the era of increasing competitive pressure and pace of changing demand, volatility and disturbance have become the standard in today's global markets. The spread of Covid-19 is a prime example of this. Supply chain (SC) managers are urged to rethink their competitive strategies and to identify ways to offer personalised products and services through making use of advanced technologies. With many SC executives recognising the role of data exploitation in improving performance, big data analytics (BDA) has become a salient factor for all kinds of organisations to increase efficiency and gain competitive advantage. Extant research in supply chain management (SCM) has provided limited understanding of strategic SC decision-making concerning BDA. Moreover, inquiry in this area is still poor in relation to providing a conceptual framework that illustrates the potential benefits of BDA utilisation in the SCO context. This study aims to investigate the real impact of BDA implementation in this context. A theoretical framework is developed to explain the motives behind adopting BDA in SCO along with the potential benefits of implementing BDA in SCO. Multiple case studies are the strategy utilised to collect qualitative data in order to gain detailed and in-depth understanding of the BDA as a new phenomenon in the context of SCOs. Semi-structured interviews were conducted in a cross-sectional time horizon across four different industries. Institutional theory and Task-Technology fit theories are utilised to provide better understanding regarding how and why firms adopt BDA as a novel technology, along with the drivers and opportunities of this technology utilisation. The empirical findings reveal that BDA is still in its infant stage, but it is a growing area which has recently been given more attention by scholars and managers. There is a disconnect between the hype and knowledge discussed in the literature and the real practice of BDA. That is, the current state of BDA use is relatively fragmented and rhetoric in discussion among practitioners and researchers. The main contribution of this study is breaking-down the process of BDA utilisation in order to evaluate its implementation in the SCO context by drawing upon a wide range of existing literature regarding BDA and SCO, in addition to present conceptual framework explaining the potential impact of BDA implementation through presenting BDA utilisation drivers, BDA capabilities, and its role in solving different issues.

Declaration

I, Ruaa Hasan, declare that the present thesis (its idea, analysis, and conclusion) is entirely my own work, and it has not been submitted for another qualification. Some of the materials contained herein have been published in the following academic conference and journals.

- **Hasan, R.**, Eldabi, T., Kamal, M. (2017) "Big Data and Big Data Analytics in Supply Chain Operations". British Academy of Management (BAM) Conference, University of Warwick, Warwick, UK.

- Daowd, A., Kamal, M. M., Eldabi, T, **Hasan, R.,** Missi, F., Dey, B. (2020) "The Impact of Social Media on the Performance of Microfinance Institutions in Developing Countries: A Quantitative Approach". ***Information Technology and People (ABS 3*).*** ISSN: 0959-3845, ***Published*** on 3 August 2020

- Daowd, A; Eldabi, T; **Hasan, R;** Rafi-Ul-Shan, P; Cao, D; Kasemsarn, N (2020) Factors Affecting eWOM Credibility, Information Adoption, and Purchase Intention on Generation Y: A Case from Thailand. ***Journal of Enterprise Information Management (ABS 2*)***. ISSN: 1741-0398, ***Published*** on 23 June 2020

- Bin Makhasen, Y; Rafi-Ul-Shan, P; Amar, H, **Hasan, R**; Khan, M (2019) "Exploring the role of ambidexterity and coopetition in designing resilient fashion supply chains: A multi-evidence-based approach*" **Journal of Enterprise Information Management (ABS 2*)***. ISSN: 1741-0398, ***Published*** on 23 April 2020

- **Hasan, R**; Kamal, M, Daowd, A; Eldabi, T; Koliousis, I "Understanding the Use and Impact of Big Data and Big Data Analytics on Supply Chain Operations: Systematic Literature Review to Proposed Conceptual Framework". ***Production Planning & Control (ABS 3*)***, ***Accepted*** subject to revision.

Acknowledgement

I am deeply indebted to the support and the help of many people who have been of tremendous assistance to me while working on this thesis. Firstly, and most importantly, I would like to express my deepest appreciation to my principal supervisor Dr Muhammad Kamal for providing me with several great opportunities and one of which was promoting my research skills to the standards that I can do a proper research, through giving time to discuss my work, reading drafts and being available to respond emails and other forms of contact within a reasonable timeframe, in addition to having listening skill and high level of communication. I am honoured to have had the opportunity to work under his supervision and learn from him along this eventful journey.

I would also like to thank Dr. Tilal Eldabi for his motivation and guidance during the first 2 years of my research. I am also grateful to Dr. Manoj Dora for his support and supervision toward the final stage of my journey.

Any attempt at any level cannot be satisfactorily completed without the support and guidance of my husband Dr Ahmad Daowd who helped me to overcome my fears and rebuild my confidence which I partly lost, and when I thought I would not be able to attain my goals.

My deepest appreciation goes to my children, the light of my life, Adam and Tia for their constant love, companionship and support which provided me with the resolve to complete this thesis.

I want to express my sincere gratitude to my family who played a role in my academic accomplishments, namely my late grandfather Dr Ahmad Ali Hasan, my father Maaz, my mother Hanan, my uncles Hayan and Dr Eias, my brother Waed, my sisters, Reef, Rood, Mais, and Rafef.

I would also like to extend my thanks to Brunel Business School and to all the staff for their kind support throughout my studies.

Finally, I am grateful for the support and encouragement I was offered from my friends who believed in my capabilities and skills, namely: Paul, Marcela, Zahra, Rabia ,and Rawida.

Table of Contents

List of Tables

List of Figures

1. CHAPTER ONE: INTRODUCTION

1.1 Introduction to the Research Field

It has become clear that the information era holds many different manifestations, no longer conventional methods and old organisational forms can create new opportunities to improve performance at this stage. As a consequence, organisations that operate as per traditional methods are not able to adjust and cope with the requirements of the current era (Pournarakis *et al*., 2017). New concepts have emerged to meet the requirements of the digital economy. Manufacturers have adopted a variety of innovative technologies to gain competitive advantage in niche markets and achieve the objective of being sufficiently flexible to cope with the continually changing environment in the digital world (Ginting, 2020). Supply chain (SC) analytics has started attracting scholars to this field, which has coincided with new challenges and opportunities in both the business and information technology environment. These challenges include issues arising from managing copious amounts of data as well as dealing with demand and supply uncertainty (Chae *et al*., 2014). Despite their calls for deep understanding of advanced technology applications to businesses, managers across SC remain concerned and confused about advanced analytical innovations (Richey *et al*., 2016).

SC is defined as a set of activities from the ordering and receipt of raw materials, manufacturing of products, through to the distribution and delivery to the customer (Xu, 2011). This definition concentrates on the core determinants of an effective SC: the integration, coordination, and collaboration of three flows of the SC namely materials, information, and finance (Janvier, 2012). Supply chain management (SCM) is the act of seeking to optimise activities across the SC. Specifically, SCM is set of synchronised activities for integrating suppliers, manufacturers, transporters, and customers efficiently to deliver right product or service in the right quantities, at the right time, to the right places (Janvier, 2012; Xu, 2011). An integrated or responsive SC cannot be without an information system (nerves system), which is defined as a combination of interconnected components that collect process, interpret, store, filter, and distribute information to support decisions (Hofmann, 2015).

Researchers also stated that achieving SC integration and coordination would not be possible without information sharing that leads to better overall performance (Xu, 2011), in addition to the profound effect of coordination and flow of information on production schedules as well

as inventory control (Eltantawy *et al.,* 2015). Many companies now realise the importance of increasing cooperation between partners and sharing more information with trading partners to avoid misinformation, which can cause serious problems in the SC, such as the bullwhip effect (Hofmann, 2015). SC analytics reflect a big interest in extracting the business value of SC data and harnessing the power of diverse analytical technologies to achieve perceived role of SCM within the organisation (Chae *et al*., 2014).

As a result of increasing uncertainty on both the demand and supply side as well as the urgent need for more precise customer assessment to personalise services and improve products, firms are under pressure to embrace big data (BD) and equip themselves with sophisticated analytics tools, which will lead to the creation of valuable business information from various aspects (operational efficiency, improving SCM, improving decision making). It is undisputed that the salient factor to gaining competitive differentiation for the long term in today's rapidly changing business environment is the ability to extract useful business information from BD. it has revolutionary effect on SC dynamic and business management which represented in data sources integration and actionable information (Wang and Alexander, 2015; Tan *et al., 2*015).

BD without analytics is simply about having substantial amounts of data where no value can be created. Hence, organisations need to make sense of their industry data and take advantage of it in terms of improving their fact-based evidence. Effective big data analytics (BDA) enables managers in not only handling vast amounts of data, for it also can uncover valuable insights (Ma *et al*, 2015). Chen (2015) defines BDA as follows: "BDA have been used to describe the data set and analytical technique in application that are so large (from terabytes to exabyte) and complex (from sensor to social media data) that they require advanced and unique data storage, management analysis and visualisation technology". Prior to implementing BDA techniques, organisations should determine the desired insights at preliminary stage, the relationship between business and BD project is bidirectional business requirement-based BDA and BDA –driven business.

1.2 Research Background

In response to the question as to why BD is important, McAfee *et al.* (2012) claim that "because of BD, managers can measure, and hence know, radically more about their business, and directly translate that knowledge into improved decision making and performance". They

emphasise the potential of BD to revolutionise management due to its enormous potential impact (Wamba *et al.,* 2015). Data extraction and analysis is almost imperative for organisations, they can either utilise BD in a systematic way to achieve competitive advantage or ignore data that they own then these organisations will lag. According to Wang and Alexander (2015), Zhang and Cheng (2016), Subramania and Gunasekara (2015), the applications of BD in SC can be beneficial in the following areas.

- ***SC planning***: BD allows for massive amounts of data to be used across SC partners. Suppliers need to know manufacturers' demand for raw materials and in turn, manufacturers require retailers to give feedback about their products in the market.
- ***Procurement*****:** The core of the purchasing process relies on evaluating options, identifying sources, and acquiring materials that are matched to the product and cost effectively. With adequate information from SC partners, enterprises can base procurement decisions on more factors, thus enabling them to make better informed decisions.
- ***Logistics***: Many firms seek to capitalise on logistics to improve customer satisfaction through selecting the appropriate delivery methods in accordance with customer preferences on the shopping platform and delivering the right item to right person at the right place. BD analytics can meet this challenge through real time logistics monitoring that facilitates determining which factors are the greatest causes of any delay (Ma *et al.*, 2015).
- ***Inventory****:* The Walmart Company pioneered the use of BD in its inventory management system, making the current situation accessible to the supplier, who can thus ascertain the exact number of their product on every shelf of every store at any time.
- ***SC collaboration*****:** Decision-making processes are subject to vulnerability in the SC relating to its characteristics (asymmetric information, serious distortion during the process of information flow, interest conflict among SC members and poor relationships). BD can help all partners understand how every other partner responds to a certain issue.
- ***End to end SC execution***: By establishing a BD platform, BD can make organisation seamless by combining and correlating different data sources to ensure end to end execution is completed effectively and efficiently.

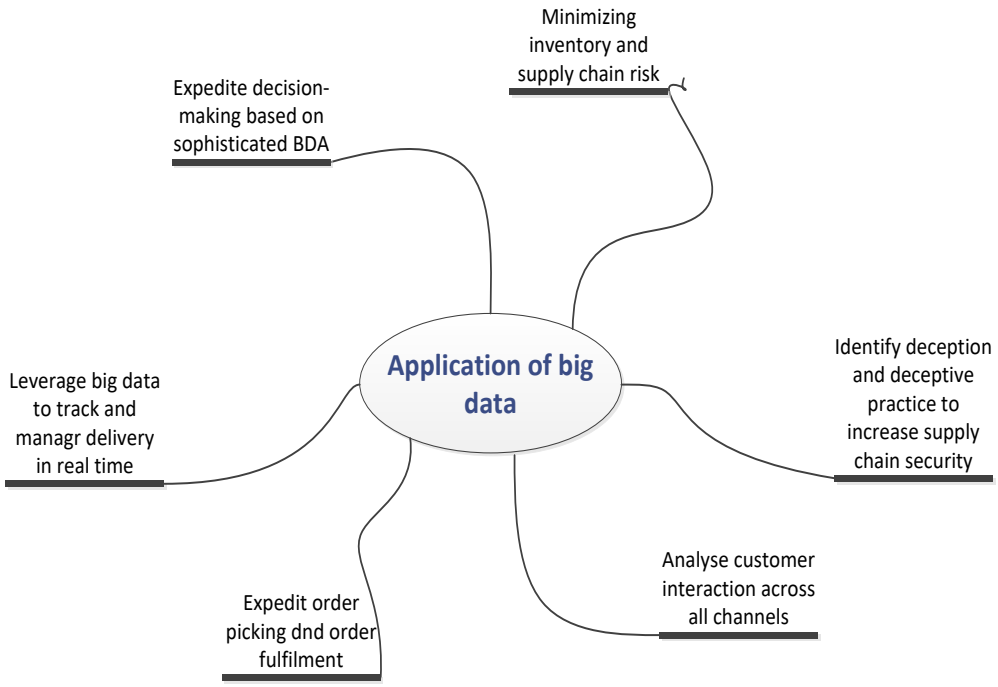

Figure 1.1: Applications of BD in the SC

1.3 The Potential of BD in SC

From a literature review, the potential impact of BD on the SC was identified as follows.

- Accurate operational information arises from BD enhancing timely correction and supplier changes (Wang and Alexander, 2015).
- BD improves product and service traceability: Researchers have proposed radio frequency identification (RFID) as a promising integrating technology that can help in improving tracing capability (Chae, 2015).
- Exposing faults in product and services by BD through early warning and avoiding recalls (Ji and Wang, 2017).
- Offering a real time view of the product demand and product sales will improve the product sourcing process (Wang and Alexander, 2015).
- Improving the transparency of information by BD can lead to better identification of potential supply problems (Wang and Alexander, 2015), which may help managers to mitigate the effects from the bullwhip phenomenon. Regarding which, a study by Hofmann (2015) focused on how BD in terms of volume, variety and velocity can stave

off the bullwhip effect, which leads to excess inventories, followed by serious inventory shortages, excess or insufficient capacity.

- Using BD enables managers to decide based on real evidence rather than being plagued by uncertainty (McAfee *et al.*, 2012).
- Integrating data sources and actionable information by BD can deliver value in SC and business management (Wang and Alexander, 2015).
- The analysis of customer interaction across all channels will provide companies with a full profile that will enable them to predict customer needs, understand personal preferences, and improve service quality. Overall, this will increase the pace of development of the next generation of products and services. Scholars have reported that companies can much better understand their customer needs by utilising data available from loyalty cards and social media. Firms with BD can generate new ideas about their products, customers, and markets trends (Tan *et al.*, 2015).

Figure 1.2: Supply Chain Optimisation

In a broad sense, Figure 1.2 shows how the BD approach enables managers to produce a lot of information by offering real time demand and product sale, and making organisation seamlessly combined to assure end-to-end SC execution efficiently (Wang and Alexander, 2015). Wamba and Akter (2015) have asserted that the optimisation of SC visibility is one of the most important core developments in SCM nowadays.

1.4 Research Problem

Sivarajah *et al.,* (2017) stated that "the potential of BD is evident as it has been included in Gartner's Top 10 Strategic Technology Trends for 2013 (Savitz, 2012a) and Top 10 Critical Tech Trends for the Next Five years". Pereira (2009) also contended that "data are streaming of raw facts representing an event occurring in organisation or the physical environment before they have been organised into a form that people can understand or use". Given the importance of sharing information in decision making processes, BD has the powerful data processing capability to improve transparency of information, reduce information asymmetry, reduce cost, save time and improve business efficiency (Ma *et al.*, 2015).

Using a new form of data or empowering BDA in SC is not about evaluation, but rather, it is necessary changing for improving SC planning, optimising performance, and enhancing informed decision making so to respond to challenges, in particular, increasing uncertainty and competition (Cecere, 2012; Chae, 2015). Research in academia and industry has found that retailers can achieve up to 15% increase in return on investment by using BDA. Mckinsey and Company has revealed that collecting, storing, and mining BD can create significant value by enhancing productivity, competitiveness, and the visibility of firm operations (Wamba *et al.*, 2015). The field of SCO lacks research that can deepen understanding of BD impact and researchers been relatively slow in identifying the potential roles and uses of BD sources, especially unstructured data, which represents 80% of BD.

To date, most reports on the business value of BDA have been from individual cases and consultancy firms that lack theoretical insights. Hence, not much known about the full range of resources that are required to develop a BDA technique, and the overall value it can achieve (Mikalef *et al*., 2020). Extant research on SCO management, including business logistics and that in operations management journals has done very little to guide strategic SC decision making concerning BDA. As a result, there is limited empirical understanding on the mechanisms through which BDA can generate business value (Richey *et al.,* 2016; Mikalef *et al.,* 2019). However, in general, the role of BD and BDA in SCO has not yet thoroughly been investigated. In particular, there has been a lack of studies that comprehensively address the impact of BDA on SCO, investigate opportunities for new theories, or emerging practices in this area. Most of the existing research studies conducted on SCO have focused on only one or two of the five dimensions of SCO, these being demand planning, production and manufacturing, logistics, procurement, and inventory. For instance, Wang and Alexander

(2015) and Wamba *et al*. (2015) assessed the BD benefits in terms of its applications and potential in the SC. Ranjan *et al.* (2016) examined the potential of ERP and SCM integrated with BDA, thereby contributing to improvement in the performance of manufacturing organisations.

Given the level of ambiguity and lack of understanding, SC managers are still confused about BD and related analytical innovations. According to Hilbert (2016), more than 3,000 managers from over 30 industries in 108 countries identified 'lack of understanding of how to use analytics to improve the business' as the primary obstacle to BD adoption. On the same lines, Coleman *et al.* (2016) reported that poor understanding of BDA by organisations' representatives is one of the challenges in business analytics and BDA implementation. It is imperative for managers to have a good understanding of how data is collected, what processes are being implemented, and where to apply the knowledge extracted from BDA (Gupta and George, 2016). To acquire the full benefits of leveraging BDA, organisations should be able to address managerial challenges regarding understanding of BDA in terms of sources, applications, and potential benefits. Moreover, enhanced understanding of BDA from the aspect of value associated with the SCM will foster the effective implementation of meaningful and sustainable BDA.

1.5 Research Aim and Objectives

Having broad understanding of the role of BDA in optimising SCM is extremely valuable, because its integration into operations and the SC can provide firms with better understanding of their customers, reduce costs, improve operational efficiency and thus, enhance profitability (Mishra *et al*., 2016). The main aim of this study is to ascertain the potential impact of BDA on SCO, by addressing the gap of empirical research. By so doing, the business value of BD will be determined, which in turn, help to broaden understanding of BDA and its role in capturing business value. In sum, this research involves investigating the impact of BD and BDA on SCO. To this end, a theoretically grounded framework is proposed that can support decision makers in enhancing SC performance and thus, adding value to customers.

The specific research objectives include:

- Critically review the literature on BD in relation to its evolution and its application. In addition, investigate the current practices, and opportunities regarding BD.

- Understanding the application of BD and BDA from the aspects of value associated with the SCO (performance and profitability).
- Investigate the internal and external factors that enhance BDA implementation in SCO.
- Develop and propose a theoretical research framework for BD and BDA in relation to SCO.
- To assess empirically the framework and thus, provide a novel contribution to the domain of BDA and SCO.

This inquiry is guided by the following research questions:

- RQ1: What are the main drivers for utilising BD analytics?
- RQ2: What are the applications of BDA in SCO?
- RQ3: What are the potentials for using BD in SCO?
- RQ4: What are the real benefits obtained from big data analytics implementation in the supply chain?

1.6 Thesis Structure

The remainder of the thesis is structured as follows. The next chapter will present a literature review covering the existing research on SCO and BDA. Initially, this chapter begins with SCM and then, SCO is discussed. The second section defines BD and BDA, including strategies, applications, techniques, tools and approaches as well as providing a review of some studies that conducted BDA from various disciplines. The third section reviews the publications on BD in relation to SCM applications in chronological order. It concludes by identifying gaps in the literature that are addressed by the current study.

Chapter 3 presents the conceptual framework and discusses its main concepts, factors, and sub-factors in relation to BDA. The proposed framework is aimed at providing understanding of the value of using BDA and explaining how this adoption of new technology is derived. To this end, first, the authors review the main concepts of TTF theory, institutional theory, and relevant literature of using both theories in various fields. This is followed by operationalisation of the theoretic perspectives adopted in the research. It is argued that the role of institutional

isomorphic pressures (macro institutional logics) on the intention behind BDA implementation, and, in the same line, the affect of fit between technology and tasks requirments on using BDA. The methodology is discussed in Chapter 4. It presents the philosophical framework and research paradigm that guides this research. It also explains and justifies the research methods used to select the cases and to collect and analyse the data through an interpretivist approach. Chapter 5 reports the key findings generated from the empirical investigations of the case studies. This chapter will start by introducing each case separately in accordance with the recommendations of Eisenhardt (1989). Then, a general understanding of what interviewees think of BD from their perspective is provided. This is followed by an analysis of the cases regarding SCO portfolio tasks. Subsequently, this the external pressure factors which enhance BDA implementation are considered. Before concluding on the impact of BDA on SCO, BDA evaluation in the SCO context is presented.

Chapter 6 provides discussion of the results. Drawing on the findings, the holistic framework is revised to give a clear picture of BDA implementation in SCO. Chapter 7, the Conclusion, is the final chapter, where an overall summary of the thesis is provided. In addition, the theoretical, practical and methodological contributions of the study are provided, followed by recommendations, limitations and suggestions for future research.

1.7 Summary

BD is attracting increasing attention among research and practitioner communities, which contain members from a range of academic fields who have been investigating the potential use of BD in various aspects of life (Chae, 2015). The unprecedented use of digital technology has led to the emergence of BDA for enhancing business value (Wang *et al*., 2016). BD is defined based on three aspects: characteristics, applications, and requirements. The application of BD can contribute to SCM in various ways, including SC planning, SC collaboration, procurement, and end to end SC execution. It can have a profound impact on SC in a two-fold manner: activity and strategy. In order to reap the benefits of BD, managers should consider the development of high-level skills that can deal with the new generation of IT (Wamba *et al.*, 2015). Manyika *et al.* (2011) stated that, by 2018 the United States alone would face a shortage of 140,000 to 190,000 people with deep analytical skills as well as 1.5 million managers and analysts with the know-how to use the analysis of BD to make effective decisions. This chapter has identified the research problem, with the research aims and objectives also having been presented. Finally, the structure of this thesis has been provided.

2 CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

Manufacturers have adopted a variety of innovative technologies to gain competitive advantage and achieve their objective of being flexible to cope with continually changing environment in digital world. In this context, SC analytics started attracting the scholars in this field and this surge of interest of SC analytic is coincide with new challenges and opportunities in both business and information technology environment. These challenges include issues arising from managing large amount of data and dealing with the demand and supply uncertainty (Chae *et al.*, 2014). BD as a term has emerged to describe the rapid generating of data from dissimilar sources represented in different forms structured, unstructured and semi structured. This data has a useful hidden information which makes it a valuable asset for any organisation.

Furthermore, BDA has become a salient factor for all kind of organisations to increase efficiency and gain competitive advantage in a world have keenly interested to gain better understanding of the hidden value of BD (e.g., expose hidden patterns, unknown correlations, new market trends, and consumer inclination). BDA could lead to enhance profitability in the SC by giving business the right time insight that help making fact-based decision, in addition to their potential in yielding new terminology and principles in SCM field.

The aim of this chapter is to clarify several aspects of BD, BDA, and SCO, in addition to dig deeper into what have been done empirically and theoretically in previous research related to BDA in SC in order to identifying and analysing the existing studies and then exploring the gap of potential research. The chapter is divided into four main sections; the first section begins with SCM and then discusses SCO. The second section identifies BD and BDA and their strategies, applications, techniques, tools, and approaches, as well reviewing some of studies that conducted BDA from various disciplines. The third section review the publications on BDA in relation to SCM applications taking into account the chronological order for these studies. Concluding with identifying significant gaps in the literature that will be addressed by this study.

2.2 Supply Chain Management (SCM)

A large and growing body of literature has investigated SCM and its significant role in achieving effectiveness and efficiency of corporate performance. Nowadays competitive strategy has changed, firms can no longer compete as independent entities, there has been a palpable switch from managing firms individually to a new way of doing business management, such considering the strategic importance of planning, controlling, and designing a SC as a whole (Min and Zhou, 2002). The term SCM originally appeared in the early 1980 when companies saw the benefits of collaborative relationship within and beyond their own organisations. Subsequently, academics have tried to give structure to SCM, and some SC initiative has emerged by various companies such as: Hewlett-Packard, whirlpool, Walmart, and Georgia-Pacific Crop, to implement changes in the physical distribution of the product, new distribution requirement planning, inventory' management of their products, and improving quality and service (Lummus and Vokurka, 1999; Lambert and Cooper, 2000).

In the literature, the SC tends to be used to refer to set of activities from the ordering and receipt of raw materials, manufacturing of products, to the distribution and delivery to the customer (Xu, 2011), in the other hand, SCM is defined as follow: it is set of synchronised activities for integrating suppliers, manufacturers, transporters, and customers efficiently to deliver right product or service of the right quantities at the right time in the right places. In a nutshell, SCM is an act of optimising activities across the SC (Janvier-James, 2012; Xu ,2011). The both abovementioned definitions concentrate on the core determinates of an effective SC, the integration, coordination, and collaboration of three flows in the SC material, information and financial (Janvier-James, 2012).

Identifying SC partners and SC network structures were the subject of researcher's interest to create SC model. According to (Lambert and Cooper, 2000; Min and Zhou, 2002), SC partners have been classified to two types: primary and supporting partners. They defined primary members of a SC to be used to refer to all those independent companies or strategic units who are performing operational and managerial activities in the business process designed to create a specific product or service for a particular customer and market like Dell and Wal-Mart. In contrast, supporting partner includes firms that provide resources, knowledge, application software, utility, and assets for SC primary partners, supporting partners could be consulting firm, transportation carrier, IT service provide, and third-party logistics providers (Lambert and

Cooper, 2000; Min and Zhou, 2002). Min and Zhou, (2002) assert that company can be both primary and supporting partner at the same time by completing primary activities related to one process and supportive activities related to another process. The upstream SC encompass of suppliers who participate at the earliest stage of product or service design.

Storey *et al*. (2006) clarified the key characteristics underpinning of idealist SCM. Anderson *et al*. (2007) determined seven fundamental principles of SCM through conducting analysis for more than 100 manufacturers, distributors, and retailers (see **Table 2.1**).

Authors	The Prerequisite for Effective SC	Trends of Effective SC
Storey *et al*. (2006)	These are: 1 -Seamless flow from initial source(s) to final customer. 2-Demand-led SC (only produce what is pulled through). 3-Shared information across the whole chain (end to end pipeline visibility). 4-Collaboration and partnership (mutual gains and added value for all; win-win; joint learning and joint design and development). 5-IT enabled. 6- All products direct to shelf. 7-Batch/ pack size configured to rate of sale. 8-Customer responsive. 9-Agile and lean. 10- Mass customisation 11-Market segmentation	-streamline SC flow -Demand–driven chain -sharing information (visibility) -collaboration -IT infrastructure -availability -inventory control -communication channel with customer -segmentation. -customisation.
(Anderson, Britt and Favre, 2007)	1-Segment customers based on the service needs of distinct groups. 2-Customize the logistics network to the service requirements and profitability of customer segments. 3-Listen to market signals and aligns demand planning accordingly across the SC, ensuring consistent forecasts and optimal resource allocation. 4-Differentiate product closer to the customer and speed conversion across the SC. 5-Manage sources of supply strategically to reduce the total cost of owning materials and services. 6-Develop a supply chain-wide technology strategy that supports multiple levels of decision making and gives a clear view of the flow of products, services, and information. 7-Adopt channel-spanning performance measures to gauge collective success in reaching the end-user effectively and efficiently.	-segmentation. -customisation. -demand- driven chain -flexibility. -Fact-based knowledge. IT infrastructure -performance measurement.

Table 2.1: Essential Characteristics of Effective SC

2.3 SCOR Model

According to Huang *et al.* (2005) and Chehbi-Gamoura *et al.* (2020), considerable number of researchers and practitioners have devoted their effort to developing SC models that includes simulation model (Towill, 1991), stochastic model (Tzafestas & Kapsiotis, 1994), economic model (Christy & Grout, 1994), deterministic model (Voudouris, 1996), process classification framework (PCF) (Mantje *et al.* 2016), value reference model (VRM) (Maruna et al. 2016). Yet, SCOR Model is the common model for evaluating, positioning, and implementing supply chain application software. It is a useful strategic tool in the hands of upper management to face the complexity in supply chain management (Hang *et al.*, 2005). The supply chain operations reference (SCOR) model, developed by the Supply Chain Council.

SCOR model builds on the concept of linking business processes, best practice, suggested action, people, and technology into a unifies structure. In addition to describing the way the processes interact along SC and how they are set suppliers to customers which enables practitioners to identify the elements that contribute to customer satisfaction (Wang, Chan, & Pauleen, 2010). The SCOR-model contains four levels of process details. Level 1 is the top level that founded on five distinct management processes leasing to the implementation of an efficient SCM strategy: 1. Plan 2. Source 3. Make 4. Deliver 5. Return (Huang et al. 2005; Wang, Chan, & Pauleen, 2010), see (**Table 2.2).**

SCOR main processes	
Plan	Plan processes deal with demand supply planning, which includes the processes that balance aggregate demand and supply to develop course of action in order to meet sourcing, production, delivery, and return requirements (Li, L., Su, Q., & Chen, X. 2011; Zhou et al., 2011).
Source	Source processes describe how to select suppliers, develop suppliers' network, manage inventory, keep delivery promise, and evaluate suppliers' performance. In summary, it contains processes that secure goods and services to meet planned or actual demand (Li, L., Su, Q., & Chen, X. 2011; Huang et al. 2005).
Make	Make processes consist of functions that transform demand through manufacturing and production to meet planned or actual demand. It contains managing the production network, equipment and facilities, and transportation (Huang *et al.,* 2005; Li, L., Su, Q., & Chen, X. 2011).
Deliver	Deliver processes includes functions that provide finished goods and services to meet planned or actual demand. It deals with order management, transportation management, and distribution management.

	Delivery decision contributes to the availability of products which has a significant impact on competitive advantage (Huang *et al.,* 2005 and Chehbi-Gamoura *et al.,* 2020).
Return	Return is the latest addition to SCOR model as it is a reversed logistics process. it includes determining product condition, requesting product return authorisation, scheduling product shipment, preparing return receipt, acknowledging received products, and transferring defective product (Huang *et al.,* 2005; Li *et al.,* 2011).

Table 2.2: SCOR Main Processes

At level 2 different categories within the level 1 can be defined (for example the source category includes source stocked products, source make to order products, and source engineer to order products). Level 2 describes the information flows of orders and the materials flow with type of goods produced and delivered. Therefore, at this level, internal redundancies can be identified and eliminated, such as overlapping planning processes, excessive intra-manufacturing, or duplicating purchasing (Huang *et al.,* 2005; Wang, Chan, & Pauleen, 2010; Zhou et al., 2011). Level 3 is the process element level and the decomposition of level 2 processes in an interrelated way, the goal at this level is to define in detail the processes identified in previous levels, as well as performance metrics and best practices for each activity. The SCOR model has a powerful role in implementing supply chains. Levels 1 and 2 metrics retain management focused, while Level 3 metrics support on-going diagnosis (Huang *et al.,* 2005).

Level 4 is an implementation stage that describes the detailed tasks within each of the Level 3 processes, it defines practices to achieve competitive advantage and to adjust to changing business conditions. This level of details is necessary to implement and manage the SC on a day-to-day basis, while level 4 tasks and their interactions are unique to each business which links specific requirements of competitive priorities for a particular SC setting **(**Huang *et al.,* 2005; Ayyildiz and Gumus, 2021). SCM studies have been broadly classified into three categories, namely: strategic, design, and operational (Huan *et al*., 2004). This research seeks to offer a list of essential supply chain operations elements based on SCOR model level 4 to present the detail task of SCO.

2.4 Supply Chain Operations (SCO)

SC literature can be categorised in several ways, but in this research, it will be examined in relation to the scope of SCO elements and objectives. SCO refer to short term activities over day-to-day basis which facilitate transforming raw materials into work in process or finished products and delivering to end consumer. During operation phase, organisations make decisions based on particular customer order (Chopra and Mendl, 2013). Therefore, the main objective of SCO is securing material flow between SC partners and handling customer order in the best possible manner (Chopra and Mendl, 2013). Before talking how SCO can achieve this goal, this study will introduce the operational elements in SC representing in demand planning, procurement, inventory management, manufacturing, and logistics.

2.4.1 Demand Planning

Demand chain management originates from changing the organisation's perspective toward the core of value chain's business strategy, represented in switching from product-oriented business system (offering standardised products and service with reasonable price) to demand-oriented business system (customising product and service to comply with the special needs of each market) (Canever *et al*., 2008; Lun *et al.*, 2013). Demand-driven supply network has been identified by Mendes *et al*. (2016) as "a system of technologies and business process that sense and response to demand signals in real time, through a network of customers, suppliers, and employees".

Demand planning is a critical function to SCO planning, as it helps to predict future demand and sale using data of real-time sale, marketing, and inventory information collected collaboratively by SC partners (Chae and Olson, 2013; G. Wang *et al*., 2016). Jain *et al*. (2015) describe demand estimation as one of the most important challenges in the field of operations management, since its role in supporting operational processes including inventory decision making and production planning (Albey *et al.*, 2015). Cecere *et al*. (2009) determined the nine-steps process of demand planning for demand-driven leader depicted in **Figure 2.2.**

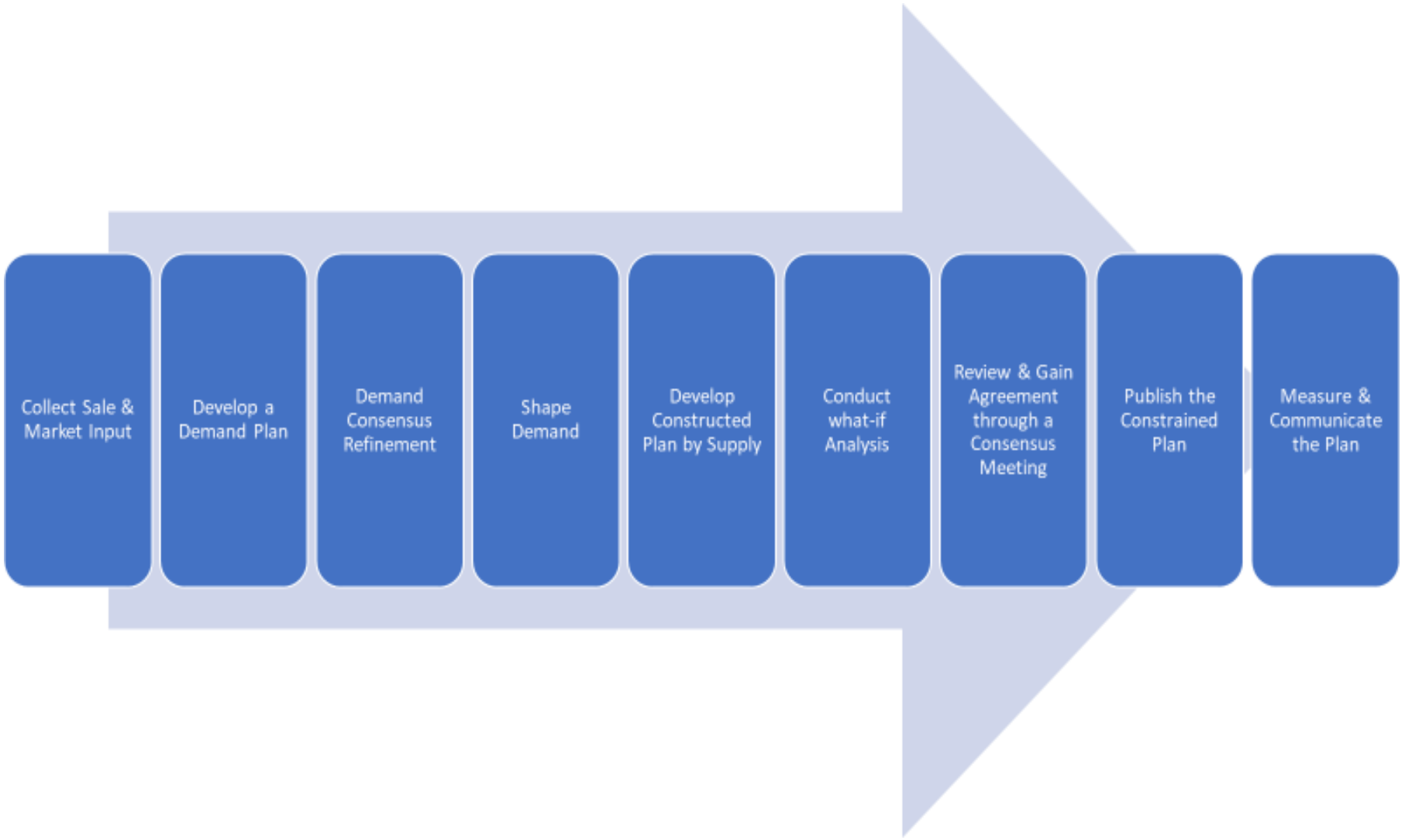

Figure 2.1: Demand Planning Processes

Demand variability amplification may arise as a result of optimising behaviours by players in the SC, where is large variance between orders to suppliers and sales to buyers (Lee *et al.*, 2004). Visibility and availability are the key magic words for efficient demand planning, visibility of customer's needs and market segmentations, availability of inventory information and sale data. The key issues in demand planning processes have been highlighted in the following **Table 2.3**.

Challenges	**Sources**
The existence of time lags in the information flow	(Hosoda & Disney, 2012)
Demand estimation	(Jain *et al.*, 2014)
Lack of visibility of stock level	(Albey *et al.*, 2015)
Lake of availability of sale data	(Albey *et al*., 2015)
Lake of visibility of customer's need and market segmentation	(Albey *et al*., 2015)

Table 2.3: The Key Issues in Demand Planning

2.4.2 Procurement

It refers to a number of procurement processes connecting manufacturers with suppliers which represent the crucial link between the source of supply and the organization itself (Tan, 2001; Zhou *et al.* 2014). Procurement is the first step in the entire SC, which depends on choosing reliable suppliers based on the bill of material and other considerations like price and reputation (Li *et al.*, 2015; Lamba and Singh, 2017). Therefore, lake of knowledge about decision-making within procurement processes is one of the most significant cost drives in SC (Bock and Isik, 2015). Van (2009) stated that purchasing function covers activities aimed at determining the purchasing specifications based upon selecting the best possible supplier, conducting negotiations with the supplier for the best legal contract, placing the order with the selected supplier, monitoring and control of the order for secure supply, evaluation, and feedback to keep file of products and suppliers up to date, in addition to supplier rating and supplier ranking.

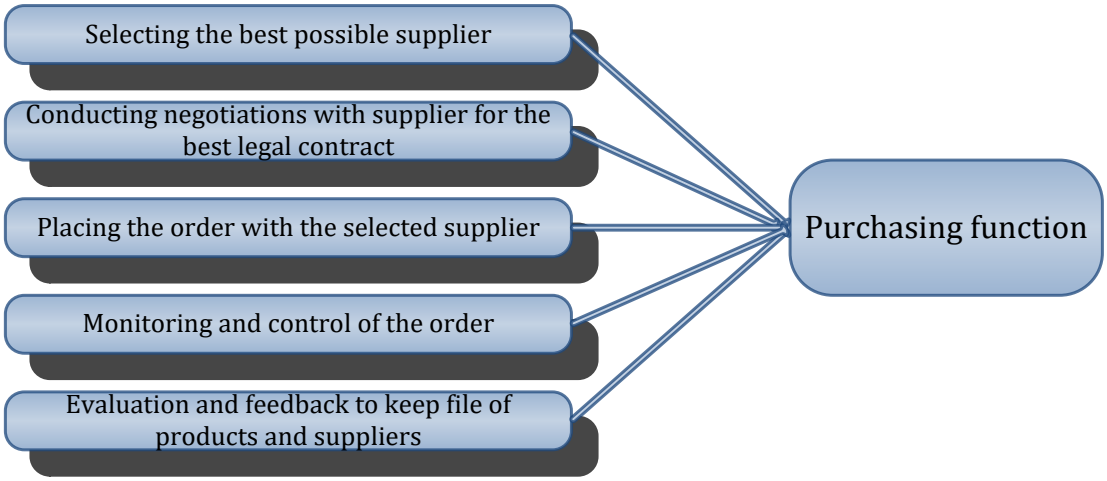

Figure 2.2: Purchasing functions source (author)

The key issues in establishing the good purchasing process encompass existence of cross functional designated purchasing team to facilitate the timely completion of purchasing activities, local sourcing to secure suppliers and achieve consistency, maintain a degree of loyalty among the supply base, cost saving, and information quality for effective information system (Ryder and Fearne, 2003). Additionally, the performance of suppliers in terms of the cost of component parts, raw materials, and service purchased becomes a viral constituent in an organisation's success or failure (Bhutta and Huq, 2002; Trivedi *et al.*, 2017). In addition to choosing the right supplier, order allocation decision process plays a significant role in improving firm's cost effectiveness; it is essential to determine the right quantity of materials from each supplier (Trivedi *et al.*, 2017). Suppliers are evaluated based on a range of criteria and performance attributes that set up trade-offs between qualitative and quantitative factors (Nazari-Shirkouhi *et al.*, 2013). See **Table 2.4** regarding the main issues in procurement processes.

Challenges	**Sources**
Optimising the total procurement cost	(Lamaba & Singh, 2017)
Choosing reliable suppliers	(Bhutta & Huq, 2002; Li *et al.*, 2016; Lamba & Singh, 2017)
Order allocation decision	(Nazari-Shirkouhi *et al.*, 2013; Trivedi *et al.*, 2017)

Table 2.4: The Main Issues in Procurement Processes

2.4.3 Inventory Management

From firm's point of view, inventory is reported under assets. But within SC, inventory embrace all required materials (raw material, semi-finished product, and finished product) for downstream and upstream level in SC (Chopra and Mendl, 2013). Since 1990, one of the

sources of competitive advantage between SC is time-based competition mode of operation, which gives inventory management a lot of challenges to be efficient, effective, and timely responsiveness to user queries (Wu and Yang, 2012). The safety inventory emerged to face challenges resulting from demand and supply uncertainty (transportation delay, production delay, and increasing customisation), and to meet the demand that exceed the amount forecasted for given period and keep its position in marketplace.

The cost of inventory considers a very costly operation that requires a regular counting of stock. Whereas the optimal level of inventory is one that maximises SC profitability (Derakhshan *et al*. 2007; Chopra and Mendl, 2013). By drawing on the concept of inventory related cost, Van Horenbeek *et al*. (2013) classified inventory cost in three types: the first one is holding cost to keep stocks availability including spare parts. The second one is ordering cost which is fixed amount assigned to each order. The third one is shortage cost or stock out cost which incurred when number of goods and services are out of stock. Accordingly, the main objective of SC inventory is a trade-off between the cost of inventory to increase product availability and the loss from not having the right product in the right time.

Challenges	Sources
Lack of information visibility for responsiveness and traceability	(Wu and Yang, 2012)
Optimising the total inventory cost	(Derakhshan *et al*., 2007; Chopra and Mendl, 2013)
Trade-off between the cost of inventory to increase product availability and the loss from not having the right product at the right time	Van Horenbeek *et al*., (2013)

Table 2.5: The Key Issues in Inventory Processes

Wu and Yang (2012) determined the key factors of optimising SC inventory (via reviewing the technology and methods used in optimising SC inventory) as follow: optimal lead time, the credit of enterprises, fuzzy level of some parameters during the optimisation process, and indicates its trends. Managing inventory intelligently is a key factor in achieving company targets in reaching to the point of minimising holding cost[1] while maintaining the required customer service level (Albey *et al*., 2015). In this sense, the more information they have the

[1] Holding cost consists of rent required place, insurance, equipment, labour, and interest on money invested in the inventory and space.

better balancing they achieve. The key issues in inventory processes have been highlighted in **Table 2.5.**

2.4.4 Manufacturing

It is the actual physical processes in the SCO that transform raw materials into finished products through a series of production stages (Chopra and Meindle 2016; Wei *et al.*, 2017). In seeking maximising profits, firms try to optimise their production through minimising the production waste, reducing the lead time, and lowering the production cost at the level of satisfying customer demand. The most researched dimension in production field was integrated production with other activity such as distribution, inventory, and demand modelling; this growing interest is the result of the emerging of hardware and software capabilities that create opportunity to increase flexibility by coordinating decision in different SC stages *(Ekşioğlu et al*., 2006). According to Chen (2010), integration of production with other operational functions in SC is crucial to achieve optimal operational performance in most manufacturing industries.

Although production disruption is unpredictable and it can be happened for many and varied reasons at any time (machine broken, supply disruption, shortage of products, labour strike, natural problem), but effective management is able to minimise SC's suffering of economic losses when disruption occur through having well planning, organising, directing, and controlling of production activities (Pal *et al.*, 2014). It is well understood that successful production system reflects the right decision that has been taken at an early stage in terms of allocation the right materials to the right product at the right time, deciding the location of facilities, and determining the manufacturer capacity each facility can process. The key issues in manufacturing processes have been highlighted in **Table 2.6**.

Challenges	**Sources**
Increase flexibility by coordination decision in different SC stages	(Ekşioğlu *et al*., 2006)
Green manufacturing	(Gungor & Gupta, 1999)
Integration of production with other operational function	(Chen, 2010)
The complexity generated in manufacturing activities due to the exploding product variety	(Mourtzis, 2016)

Table 2.6: The Key Issues in Manufacturing Processes

It can be seen from the above discussion that the main challenges in SCO which influence the operation efficiency summarised in few points: disruption, unexpected factors (human and organisations factors, natural disaster), supply uncertainty, demand uncertainty, cost, and disaster. In addition to market turbulence situation, such as global competition, modern technology, customised solution, and product introduction have increased the complexity of modern global SC. It also worth noting that every activity in SCO affects and is affected by other activities; based on (Albey *et al.* 2015) there is an intimately interrelation between production planning and inventory management.

On the other hand, successful inventory decision depends on accurate modelling of demand and demand distribution. Therefore, we can state that achieving coordination between SCO activities, and creating agility in SCO through increasing visibility has significant impact on SC performance (see **Figure 2.3**). This statement is consistent with what Leveling *et al.* (2014) state about the importance of cooperation among involved people, activities, material and information flow, and the significant role that optimisation of the SC visibility can be made to reach this point of cooperative. SCO is an integrated set of business functions consisting of many activities from raw material acquisition to final customer delivery (Beamon and Ware, 1998).

Market turbulence situation (resulting from several reasons such as global competition, innovative technology, customised solution, and new product introduction) has turned modern global SC more complex than before (Power, 2016). Therefore, the need arises to stimulate agility and adopt tools to increase organisations flexibility.

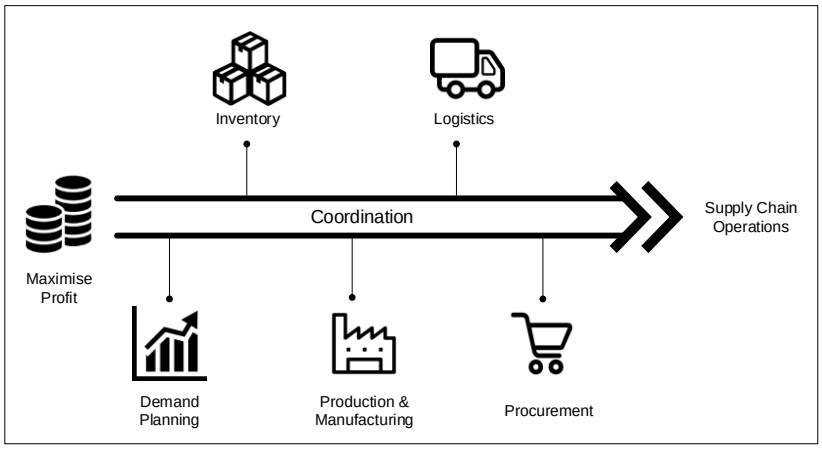

Figure 2.3: The Activities in *SCO* and the Importance of Coordination

Agility has been considered as the ability of firm to better deal with market turbulence and makes SC capable to adopt ever changing market environment. In this regard, BD has an instigating role in agility of organisations through gathering and analysing data. On the other hand, successful inventory decision depends on accurate modelling of demand and demand distribution. Therefore, creating agility in SCO to react quickly to unexpected shift in the market, by increasing visibility, has a significant impact on SC performance (Tiwari *et al.*, 2018).

2.4.5 Logistics

It means all distribution processes involved in delivering product from the stage of raw materials to the end consumer and return service, which aims to satisfy manufacturer, distributer, shipper, raw material supplier, and retailer. Customer expectations have changed. Globalisation, online business, and wide range choices of companies have played a fatal role to raise the level of customer satisfaction, which has raised the necessity to offer product with best quality, lower cost, short time, and best return service. All that increased the pressure on organisations to optimise logistics processes to reach cost and service advantage, in addition to their role in motivating scholars to do research in logistics domain. Some of the research intentions were to design a knowledge- based logistics system (Chow *et al.*, 2005), to propose optimisation model for logistics problem in facing uncertainty about the future (Yu and Li, 2000), and to evaluate logistics capability on firm performance (Lin and Lai, 2017).

In fact, the main trend of logistics service in SC is seeking to outsource their logistics activities to logistics service providers. Jharkharia and Shankar (2007) list the key reasons why organisations are looking for logistics service provider. These are: “needs of organisation to concentrate on core competencies, cost reduction, development of SC partnerships, restructuring of the company, success of the firms using contract logistics, globalisation, improvement of services and efficient operations, etc.” Similarly, Lai (2004) highlights the needs of organisations to find logistics service providers as a quick way to introduce products and service innovations into market. In general, well controlled logistics contributes to minimise the risk in SC service through avoiding the effect of interrupted direct supply of materials resulting from different factors: unforeseen incidents, human factors, organization factors, and natural disaster (Jeske *et al.*, 2013). The key issues in logistics processes have been highlighted in following **Table 2.7.**

Challenges	Sources
Logistics problem in facing uncertainty about the future	(Jharkharia and Shankar, 2007; Lai, 2014)
Outsourcing logistics activities to logistics service providers	(Yu and Li, 2000)
Limited capacity of vehicles and time consumption of the shop floor logistics processes	(Gyulai *et al.*, 2013)

Table 2.7: The Key Issues in Logistics Processes

2.5 Information Technology and Information Management in SC

Informational efficiency has become one of the competitive advantages for organisation as it helps in planning process that directly reflect the firm's condition (Chae *et al*., 2014). It has a vital role in mitigating the impact of risk present in SC activities such as deviation, disruption, and disasters (Pereira, 2009). At the beginning, adapting information technology culture and building its infrastructure in organisations has required large amount of money and time, but over time, IT has accordingly increased its potential and decreased its cost. Some researchers consider IT as one of the main sources of competitive advantage by itself, and others go beyond this border by asserting that IT must be embedded in an organisation's strategy by considering strategic planning of IT in SCM to achieve an effective SCM system (Gunasekaran and Ngai, 2004; Pereira, 2009). IT is an enabler in agile SC that can speed up the seamless information flow to make SC more robust and resilient without impairing its efficiency (Pereira, 2009). Despite its efficacy and importance, IT considered as a source of instability (vulnerability) in the SC, therefor, IT managers should be aware how to implement IT tool in SC to improve the resilience, cooperative, robustness, and eliminate redundant activities (Pereira, 2009).

The past decades have seen an increasing calling to simulate intelligent integrated SC processes through improving information system in terms of sharing real time information and developing firms' information processing capabilities to reach collaborative operational effort. Xu (2011) reviewed the key technologies that help make SC more integrated and improve quality monitoring system as follow:

- ✓ *service-oriented computing (SOC*) is a computing paradigm that takes business application and break it down individual functions and processes as service, at the same time each service can be reconstructed and reused to create new application.
- ✓ *Radio frequency identification (RFID)* is a mobile technology that enables timely product identification and tracking using radio waves in identifying objects.

- ✓ *Agent* is an autonomous software entity that can interact with its environment and respond to other agents, and has control over its internal state and actions, independent components as software agents are suitable for coordinating the complexity of interconnection between activities of independent organisations forming SC.
- ✓ *Workflow management* is implemented across diverse organisations consequently firms have the opportunity to reshape their business processes beyond organisational boundaries; researchers have clarified three types of workflows, firstly, production workflow, secondly, Ad hoc workflow, thirdly, administrative workflow.
- ✓ *Cross-organisational integration definition* is a new way of integrating multi business activities within an organisation by enabling flow and sharing information with suppliers, distributors, and customers. This kind of integration was enabled by the development in enterprise information system.

Gunasekaran and Ngai (2004) determined the key components of IT enabled SCM by conducting literature survey, the major components are: (i) strategic planning, (ii) virtual enterprise, (iii) e-commerce, (iv) infrastructure, (v) knowledge and IT management and (vi) implementation. One of the most important virtual enterprises in IT is enterprise resource planning ERP (Gunasekaran and Ngai, 2004). ERP defined as information technology that serves as massive database to integrate transaction functions in firms from finance, resources, operation, procurement, sales, logistic...etc., and to align business decision, in addition to enhancing transactions visibility across internal functions (Huang and Handfield, 2015). In other words, ERP acts as enabler of sharing information in SCM, and linking internal SC with external SC (Ranjan *et al*., 2016).

New form of IT has emerged new terminology for SC activities and other activities like manufacturing 4.0, industrial internet, and made in China (Tao and Qi, 2017). New form of IT refers to IoT (device to device connection), mobile internet, BD, wireless sensor network, and cloud computing, these emerging technologies facilitate the implementation of sustainable production mode to cope with the global challenges and approach the fourth industrial revolution (Wang *et al.*, 2016). this development in IT manufacturing infrastructures allow to emerge a new form of integration between cyber and physical world called cyber - physical system (CPS), "Data generated in the physical world can be sensed and transferred to the cyber world through IoT and the Internet, and be processed and analysed by cloud computing, BD technologies to adjust the physical world" (Tao and Qi, 2017). As a result of multiplicity,

diversity and evolution of the information system, huge volume of data has emerged with new opportunities and challenges. It is concluded from the literature that organisations which apply traditional analysis methods will not be able to adjust and cope with the requirements of the new stage. Therefore, new concepts emerged to meet the stage requirements and the age of the digital economy such as BD and BDA.

2.6 Big Data (BD) and Big Data Analytics (BDA)

In the literature, BD has been associated with development of digital universe from autonomous cars to smart home device which have made a profound change transforming the way we live, work, and spend our time. International Data Corporate make an estimate of BD that by 2025, nearly 20% of the data will be critical to our daily lives (Reinsel *et al*., 2017). Researchers have addressed disciplinarily revolutionary changes caused by BD at healthcare, public sector, service sector, business management, crisis management, such as the way of taking decision, emerging new management principle, gaining a considerable lead in the trade world, understanding psychological concepts, and discovering significant insight into the past biological history. But foremost, before talking in depth about the influence of BD on the several aspects of life, it is necessary here to clarify exactly what is meant by BD and how does this term emerge, and what BD attributes are.

2.6.1 Big Data

2.6.1.1 Background of BD

There is no consensus of providing an overview of the origins of BD as a term. As per the literature, Diebold (2012) confirmed that first emergence of the term of BD was in lunch-table conversation at Silicon Graphics Inc. in the mid-1990. According to Diebold (2012), before that time both academic and non-academic were using the term without being aware of the phenomena. Contrarily, later academics were aware of the phenomena but not the term. This view is supported by Seddon and Currie (2017) who write that BD emerged during the 1990s with one of the first academic articles published at the end of the decade. Dissimilarly, Duan and Xiong (2015) point out that BD appeared in the 1970 but explosion of publication has been happened since 2008.

One of the experts in BD arena, Bernard Marr, in (2015) on his Linkedin profile, established the origin of BD to 18,000 BCE when Ishango bone was discovered in 1960 and it is considered one of the earliest pieces of evidence of prehistoric data storage, he argued that comparing sticks and notches would help tribespeople to carry out calculation to make prediction such as how long their food supplier will last. He asserts that the first use of the term BD was mentioned by Erik Larson pens an article for Harper's magazine in 1989. In contrast, Wang *et al*. (2015) disagree with Marr's view as they argue that the first use of the term was in 1997 by Michael Cox and David Ellsworth when they presented a paper at the IEEE's 8th conference on visualization.

2.6.1.2 BD Attributes

Doug Laney (an analyst) pioneered of defining the challenges associated managing large set of data in terms of three dimensions 3(V) volume in 2001, Velocity, Veracity, which has become later central to understanding BD (Matthias *et al.*, 2017). McAfee and Brynjolfsson (2012) in their attempt to distinguish between BD and analytics, they determine three key differences which characterising BD, volume, velocity, and variety. Addo-Tenkorang and Helo (2016) stated that McAfee and Brynjolfesson are probably the best-known researchers that defined BD in terms of 3(V), followed by IBM which expanded this definition to include the term dimension of veracity. Microsoft increased BD attributes for variability, veracity and visibility to be 6Vs (Wu *et al*., 2014).

Authors	**BD Attributes**	
(Seddon & Currie, 2017), (Mikalef *et al.*, 2017).	7Vs	Volume, velocity, variety, value, variability, veracity, visualization
(Wang & Alexander, 2015), (Gandomi & Haider, 2015)	6Vs	Volume, velocity, variety, value, visibility, veracity
(Wamba *et al.*, 2015), *(*Li, 015), (Jin *et al*., 2015)	5Vs	Volume, velocity, variety, value, veracity
(Joshi *et al*.,2015), (Ma *et al*,2015), (Addo-Tenkorang & Helo, 2016).	4Vs	Volume, velocity, variety, veracity
(Russom, 2011), (McAfee *et al*., 2012), (Sanders, 2014), (Matthias *et al.*, 2017).	3Vs	Volume, velocity, value

Table 2.8: Scholars and Practitioners Use the Notion of 'V' to Define BD

According to Rehman *et al.* (2016), the key characteristics of BD are namely, (i) volume, (ii) velocity, and (iii) value, then the three new Vs: (i) variety, (ii) variability, and (iii) veracity added later. Finally, visualisation as a BD attribute added by (Seddon and Currie, 2017). In the

Table 2.8, data attributes are presented according to the sources that were mentioned. For the sake of better understanding of BD, based on the literature(e.g. Russom, 2011; McAfee and Brynjolfsson, 2012; Demchenko *et al*., 2013; Leveling, *et al.,* 2014 ; Mishra *et al.*, 2016; Seddon and Currie, 2017), the characteristic can be described by 7Vs as follow:

- ***Volume***: it is considered a distinctive character of BD which refers to the magnitude amount of data stored within the IT infrastructure. As a result of impressive development of technological industries (such as mobile phone, GPS, sensor devices and all kind of electronic devices) we. as a technology consumer, have become a data generator at every single minute whenever we do online shopping, interact on social media, communicate with other people, and navigate our journey way. According to Bernard Marr (2014), taking all the data generated in the world between the beginning of the time and 2008, the same amount of data will be generated every single minute. Some researchers declare that storing big size of data creates a big issue for IT infrastructures dealing with BD.

- ***Velocity*****:** this term refers to the rate at which data is created and become available to all, some scholars believe that velocity is the ever-reducing time taken for data to be structured into new feed. As it is mentioned earlier, due to unprecedented evolution in digital world, data is generated at an atypical rate which emerges the need for real time analytics. It is not about how to deal with BD, but it is about how to keep pace with its growth. Addo-Tenkorang and Helo (2016) found that velocity of data growth is considered as one of the main reasons that make the era of BD different from past data management project.

- ***Variety***: this term refers to the diversity of BD sources and its formats, what makes data big is greater variety of sources than ever before (Russom, 2011). Some examples of these sources are online search, viewing history, social media sharing video and picture, commercial transaction, and other data acquisition devices like Radio Frequency Identification (RFI), and internet of thing (IOT). Walmart has over 200 streams of data, including 40 petabytes of recent transactional data (Bernard Marr, 2017). Data are generated from various channels and contains multidimensional data fields, structured (administrative data, demographic data), unstructured (social media data), and semi

structure data (business-to-business process). However, most of the data is unstructured because it is captured by IT-based innovation.

The above-mentioned 3Vs (volume, velocity, and variety) are the core characteristics of BD, and four other characteristics veracity, value, variability, visibility have been explained as following:

- ***Veracity***: It refers to "the biases, noise and abnormality in data..., veracity covers question of trust and uncertainty" (Daniel, 2015). Demchenko *et al.* (2013) divided veracity dimension of BD into two aspects: data certainty (computer and storage reliability) and data trustworthy which defines the level of reliability of the source of data.

- ***Value:*** this "V" is what practitioners and researcher are working for long time to discover in BD phenomena. What are the potential benefits and what are the possible costs of using BD aiming to explore the current statue and future insights of organisation? Mishra *et al*. (2016) gave a good example of explaining the value of BDA in SCM context through analysing BD related to temperature and weather patterns, Tesco was able to increase their operating margins. Researchers shows that companies that have adopted data-driven decision making achieved 5% to 6% of productivity and output higher than other firms (Watson, 2014).

- ***Variability:*** in this character lies the probable challenges hidden in BD which drives to developing sophisticated programs that help in interpreting the data. According to (Jukić *et al.*, 2015) "variability of BD refers to the possibility of interpreting the data in different way…., a collection of GPS signal recording is open to various interpretation as to what kind of meaning and knowledge they contain". Variability means that the same data in separate times gives different meaning.

- ***Visualization:*** it can be defined as a tool which interprets the patterns and trend that are presented in data in form of chart, graph or picture (Seddon and Currie, 2017). The necessity of visualization of BD comes from a need to make data more understandable, accessible and able to be retaining for future. Sivarajah *et al.* (2017) state that eBay, as one of the e-commerce corporations with millions of users who sell millions of goods

every month, has dealt with BD visualization tool called Tableau. This tool provides visualization software for transforming large and complex datasets into interactive picture and facilitates procedures for eBay employees to visualize search relevant and quality. Another visualization tool has been mentioned by Lavalle *et al.* (2011) is verbal map that depict word frequency which allows vendor to see how their products are perceived.

In answering the question whether BD should hold all its characterises, Kitchin (2014) declares that some data may have many of the characteristics thought to give the meaning of BD (volume, variety and velocity), and other classification of BD may carry a different set of characteristics (7V), or only a single BD attribute (Connelly *et al.*, 2016). Having defined what is meant by BD, next section will discuss different kinds of applications that BD can bring about.

2.6.1.3 BD Applications

Information extracted from BD has become a knowledge asset that can create value for firms (De Mauro *et al*., 2016). Whereas this information is obtained using certain applications that suit organisations' target. BD applications have demonstrated the ability to adapt the different requirements arising from different scientific domains and industrial organisations (Frizzo-Barker *et al.*, 2016). Some of these applications are explained below, such as traceability, customer preference track, improve recommendation system, and managing warning communication during disaster.

- **Traceability**

There is a massive amount of geospatial data generated by GPS devices and mobile phones. For instance, Using GPS-enabled navigation devices that provides geolocation and time information, their user can predict real time traffic pattern and recommend the best time to drivers (Lavalle *et al.*, 2011). Another example about BD-enabled platform of real time tracking is using radio frequency identification (RFID) technologies to trace assets and individuals in addition to track shelf availability, like using attached RFID tags on blood bags to track their location, and constantly monitor their temperatures to ensure their validity for transfusion, and the same for patient's location and monitoring their health statuses (Cheng and Kuo, 2016).

- **Customer Preferences Track**

The existence of web search engine (e.g., Google and Yahoo), e-commerce business (eBay, Netflix), social media (Tweeter, Instagram) allow organisations to present their business online and get the feedback directly from customers (what people think about new product) through observing their comments, mouse clicks, likes, which can be called electronical conversation (Chen *et al.*, 2012). This kind of conversation provides better understanding of buyer's behaviours and makes firms able to influence their shopping by recommending specific products (Watson, 2014). Good example of that was how Starbucks monitored Twitter, blogs, niche coffee forum discussion to discover the customer's reception of a new coffee product, whereas Starbucks spotted that the people like the taste of the coffee, but they find it expensive at the same time. This, however, instigated Starbucks to lower the price (Watson, 2014).

- **Improve Recommendation System**

Recommendation system means personalising the recommendations of website for each user individually. The online recommendation system is a tool that used to improve user experience through recommending products to consumers based on purchase history of all users. It is a complex behaviour that cannot be directly observed from the purchase history data but can be extracted by analysing the immense amount of data generated and collected on e-commerce platforms (Xu *et al.,* 2015). The huge amount of data collected and extracted on e-commerce from different platform offers opportunities and challenges for BDA to create business value (He *et al.,* 2016). Netflix uses recommendation system where a multidimensional tensor represents how different users rate different movies under various contexts, and if they can discover latent features, Netflix should be able to predict a rating with respect to a certain user and a certain item under specific contexts (Guo and Karimi, 2017). Amazon and eBay have adopted personalised recommendation system in their e-commerce platform as an important field in BDA to create value and generate huge effect (He *et al.,* 2016).

- **Managing warning communication during disaster**

As a result of crowdsourcing, speed, and the easy accessibility from mobile devices, social media become the most popularity way to communicate and deliver up to date information

about everything (Carley *et al*., 2016). They play a crucial role in knowledge management system particularly in disaster management. Scholars have addressed the significance of using data produced through social media and mobile phone communication to determine critical needs, select spatio-temporal pattern of individual at near real-time, and identify focusing response during disaster period to minimise contact between populations in global health emergency and to provide early warning in natural disaster like Tsunami (Cinnamon *et al*., 2016; Landwehr *et al*., 2016; Carley *et al*., 2016).

2.6.1.4 Terminologies in BD Era

Some researcher created new terms related to BD while they are writing their researcher like data oil, BD chain and some of them kept repeating some terms. Such terms are new for investigator with no IT background such as cloud computing and Hadoop / Mapreduce. Therefore, this section will try to identify and introduce the most frequent and modern terminology that mentioned in BD literature.

- ***BD chain*****:** in a study which set out to determine the factors influencing BD decision-making quality, Janssen *et al.* (2017) introduced the BD chain term in order to refer to the series of activities that BDA require to be done. It is a chain of collaboration processes that helps to increase the quantity and quality of published data over time including removing noise, transferring needed data into machine readable and linked data. The term chain embodies the analytics sub-dimension in BD (Janssen *et al.*, 2017).
- ***Big social data***: social data stream characterise as real time data representing in sharing information at any time through using social media applications, which includes posting photos, sharing a statue, or narrating an event (Nguyen and Jung, 2017). Big social media has potential to identify an early event by implementing appropriate approach (Nguyen and Jung, 2017).
- ***Cloud computing:*** The trendiest technology that accompanied the emergence of BDA is the use of cloud in conjunction with data, organisations have been towards the use of software as a service (SaaS) that offers an attractive alternative with lower cost, back up recovery, and quick deployment (Wang *et al.*, 2015). The two forms of cloud-based service have been described by Watson (2014) as follow: public clouds are offered by third party and private cloud are implemented within a company.

- ***Data Café*:** Walmart, as the world's biggest retailer with 20,000, is taking the lead of adopting BD infrastructure and utilising BDA to make sense of all this data by building the world' biggest private cloud to process 2.5 petabytes of data every hour. The company has recently completed construction of a state-of-the-art analytics hub which is called Data Café. This tool has reduced the amount of time to solve business problem by manipulating and visualising over 200 streams of internal and external data, including 40 petabytes of recent transactional data according to Bernard Marr (2017) LinkedIn profile.
- ***Hadoop/ MapReduce*:** "Hadoop is about data variety, not just data volume. Hadoop is an analytics platform" (Russom, 2011). Hadoop is one of the BD processing technologies that is used to improve data processing capability through achieving the distribution storage and analysis work of collected BD (Yan *et al.*, 2014). The main core of Hadoop is MapReduce which is a programming paradigm that allows processing vast data set with large number of distributed clusters of servers (Gu *et al.*, 2017).
- ***Internet of things* (IoT):** it is a set of electronic devices that generate data at high-speed rate and considerable amount to describe the objects and processes in their current situation. IoT includes wireless sensors, Radio Frequency Identification RFI, and communication technologies that provide information technology infrastructure to enable the information exchange in real time and convenient manner (Zhang *et al.*, 2017).

2.6.2 Big Data Analytics (BDA)

Many researchers have called to take action toward BD to be collected, stored, analysed and visualised in real time at required authentication verified and required security and privacy level (Gantz and Reinsel, 2012; Demchenko *et al.*, 2013; Kache and Seuring, 2017; Jhang-Li and Chang, 2017). In recent years, BDA importance has increased in various fields. Analysing BD is recognised as a tool for generating a new culture of decision making and improving organisation predictions through extracting knowledge from information and creating optimal methods for management. BD is widely regarded as a main motivation for transforming the way people work and live (Gamage, 2016). However, BDA as a concept is not new.

Moreover, mathematics technique (regression), simulation and machine learning which are used for analysis as analytical techniques were already existed, the new is what comes with BD such as advanced computer technologies and software in addition to the new attributes that characterise BD (e.g., diverse sources, speed rate generation, immense size) (Watson, 2014). Gantz and Reinsel (2012) declare that by 2020 a third of the data more than 13,000 Exabyte in the digital universe will have value if it is tagged and analysed. With this importunity of extracting value information of BD, there is an urgent need for advanced analytic technique.

The earliest organisation to conduct BDA and to have impact on improving business process were banks and e-commerce (Wang *et al*., 2016). Lavalle *et al.* (2011) addressed on his survey research that one of the salient constrain to adopt BDA is lack of understanding the potential of BDA on business improvement. Lavalle *et al.* (2011) have mentioned that the major contributing factor for reducing the time for cleaning up the data is defining the desired insights which determines targeted data needs and exact process improvements that the insights identify.

2.6.2.1 The Definition of BD & BDA

Wamba *et al.* (2015) define BDA as a holistic approach to manage, process, and analyse 5 Vs (i.e., volume, variety, velocity, veracity and value) in order to create actionable insights for sustained value delivery, measuring performance and establishing competitive advantages. On the other side, Chen *et al*. (2012) gave BDA definition from another dimension representing in the challenges facing BDA adopter in having sophisticated analytical technique and technology More recently BD and BDA have been used to describe the data sets and analytical techniques in applications that are so large (from terabytes to Exabyte's) and complex (from sensor to social media data) that they require advanced and unique data storage, management, analysis, and visualisation technologies. Having discussed BDA and its definition, the next section is to address BDA techniques, tools, and approach.

Universal definition for BD has not established yet, there is diversity of how organisations, data scientists, researchers and practitioners are looking at BD. It has been defined from manifold perspective as shown in **Table 2.8**. We can classify these definitions based on three directions as follow: first direction defines BD depending on significances, applications, and opportunities (e.g., Martin, 2016; Hofmann, 2015; Jin *et al*., 2015). Second direction defines

BD in terms of important attributes notion of" V" (e.g. Kshetri 2014, Russom, 2011). Third direction defines BD based on the fundamental requirements to reap the benefits of using BD as adopting sophisticated and modern storage and analysis techniques (e.g., Sanders, 2014; Rathore, *et al*., 2015; Wang and Alexander, 2015). In today's academic literature, BD is far clearer than the definition that was used in the past. We can explain the philosophies of BD more precisely than ever before based on their attributes. Based on the definitions in **Table 2.9** the author of this study defines BDA as *a tool that uses a huge volume of data generated from diverse sources at high speed, analysed by advanced techniques in order to produce detailed image of current situation, predict future, and make the past readable when needed.*

A broad range of technique and technology have been developed to explore patterns from large volume data by number of disciplines such computer science, economics, mathematics, statistics, and other expertise. At the same time, BDA includes a number of disciplines, statistics, data mining, machine learning, optimisations methods, social network analysis and visualisation approaches. Every one of these has been applied to a particular field to achieve different goals with specific computational strategy (Chen and Zhang, 2014). By a way of illustration, advanced statistical technique (regression, factor analysis, clustering, and discriminant analysis) is the most used analytical technique in business schools according to Chen *et al*. (2012).

Source	The definition	Dimension of Definition
(Russom, 2011)	BD is not just about giant data volumes; it is also about an extraordinary diversity of data types, delivered at various speeds and frequencies.	BD attributes
(Manyika *et al.*, 2011)	BD refers to datasets whose size is beyond the ability of typical database software tools to capture, store, manage, and analyse.	BD requirements
(Kshetri, 2014)	BD involves the availability of data in real time, at larger scale, with less structure, and on different types of variables than previously used	BD attributes
(Sanders, 2014)	BD is simply lots of data that the quantity can no longer fit into the memory that computer use for processing.	BD fundamental requirements
(Watson, 2014)	BD is a term that is used to describe data that is high volume, high velocity, and/or high variety; requires new technologies and techniques to capture, store, and analyse it; and is used to enhance decision making, provide insight and discovery, and support and optimize processes.	BD attributes Requirements opportunities
(Hashem *et al.*, 2015)	BD is a set of techniques and technologies that require new forms of integration to uncover large hidden values from large datasets that are diverse, complex, and of a massive scale.	BD attributes requirements
(Hofmann, 2015)	BD is the ability of society to harness information in novel ways to produce useful insights or goods and services of significant value	BD significances, applications, and opportunities
(Rathore, *et al*., 2015)	BD are usually generated by online transaction, video/audio, email, number of clicks, logs, posts, social network data, scientific data, remote access sensory data, mobile phones, and their applications. These data are accumulated in databases that grow extraordinarily and become complicated to confine, form, store, manage, share, process, analyse, and visualize via typical database software tools	BD attributes and requirements
(Jin *et al*., 2015)	BD can be regarded as a bond that subtly connects and integrates the physical world, the human society, and cyberspace.	BD significances, applications, and opportunities
(Wang & Alexander, 2015)	BD is data that exceeds the processing capacity of conventional database systems.	BD fundamental requirements
(Osuszek *et al.*, 2016)	BD is a broad term for data sets so large or complex that traditional data processing applications are inadequate. Challenges include analysis, capture, data curation, search, sharing, storage, transfer, visualisation, querying and information privacy	BD fundamental requirements
(Gartner)	BD is high-volume, high-velocity and/or high-variety information assets that demand cost-effective, innovative forms of information processing that enable enhanced insight, decision making, and process automation	BD attributes Requirements opportunities
(Martin, 2016)	The term “big data” refers to the marriage of modern predictive tools with these large data sets of consumer information	BD significances, applications, and opportunities.
(Wamba & Akter, 2019)	BD is defined as “a holistic process that involves 5V (volume, velocity, variety, value, and veracity) in terms of collection, analysis, use, and interpretation of data for various functional divisions, with a view to gaining actionable insights, creating business value, and establishing competitive advantages	BD attributes, and opportunities

Table 2.9: Set of BD Definitions and Perspectives

2.6.2.2 BDA Tools and Technique

Manyika *et al.* (2011) identified a number of widely used BDA techniques that includes: cluster analysis, genetic algorithms, natural language processing, machine learning, neural networks, predictive modelling, regression models, social network analysis, sentiment analysis, signal processing and data visualisation. Each of these techniques has been applied to each of the five dimensions of SCO to achieve specific goals relevant to each of the dimensions with specific computational strategy. Gandomi and Haider (2015) reviewed analytics technique for structured and unstructured BD as follow: text analytics (text summarisation techniques automatically, question answering, sentiment analysis), audio analytics (LVCSR system, phonetic-based systems), video analytics (server-based architecture and edge-based architecture), social media analytics (content-based analytics, structure-based analytics) and predictive analysis (statistical methods).

By drawing on the concept of BDA tools (platforms), Chen and Zhang (2014) have been able to show that analytics tools have three classes: Firstly, batch processing tools based on Apache Hadoop infrastructure as a platform for storing and analysing of data across parallel cluster of data. Secondly, stream processing tools like storm, S4 and Tibco Stream Base which provide real time processes for data and ability to take immediate action. Thirdly, the interactive analysis process which allowed data to be reviewed compared and analysed in Tableau, graphic format, verbal map, and other display way.

2.6.2.3 BDA Approach

Watson and Marjanovic (2012) conclude their research that business intelligent is limited to descriptive analytics. A broader perspective has been adopted by Wu *et al*. (2014) who extend the role of business intelligent to include predictive analysis by stating that the main aim of BDA is to seek for business intelligent which enable to make right decision based on prediction. BD can provide organisation the descriptive view about current situation and problems, the predictive tool to mitigate future difficulties and to exploit opportunities, and the prescriptive to be aware of what should happen. From above discussion, it can conclude that the crucial contribution of BD is represented in the applications of three data analytics models of descriptive analytics, predictive analytics and prescriptive analytics (Daniel, 2015).

- ***Descriptive approach*:** descriptive analytics helps to fathom what is happening and what happened, it is described as a simple form of BDA to be used for summarising data describing current and past events to make big and complex set of data (large volume of historical and administrative data are used in this kind of analytics) more easily accessible for interpreting by human. Simple statistical methods, such as mean, median, standard deviation are used in descriptive analytics (Coleman *et al*. 2016; Daniel, 2015; Phillips-Wren and Hoskisson 2015; Rehman *et al.*, 2016; Sivarajah *et al.*, 2017). Wang and Hajli (2017) assert that descriptive analytics is such a way to empower ability to describe data in summary form for exploratory insights and to answer what has happened.

- ***Predictive approach:*** predictive analytics helps to discern what could happen, it pertinent to many quantitative approaches which include employing sophisticated statistical tools, data mining and machine learning technique aimed at detecting relationship and generating right prediction of extraction information of large amount of data to reduce the degree of uncertainty (Wang *et al*., 2015; Waller and Fawcett 2013). In other words, predictive analytics is a set of process to uncover future event pattern and make prediction about categories of data that are not available from structured, unstructured and semi-structured data (Kokina *et al*., 2017).

- ***Prescriptive analytics:*** prescriptive analytics assist to determine what should be done. It refers to decision-making mechanism and tool (Nguyen *et al.,* 2018). It is described as a new kind of analytics and the last process of BDA which transforms the result of descriptive and predictive analytics into business decision (Coleman *et al.,* 2016; Wang and Hajli, 2017). This view is supported by Vojtovič *et al*. (2016) who state that prescriptive model takes advantage of the descriptive model results and the hypothesis's substantiation of predictive model and develop a strategy for every possible case. In the same vine, Rehman *et al.* (2016) declare the same statement that, for prescriptive analytics, enterprises optimise their business models based on the findings provided by predictive analytic models. Some of techniques used in analytics distinguish prescriptive analysis such as optimisation, simulation, and heuristics-based predictive modelling technique.

2.6.2.4 BDA Strategies for Successful Implementation

The significances of BDA embedded in its capabilities that allow managing immense amount of unstructured data to get demanded insight which empower decision making process. Wang *et al.* (2015) define BDA capability as "the ability to acquire, store, process and analyse large amount of health data in various forms and deliver meaningful information to users that allows them to discover business values and insights in a timely fashion."

Numerous studies have drawn attention to the sorely need of identifying the strategies and requirements for wealthy use of BDA. In this context, the current study will report some of these studies starting with Wang *et al.* (2015) who recommended five strategies for being successful in BDA domain. First strategy is *"implementing BD governance,"* second strategy is *"developing an information culture"*, third strategy is *"training key personnel"* to use BDA, fourth strategy is "*incorporating cloud computing into the organization's BDA"*, and fifth strategy is "*generating a new business idea from BDA"*.

Watson (2014) argues that there is important requirement for being successful with BDA. Beginning at addressing business needs clearly, organisation's project should be business driven rather than technology driven. It needs a strong committed sponsorship which is considered as a principal factor to guarantee success with any IT project. It requires alignment between business strategy and BDA projects. Being successful with BDA demands a fact-based decision-making culture. Such culture includes many procedures that should be done by senior management related to replacing some people who cannot and will not adjust, increasing availability of training in data analytics, discount outdated methods. Lastly, Strong data infrastructure for optimising use of applications, without data infrastructure application will never be completed.

In line with this evolving view of adopting strategies to make best use of BDA, Gupta and George (2016) address seven resources that will support firms to create BDA capability encompassing *Tangible* resources representing in: data (internal, external, merging of internal and external); technology (Hadoop, No SQL); basic resource (time investment); *Human* (managerial skills, technical skills); and *Intangible resources* (data driven culture, intensity of organisation learning). Similarly, survey conducted by Akter *et al.* (2016) have shown that

management capability, technology capability and talent capability are the main conditions to build an overall BDA capability climate. Other studies were limited only to technical needs for effective applications of BDA such as Wang and Hajli (2017) who addressed three BDA architectural components: data aggregation (like data warehouse tool and Hadoop distributed file system), data processing (including BDA technique), and data visualisation (which has visual dashboards/system and reporting system/interfaces).

Although the debate continues about the best strategies for effectively establishing BDA environment, to date there has been a little agreement on conceptualising what BD infrastructure needs. Concisely, it is important to have management skills, technological competencies, and sophisticated analytical toolkits to constitute BDA climate. In the next section is a discussion over the significance of BDA through reviewing some scholarly research about this topic from different fields.

2.6.2.5 The Significance of BDA

As it was pointed out before, the significant impact of BDA has been the subject of intense debate, and researchers have addressed disciplinarily revolutionary changes caused by BD at different fields. This section will review some of studies that conducted BDA. In 2017, Chen and Lu published a paper in which they described identifying factors influencing demolition waste generation in Hong Kong using well-structured transaction data as a BD and statistical methods to find out the hidden pattern on demolition waste generation and isolate the effect of the factors to identify the one that really matter to demolition waste generation. He *et al.* (2016) exploit the advantage of user's social connection influences of travel dataset using individual travel history and information on social relationship between users, the aim of this study is to enhance the travel-package recommendation quality in e-tourism by providing a unified recommendation model which integrates various type of information.

In knowledge management system, particularly in disaster management, Carley *et al*. (2016) demonstrate the importance of collecting and analysing data from social media especially from Twitter for disaster planning management and early effective alert. They conclude that through collecting and analysing data from social media, we can have the local population distribution and the language that they can communicate with, who is online and who are the local opinion leaders.

One of the remarkable studies in BDA has been done by Guo *et al.* (2017) to identify the key dimensions of consumer satisfaction extracted from valuable comments provided by hotel visitors, their target was consumer review website, TripAdvisor, using automated techniques for data collection and analysis, in addition to these reviews they have extracted and stored numerical data representing in rating. They utilised laten Dirichlet allocation LDA a generated statistical model to discover a matrix of the most important aspects influencing hotel customers satisfaction from big numbers of reviews, and they further run a stepwise regression analysis based on equation to compute the impact of the five ratings on the degree of consumer satisfaction. The analysis means applied in this case have identified the major contributing factors of customer satisfaction from user-generated data that are not found via traditional methods and have provided deep insights to guide decision makers in their attempting to improve service quality.

In cleaner production research domain, Zhang *et al*., (2017) introduced an overall architecture of the issue on how to utilise BDA in context of product lifecycle management and the whole cleaner production process in order to solve key problems in capturing lifecycle data, discovering knowledge from this data, and sharing discovered knowledge amongst all lifecycle stakeholders. Their findings reported that applying big data-based analytics for product life cycle (BDA-PL) provides an advanced analytics tool to take a deep dive into real-time and historical manufacturing and maintaining process, detect hidden relationship among various stages of lifecycle, discover important insights, and enhance the elements that have a strong influence on the cleaner production. Much like the situation in industrial, governmental, and educational community, healthcare organisations are facing huge volume of data generated from various sources such as genomics-driven data (genotyping, gene expression) and payer–provider BD (insurance records, patient feedback, electronic health records, pharmacy prescription, and responses) (Chen *et al*., 2012) which needs to be analysed to improve service quality, operational efficiency, and financial performance to benefit the stakeholders at health sector.

Wang and Hajli (2017) performed a content analysis for real world success implementation cases from multiple sources to understand how health organisations can capture business value from BDA, and they found that the potential benefits driven by business analytics in health care can be grouped in five categories: (1) IT infrastructure benefits; (2) operational benefits; (3) organizational benefits; (4) managerial benefits; and (5) strategic benefits.

Theme of Traditional Data Analysis	Theme of BDA	
Data are mostly structured, collected by companies through various legacy systems, and often stored in commercial relational database management systems (RDBMS). The which was the only query processing program (Chen, Chiang and Storey, 2012)	New Hadoop- and MapReduce-based systems have become another viable option for BDA in addition to the RDBMS(Chen, Chiang and Storey, 2012)	Structure
Relational database, Data is stored in rows and columns and can be accessed through SQL queries(Watson, 2014)	Non-relational Database can store data of any structure, and do not rely on SQL to retrieve data (though some do support SQL and are perhaps better called "not only SQL databases").(Watson, 2014) It has a unique ability to analyse semi-structured data or unstructured data(Wang, Kung and Byrd, 2016)	Storage
Data analytics aiming to investigate consumer satisfaction has restrictions pertinent to utilizing cross-sectional questionnaire surveys and focus groups, which is limited by number of respondents (Guo, Barnes and Jia, 2017)	Using online reviews voiced by consumer as a data for analysis do not suffer from these restrictions (limitation of respondents) (Guo, Barnes and Jia, 2017)	Content
Scope of traditional data sources is limited, which result in less information, less facts, and uncertainty decisions.	BDA has ability to analyse and visualize more type of information than ever before, which in turn capable to provide more facts for decision making by combining information from multiple sources (Watson, 2014).	Scope
Data quality in the past was good considering the limited and well known sources in data processing (Hashem *et al.*, 2015),	BD is described as a poor data quality by cause of collecting data from different sources (Hashem *et al.*, 2015).	Quality
Traditional analytics concentrate mainly on improving key performance indicators for better insights Xu *et al*., (2016).	BDA usage aims to follow the flow of information and analyse huge volume of data in real time Xu *et al*., (2016).	Aim/Focus

Table 2.10: The Difference between Data Analysis and BDA

In the same vine, Cheng and Kuo (2016) conducted a pilot experiment to investigate the significance of the implementation of the RFID-enabled platform for hospital ward management through keep tracking the location of patient, personnel, and medical equipment for two medical worlds of the intensive care unit of one of the largest public general hospital in Hong Kong PWH. They installed RFID tags to the patient, caregivers, and equipment in addition to place four RFID readers to track the location of the objects. This case has shown that utilising FRID technology empowers real time monitoring and tracking of objects constantly, reporting of ward statistic, and providing analytics. Overall, this study supports the view that utilising BD generates values to benefit the organisation stakeholders. Therefore, **Table 2.10** was conducted to show the difference between traditional data analysis and BDA.

2.7 Interest in BDA within SC

To reach the goal of this study, which is to describe the potential of BDA in SCO, the aim of this section is to review BDA publications in relation to SCM considering the chronological order for this research, then examining the existing literature related to BDA applications in each function in SCO.

2.7.1 Early Stage of Conceptualising BD in SCM

Cecere (2012) used a survey based on discussion with 32 industry leaders working on SC to help managers in better understanding of BD concepts and techniques, and to describe the current situation to which extent SC leaders are ready for this new phenomenon. A survey completed by 53 respondents at over 40 companies concluded that: 36% of respondent companies have a cross-functional team for assessing the potential of BD for the SC, and the responses demonstrate a low understanding of the BD concept by leaders. The survey revealed that SC mangers are much more comfortable in dealing with structured data than unstructured data, in addition to the fact that data is growing in the enterprise remarkably. One year later, Cecere (2013) investigated how SC mangers are building capability to harness BD through conducting a survey distributed to 123 retailers, manufacturers, wholesalers, third party logistics providers, and distributors. The study recommended that taking advantage of using BD requires a new form of leadership, adopt sophisticated technologies, and redesign process.

At the same year, Waller and Fawcett (2013) had two publications relevant to SC and BD; they defined data science and predictive analytics in context of SCM and provided examples of discipline related to predictive analytics with research question from this application stemming from management theory. The significance of using BDA to improve operation processes was highlighted by Jeske *et al.* (2013) who classified the dimensions of using BDA across the industries (as shown in **Figure 2.4**).

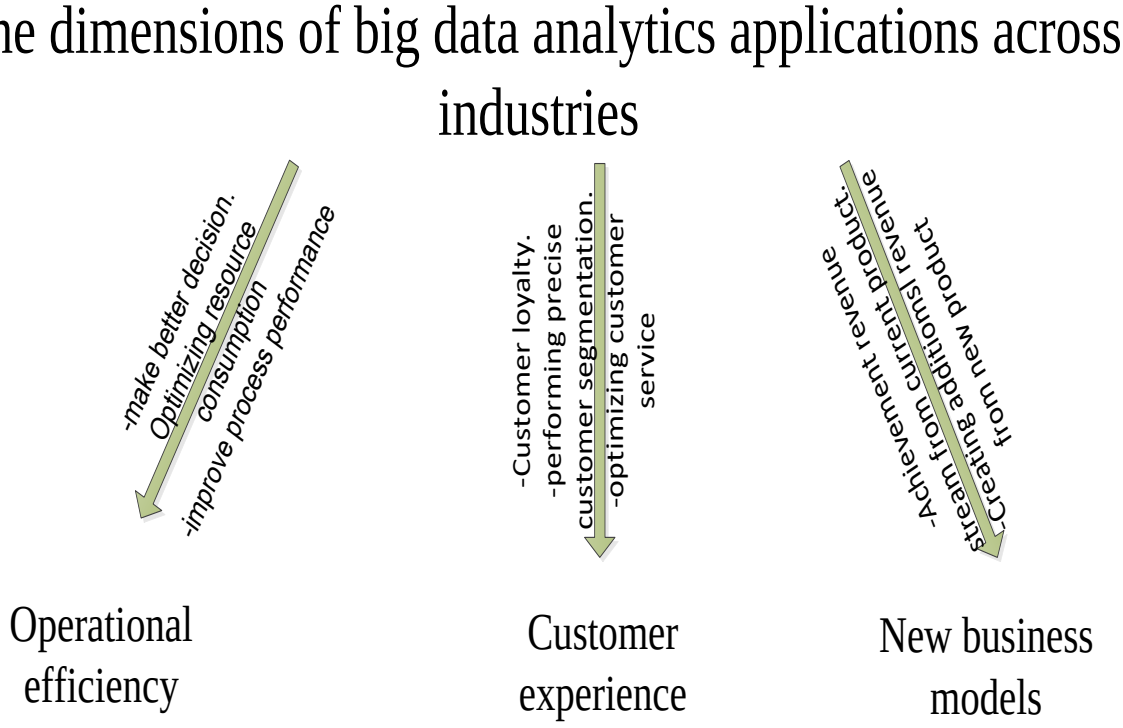

Figure 2.4: Application of BDA across Industries

In their study on SC analytics, Chae *et al.* (2014) defined SC analytics as "the use of data and quantitative tools and techniques to improve operational performance, often indicated by such metric as order fulfilment and flexibility, in SCM". They tested the relationship between utilising data, quantitative tools, technique, and increasing the SC planning and performance capabilities. Their results reported that there is a real impact of analytics on SC performance resulting in increased chance of acquisition competitive advantage and performance improvement.

The problem of finding solutions for enhancing the SC visibility based on a data source classification and potential benefit was studied by Leveling *et al*. (2014). The first systematic review study of BD in the era of logistics was reported by Frehe *et al*. (2014), who conducted a case study analysis in addition to literature review and interviewed experts to capture the current state of BD in logistic. The study showed that due to costly infrastructure, lots of data collected from diverse sources has a lack of analytical opportunities. The importance and influence of data quality on SC processes have been discussed by Hazen *et al*. (2014) who stressed that monitoring and controlling data quality by using application of statistical control is critical for SC.

2.8 The Start of Empirical Stage

The year of 2015 has slightly witnessed a shift toward empirical studies in attempting to touch BD and extract the insights inside it to put them in decision makers' hands. It also witnessed a remarkable development in proposing a novel approach, in addition to presenting an analytical framework for analysing the potential role of BD in SC. Li and Wang (2015) gave a good example of using unstructured data to support SC decision, they used data generated from sensor network that record time and temperature with which food product are stored and delivered to predict more accurate timely product shelf-life information, which in turn support pricing policy. The study of the role of BD levers in reducing the problem effect in SC (such as bullwhip effect) was first carried out by Hofmann (2015), who applied control theory and used the system dynamic approach to show the impact of BD attributes on the bullwhip effect. The study found that the BD lever "velocity" has crucial impact in decision making in the context of SCM.

On the topic of social media data and SC, which is considered as an external data for SC, Chae (2015) stated that there is lack in research identifying the significance of social media data for SC practice and research. Therefore, he introduced a novel analytical framework combined of three types of research technique: descriptive analytics, content analytics, and network analytics. This framework has potential to explore the possible role of Twitter in SC context. As for data generated within SC processes through using IoT devices (RFID), Zhong *et al.*, (2015) proposed a BD approach to mining frequent trajectory patterns hidden in RFID-enabled manufacturing data for supporting further an advanced logistics decision making.

Chen *et al*., (2015) viewed the organisational usage level of BDA in value creation as a dynamic capability and identified the key associated factors that facilitate organisation's level of BDA usage in the domain of SC. The above authors carried out a survey to test an integrated theoretical model based on dynamic capability theory and technology organisation environment (TOE) framework. The findings of this research reported that the usage of BDA has a positive impact on asset productivity and business growth.

Astonishing promising benefits of BD does not lie in data acquisition from various sources, but the issue is how to make the best possible use of data to get the desirable insights and information. Similarly, in spirit with the latter statement, Tan *et al.* (2015) reported that "what manger need is an analytic infrastructure that use BD as input to make more informed strategic

decisions", and they proposed and tested an analytic infrastructure based on deduction graph technique. The aim of this approach is to incorporate firm's existing competence set of knowledge and information with other firms to capture the potential of innovation capability (produce new product) accorded by BD.

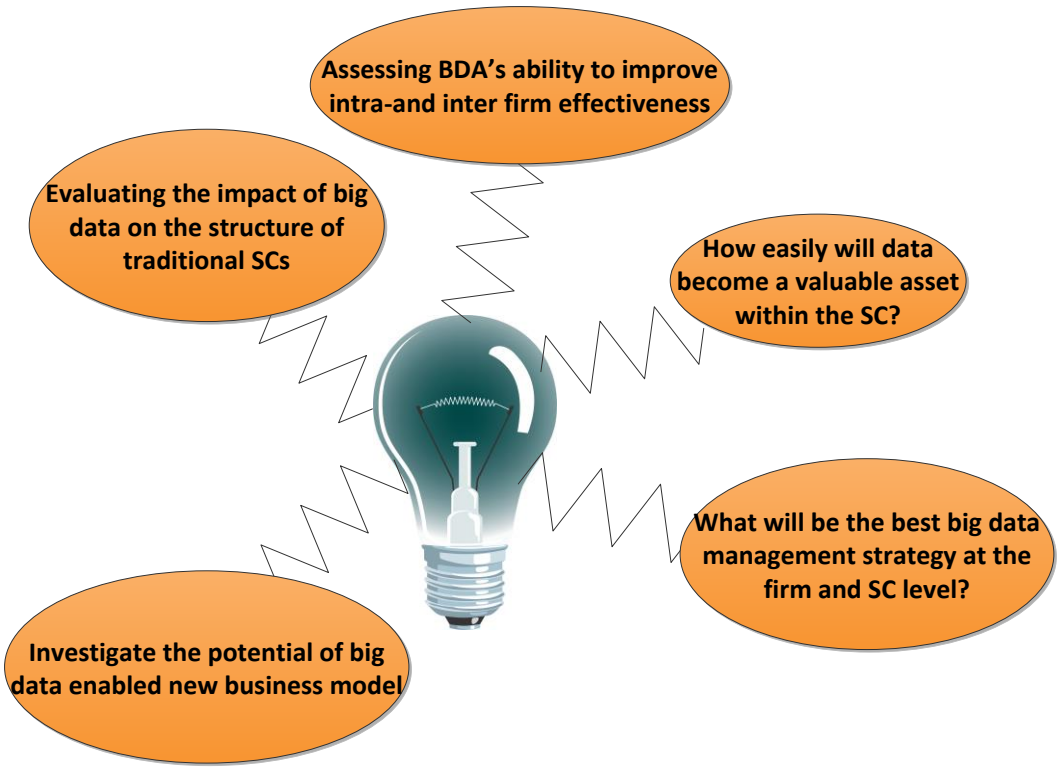

Figure 2.5: Further Research Directions in BD and SCO

To comprehend the significant data value in improving SCM, Wang and Alexander (2015) presented a comprehensive view of BD concept and its characteristics, they also listed four vital benefits of BD in business administration and SCM as follow: more enhanced visibility and product quality, higher operational efficiencies, increase customer engagement, and new business model with better prediction. Schoenherr and Speier-Pero (2015) conducted a survey of 531 SCM professionals in order to have insights into current use, motivation, benefits, and barriers to predictive analytics in SC domain. The authors stressed that one of the main obstacles for grasping the full potential of SCM is lack of trained talent. Wamba and Akter (2015) collected and analysed 17 research studies in Scopus related to BD and SC to highlight the potential of BDA in SC and recommended future research directions as shown in **Figure 2.5.**

2.9 BDA in SC as a Research Trend

In 2016, calling for BD and BDA related research in many disciplines was academic journals trend, and more research articles in this field emerged. Zhong *et al*. (2016) investigated the current state of BD applications and its technology used in typical service and manufacturing SCM, the challenges, opportunities, and future perspectives in service and manufacturing. SCM were classified into six aspects: storage technology, data processing technology, data visualization technology, BDA, model, and algorithm for decision makings. In demand chain management context, Li *et al*. (2016) reviewed the role of BDA in optimising demand chain management performance through using BDA tool, they found that BD enables companies to understand their customer's habits, needs, behaviours, and thoughts which in turn play a crucial role in fulfilling the main target of SCM customer satisfaction. In other words, the importance of BD comes from its ability to support sharing information more easily and efficiently among SC partners.

In an attempt to cover the lack of research related to BD and predictive analytics assimilation influences on SC and organizational performance, Gunasekaran *et al.* (2016) carried out a survey amongst 315 firms to test the proposed model based on resource-based view theory (RBV), which considers connectivity and information sharing as main resources to build capability (BD and predictive analytics assimilation) that impacts SC and organisational performance. The study concludes that BD and predictive analytics assimilation as a capability is dependent on the following resources: information sharing and connectivity. Their second conclusion confirms a positive relationship between BD assimilation and SC performance which subsequently impacts the achievement of competitive advantage positively.

One study by Richey *et al*. (2016) used the native category qualitative interview approach in SCM and logistics to develop an industry grounded definition of BD in SC including its dimensions and issues. They inferred by analysing definition set of industry professionals as following: *First*, there is no international definition and understanding of BD. *Second*, BD has four dimensions (volume, velocity, variety, and veracity). *Third*, the key benefits of BD lie in; better decision making, data security, adequate storage, operational efficiency, and transparency in partnerships to consume BD. A large and growing body of literature has investigated the previous studies relevant to BD and SCM to conceptualise BD role in SC process and strategy by implementing systematic literature review.

For example, Mishra *et al*. (2016) used the technique of bibliometric and network analyses to evaluate 286 articles published between 2010 and 2016 in order to cluster future research concerned in BD and SC in which researchers could be determined to investigate in. Similarly, Wang *et al.* (2016) reviewed the literature on the applications of BD business analytics on logistics and SCM covering the period from 2004 to 2014. Their findings show the significance of BD business analytics for logistics and SCM through enabling organisations to measure the performance of various area in logistics and SCM. Another systematic literature review by Feki *et al*. (2016) was introduces in this field, they recommended the use of different methodologies (qualitative and quantitative) to investigate the impact of BD and SC, as well as expand in using more theories than used before like resource-based view, systems theory, and contingency theory.

To examine the real impact of current application of BD on creating competitive advantage, Matthias *et al*. (2017) used current literature and secondary research (which examines vendor offering) to evaluate organisational BDA usage and to assess whether the outcome of BD matches the widely presented potential. They proposed a framework of desirable outcome of BD applications through conducting content analysis for each of the descriptive paragraph of the cases studies (see **Figure 2.6)**. Matthias *et al*. (2017) emphasised that there is potential in using BD to discover the hidden insights for sustainable performance although there was limitation with their case studies, and they suggested extensive range of further research to assist in solving number of problems like access and reliability, staff requirements, operation management capacity (how much data can cope with), identifying the new skills people need in order to be able to maximise the potential that BD offers.

To estimate the significance of different dimensions and subdimensions of BD-driven SCA capability model and their overall effects on SC agility and firm performance, Wamba and Akter (2019) used resource-based view (RBV) and the dynamic capability theory to develop a multi-dimensional SCAC model. Then, they tested the model using data collected from SCA professionals, managers, and mid-level manager in the USA. In the same vine, Dubey *et al.* (2019) draw on the resource-based view of the firm, institutional theory and organisational culture to develop and test a model that describes the influence of BD and predictive analytics for improved SC and operational performance; their model was examined through data of 195 responses. Wamba *et al*., (2020) suggested that BDA has positive effects on improving SC

agility, SC adaptability, and performance measures but these effects are contingent upon the level of environmental dynamism. Their research draws on the dynamic capability view of the organisation under the contingent effect of environmental dynamism. They tested their research hypotheses using a survey of 281 responses.

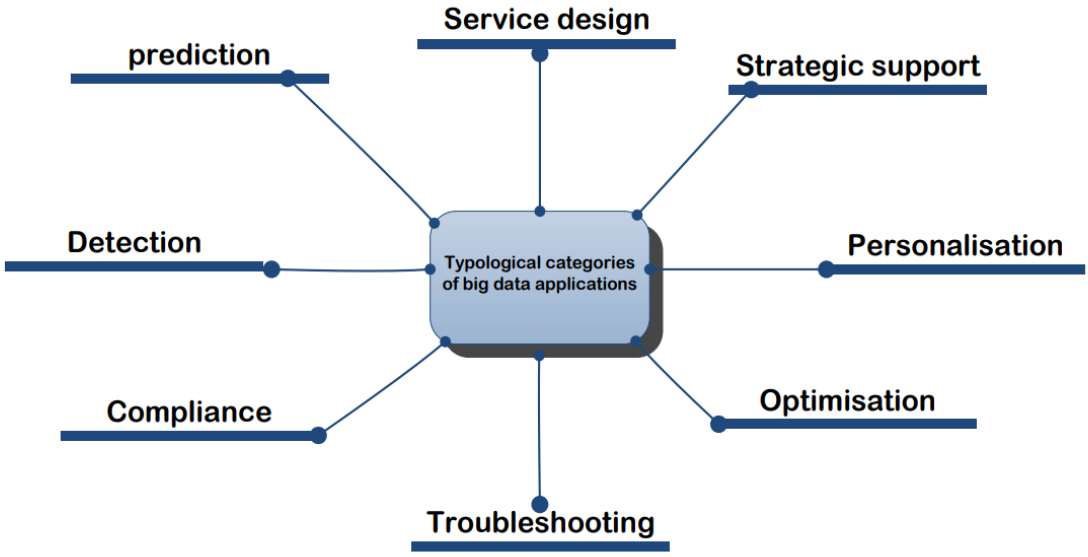

Figure 2.6: Typological Categories of BD Applications (Author)

Source of Content (Matthias *et al*., 2017)

More researcher used resource-based view and dynamic capability theories such as Mikalef *et al*., (2020); they investigated the indirect relationship between a firm's BDA capability (BDAC) and competitive performance. Dubey *et al*., (2020) tested the role entrepreneurial orientation (EO) on the adoption of BDA which in its turn influences improved operational performance, they employed dynamic capabilities view of firms and contingency theory to develop and test a model that describes the role of EO on the adoption of BDA powered by artificial intelligence and operational performance. Regarding industry 4.0 and disruption risk, conceptual research has been conducted by Ivanov and Dolgui (2020) to explain the role of digital SC twin as a model in achieving end to end SC visibility for the sake of improving resilience and testing contingency plan. They stressed the urgent needs of digital twins for mapping supply networks and ensuring visibility, especially with risk like Covid-19 when many organisations needed to adopt new polices quickly.

2.10 BDA Optimising SCO

Businesses need to make informed SC and operational decisions to improve effectiveness and efficiency. Organisations, thus, need to focus on reshaping proactive strategy formulation and decision-making based on BDA in SCO. In addition to presenting how BDA optimises SCO in terms of enabling autonomous corrective control action, agility, and enhancing real forecasting, i.e., achieving the benefits of adopting BDA for each of the five dimensions of SCO: demand planning, manufacturing, procurement, inventory, and logistic.

2.10.1 Demand Planning

Customer demand forecasting is the most crucial concept of prediction leading to reducing uncertainty and increasing profitability in the entire SC. One of the leading examples is predicting customer demand using electronic commerce data. Accurate demand prediction result in less inventory pressure and cut down its direct factor for bullwhip effect (Li *et al.*, 2018). See-To and Ngai (2018), who provided analysis of the BD collected from transactions data and customer review data to improve sales forecasting, and to reveal the influence of customer sentiment on product sales, have addressed the effectiveness of demand planning. They found that utilising BDA for demand planning has a profound consequence for inventory. Real time sales forecasting offers an optimised solution for the online inventory management, reducing the cost of stocking and avoiding under stocking.

With the dilemma of continuously changing customers' demands, BDA is an effective tool that enables companies to predict precise demand from an increasing volume of data. For example, an accurate prediction of sales performance is highly beneficial for long-term development, as it has significant impact on marketing strategies and inventory management through enabling managers to make a competent market strategy (Lau *et al.*, 2017). Another advantage of analysing BD aiming to real demand planning is developing consumer centric sustainable SC, by means of carrying out cluster analysis on consumers' information from Twitter in the form of BD (topic sentiment mining) to investigate the purchasing behaviour of consumers (Mishra *et al.*, 2017). This mined information helps to sharpen the competitiveness and to timely regulate the inventory and then control the inventory cost. The outcome enhances management's decision-making and enables firm's sustainable competitive advantage *(*Yuan *et al.*, 2018).

2.10.2 Manufacturing

Analysing production and manufacturing data embedded in IoT drives to improve manufacturing processes that significantly enhance productivity (Kumar *et al.,* 2016). Ever growing manufacturing requirements have carried on the necessity of timely fault detection, early warning, and avoid recall minimising the downtime and improve efficiency. Thus, relying on the potential of analysing manufacturing data and new requirements of production operations, it is evident that BDA has ability to revolutionise the manufacturing process to reach optimal production level.

Ahmadov and Helo (2018) investigated the impact of real data from machinery and data from production in order to solve sequencing problem in short time, besides optimising the machine task list. They found that conducting BDA by applying; clustering, nearest neighbour, and travelling methods saved more than 10% of the setup time and solved the sequencing problems in less than 30s in average. Researchers shed light on the diverse potential use of BDA through classifying the different sources of data concerning manufacturing, and its analytics impact on reducing customer's order time in addition to achieving sustainability. For instance, Kumar *et al.* (2016) developed a Map-Reduce framework for automatic pattern recognition based on fault diagnosis by solving data imbalance problem in cloud-based manufacturing on steel plate manufacturing dataset to help in reducing the occurrence of fault conditions.

The framework proposed by Xu *et al.* (2016) utilised a hybrid approach to deal with BD set for making smarter decisions. Conversely, extracting useful information of personal customer' attributes and preferences datasets in the atmosphere of mass customisation for product design has been credited with providing a rule base for designers to make design decisions according to real requirements of customers (Xu *et al.,* 2016). Considering the maintenance prioritisation, Bumblauskas *et al.,* (2017) clarified the function of BDA of establishing parameters to predict the point of failure in a specific part, in order to replace it in a timely manner, along with receiving a comprehensive proposal for service to fulfil the recommendations created by analytical model.

2.10.3 Procurement

Several areas of procurement performance (e.g., measuring and managing third party spending, enhancing the accuracy reliability of partner choices, and improving suppliers' performance) have drawn the academic attention to achieve optimised procurement operations. Using publicly available data as sources for implementing ERP systems provides a foundation for measuring and managing third party spending. This is expected to form the basis for effective supply management strategies, including strategic sourcing, category management, and supplier relationship management (Huang and Handfield, 2015). Moretto *et al.* (2017) discussed to what extent adopting BDA may affect diverse practicing in the procurement process by running a focus group including procurements managers in attempt to get their perceptions on BD support. They point out that embracing BD on the phases of procurement processes improves suppliers' performance and internal procurement performance. Undeniably, cost reductions and improving the customer satisfaction are some of the leading objectives of decision-makers. In order to mitigate or eliminate the ever-increasing driving costs and facilitate evidence-based decision-making, organisations need efficient methods to process large volumes of assorted data into meaningful knowledge (Gandomi and Haider, 2015).

The potentials of using BD are endless but restricted by the availability of different technologies, tools, and skills available for BDA. Nevertheless, these technologies, tools and skills have proved a success in many aspects such as quantifying the intricacy in purchase order sizing, in context of identifying the amount and structure of occurring costs, processes with a significant and simple structured error pattern, may improve self-awareness skills of decision-makers through analyse of known entropy-based complexity measures entropy (Bock and Isik, 2015). With adequate information from SC partners, enterprises can make better-informed decisions.

2.10.4 Inventory Management

The core usefulness of BDA in inventory is leveraging visibility for responsiveness and traceability of item. Several empirical research findings reveal the operational value of BD when making inventory completely visible to members. For instance, Demey and Wolff (2016)

illustrated a model called semantic inventory management for international space station (SIMISS). Where possible locations of lost items are calculated based on contextual features in three dimensions i.e., spatial, temporal, and human. Demey and Wolff (2016) revealed that by using SIMISS, it was possible to reduce re-supply cost for long duration missions on international space station, reduce waste of crew time, and assure mission success. Data accuracy is pivotal for decision makers for SC, especially in spare part inventory management, requiring informed decision-making to face demand, supply uncertainty, and achieve just in time inventory (Zheng and Wu, 2017). Coordination between SC activities can be a source of superior optimised operations. For instance, timely information about demand distribution offers an optimised solution for the online stores to manage their inventory. Thus, it is important to identify the demand distribution as an input to the newsvendor model (See-To and Ngai, 2018). Estimating ordering probability, amount, and timing by analysing clickstream data, can achieve advanced demand patterns, which have a significant role of reducing the inventory holding and its cost, and accordingly reducing operational cost and reaching optimal inventory (Huang and Van Mieghem, 2014).

2.10.5 Logistics

SC businesses seek to capitalise on logistics for gaining customer satisfaction through selecting the appropriate delivery methods in accordance with customer reference on the shopping platform, delivering the right item to right person at the right place (Ma *et al.*, 2015). The main areas where the use of BDA can drastically enhance logistics decision-making process include: (a) precise outage prediction, (b) visualisation of the logistics trajectory, (c) fleet monitoring, and (d) predict customers' behaviour. Chen and Kezunovic (2016) analysed weather data using fuzzy logic approach to devise strategies aiming to mitigate weather impacts; this allows utility operators to achieve more precise outage predictions and optimise real time operation including maintenance scheduling.

BDA can deal with the challenges of data analysis, capture, curation, information privacy, visualisation of RFID-Data, and mining invaluable trajectory knowledge to support advanced decision-making (Zhong *et al.*, 2016). In using predictive approach to analyse data generated from sensor used to support fleet truck monitoring system, Preethi *et al.* (2016) found that BD predictive analysis can generate information such as ultimatum for repair or replace items even before they break, suggestions on driving patterns on various road conditions to both the driver

and fleet owner. Bhattacharjya *et al.* (2016) investigated the impact of the logistics-related customer service interactions of e-retailers via Twitter to reach out to their consumer and resolve delivery related queries rapidly and effectively.

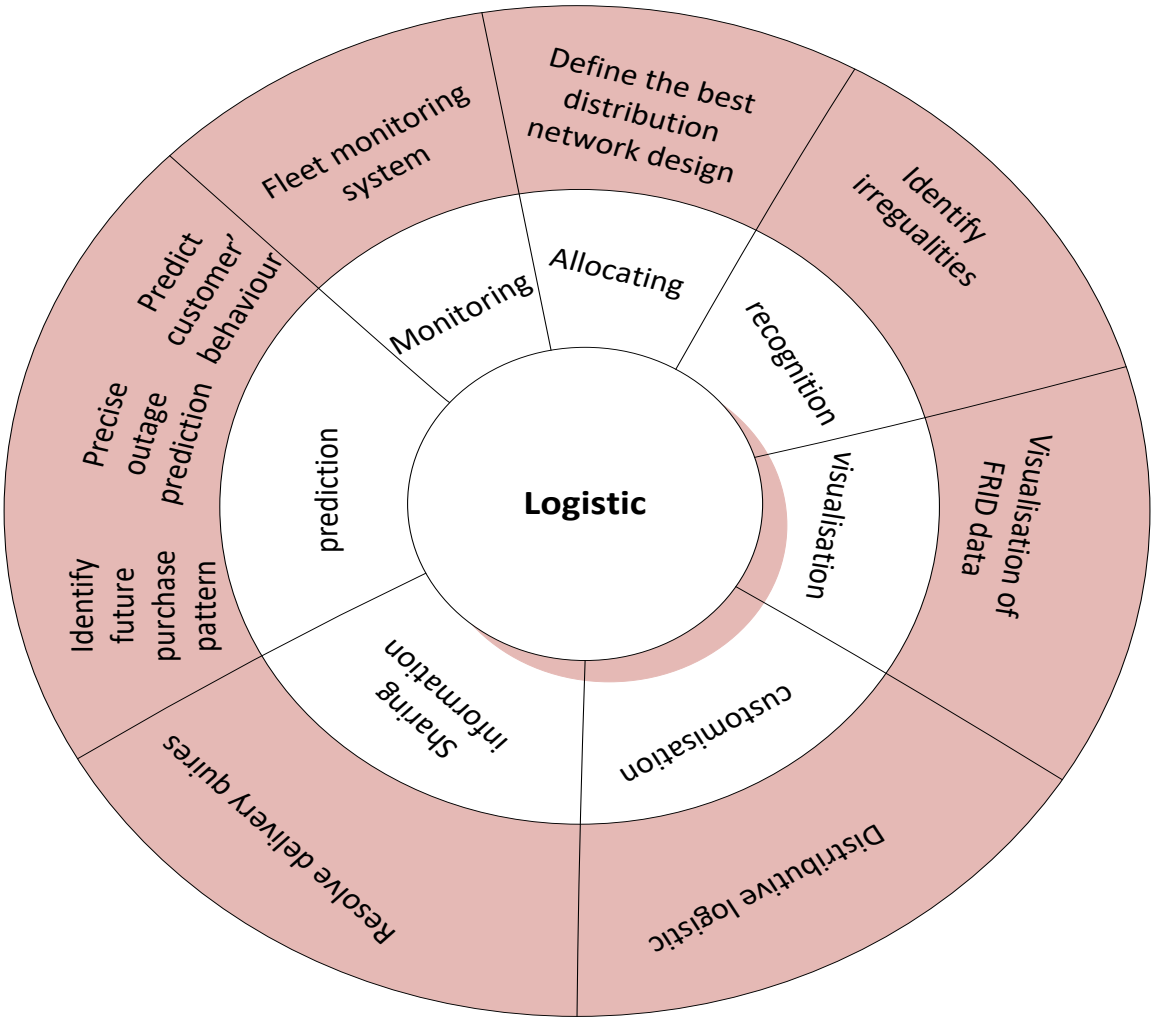

Figure 2.7: The Key BDA Applications in Logistics Function

Similarly, Li *et al.* (2018) reviewed the role of BDA in optimising demand chain management performance through using BDA tools; they found that BDA enables companies to understand their customer's habits, needs, behaviours, and thoughts, which in turn play a crucial role in improving customer satisfaction. Thus, the importance of BDA comes from its ability to support sharing information more easily and efficiently among SC partners. Brandau and Tolujevs (2013) applied data mining algorithm to extract information from location and sensor devices in order to identify causes and dependencies of the irregularities in the logistics process

to achieve a transparent flow of goods. The key BDA applications in logistics function of the examined literature is shown in **Figure 2.7**. As seen in the **Figure 2.7,** prediction is the most used application in logistics function following by visualisation, sharing information, customisation, recognition, allocating, and monitoring. BDA allows for massive amount of data to be used between SC partners to understand why and how decisions were made (for example suppliers need to know manufacturers demand of raw materials in turn manufacturers require retailer to give feedback about how their products in currency through the market).

2.11 Literature Gaps and Research Questions

In modern SC environment, huge amount of data is generated as a result of evolving electronic devices that monitor and trace objects and individuals, this opens a new path for researchers and practitioners to exploit hidden knowledge pattern inside data through implementing BDA in different applications. They deemed BDA as an impetus tool to revolutionise the traditional management system. Real time data or real-adding information is the keyword for achieving efficiency in operation system, it leads to reduce cost and risk in addition to stimulate innovation (Sheng *et al*., 2017). This is in line with promising avenues of BD that has presented in academic literature, especially in transforming prediction from low frequency quarterly or monthly forecasting to very high frequency daily prediction (See-To and Ngai, 2016).

The research discussed BDA in SCO differ substantially, for instance some papers provide an overview of the BD research in SCM domain in terms of discussing the main trends and perspectives in this research area (Addo-Tenkorang and Helo, 2016; Lamba and Singh, 2017; Brinch *et al.,* 2017). Others investigate the factors that shape the organisational adoption and assimilation to BDA (Chen *et al*., 2015; Gunasekaran *et al.,* 2017). One qualitative study conducted by Richey *et al.* (2016) to develop an industry grounded definition of BD. Most research articles have aimed to explore the role of BD in approaching organisations' goal of sustainability, profitability, financial performance, customer satisfaction, agility, efficiency...etc. (Dubey *et al.*, 2016; See-To and Ngai, 2016; Yu *et al.*, 2016; Gunasekaran *et al.*, 2017; Matthias *et al*., 2017).

Conceptualising BD capabilities, opportunities, and challenges have taken the scholars attention and efforts (e.g. Frehe *et al*., 2014; Arunachalam *et al*. , 2016; Wang *et al.*, 2016; Arya *et al*., 2017; Kache and Seuring, 2017). There are limited case studies focuses on organisations that apply BDA or undergo the period of shifting and adopting BDA. Wamba *et*

al. (2015) conducted in-depth analysis of the longitudinal case study of a state emergency service which was using BD for improving operations delivery. In addition, Gunasekaran *et al.* (2017) deployed structured interviews among four UK organisations as case studies to investigate the role of BDA in agile manufacturing.

There is direction of research in context of BDA and SCO tend to test sample data by using certain models and methods to extract the potentials of using BDA in the matter of supporting decision making or optimising operations. Chen and Kezunovic (2016) analysed weather data (the application of historical weather data analysis automated WFS and GIS processing tool) using Fuzzy logic approach to devise strategies aiming to mitigate weather impacts; this allows utility operators to achieve more *precise outage predictions* and optimise real time operation in addition to maintenance scheduling. In using predictive approach to analyse data generated from sensor to support fleet truck monitoring system, Preethi Varsha *et al.* (2016) found that BD predictive analysis can generate information like ultimatum for repair or replace items even before they break; suggestions on driving patterns on various road conditions to both the driver and fleet owner (*Fleet monitoring*).

Demey and Wolff (2016) illustrated a model called *semantic inventory management* for international space station ISS (SIMISS) where possible locations of lost items will be calculated based on contextual features in three dimensions: spatial, temporal, and human. Ahmadov and Helo (2018) investigated the impact of real data from machinery and data from production in order to solve sequencing problem in short time, besides *optimising the machine task list*. They found that conducting BDA saved more than 10% of the setup time and solved the sequencing problems in less than 30s in average. Jin and Ji (2013) reported that 3D printing, and BDA based on analytic hierarchy process and fuzzy synthetic evaluation reduce the influence of subjective factors on partner choice which enhance the *accuracy and reliability of partner choice* during procurement processes.

The effectiveness of actual demand planning has been addressed by (See-To and Ngai, 2016), who provided analysis of the BD collected from transactions data and customer review data to improve sales nowcasting, and to reveal the actual influence of customer sentiment on product sales. They found that utilising BDA for demand planning has a profound consequence for inventory. Real time sales nowcasting offers an optimised solution for the online inventory management, resulting in reducing the cost of stocking and avoiding the under stocking. In

operation management of the food SC, Ji *et al*. (2017) proposed a BD harvest model as a tool to support decision making, they used deduction graph model to convert data into insights to make informed production decision.

From the above discussion, we can address the significant gaps in the literature in following points:

- ✓ Most of the empirical studies have conducted in respect to one perspective in SCO either manufacturing, inventory, demand planning, procurement, or logistic. One researcher discussed the impact of BDA on SCO theoretically in relevant to three key areas of operations, logistic, manufacturing, and procurement (Wang *et al.*, 2016). Followed by (Lamba and Singh, 2017) who considered three different phases of SCO i.e., procurement, manufacturing, and logistics. Addo-Tenkorang and Helo (2016) stated that there is no clear picture clarify the valuable use or performance of BD regarding the operations processes.
- ✓ There is a shortage of articles testing theories as an interpretation for the response to their research questions (Kamal and Irani, 2014), and lack of theory-based understanding in BD phenomena. Furthermore, Mikalef *et al*. (2019) argued that the organisational diffusion of such technology is the biggest inhibitors in realising the full potential of BDA investment, and this is due to the fact that most of the research on BDA has been done by consultant and there is lacking in theoretical grounding and large-scale empirical testing that enables better understanding of leveraging BDA (Gupta and George, 2016). Few theories have been used to conceptualise and characterise the usage of BD especially in SCO as follow: Dynamic capability theory (Chen *et al*., 2015), Resource based view (RBV) (Yu *et al.*, 2016; Gunasekaran*et al.*, 2017), Gratification theory (Bhattacharjya *et al*., 2016; Yu *et al.*, 2016). Following the scholars' recommendations (Wamba *et al.*, 2015; Feki and Wamba, 2016) on developing theoretical ground in utilising BDA in SC for better understanding.
- ✓ Although BDA is a new phenomenon and it needs more textual descriptions and interpretation to better understand the complex reality of it, there is a scarcity in the studies that used qualitative methodology to explore the real usage of BDA in SCO. Therefore, this study is expected to fill a gap that exists in previous research related to BDA and CSO.

Research Gaps	Deficiencies in Research	References
Limited understanding of the impact of BDA business value on SCO	Most of the empirical studies have conducted in respect to one perspective in SCO either manufacturing, inventory, demand planning, procurement, or logistic	(G. Wang *et al.*, 2016), (Lamba and Singh, 2017), Addo-Tenkorang and Helo, (2016).
Lacking in theoretical grounding	there is lacking in theoretical grounding and large-scale empirical testing that enables better understanding of leveraging BDA. Few theories have been used to conceptualise and characterise the usage of BD especially in SCO	(Chen *et al*., 2015) (Yu *et al.*, 2016) (Bhattacharjya *et al*., 2016) (Gupta and George, 2016) (Gunasekaran, , *et al.*, 2017)
scarcity in the studies that used qualitative methodology	BDA is new phenomenon, and it needs more textual descriptions and interpretation to better understand the complex reality of it. One qualitative study has been conducted to develop an industry grounded definition of BD	(Richey Jr *et al.*, 2016)

Table 2.11: Research Gaps

The main objectives for this study are: first, reviewing exist literature to identify the gap in related research field; second, producing a theoretical understanding to clarify the nature of the BDA adaptation in SCO and to clarify the impact of this change on the SCO performance related activities; third, providing detailed empirical evidence about the real-live of BDA implementation to understand the real and current situation of potential value of BDA in SCO, and test the purported bandwagon for BD capabilities regarding business value in SCO.

This study addresses the present gaps (as addressed above, and as presented in **Table 2.10**) in the literature by investigate the current and real statue of BD in SCO where BD has been applied to show the real application of BDA in SCO. The research overarching research question is: *What is the real impact of BD analytics in SCO? Identify the hype and reality.*

2.12 Summary

The aim of this chapter was to provide an overview of BD and BDA as emerging technology terms in information system field, in addition to examining the SCO in relation to the scope of SCO elements: demand planning, logistic, inventory, manufacturing, and procurement. SCO has been identified as short activities over day-to-day basis which facilitate the transformation of raw material into work in process or finished products and delivering to end customers. After presenting the explanation of SCO elements, the information technology and information management in SC is discussed as critical elements in reflecting the firm's condition (Chae *et al.*, 2014), and mitigating the impact of risk present in SC activities such as deviation, disruption, and disaster (Pereira, 2009). A clear conceptualisation of BDA is given through the chapter, starting from reviewing the origin of BD as a term, then illustrating the meaning of BD by classifying the BD definitions based on three directions: The first direction defines BD depending on significances, applications, and opportunities (e.g., Martin, 2016; Hofmann, 2015; Jin *et al.*, 2015). The second direction defines BD in terms of important attributes notion of" V" (e.g., Kshetri, 2014, Russom, 2011). The third direction defines BD based on the fundamental requirements to reap the benefits of using BD as adopting sophisticated and modern storage and analysis techniques (e.g., Sanders, 2014; Rathore *et al.*, 2015; Wang and Alexander, 2015). Later, this chapter offered identifications related to BDA technique, tools, approaches, and applications. Before introducing the interest in BDA within SC, an overview of the significance of BD have been presented to address disciplinary revolutionary changes caused by BD at different fields e.g., demolition waste management (Chen and Lu, 2017), disaster management (Carley *et al*., 2016), hospital ward management (Cheng and Kuo, 2016) etc. To reach our goal of this study of deepen understanding of BDA impacts in SCO, section 2.6 set forth BD publications in relation to SCM applications considering the chronological order for these studies. This study addresses the gaps in the literature regarding the scarcity in the studies that used qualitative methodology to explore the real usage of BDA in SCO. This clearly motivate the current study to bridge the present gaps in the literature by investigating the current and real statue of BD in SCO where BD has been applied to show the real application of BDA in SCO. Thus, the conceptual model in chapter 3 has a dual role. It is designed to provide an understanding of the value of using BDA and how this adoption of new technology is derived. This study is an attempt to develop a theoretical framework to conceptualise the potential of BDA in SCO and to explain the motives behinds adopting BDA in SCO.

3. CHAPTER THREE: CONCEPTUAL FRAMEWORK

3.1 Introduction

The review of the literature in chapter 2 has identified the need for further evaluation to understand the impact of BDA technology in the context of SCO. As previously discussed, realising the full potential of BDA investment by leadership is the main challenge in attainting desired outcome of leveraging BDA. In consequence, how and why firms adopt novelty technology has motivated researchers to investigate the drivers and opportunities of this technology utilisation. Straub (2009) stressed the importance of doing research on technology adoption models to create a holistic understanding of how technology changing influences the organisation. On the other side, BDA as an innovation has created a new challenge for mangers, it lies in extracting new insight and knowledge of massive amount of data generated at every stage of SCO. Otherwise, the organisations that do not analyse their data are at the risk of lagging behind in marketplace.

The literature confirms a gap on testing the fit of BD to resolving the issues within each of SCO tasks. The following section thereby aims to contribute towards this research needs by developing a conceptual framework for analysing the impact of BD and BDA on SCO underpinned by the Task-Technology Fit (TTF) and the institutional theories. Therefore, TTF will be used to address these gaps. Furthermore, the institutional theory will help in answering to what extent the institutional structure will accept the adoption of BDA. As addressed above, both theories were not previously considered in this context. These theories will help in understanding the phenomenon of BD and BDA in SCOs.

3.2 Theoretical Lens

Despite the remarkable benefits of BD that have been clarified in theoretical research and little of empirical research, yet the full picture of BD potential and implementations in SCO still in its infancy stage. Lavalle *et al.* (2011) reported that one of the main constrains to adopt BDA is poor understanding of the potential of BDA on business environment. Thus, a broad view of BDA utilisation may be needed to explain the role of BDA in SCO. Furthermore, many researchers reported the limitation of theory-driven research in this domain (Wamba *et al.*,

2015; Feki *et al*., 2016; Wamba *et al.*, 2018), and they suggested further research to determine theories which can be mobilised for studying BDA in SCO.

Resource based view (RBV) is broadly used in relevant literature to explore the effect of BDA as a firm resource in enabling sustain competitive advantage. The RBV holds that firms possessing resources that are valuable, rare, inimitable and non-substitutable can enable performance improvement and sustain competitive advantage over the time (Chae *et a*l, 2013; Yu *et al.*, 2016). The RBV is attractive to operation management researchers because it argues that the internal resources and capabilities of firms are the key resources for achieving sustained competitive advantage, so it emphasises on capabilities inhabiting within the organisation, which is in line with the general orientation of operation management (Amundson, 1998; Lin and Lai, 2017).

Dynamic capabilities theory (DC) comes to overcome weaknesses in RBV theory of not considering the rapid and unpredictable mutation in changing environment (O'Connor, 2008). DC theory provides an explanation of competitive heterogeneity based on the premise of the role of strategic management in adapting, integrating, and reconfiguring internal and external resources to match the requirements of the changing environment (O'Connor, 2008)**.** In BD context, Chen *et al*. (2015) theorised BDA usage as dynamic capability in terms of information processing which brings competitive advantage to organisation. Such advantage is gained through enriching the organisation decision makers with knowledge to produce better resources configurations and reconfigurations, which in turn has a significant impact on SC value creation. Similarly, Richey *et al.* (2016) supposed that the abilities to collect, store, and leverage BD as a SC construct constitute a firm's dynamic capability (DC).

Through using Gratification theory, Bhattacharjya *et al*. (2016) investigated the role of social media (Twitter) as a source of unstructured BD in helping e-retailers to conduct customers service interaction and solve customers' logistics quires. Most of the theories used to study BDA in SCO fail to encompass the notion of BD 7(V) as forces that potentially shaped organisation initiation to BDA use and therefore improve performance. In order to play a key role in improving organisational performance, BDA needs to establish credibility by understanding its potential in adding value. The way toward having a deep understanding of BDA capabilities is by digging in BDA characteristics and see how these characteristics fit the required tasks, in addition explaining the forces that potentially shaped organisation' initiative to BDA usage.

Based on the above, this paper uses an integration of TTF and institutional theory. TTF theory argues that the actual use of a new technology and performance benefits are attained when technology characteristic fits the task requirements (Michael *et al*., 2012; Lai, 2017). On the other hand, institutional theory provides a comprehensive understanding of the intention behind adoption of practices and the implementation through examining the causes of isomorphism represented in three dimensions of institutional pressures: coercive pressures, normative pressures, and mimetic pressures (Kauppi, 2013; Dubey *et al.*, 2017). The role of TTF and institutional theory has not yet been tested in the BDA domain, which emerges the need for research on the factors that influence the successful adoption of this tool (BDA).

3.3 Task-Technology Fit Theory (TTF)

TTF is based on the idea that IT has a positive effect on individual and organisations performance if there is a fit between the task' characteristic and technology' characteristics (Goodhue and Thompson, 1995). They tested the technology-to-performance model (TPC) by an analysis of data from 600 users in two companies using 25 different information technologies, they found supportive evidence that IT has a positive impact on performance when there is concord between the functionalities of technology and the task requirements. The fit between task and technology has been shown as a main reason that influences both the use of information system and their performance (Tam and Oliveira 2016). In other words, to reap the benefit of utilising technology on performance, the technology must be utilised and must be a good fit with the task it works for (Goodhue and Thompson, 1995). Furneaux, (2012) linked the root of TTF theory to contingency theory that argues that fit between practices and the environment should be in organisation which determines performance improvement (Yu *et al.*, 2016). More advantages of using TTF have been clarified by researchers. Starting with its ability, as a strong tool to assess whether information system in a given organisation, is meeting user needs, in addition to provide a comprehensive understanding of the value of adopting technology and how this value is derived (Goodhue and Thompson, 1995; Furneaux, 2012).

Earlier research has used TTF, D'Ambra *et al.* (2012) employed TTF model to conduct qualitative research in order to explore the correlation of e-books, the affordances offered by smart readers, the information needs of academics, and the fit of technology to tasks as well as performance. To investigate the determinants of mobile banking for individual performance, Tam and Oliveira (2016) highlighted the TTF model to understand the determinants that

influence the individual performance of m-banking. TTF theory has been also used in learning management system (McGill and Klobas, 2009), understanding knowledge management system usage antecedents (Lin and Huang, 2008), understanding of massive Open Online Courses (Ouyang *et al*., 2017), social networking site (Lu and Yang, 2014), and online user context (Aljukhadar *et al*., 2014).

As dissused before, TTf theory has been founded on the premise that the motivation to use a particular technology will be driven by the fit between the tasks' characterestics and the technology' attributes. Consequently the affect of fit on performance occures either directly or indirectly throught TTF impact on utilisation of technology (Furneaux, 2012).

3.3.1 Operationalising the Notion of TTF

3.3.1.1 Task Characteristic

Lu and Yang (2014) identified the task as a piece of work that a person performs through a sequence action to reach greatest net benefits. Similarly, Aljukhadar *et al*. (2014) and Lin and Huang (2008) reported that tasks are users action resulting in turning inputs to outputs. Vongjaturapat (2018) described tasks characteristics as those that user might use information technology to perform. In this study, constructed tasks were derived from analysing literature within the context of SCO, and then the required tasks we classified as follow: optimum assets work such as detecting, recognition, and diagnosis the fault and irregularities in timely manner to ensure that all production processes are under control.

In addition to optimising machine task list, prioritising maintenance, and autonomous (automated decision, automated control, and automated diagnostic); secondly, *product design* which includes generalised product, and quality assurance; thirdly, *sales nowcasting* for optimal inventory solution and optimising logistics service, in addition to precise demand planning; fourthly, *improving procurement processes*; fifthly, *identifying customers' preferences* to enhance engagement; sixthly, *determining the allocation* of products to distributors centres (DCs) and allocation of the DCs; seventhly, *resolve delivery queries and predict truck arrival time* (See **Table 3.1**).

Tasks	References
Optimum assets work	(Kumar *et al.*, 2016), (M. Giannakis and Louis, 2016), (Ahmadov and Helo, 2018), (Preethi Varsha *et al;* 2016), (S. Wang, Wan, Zhang, *et al.*, 2016), (Bumblauskas *et al.*, 2017), (Chien *et al;* 2017), (Gu, 2017), (Wan *et al.*, 2017), (Jang and Kim, 2017), (DiBiano and Mukhopadhyay, 2017), (Ku, 2017), (Ji and Wang, 2017), (Lee *et al;* 2017), (Akilu Yunusa-kaltungo, 2017).
Product design	(H. Li *et al*., 2016), (Li *et al*., 2015), (Yang *et al.*, 2017), (Tao et al., 2017)
Sales nowcasting	(See-To and Ngai, 2016), (Huang and Van Mieghem, 2014)
Improving procurement processes	(Jin and Ji, 2013), (Moretto *et al;* 2017)
Identifying customers' preferences	(L. Li *et al.*, 2016), (Yuan *et al*., 2017), (Lau, *et al.*, 2017), (Mishra *et al.*, 2017)
Determining the allocation	(Wang *et al;* 2016), (Liu and Wang, 2016), (Lee, 2017)
Resolve delivery queries and predict truck arrival time	(van der Spoel *et al.,* 2015), (Bhattacharjya *et al.,* 2016)

Table 3.1: Tasks Characteristics

3.3.1.2 Technology Characteristic

Doug Laney (an analyst) pioneered of defining the challenges associated to managing a large set of data in terms of three dimensions 3(V) volume in 2001, Velocity, Veracity, which has become later central to understanding BD (Matthias *et al.,* 2017). McAfee and Brynjolfsson (2012) in their attempt to distinguish between BD and analytics, they determine three key differences which characterising BD, volume, velocity and variety. Addo-Tenkorang and Helo (2016) stated that McAfee and Brynjolfsson (2012) are probably the best-known researchers defining BD in terms of 3(V), followed by IBM which expanded this definition to include the term dimension of veracity. Microsoft increased BD attributes for variability, veracity and visibility to be 6Vs (Wu *et al*., 2014) . According to Rehman *et al.* (2016), the key characteristics of BD are namely, (i) volume, (ii) velocity, and (iii) value, then the three new Vs: (i) variety, (ii) variability, and (iii) veracity added later. Finally, visualisation as a BD attribute added by (Seddon and Currie, 2017).

In answering the question if BD should hold all its characterises, Kitchin, (2014) declare that some data may have many of the characteristics thought to give the meaning of BD (size,

variety and velocity), and other classification of BD may carry a different set of characteristics (7V), or only a single BD attribute (Connelly *et al.*, 2016).

3.3.1.3 Task-Technology Fit Measurements

Furneaux, (2012) listed two appraoches to empricaly operationlise the concept of TTF. The first approach is fit-as-match which sees fit as being represented by a match between tasks and the capabilities of an information system. For instance, identifying some dimentions of IT capabilities like locability, timeliness, and compatibility (Goodhue and Thompson, 1995). The second approach is fit–as-profile that measure fit by evaluating the extent to which a technology deviates from a theoretical profile of ideal set characteristics (Furneaux, 2012). It emphasis that fit can be defined as ideal profiles composed of an internally consistent set of tasks and technology elements that affect the organisation performance (Zigurs and Buckland, 1998). This study is guided by Zigurs and Buckland (1998) and D'Ambra *et al.* (2013) in measuring TTF, which evaluated the fit between task and technology characteristics by applying fit -as -profile approach.

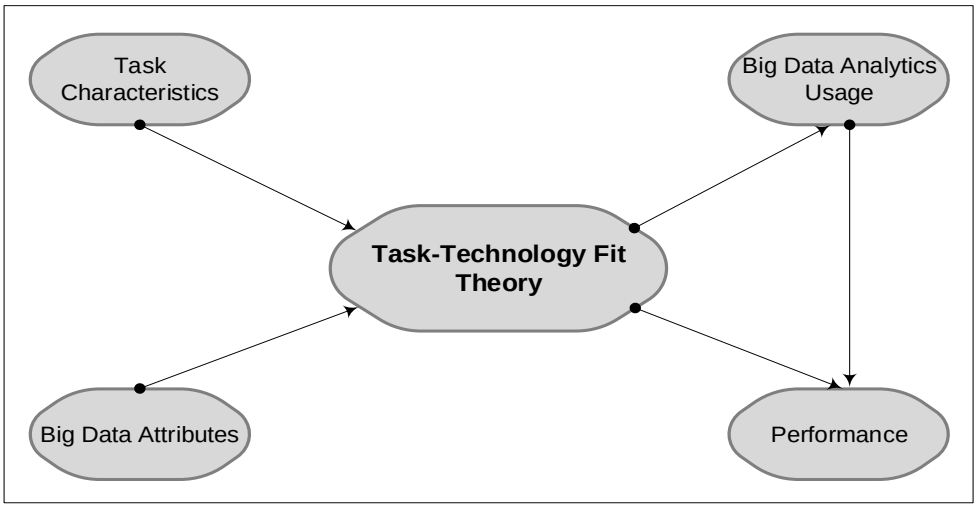

Figure 3.1: TTF-BDA Attributes Framework (Adapted from Goodhue and Thompson, 1995)

It seems reasonable to assume that the match between SCO portfolio of tasks and BD characteristics will directly affect the utilisation of BDA and organisations performance. Based on the above benefits of using TTF theory in assessing whether information system in a given organisation are meeting user needs, in addition to its ability of providing a comprehensive

understanding of the value of adopting technology and how this value is derived (Goodhue and Thompson, 1995; Furneaux, 2012). Accordingly, the following research question arises:

RQ1: Is BD as a new concept is just hype or there is a real benefit of using BD in SCO, and what are the applications of BDA in SCO?

3.4 Institutional Theory

Institutional theory considers the processes by which structures (including routines, norms, rules, and schemas) become instituted as authoritative guidelines for social behaviour (Scott, 2005). It has been found on the premise illustrating the organisational pressures in shaping organisational structure (Oliveira and Martins, 2011). The study of Dimaggio and Powell (1983) was one of the key works that established neo-institutional theory (Thomas B. Lawrence, 2008). It assumes that organisations in a structured field respond to an environment that consist of other organisations responding to their environment (Dimaggio and Powell, 1983), trying to explain institutional context that forces organisations to be similar to each other (isomorphism). Institutional isomorphic change processes have been identified in three mechanisms: coercive isomorphism, mimetic isomorphism, and normative isomorphism (Pishdad *et al*., 2014).

At early stage, the object of adopting organisational innovation was improving performance, then once a set of organisations emerges as a field, the goal was gaining legitimacy rather than improving performance (Dimaggio and Powell, 1983). Rational goals of efficiency are not only the main driver of organisational decision, but also social and culture factors (Oliveira and Martins, 2011). Kauppi (2013) asserted the importance of distinguishing between two variants of the institutional theory utilised within operation management and SCM: Firstly, the economic variant (frequency-based imitation, trait-based imitation, outcome-based imitation), secondly, the social variant (coercive pressures, mimetic pressures and normative pressures).

Institutional theory became a major research direction to clarify environmental related practice in SCM, and to study utilisation of technology application (Kauppi, 2013). Several studies have considered an institutional theory in SCM. For instance, Dubey, *et al.* (2017) highlighted the role of institutional pressures on internal pressures and commitment; they stressed the need to translate these pressures into appropriate strategy to achieve sustainability. In the same vine,

Touboulic and Walker (2015) reported that institutional theory provides a better understanding of the pressure that firms put on one another in the movement towards adopting more sustainable practice in the SC.

3.4.1 Operationalising the Notion of Institutional Theory

The core assumption of institutional theory is that organisations and organisational actors attempt to gain legitimacy, status, and reputation in their environments in order to be accepted and thus ensure long-term survival (Mignerat and Rivard, 2009). Suchman (1995) identified legitimacy as follow: "Legitimacy is a generalised perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions". Two elements have been examined in institutional theory, institutionalisation process and institutional effects (Pishdad *et al*., 2014). In this study we will focus on institutional effects process which was called by Pishdad, *et al*. (2014) 'environmental institutional mechanism' coercive, mimetic, and normative isomorphism.

3.4.1.1 Coercive Isomorphism

It is the outcome of formal and informal external pressures by other organisations (government, trade partners, customers) on which they are dependent, and by culture expectations in the society within which organisation embedded, for example (organisations adopt new control policy to comply to environmental regulations) (Dimaggio and Powell, 1983). Online business, globalisation, and wide range choices of companies have played a fatal role to raise the level of customer satisfaction and change customer expectations, which has raised the necessity to offer product with best quality, lower cost, shorter time, and best delivery service. All these factors increased the pressure on organisations to implement precise customers' assessment to personalise service and customise product, through implementing sophisticated analytics tool to analyse data generated from customer's location, customer's hit, browsing time, and shopping cart (See-To and Ngai, 2016).

3.4.1.2 *Mimetic Isomorphism*

It occurs by organisational desire to mimetic other organisation action, especially when the environment creates symbolic uncertainty (Dimaggio and Powell, 1983). Mimesis is more existed in anxiety than in rational action in order to reduce uncertainty and increase predictability (Kauppi, 2013; Pishdad and Haider, 2013). One of the main challenges in SCO which influence the operation efficiency and cause problem in SCO (such bullwhip effect) is uncertainty presented in demand and supply uncertainty, and uncertainty is also related to timely delivery of items as a row material or finished products (Bag, 2017). The causes of uncertainty in SC are not limited to reasons mentioned above, there is a high uncertainty at every stage of the SC (Bag, 2017) . The increased level of SC uncertainty raises the need to adopt mimetic predictable analytics tool and use predictive analytics to uncover future event pattern and make prediction (Kokina *et al*., 2017), along with providing real insights that enable manager to decide on the basis of evidence rather than uncertainty.

3.4.1.3 *Normative Isomorphism*

Normative is stemmed from professionalisation (Dimaggio and Powell, 1983). Normative pressures consider the moral aspect of legitimacy by assessing whether the organisation performs in desirable way (Haider, 2013). Normative pressures implies that strategic processes taken by organisations are subject to the values and norms shared among members of their social networks such as organisation-supplier and organisation-customer inter-organisational channels (Son and Benbasat, 2007; Haider, 2013). Pishdad and Haider (2013) gave an example of normative influences such as using ATM survives in retail bank, and the banks that do not provide this service are at the risk of damaging their legitimacy. In SCO field, there is a wide range of normative pressures pertained to environmental concerns, individual safety, and SC sustainability (for example emergency rescue, electronic waste reducing, green SC). Therefore, making informed operational decisions is an important step needs to be adopted by organisations to execute their operations productively in this new changing environment. This can be achieved through reshaping proactive strategy formulation and decision making based on BDA in SCO.

In this research, the role of institutional isomorphic pressures (macro institutional logics) on the intention behind BDA implementation will be investigated.

RQ2: What are the main drivers of utilising BDA?

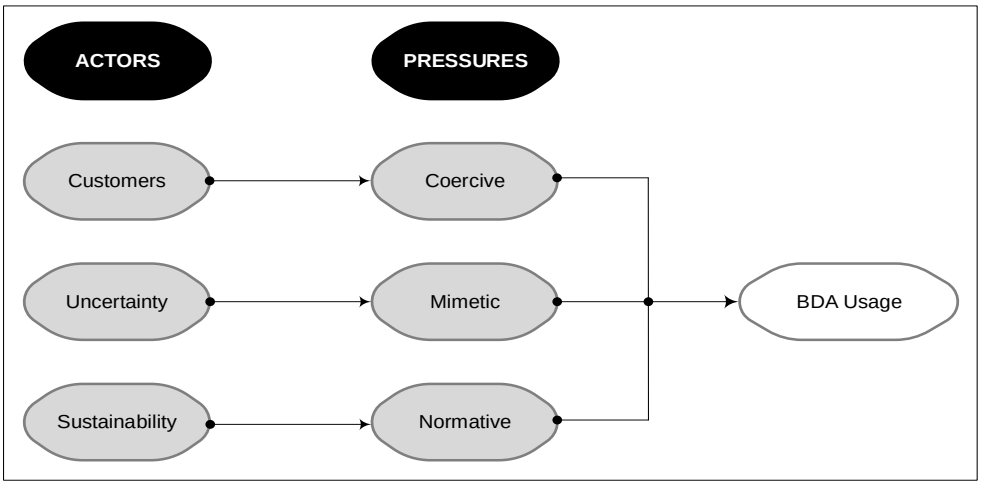

Figure 3.2: Institutional Theory and BDA usage Framework (Sour Adapted from Scott [2005])

3.5 Building Blocks of the Proposed Conceptual Framework

BD is a big buzz word flying around these days, it holds promising benefits for all organisation and all kind of businesses, especially SCO. Whereas, implementing BDA in SCO will enhance visibility, share right and timely information, prevent disruption, and achieve efficient performance. Despite the growing attention on BDA in SCO context, the utilisation of BDA as an advanced tool is still in a very early stage, and the reason behind this delay is the absence of a comprehensive framework that clarifies BDA from the aspect of value associated with SCO which plays a significant role in facilitating a shift to the implementation of BDA in SCO. Therefore, to provide understanding of the value of using BDA and how this adoption of new technology is derived, this study undertook two theories (TTF and Institutional theory) to better understand how and why firms adopt BDA as a novelty technology, along with the drivers and opportunities of this technology utilisation.

TTF theory has been developed based on attributes of required tasks and their relationship to relevant characteristics of technology (Zigurs and Buckland, 1998). From the above statement we can assume that the fit between tasks characteristics in SCO and BD attributes is a rational action toward adopting BDA, in this case we need a new lens for taking into account the irrational arising within the institutional context that surrounds organisational actors (Mignerat

and Rivard, 2009). The institutional theory attempts to solve limitation of TTF for understanding the social forces behind BDA utilisation.

According to Currie (2011), in theory the main motive behind processes of developing and using IT are subject to social pressures. He clarified in his research article that institutional theory explicates the phenomena in which it is different from economic-rationalist model, it provides the social nature of phenomena. In this research, the institutional theory adds to the constructs (IT capabilities and tasks characteristics) of TTF framework the external pressures, which speeds up the processes toward utilising BDA, these pressures include pressures from competitors and pressures exerted by trading partners (Oliveira and Martins, 2011). In this regard, institutional theory is used as a lens to investigate the relationship between constructs drawn from isomorphism and utilising BDA. Therefore, institutional studies of the impact of BDA implementation on SCO efficiency would possibly contribute to both research and practice. Therefore, this study tackles the following research question:

RQ3: What are the potentials of using BD in SCO?

The objective of this framework is to explore the inner factors (fit between technology and task characteristics) and outer factors (social factors) affecting the overall effective utilisation of BDA in the SCO context, resulting in realising the benefits of BDA implementation. **Figure 3.3** presents the building blocks of proposed framework that may support other researchers in better understanding BDA initiatives in SCO with the objective of making robust investment decisions in BDA.

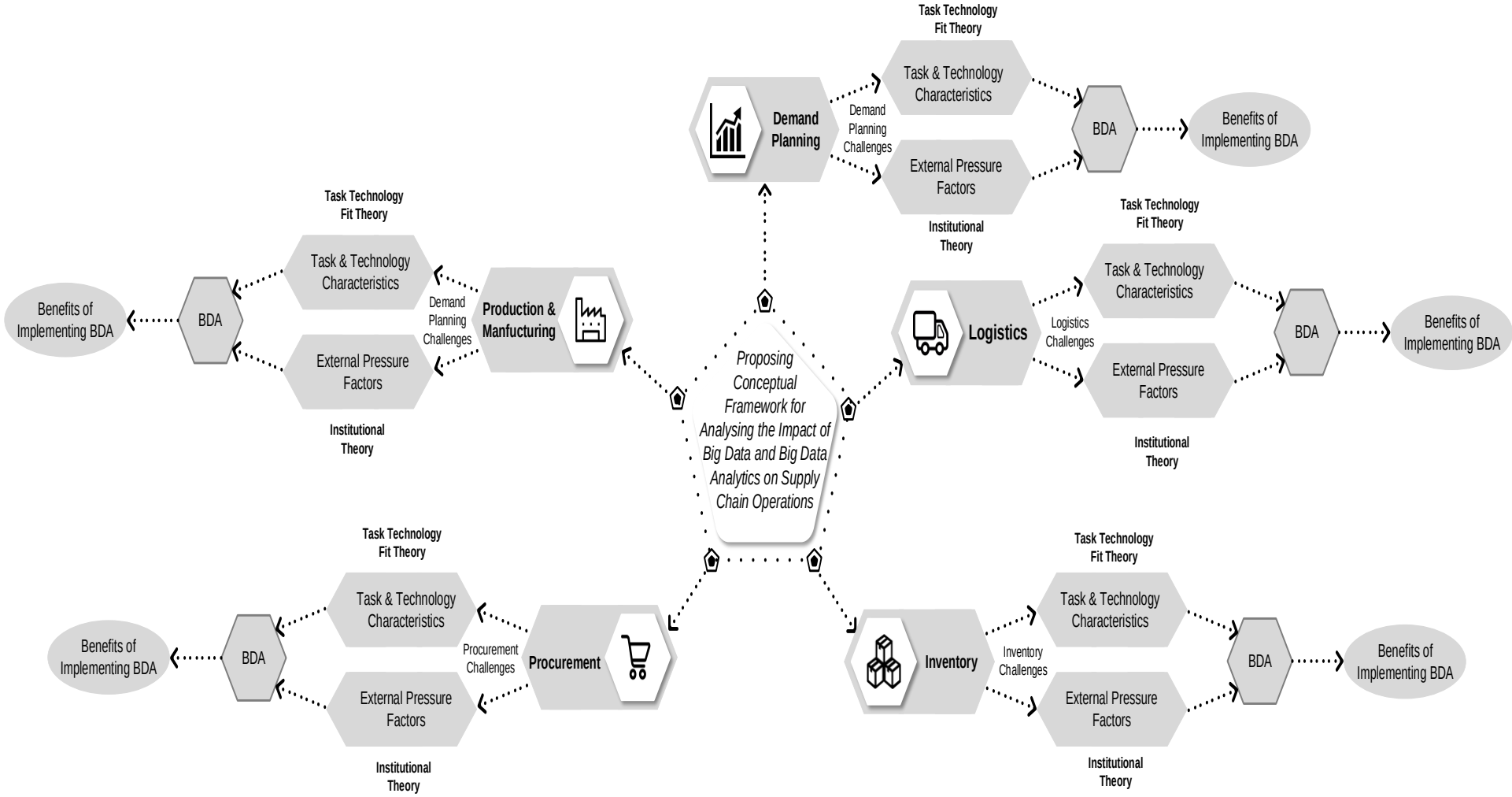

Figure 3.3: Proposed Theoretical Framework – Building Blocks (Source: Author)

3.6 Summary

In the last few years, the voices of researchers have raised to draw attention toward discovering the potentials of BD in different fields. This study is an attempt to develop a theoretical framework to conceptualise the potential of BDA in SCO and to explain the motives behinds adopting BDA in SCO. This study undertook two theories to better understand how and why firms adopt BDA as a novelty technology, along with the drivers and opportunities of this technology utilisation.

The proposed framework is intended to provide understanding of the value of using BDA and how this adoption of new technology is derived. To this end, the study first reviews the main concepts of TTF theory and institutional theory and relevant literature of using both theories in the different fields, followed by operationalising the particular theoretic perspectives adopted in the research. This research argues the role of institutional isomorphic pressures (macro institutional logics) on the intention behind BDA implementation, and in the same line the affect of fit between technology and tasks requirments on using BDA.

4. CHAPTER FOUR: RESEARCH METHODOLOGY

4.1 Introduction

The aim of this section is to give explanation of the methods used to gather and analysis the required data to address the research problem and to seek information to answer research question. It will present what philosophy was adopted along with justification for this use. Similarly, the research design and strategy will be discussed in order to adopt the most appropriate ones which help the researcher to answer the research question. Full details of data collection and data analysis procedure is also presented.

4.2 Research Philosophy

Research philosophy is referred to the system that helps the researcher to identify research methods to be used in this study (Crossan, 2003). In other words, it is the tool that enables and assists researchers to refine and specify different methodology and to identify the limitation of particular approaches at early stage. The literature provides many definitions of research paradigm (philosophy of research), which guides how scientific research should be conducted based on people' assumption about the world and the nature of knowledge (Collis and Hussey, 2014). Saunders *et al*. (2016) defined the term of research philosophy as a system of beliefs and assumptions about the advancement of knowledge and understanding. Creswell (2013) declared that philosophy means the use of abstract thoughts and beliefs which informs our research. In this perspective, articulating and considering philosophical assumptions are the first step to constitute a solid piece of research.

Designing a coherent research project depends on credible research philosophy which in turn relies on a consistent set of assumption (Saunders *et al*. 2016) p.123. Social science is not rooted to in a single assumption; there are sets of philosophical assumptions that is convenient to conceptualise social science (Burrell and Morgan, 1979). According to Saunders *et al*. (2016) research philosophy consists of three types of research assumptions: ontology, epistemology, and axiology.

- **Ontological** assumption considers a social construction of reality and the fundamental inquiries into the nature of existence "what is the nature of reality" (Crossan, 2003). That is, whether reality may be supposed to exist in an objective plane which is external to individual (Chua, 1986), and therefore, everyone has the same sense of reality "objectivism" (Collis and Hussey, 2014), or reality is the product of people cognition and, therefore everyone has his own sense of reality and there are multiple realities "subjectivism" (Collis and Hussey, 2014). "Ontology refers to understandings of the nature of being and of the existence of "things." One's ontology is one's set of assumptions about what exists and how it exists, whether such things are understood to be "real" facts in the world or conceptual fictions created by people"(Reyes, 2014). Saunders *et al*. (2016) gave more clarification how ontology can be used in business and management, ontological assumption shapes the way in which you see research objects like organisation, management, organisational event, and artefact… etc. The issue of ontology prior to and governs subsequent other philosophical assumption (epistemology) (Chua, 1986). Moreover, ontology defines the concepts that inform an epistemic domain, their properties, and their interdependencies (Kuiler, 2014).
- **Epistemological** assumption considers the establishment of acceptable knowledge in a field of study "how can one sort out what is to be regarded as true from what is to be regarded as false" (Burrell and Morgan, 1979), and specifies the nature of relationship between the researcher and investigated phenomenon (Collis and Hussey, 2014). In this kind of philosophical assumption, the nature of knowledge can be viewed from two perspectives, whether the knowledge comes from objective evidence which is assembled based on observable and measurable phenomena (Collis and Hussey, 2014), or knowledge come from subjective evidence based on individual view (from participant) Creswell, (2013).
- **Axiological** assumption depicts the role of values and nature of ethics within the research process Saunders *et al*. (2016), "how does the researcher implement this assumption in practice" Creswell (2013). This philosophical assumption explains how research demonstrate axiological skills that articulate their value as a basis of for making decision about what research they are conducting and how they go about doing it and draw conclusion about data Saunders *et al*. (2016). Drawing on Saunders *et al*. (2016) and others, research philosophies have two opposing extreme which help in

providing definition for them and discussing how they are illustrated in study (objectivism, and subjectivism).

- **Objectivism** means social reality that we study is external to researchers and it comes from objective evidence about observable phenomena (Collis and Hussey, 2014). Objectivism embraces realism which perceives social entities to be like physical entities of the natural world as independent. Because the social and physical world phenomena exist independently the objectivist believes that there is only one social reality experienced by all social actors (Saunders *et al*., 2016).
- **Subjectivism** asserts that social world is product of social interactions between actors (socially constructive) and should be treated subjectively. Knowledge in this case acquires from subjective evidence and researchers are involved in different form of participative inquiry. Such view involve multiply realities as researchers is interested in different opinion of different social actors that constitute different social realities (Burrell and Morgan, 1979; Collis and Hussey, 2014; Saunders *et al*., 2016). The following section will provide further explanation for two major philosophies: positivism and interpretivism.

4.2.1 Positivism Paradigms

It has been described as traditional scientific approach which has its roots in the natural sciences, and works with observable social reality to produce law-like generalisations (Orlikowski and Baroudi, 1991; Crossan, 2003). This approach seeks primarily to test the theory by formulating the hypothesis and testing it through experimental research, in an attempt to increase the predictive understanding of phenomena (Orlikowski and Baroudi, 1991). Therefore, positivism adopts quantitative approach of analysis based on the statistical analysis of research data (Collis and Hussey, 2014). For instance, Orlikowski and Baroudi, (1991) count on three special ideas for categorizing positivist articles as follow: *beliefs about physical and social reality* which exists independent of human, *beliefs about knowledge* what is known as the hypothetic-deductive account of scientific explanation, *beliefs about the relationship between theory and practice* which is first and foremost technical. (Walsham, 1995) claimed that in IS context, positivism paradigm is still dominant philosophy in the mainstream journals. The major two criticisms of the positivist approach as follow: firstly, it does not provide tools

to examine human behaviour in a depth way. Secondly, it provides a superficial view of the phenomena it investigates through yielding useful but limited data (Crossan, 2003).

4.2.2 Interpretivism Paradigms

Interpretive methods of research adopt that knowledge of reality is subjective (social construction) because it shapes by human perceptions (Walsham, 1995; Collis and Hussey, 2014). Interpretivism assumes that human beings are different from physical entities, and they cannot study in the same way, as reality' configuration is influenced by its context (Crossan, 2003). The aim of this research method is to generate new interpretation and richer understanding of phenomena from a qualitative perspective, rather than seeking generalisation (Saunders *et al*., 2016). Conversely to processes followed in positivist approach, hypothesis does not exist at the early stages of the interpretivist approach, and theory may develop as a result of the research (Lancaster, 2005). Regarding to IS research field, Walsham, (1995) argued the valuable role of an interpretive methods of research in IS field, "interpretive methods of research, aimed at producing an understanding of the context of the information system, and the process whereby the information system influences and is influenced by its context" (Walsham, 1995).

In the same vine, Chen and Hirschheim, (2004) they showed the research trend in IS and compared the traditional prevalent positivist approach and the emerging interpretive approach, to find out that reviewer tend to be less perspective to interpretive as the evaluation criteria are less objective. Accordingly, researchers will avoid conducting time-consuming interpretivism research where they are less likely to be published. Orlikowski and Baroudi, (1991) count on three special ideas for categorizing positivist articles of IS research as follow: *beliefs about physical and social reality*, where humans construct and reconstruct their reality, *beliefs about knowledge,* which is acquired through inductive method of scientific explanation, *beliefs about the relationship between theory and practice,* which is the researcher can under no circumstances adopt a value-neutral stance. The main three criticisms of the positivist approach are due to the nature of qualitative research: Firstly, it is strongly subject to research bias. Secondly, it lacks reproducibility. Thirdly, it lacks generalisability.

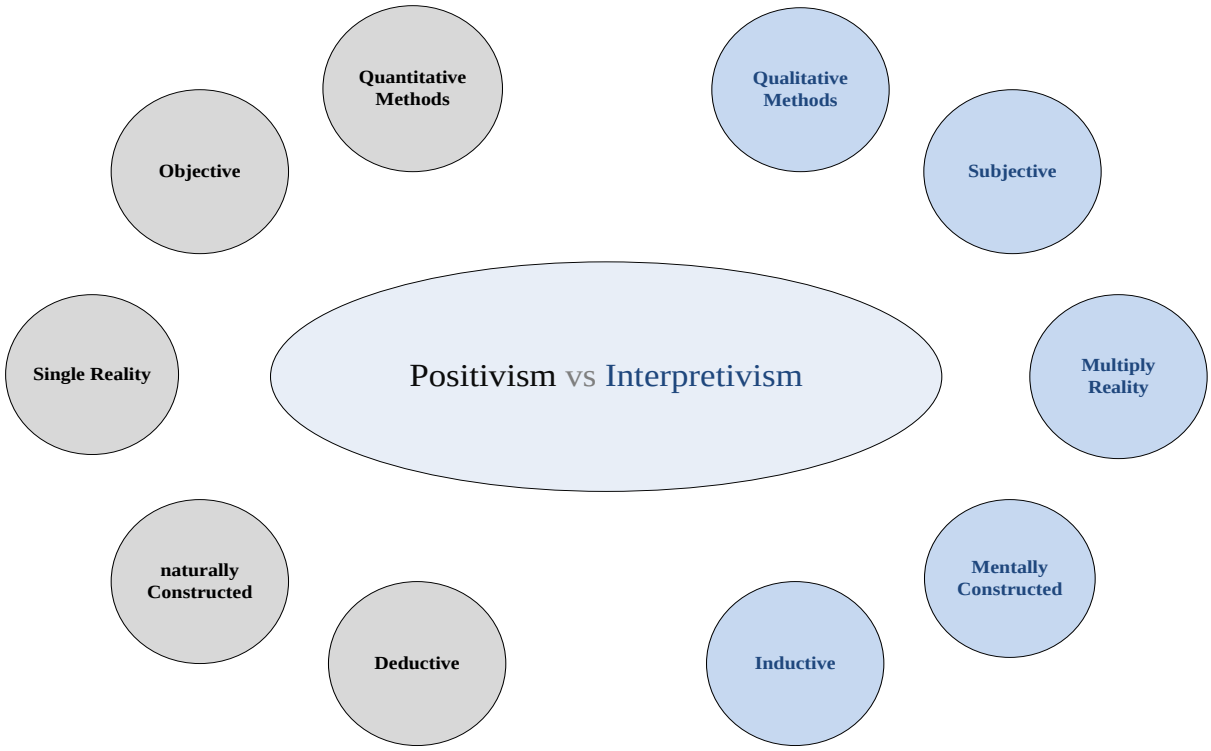

Figure 4.1: Research Philosophy (Source: Author)

Inductive and deductive reasoning describe the structure of research processes that investigators rely on to answer the research question and reach the research goal. **Deductive** reasoning is the top-down approach that starts a study with developing theory, then testing hypothesis through empirical observation to test and assess their validity (Lancaster, 2005). **Inductive** reasoning is the bottom-up approach that starts a study with observation of empirical reality facts and details in order to achieve a better understanding of phenomena, and then move to general inferences in the form of conceptual framework (Collis and Hussey, 2014). (See **Figure 4.2)**

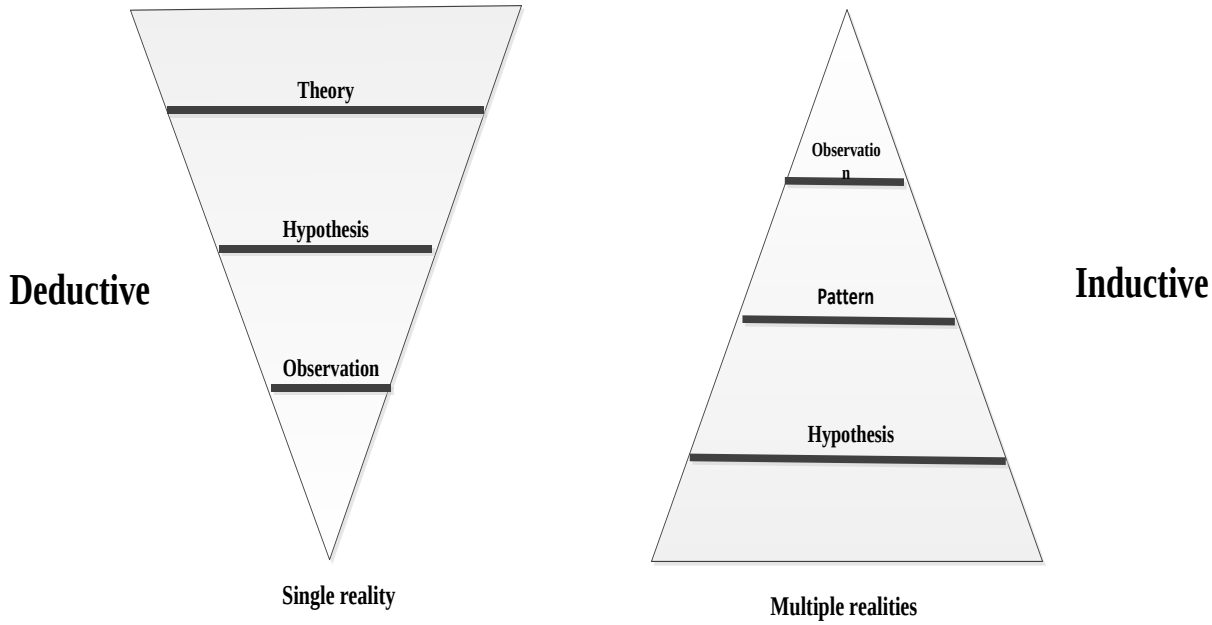

Figure 4.2: Deductive and Inductive Reasoning (The Relationship Between Research and Theory)

(Source: Designed by the Author)

4.2.3 Justification for Adopting Interpretive Philosophy

The particular paradigm adopted for a specific research project is determined by paradigm ability to provide unique attributes for different purposes of scientific inquiry (Chen and Hirschheim, 2004), and to better investigate research question of interest. According to Chen and Hirschheim (2014), the paradigm issue is not about paradigm wars but about the research questions investigated (scope and depth of the research). The research aims at understanding the interrelation between BDA adoptions and improves performance in the SCO where the phenomenon is suited in the natural context from the participants'' perspectives. In particular, the research is interested in looking at processes that have significantly influenced the adoption intention of BDA, and how this adoption influences the performance in CSO in terms of optimising operations or enhancing decision making. In other words, what are the main motives behind processes of developing and using IT represented in BDA, and what is the real impact of utilising BDA?

Based on Walsham (1995) statement that interpretive approach of research, aimed at generating an understanding of the context of the IS, and the process whereby the IS influences and is influenced by its context. Hence, to consider the scope and depth of this research, an

interpretivist method is adopted. BDA as IT-related phenomenon needs more textual descriptions and interpretation to better understand the complex reality of it, there is a scarcity in the studies that used qualitative methodology in order to explore the real usage of BDA in SCO. Therefore, to increase understanding towards reality of such phenomenon, this study is conducted in its natural setting rather than working with observable facts to produce universal discoveries which serve the purpose of generalizability.

4.3 Methodological Choice

Methodology is an approach to the process of the research (Collis and Hussey, 2014), aiming to clarify which research methods are appropriate for collecting and analysing data (methods), which in turn should meets the philosophical assumption of chosen paradigm. Collis and Hussey, (2014) indicated that the use of the term quantitative and qualitative is to describe the technique of collecting data rather than describing research paradigms. There are two types of research methods: (1) Qualitative; (2) Quantitative. The following subsection includes detail description of each method, and justification for using qualitative research.

4.3.1 Quantitative Research Methodology

Quantitative research is an approach to test objectivist conception of social reality, quantities research methodology is used as a synonym for data collection technique such as questionnaire, laboratory experiments, mathematical modelling, and econometrics (Saunders *et al*. 2016) which produces data in numerical form through using statistical tools. Regarding structure of research processes, qualitative study follows deductive reasoning which employs theory first to guide the research and construct hypothesises. The hypotheses thereafter will be tested using empirical observation to test and assess their validity (Lancaster, 2005). This method examines relationship between variable, which are measured numerically and analysed by means of a variety of statistical and graphical technique (Saunders *et al*. 2016). Lancaster, (2005) determines the factors affecting the selection of appropriate and effective qualitative analysis tools as follow: the degree of accuracy, validity and reliability required, the time and resources available, the needs of the client. Since the quantitative approach is associated with positivism, the quantitative researchers are independent from respondents, and they should be aware that question is expressed clearly and understood by each participant in the same way (Saunders *et al*. 2016).

4.3.2 Qualitative Research Methodology

Quantitative research is an approach to test subjectivist conception of social reality, this kind of method is used as a synonym for data collection technique such as interview and questionnaires, document and text, and the researcher's impression, which produces data in non-numerical form (Saunders *et al*. 2016; Myers, 1997). In contrast to quantitative method, this method is designed to help researcher understand people and the social and cultural context by operating within a natural setting, or research context (Saunders *et al*. 2016; Myers, 1997). Regarding structure of research processes, qualitative study follows inductive reasoning that starts a study with observation of empirical reality facts and details in order to achieve a better understanding of phenomena, and then move to develop a conceptual framework and theoretical contribution (Collis and Hussey, 2014). Creswell, (2013) discussed the appropriate research condition that tend to apply qualitative methods, for instance. Qualitative research is used when inadequate theories exist for certain sample, or existing theory does not adequately capture the complexity of the examining phenomenon, OR when research problem needs to be explored and examined, OR when issue require more detailed and complex understanding, which allow researchers to tell stories unencumbered by what we expect to find or what we have read in the literature. "Qualitative researchers use a lens established using the views of people who conduct, participate in, or read and review a study" (Miller and To, 2000). The quantitative researchers interact with phenomena under study, and they engage to more time-consuming projects, in terms of collecting extensive data and analysing these data through reducing them to a few themes or categories (Creswell, 2013). Therefore, the researcher is a key instrument in qualitative research.

4.3.3 Justification for Adopting Qualitative Research

Adopting qualitative research in this study was based on three points as follow: First, the need to create richer understanding about social and cultural context within they live. Second, the requisite of collecting data in natural setting that is sensitive to people and places under study in order to compare hype with reality. Third, building and generating theory. These considerations are highlighted in this section to ensure the consistency between theoretical and philosophical underpinning.

Firstly, the philosophical perspective of this study is to gain knowledge of reality "interpretive" which is consistent with the main aim of this research "interpretation of the phenomenon under investigation. This research applies a framework based on interpretative the rational action toward adopting BDA in SCO and the irrational action arising within the institutional context that surrounds organisational actors. It potentially produces understanding toward main motive behind processes of developing and using BDA in SCO.

Secondly, as previously explained in chapter two, BDA is new phenomena and it needs more textual descriptions and interpretation to better understand the complex reality of it, there was a scarcity in the studies that used qualitative methodology in order to explore the real usage of BDA in SCO, providing detailed empirical evidence about the real-live of BDA implementation to understand the real and current situation of potential value of BDA in SCO, and test the purported bandwagon for BD capabilities regarding business value in SCO. Therefore, qualitative method is seen as having potential in presenting a clear picture clarifying the valuable use or performance of BDA regarding the operations processes in SC.

Thirdly, from the theoretical side, few articles have tested theories as an interpretation for the response to their research questions. There is lack of theory-based understanding in BD phenomenon, in other side, according to Creswell, (2013) qualitative research is used when inadequate theories exist for certain sample, or existing theory does not adequately capture the complexity of the examining phenomenon. Therefore, qualitative research is regarded as the appropriate choice for this inquiry in terms of generating and building theory.

4.4 Research Strategy

Research strategy is the plan that guides researchers how to answer research questions and achieve desired goal. According to Saunders *et al*., (2016) research strategy is a methodological layer that links between philosophy and subsequent choice of methods to collect and analyse data. Therefore, the choice of strategies is guided by research' aim and objectives, in addition to fit between research strategy characteristics and study characteristics, Benbasat *et al*. (1987) stresses that the goals and nature of research play a vital role in choosing research strategies. There are several research strategies that have been discussed and used by researchers include action research, case study research, ethnographic research, grounded theory, experiment,

survey, archival and documentary research, narrative inquiry, longitudinal research, cross-sectional research (Myers, 2013; Collis and Hussey, 2014; Saunders *et al*., 2016). In the context of the present research, we follow the view of Benbasat *et al*. (1987) that is the most appropriate research strategy for conducting IS empirical research is the case study research, as he termed it "viable information system research strategy". The following section discuss the justification for adopting case study research.

4.4.1 Case Study Research

Case study research is one of the research methods that have been discussed and used by researchers for in depth understanding of complex phenomena. Many authors have identified the main characteristics of case study as follow: it focuses on understanding the dynamics*2* present within single setting (Eisenhardt, 1989); it does not explicitly control or operated variable (Cavaye, 1996); it studies a contemporary event in its natural context (Yin,2014); it is useful in the early stage of research on a new topic (Myers,2013); it applies various methods of data collection (interviews, observation, questionnaires, and written materials) to have information from one or more entities Benbasat *et al.,* (1987). Yin (1981) define case study as an empirical inquiry must examine a contemporary phenomenon within 'real-life' setting, particularly when the boundaries between phenomenon and context are not clearly marked.

According to Myers, (2013) case study research is the most popular qualitative research methods used in the business research, which use empirical evidence from real people in real organisation to make an original contribution to knowledge. Regarding the IS research, Cavaye (1996) deemed case research as a method for IS investigation is a multi-faceted research approach, which can be employed in several ways and can be led to different type of research output. Classifying the type of research question being asked is the most important step for differentiating between numbers of research methods (Yin, 2014). Yin (2014) grouped case study types in distinct categories such as exploratory, descriptive, and explanatory depending on the type of research question what, how, and why questions. According to Saunders *et al*., (2016) An exploratory study aims to find out what is happening; to gain insights about research

2 "Understanding the dynamic of topic refer to the interaction between the subject of the case and its context" (Saunders *et al.,* 2016).

subject; and to provide understanding of a problem and phenomenon by asking open questions that begin with “what” or “how”.

The main techniques of conducting this research would include literature review; interviewing experts in the subjects; and conducting focus group interview. In contrast, explanatory research aims to understand phenomenon by discovering and measuring causal relationship among variable where data is subjected to statistical test such as correlation. Research question that seeks explanatory answers begin with “why” or “how” (Saunders *et al*., 2016; Collis and Hussey, 2014. Descriptive studies aim to gain a precise profile of event, person, or situation by asking question that start with “what” or “how” because the aim is to describe something (Collis and Hussey, 2014).

Based on this classification, the case study followed in this research can be classified as exploratory. The reason is that the research focuses more on question of what type (e.g what is the real impact of BDA in SCO? Identify the hype and reality). Benbasat *et al.,* (1987) reported that the case study research is specifically appropriate for a research and theory are at their early, formative stages, and where the experiences of the actors are essential, and the context of action is critical. Moreover, they summarised the importance of conducting case study research in IS field in following reasons: first, generate theories from practice, second, enrich a specific research area in which few previous studies have been carried out. As stated in previous chapters the research objective is to understand the real and current situation of potential value of BDA in SCO, and if its benefits match its widely presented potential. Given that this is a relatively new research area and the research largely exploratory.

4.4.1.1 Single and Multiple Case Study Research

A preliminary decision in case research design is the decision to conduct either a single case study or if a better understanding of the phenomenon will be gained through conducting a multiple case study (Baxter and Jack, 2008). Single and multiple case study can have different design situation like holistic which include one unit of analysis and embedded that have multiple units of analysis (Yin, 2014). Single case study enables researchers to have rich description of phenomenon and revealing its deep structure, in addition it can be used for exploration at the outset of theory generation and late for theory testing (Cavaye, 1996). Yin (2014) reported that single –case study is appropriate under the following circumstances:

critical, common revelatory, unusual, or longitudinal case. In the context of this research, it may enable to develop a full picture of the organisational idiosyncrasies and allow the researcher to investigate BDA utilisation in SCO.

As we mentioned before, single case may enable to provide rich description of phenomenon, and it could be more than what multiple cases can do in terms of thick detailed description, but multiple cases enable analysis of data across cases, this enables the researcher to prove that findings are not only the result of idiosyncrasies of the research setting (Cavaye, 1996). In multi case design, conclusion is drawn from a group of cases for replicating or confirming the results, which is applicable when the same phenomenon is believed to exist in a variety of situation (Yin, 1979). There is no agreed number of cases to be studied in multiple cases design. The appropriate number of cases depends on how much known about the phenomenon, and how much information is likely to uncover from conducting additional cases (Cavaye, 1996).

4.5 Research Design

The empirical research methodology starts with research design as a first phase. The research resign is the general plan of how the researcher will go about answering research question (Saunders *et al*., 2016. p 162). Research design is a "blueprint" for the research which deals with at least four questions: what questions to study, what data are relevant, what data to collect, and how to analyse the results (Philliber *et al*., 1980 via Yin, 2014) therefore developing a research design involves considering the most fit approach and the most suitable method of data collection and data analysis. Yin (2014) has also confirmed that case study design involves a careful development of the research design which, as per to (Frankfort-Nachima and Nachima, 1992), will allow the researcher to establish the relations between the different variables under investigation. Following sections will present detailed discussion over the case selection and data collection techniques and data analysis procedures.

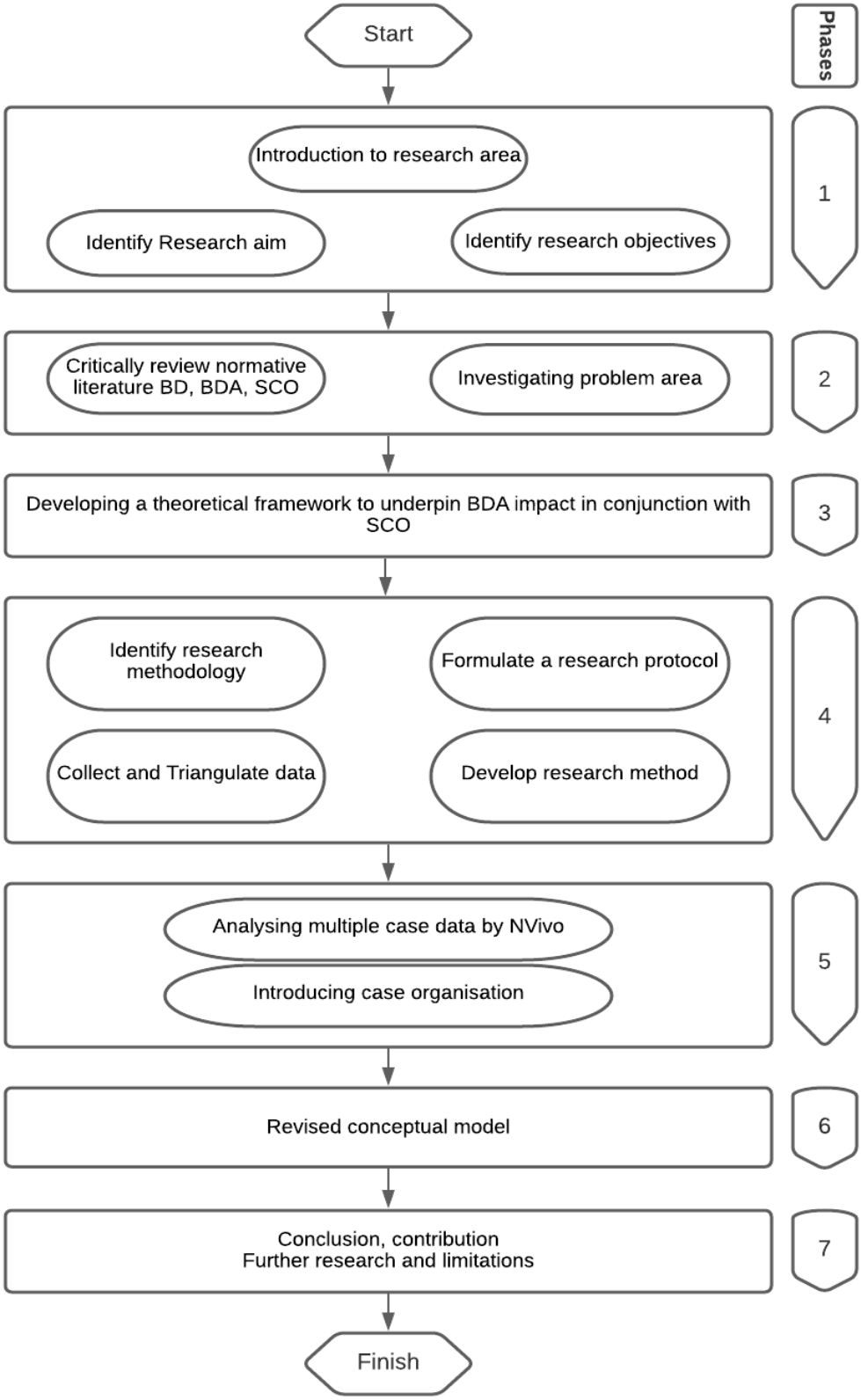

Figure 4.3: Empirical Research Framework of the PhD Process

4.6 Data Collection

4.6.1 Case Selection

A proper access to the data for the potential case is essential whether to interview people, review organisation's documents and records, or make field observations (Yin, 2014). As this study focuses on addressing the reality of BD in SCO area, there is a need for in-depth view of how BDA is employed inside organisations. Therefore, this study gained access to 4 different companies to collect adequate data and information in order to explore the reality of such use. According to Gerring (2007), building a new theory should be through cases that are comparable in terms of contributing to the result and these cases should vary the outcome of the theoretical interest at the same time. The author decided to collect cases from the UK as it started early to consider implementing BDA and there is a growing attention on this phenomenon. (e.g., in October 2016, the UK government launched the All-Party Parliamentary Group on Data Analytics, with the aim of highlighting the opportunities big data offers for all sectors (Reuters, 2016)

SC firms, which have implemented BDA within their operations, were contacted via emails, LinkedIn, and over the phone asking them to participate in the study. Four companies from completely different sectors agreed to take part in this study. Car and Aeroplane manufacturer, fashion designer, transportation and logistics provider, and telecommunication supplier were accessed and explored to answer the research questions. The study only considered organisations have implemented BDA within at least one of its SCO.

4.6.2 Data Collection Technique

As discussed earlier in this chapter, qualitative methodology fits with new phenomena such as the BD and its potentials. In depth consideration of the implementations of BDA understanding will significantly help in revealing all benefits and potentials along with challenges and difficulties. Under the adopted philosophy, interpretivist, interviews are concerned with exploring data on understandings, opinions, what people remember doing, attitudes, feelings and the like, the people have in common (Arkesey and Knight, 1999 via Collis and Hussey, 2014). Therefore, as this study aims to capture full understanding of BDA phenomenon, interviews were selected as a data collection technique. This selection provides a degree of comfort for interviewees and encourage them to simulate the discussion (Burns, 2010). Semi-

structured interviews were favoured where a list of themes was prepared and questions to be covered giving the researcher more flexibility to omit and/or add depending on the organisational context (Saunders *et al*., 2016. p 391). In this interview style, the researcher starts with some questions to encourage the participants to discuss further about the topic of interest and more questions to be developed during interview (Collis and Hussey, 2014).

4.7 Data Analysis

Data analysis in qualitative studies consists of preparing and organising the data for analysis, then reducing the data into themes through a process of coding and condensing the codes, and finally representing the data in figures, tables, or a discussion (Creswell, 2013 p180). The early stage of data analysis after collecting the data is data management. As the researcher intends to use computer software for this purpose, this stage involves sorting the data in an appropriate computer file whether it is text, recording, memos or notes (Creswell, 2013 p180). Saunders *et al*. (2016) highlighted potential problems of using alternative options for data transcription such as paying a touch-typist, borrowing transcription machine, voice-recognition software, or part transcript. Among the problems suggested above are the cost, not getting familiarise with the data, missing important data (coughs, pauses, sighs, etc.), more time to be invested for extra check and many more. Therefore, the researcher transcribed all interviews manually then asked for a second review by another academic colleague avoiding making sure of the quality.

Thereafter, it is very important for the researcher to have a close look at the content and get a sense of the whole database. Reading the transcripts in their entirety several times will be vital in this regard, as suggested by Agar (1980), the researcher should immerse himself in the details, trying to get a sense of the interview as whole before coding it and making it into themes. In this type of research, understanding qualitative data will help the researcher to analyse it meaningfully (Saunders *et al*., 2016). The process of coding involves aggregating the text into small categories by seeking the evidence for the code from the interviews and then assigning a label to the code (Creswell, 2013 p186). Several codes aggregated together will form a common idea as broad units of information, which in qualitative studies called themes or categories (Creswell, 2013 p180). Thematic analysis is a foundational method for qualitative analysis which offers a systematic flexible and accessible approach to analyse qualitative data (Braun & Clarke, 2006 p78). The literature suggested using the use of computer software to help with analysing qualitative data same as the quantitative one (Myers, 2009). NVivo 12 is

used in the analysis process because it is considered as a reliable tool which delivers accurate results rapidly, it also helps with managing and organising textual data, coding and identifying any patterns. NVivo 12 can handle large set of qualitative data at a high speed and good quality.

Topical, conceptual, and thematic word coding of all transcript data in this research was conducted using NVivo 12. Audio recording was transcribed and imported to NVivo; the transcript data gathered into a specific topic of theme. Initial codes were created based on our research goals and the interview questions, then concepts nodes are developed to denote concepts found in the transcript and to provide a collection of all instances of evidence. This process involved categorising the text into meaningful segments and labelling them with an appropriate title to best define the main patterns in this research (Creswell & Poth 2016). For example, expression and definition of a topic gathered into a node, and any references related to the practitioner's perspective about BDA is coded under the node Current view. The thematic analysis reveals that the human factor is significant obstacle when it comes to applying BDA, as one of the interviews stated: "as long as my parts system can be on Excel sheet we are not going to move dealing with BDA".

4.8 Triangulation

Triangulation is the use of multiple sources of data, different research methods, and/or more than one researcher to investigate the same phenomenon in a study (Collis and Hussey, 2014). It is agreed that when adopting case study, the findings are more convincing when data is confirmed by several sources of information (Yin, 2009). This procedure is very helpful, according to Flick (2008) in verifying facts through multiple-data sources. This involves using different methods as a check on one another, seeing if methods with different strengths and limitations all support a single conclusion (Maxwell, 2012).

Using a multiple-case study is helpful to the study and its findings. As this research adopted multiple-cases approach, data credibility was confirmed. In addition, the interviews collected from different organisations and different sectors helped the author to view the study's points from multiple perspectives. For the purpose of this study, and prior to conducting the interviews, enough information was collected regarding each case through the organisations' website, social media platforms, cite visits, available YouTube videos and interviews, and what others said about these cases. This information base was used and triangulated with the

interviewees answers which helped the researcher to significantly increase the reliability and validity of the data collected from interviews (Miles and Huberman, 1994).

The authors made a great effort to confirm check the data quality and systematic procedures were followed to achieve this goal including: The use of multiple-cases study; multiple sources of information, the use of non-probability sampling technique, which is snowball sampling, collecting data through semi-structured interviews, videos (e.g., YouTube video posted by the organization itself or posted by others about the company), observation, documentation and archival record review.

4.9 Pilot Study

A pilot case study will help the researcher to refine the data collection plans in term of the data quality and the procedure to be followed for data collection (Yin, 2014). The pilot test is not pre-test, and it is more formative helping the researcher to develop relevant questions. Within the pilot testing, the researcher ensures the accuracy during questioning to see whether the participants properly understand them in term of the language clarity and the content quality (Yin, 2014; Van Teijlingen *et al*., 2001). Therefore, a significant improvement can be made to the interview protocol in areas where the answers generated are not in line with the research objectives or where there is a lack of understanding from respondents (Morin, 2013). For the researcher to make the best out of the pilot testing, the cases for pilot study should be carefully selected. According to Yin (2014), the scope of the pilot inquiry can be much broader than the ultimate data collection plan covering substantive and methodological issues.

Hence, in order to check the clarity and the suitability of the questions, the author of this study conducted three small scale exploratory pilot tests reviewing all interview questions with one industry expert and two academic experts. These tests were critical to help in confirming understanding the interview content and assessing the quality of the interview questions. Following the pilot test, the author made some minor changes including rephrasing some questions as suggested by most of the pilot interviewees, breaking down and simplifying some other questions, and considering the terminology more carefully by adding detailed explanation to some technical and academic terms.

4.10 Data Quality: Validity and Reliability

The research is conducted to draw theoretical and practical conclusions which are significantly based on empirical investigation. Data is the raw material for the empirical examination and its findings, and the quality of the data is of a great importance for establishing a solid and reliable conclusion. In order for the researcher to confirm the data quality, validity and reliability were carefully considered.

Validity in qualitative research indicates consistency and trustworthiness regarding activities and events associated with the phenomenon as signified by the study results explored in the research (Golafshani, 2003) while reliability was defined by Creswell (2013) as the stability of responses to multiple coders to analyse transcript data. Reliability is concerned with the consistency, stability and repeatability of the informant's accounts as well as the investigators' ability to collect and record information accurately (Selltiz *et al*., 1976:182). Silverman (2005) (via Creswell, 2013) suggested that reliability in qualitative studies can be improved if the researcher obtains detailed field notes by employing good quality tape for recording and by transcribing the tape. A proper recording by two devices was performed in order to make sure that all interviews are properly captured, and any type of technological faults is backed up.

Lincoln and Guba (1985) used "trustworthiness" of a study as the naturalist's equivalent for internal validation, external validation, reliability, and objectivity. They explained that trustworthiness is achieved by credibility, authenticity, transferability, dependability, and confirmability in qualitative research. The author checked these aspects through further search, investigation, and reviewing cases documents and websites until the quality of these interviews is confirmed. Similarly, in order to gain as much accurate information as possible, transcription was performed by the researcher and was reviewed by another expert for extra check. As per to Creswell (2013), one of the main issues here is agreement on code names, the code passages, or the same passages coded the same way. In this regard, NVivo 12 was of a great help in data processing and confirming reliability as it can analyse across different data formats utilising the same thematic (node) structure.

4.11 Ethical Consideration

As soon as the research is designed and planned, ethical concerns will emerge in term of seeking access to individuals and to organisation, collect, analyse, manage and report the data (Saunders *et al*., 2016). Saunders *et al*. (2016) defined ethics as they refer to the standards of behaviour that guide the researcher's conduct in relation to the rights of those who become the subject of the study or are affected by it. Therefore, before conducting any academic study, it is essential to gain ethical approval to uphold a high ethical standard for the research project (Broom, 2006). Accordingly, prior to starting any data collection process, the research team must highly consider these ethics and obtain the relevant approvals.

It is recommended that the researcher should show the committee the purpose of the research, the research design, and all measures which will be taken to preserve the confidentiality of the data supplied and respect the anonymity of respondents (Ghauri *et al*., 2020). For the sake of this study, the researcher has submitted an application to Brunel University research ethics committee showing the related documents of participant information sheet which introduce and briefly present about the research and its purpose, consent form which confirms the agreement of the participant to take part in this study, interview protocol and questions, . All these documents were properly reviewed by the committee and the researcher was granted ethical approval upon it.

4.12 Summary

This chapter presented the methods to handle the research question by first starting with a justification of the research philosophy. Interpretivism philosophy was adopted leading to a deductive approach. Multiple case studies were the strategy to collect qualitative data in order to gain detailed and in-depth understanding of the BDA as a new phenomenon in the context of SCOs. To collect primary data, semi-structured interviews were conducted in cross-sectional time horizon in four different industries helping the researcher to closely look at the reality of BD and its implementation. Furthermore, online sources including the organization's website, videos, reports, and other documents were used to triangulate the data collected from interviews. The following chapter will be focused on analyzing the data in order to draw a conclusion and examine the research questions.

5. CHAPTER FIVE: DATA ANALYSIS

5.1 Introduction

The previous chapter discussed the research methodology employed in this study. This chapter applies data analysis method described in the research methodology and presents the finding from the analysis of four cases in order to test the proposed conceptual model for better understanding BDA initiatives in SCO with the objective of making robust investment decisions in BDA. Therefore, this chapter will start introducing each case separately in accordance with the recommendations of Eisenhardt (1989). Then, it will develop an understanding of what interviewees think of BD from their perspective. This is followed by an analysis of the cases with regard to SCO portfolio tasks. Later, this chapter presents the external pressures factors which enhance BDA implementation. Before concluding with the real impact of BDA on SCO; BDA evaluation in SCO context will be investigated.

All companies considered operate inside the United Kingdom. The data collected for each case mainly obtained by: Interviews, observations, reports, online resources including social media platforms and videos, and company statements. The structure of data analysis is designed to evaluate each construct of the conceptual framework across the cases.

5.2 Background to Case Organisations

5.2.1 Case_Organisation_1

This is a UK establishment for an American multinational conglomerate telecommunication holding company founded in 1870s. The company claimed that its revenue for 2019 was over 180 billion dollars and the net income was around 14 billion with over 550 billion of assets and 250 thousand employees. It provides products and services for individuals and large-size businesses. Through its SC sustainability efforts, it claimed that it is getting smarter to serve its customers better and ensure that the values of its suppliers match those of its own company. This company introduce itself as a modern media company with unique blend of businesses work together, providing our customers around the world with connectivity, technology, entertainment, news, advertising and more. Its procurement team works

specifically with the transactional vendors setting up the company's processes and flow for how it procures materials. The author conducted the main interview with a senior IT staff and it took 57 minutes.

The company's SC supports three distinct functions: A consumer group handles handsets, tablets, devices, set-top boxes and other customer-facing products that are distributed to more than 2,500 stores inside the US and other retailers and agents. This group is served by two distribution centers. In addition, the company's network group handles the logistics, planning and sourcing associated with maintaining the company's wireless network as well as its 22-state wireline franchise communication business. The third SC group supports the efforts of the company's sales organization in managed services hardware and video and data premise equipment and performs planning, sourcing and logistics activities for the entire company. In total, the company purchases roughly $63 billion worth of materials annually. Telecommunication company has implemented BDA in inventory management, they collect generated data from assets and apply to inventory to give reliability factor to all these assets that would say it is safe to use more than what it is said by the manufacturer.

5.2.2 Case_Organisation_2

It is a Scottish manufacturer of Cashmere and woolen accessories. It is a family business established over 200 years ago. The company size has over 1000 employees. They take part in international fashion catwalk and fashion weeks around the globe such as London Fashion Week. They implement modern technologies within their production lines, and they adopt "REDUCE, REUSE, RECYCLE". The show high level of care toward the environment through repairing services. It has built a global customer base for a range of products made in The UK which includes scarves, jackets, coats, jumpers, and cardigans. The company suppliers of raw material fiber from China, Mongolia, Australia, India, and other countries. Almost all production takes place in company-owned and operated manufacturing sites in the UK.
The author conducted the main interview with sale manager, and it took 40 minutes.

It sells to luxury brands but also markets its own branded products, which are distributed through its own UK factory outlets, online and through sales agents around the world. The privately-owned company has a strong balance sheet and it made £6.41m profit before tax in 2019. In their ERP system, they have a system used for the retail part of the business which

are not manufacturing. They collect data as well from the machines that they use within the operations of the business. Start on scheduling and that just to look for efficiency, so they can have a fewer or less time spent on change overs because they have applied a complex set of patterns that company could use, they were trying to reduce complexity to reduce change over times.

5.2.3 Case_Organisation_3

This case is considering a transport and logistics company has branches in 8 different countries around the world. The company was formed in 2006 in order to better serve its existing clients with European cargo requirements as well as addressing issues with the fleet management. Services it offers to customers that are based in the United Kingdom and Ireland are as below:

- Carriage of Groupage / LCL cargo
- Carriage of Full loads / FCL - Oversize Cargo - Airfreight - Solutions by Sea - Carriage by Railways - Storage - Pick & Pack - Customs & Bonded Facility

In addition to the UK, the company operates in Germany, Georgia, Azerbaijan, Iraq, and other countries. The author conducted the main interview with UK branch manager, and it took 56 minutes.

In term of financial performance, we were not able to obtain any helpful insight in this regard. Few years ago, the company achieved the Fleet Operator Recognition Scheme (FORS) which is a voluntary accreditation scheme encompassing all aspects of safety, fuel efficiency, vehicle emissions and improved operations. The company addressed that the use of recent technology helped it to achieve it. They use a satellite system called Castrol which not only provide the location of the vehicle but also gives the statue of it, whether it is on the move, switched on or off. It is also providing the transport manager timely information in regard of all vehicles' data such as mileage, carbon emission and pollution created. They analyse data coming from diverse sources such as government websites to analyse different uses and regulations which affect industry (legal side), they analyse data from UK border agency too from their website and database, data bank, archive to find a decision at a particular point of time and apply to their mission.

5.2.4 Case_Organisation_4

This case organisation is a specialist in Mechanical Engineering and produces Civil Aerospace, Defence Aerospace, Services, and Power Systems. The company size is more than 10000 employees. This company is listed on the London Stock Exchange, where it is a constituent of the FTSE 100 Index. The author conducted the main interview with UK IT senior manager, and it took 117 minutes. This company claims that it is creating a major step-change in the capability of our data-enabled services to take customers further and faster in their pursuit of optimised efficiency. Examples of such data use provided that new insights from data have led to a better understanding of taxiing fuel consumption, drinking water requirements, diversion flight planning and the zero-fuel weight of its aircraft – saving nearly $10 million in annual fuel costs.

With technology becoming a major part of SC around the globe, this company claimed that it continuously invests in modern IT solutions to support SCM functions. It employs web enabled sourcing software through a service provider which includes the use of e-auctions and electronic request for quotes/proposal. The company has also implemented tools such as:

- Strategic sourcing toolset - an online system facilitating the creation of commodity and supplier strategies, contract creation and negotiation, supplier performance management and SC spend analysis.
- Raw material planning/ SC mapping - an integrated software package which maps the sub tier SC providing demand signal visibility, risk and utilisation analysis, demand simulation and key points of failure analysis.
- An accessible web-based "Global Supplier Portal" which enables rapid information interactions and provides valuable SC quality and performance data.

It invests a considerable proportion of time identifying and mitigating potential points of weakness in its external SC. The firm spends more than £7bn annually with its suppliers. From purchasing raw materials to manufacturing components to assembling for getting a finished product, in order to run an efficient inbound network, it selects its partners involved in each phase in strict accordance with global sourcing process which assesses the ability to deliver to the company's standards. Its partners as logistics nodes in the entire process varying from suppliers to manufacturers, home and abroad collaborate with each other smoothly. The company's suppliers are from all around the world. For instance, it purchases titanium materials

from a Russian company. Also, a Chinese company supplies special steel to produce the disk and blade of the low-pressure rotor. Then, those raw materials and small parts will be sent to Japan and UK to manufacture more complex components. They digitalise all manufacturing data coming from machines to track back the source of defects and control manufacturing processes.

5.3 From Industries Perspective: What is BD and Why was it Implemented?

Despite the BD became a new buzz word and its applications have increasingly captured interest of scholar and practitioners, there is no consensus about the meaning of BD. Chapter two discussed the absent of universal definition for BD, and there is diversity of how organisations, researchers and practitioners are looking at BD. The hype surrounding BD is beyond what is reasonable, and the perception of the meaning and value of BD is confused. Therefore, the understanding of BD from the perspective of practitioners will facilitate building up the fragmented picture of BD in SCO. Thus, the first step was to develop an understanding of what interviewees think BD is from their perspective.

Based on the investigation with research participants regarding their perception of BD, most participants defined BD based on two themes as follow: **The first theme** concentrates on the significances, applications, and opportunities of BD.

"*Data which can enable you to optimise your outcomes and improve to use that statistically and implement it to your business processes to improve the functionality of a particular area".*

The second theme defines BD in terms of its benefits (profitability) and its attribute (size).

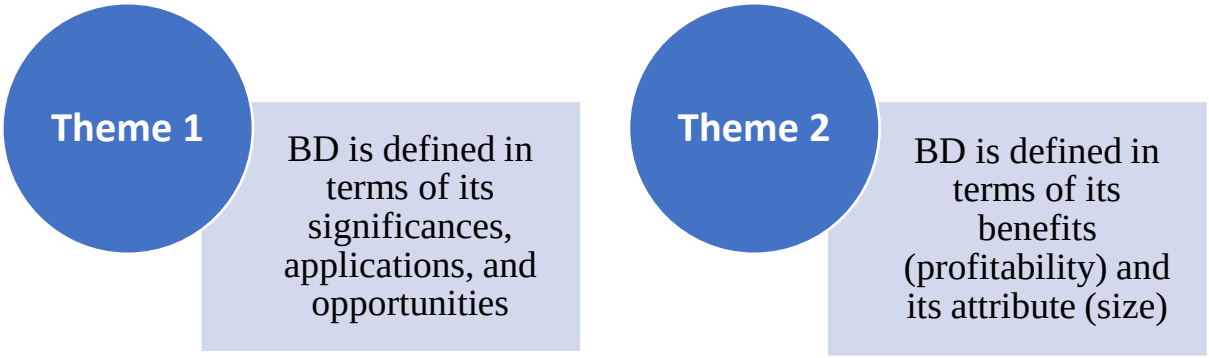

Figure 5.1: The Themes Conducted from Participants' Perception of BD

"Well for me because I'm working on my in the telecoms industry. Motive is about taking Masses in gigabytes of data like, data-likes to likes, processing it and turning it into something meaningful for business improvements and business initiatives. ultimately all comes down to money how can we save money or how can we do something better. That was very much what we were doing because when I met with people within organization that manage BD, we were talking about thirty thousand assets and these pieces of information from them which might be create a file of 20 megabits and these guys talking about terabytes of data that comes from millions of mobile devices have to be stored on huge service because it is so big. For me, the BD, I think the big might be, what is the definition of big: Is it big because you are using so much data or is it just really data renovations and the use of data renovations. I think the BIG for me is a bit misleading".

Practitioners' perception of BD
Optimisation tool
Improve profitability
Big size of data

Table 5.1: BD as Seen by Practitioners

In literature, scholar ascertain that the benefits of BD to SC processes improvement have profound influences in organisation' sustainability. For instance, enhancing a better

understanding of customer preferences and market trend helps in building responsive/ agile SC, in addition to improving operation efficiencies and maintenance through having transparent information at higher frequency (Kache and Seuring, 2017; Tiwari *et al*., 2018). In order to investigate motivations behind implementing BDA, the interviewees were asked to identify their drivers to utilise BDA. They asserted that profitability and cost saving played a significant role in adopting BDA.

"However, our first motivation was mainly profitability, ……. cost saving, you know it was a time of contract negotiations"

Decision making model based on BDA is one of the opportunities and future perspective in SCM, whereas decision making in SCM requires associated knowledge which could be elicited from BD (Zhong *et al.,* 2016). The Value Engineer Lead with 3 years of experience in automotive industry highlighted that one of the biggest motivations is to keep up-to-date immediately any changes to take timely decision as one of the interviewees stated:

"find a decision at a particular point of time and apply to our mission"

Sharing information between supply SC partners always been considered one of the paramount important factors to improve product availability and reduce cost. On the other side, BDA has deemed a tool that can help sharing information in SC more easily, clearly and efficiently (Li *et.al*, 2018). From our data analysis, the managers in general have mentioned that their drive to apply BDA arise from its powerful data processing capability to reduce information asymmetry, reduce cost, save time. He stated:

"*The biggest motivation is to keep the knowledge and to make it sharable in a way I don't need to print something and drop it by email when I can access one system so I can go and find what I need in regard to this part without interrupting anyone else. That is where we recognise there is a need and this need translated into saving, saving of the time, money, knowledge, etc*"

In addition to the abovementioned motivations, more has been discussed by interviewees such as assets maintenance, improving customer track ability, safety standard, and adding value to client. Finally, two mangers from telecom industry and logistics industry have stressed the important of implementing BDA as branding strategy to attract customers/clients, they wanted to be keeping up with the advanced technology in order to maintain good reputation. One of them said:

"we could use the buzz word and encourage the customers "Wow ok great, they are using BDa

then they must be good", it is a positive selling point……. so we can update our client at any moment which have very positive impact on the company profitability definitely"

Figure 5.2: Internal Motivating Forces

From analysing data, managers understand BD as a way to create better opportunities of improvement through storing and analysing the huge amount of data generated from different devices. Despite the different terminology used to describe their motivations for implementing BDA, all these motives focus on improving performance and increasing profitability.

5.4 Task and Technology Characteristics

5.4.1 SCO Portfolio Tasks

Unquestionably, in the realm of increasing competitive pressure and the pace of changing demand, volatility and disturbance have become the standard in today's global markets.

Therefore, there is a general agreement concerning new and ongoing challenges in today's business activities which require empowering capabilities and sensing opportunities.

SCO refer to short term activities over day-to-day basis which facilitate transforming raw materials into work in process or finished products and delivering to end consumer. the main objective of SCO is securing material flow between SC partners and handling customer order in the best possible manner(Chopra and Mendl, 2013).

choosing reliable suppliers based on the bill of material and other considerations like low cost, consistent high quality, quick respond, flexibility, and reputation, has been a quite huge procurement process challenge to address (Bhutta and Huq, 2002; Li *et al.*, 2015; Lamba and Singh, 2017). The performance of suppliers in terms of the cost of component parts, raw material, and service purchased becomes a crucial constituent in an organisation's success or failure (Bhutta and Huq, 2002; Trivedi *et al*., 2017).

In this study, five phases of SCO were considered. i.e. procurement, manufacturing, logistics, inventory, and demand planning.

5.4.2 Demand planning

Demand planning is a critical function to SCO planning as it helps to predict future demand and sale using data of real-time sale, marketing, and inventory information collected collaboratively by SC partners (Wang *et al.*, 2016). Predict precise demand is one of the most important challenges in the field of operations management, because of its role in supporting operational processes including inventory decision making and production planning (Albey *et al*., 2015; Jain *et al*., 2015). Similarly, Jain *et al.*, (2014) stressed that demand estimation as one of the most important challenges in the field of operations management. The roadblock in demand planning is the existence of time lags in the information flow (Hosoda and Disney, 2012), which can be interpreted into lack of visibility of stock level, availability of sale data, visibility of customer's need and market segmentation (Albey *et al.*, 2015).

Customer demand forecasting was confirmed by interviewee as the most crucial task that leds to increasing profitability in the entire SC. One of the interviewees stated that:
"*Demand planning works hand in hand with production and manufacturing, it told us when we would need certain piece of equipment. In terms of demand planning, ask the customer in 12*

month you will need to replace this, would you need technology, or replacing it like to like, then that will be feeding the manufacturing side that we need x number of these kind of devices. It allows us to be more predictive"

According to Stadtler, (2005), "The step from pure demand forecasting to demand planning is made by adding to the demand forecasts those unusual influences expected to happen in the future and their impact on sales. In the same vine, our interviewees raised one concern that demand planning had held back their operations. One manager from transport industry reported:

"In term of demand planning operations, example of the main challenges. Sometimes we take big projects the client asks us to carry the goods on our own trucks, not using sub-contractors. This makes it a bit difficult as we have the contract, but we do not have the capability of maintain those standards"

This statement indicated that the manager had real concerns over demand variability and process variation, referring to the number of resources that would be needed in terms of vehicles, time, and staff to be capable to maintain good standard of services. Demand planning task includes:

- Predicting customer demand more accurately
- Controlling of demand variability and process variation
- Collaborating with manufacturing
- Collecting timely data to segment customer preferences

5.4.3 Procurement

In procurement context, choosing reliable suppliers based on critical considerations such as (bill of materials, low cost, consistent high quality, quick respond, flexibility, and reputation) has been a quite huge procurement process challenge to address (Bhutta and Huq, 2002; Li *et al*., 2016; Lamba and Singh, 2017). In addition to choosing the right supplier, order allocation decision process plays a significant role in improving firm's cost effectiveness; it is essential to determine the right quantity of materials from each supplier (Trivedi *et al.,* 2017). Suppliers

are evaluated based on a range of criteria and performance attributes that set up trade-offs between qualitative and quantitative factors (Nazari-Shirkouhi *et al*., 2013). As from literature, scholars stated that there are many challenges in procurement processes as follow: Outsourcing logistics activities to logistics service providers (Yu and Li, 2000), selecting the best possible supplier (Van 2009), Limited capacity of vehicles and time consumption of the shop floor logistics processes Gyulai *et al.,* 2013), Optimising the total procurement cost (Lamaba and Singh, 2017). The performance of suppliers in terms of the cost of component parts, raw material, and service purchased becomes a crucial constituent in an organisation's success or failure (Bhutta and Huq, 2002; Trivedi *et al.,* 2017).

When the interviewees were asked about the main tasks in SCO in terms of procurement, the interviewees from the telecom and fashion industry specified just one challenge in their procurement processes, selecting the best suppliers based on prices and flexibility. Our interviewees reported:

"*Procurement is always about Selecting the best possible supplier …….. The best price, contracting price and ensuring you got the best price, flexibility, particularly today*".

"*Procurement team are a nightmare, they are very demanding, they want the best possible price, it is not very pleasant anymore, now they sent us, for example, close of business today and they want the answer the next morning. Procurement is always about the price, contracting price and ensuring you got the best price, flexibility, particularly today"*

As a result, it was found that the main task of procurement is:

- Selecting best possible supplier.

5.4.4 Inventory Management

The cost of inventory considers a very costly operation that requires a regular counting of stock. Whereas the optimal level of inventory is one that maximizes SC profitability (Derakhshan *et al*. 2007; Chopra and Mendl, 2013). The safety inventory emerged to face challenges resulting from demand and supply uncertainty such as transportation delay, production delay, increasing customization, and capacity constraints, in addition to meeting the demand that exceeds the amount forecasted for given period and keeps organisation's position in marketplace. The main task of inventory process is ensuring visibility for responsiveness and traceability of items

(Demey and Wolff ,2016). Lack of information visibility for responsiveness and traceability has been identified as an important challenge for inventory process

The above-mentioned discussion resonates with the view of our interviewees where they affirmed that completeness, accuracy, and consistency are the main factors to success inventory operations. One of the responses was as follow:

"*Completeness accuracy and consistency these are the kind of a mentors that he instilled in us when we were thinking about inventory. If you don't have an accurate inventory, then you know you're screwed basically. Same for consistency, we talked about it already. Completeness, if you have not got everything captured that means you got "no knowns no known knowns" a common terminology that we use*".

The manager clearly believed that visibility of inventory for traceability is very crucial for inventory, and this is in line with what was stated in the literature. Another concern highlighted, that accurate inventory information is very needed for efficient inventory, in the way of enhancing coordination between SC partners by sharing right information.

One more challenge in inventory processes has been added by manager in logistics company, it is about inventory reduction to free up space, He said:

"*Challenge is that we need more space. This force us to customise our clients*"

This statement highlights that holding inventory cost is very challenging in inventory processes especially when there is a need to increase space capacity. Inventory task compass of:

- Improving completeness, accuracy, and consistency
- Inventory reduction to fee up space

5.4.5 Manufacturing

Manufacturing includes the ''hard" part i.e., activities where people use the machines and tools to transform raw materials to finished goods, move goods from manufacturers to retailers by vehicles, and carry out disposal of recycling of used goods (Zhong *et al.*, 2016). Manufacturing is a main core of SCO, and it has been affected like abovementioned operations

by globalisation and technological development. The complexity generated in manufacturing activities due to the exploding product variety requires designing and operating sustainable and efficient manufacturing networks (Mourtzis, 2016).

Organisations try to optimise their manufacture through minimising the production waste, reducing the lead time, and lowering the production cost at the level of satisfying customer demand. Furthermore, more pressure was put on the production section to move toward green manufacturing and to become environmentally sustainable. These include environmentally friendly product design, packaging methods, saving energy, and material recovery or recycling (Gungor and Gupta, 1999).

In seeking maximising profits, firms try to optimise their production through facing following challenges: cutting of production waste, sustainability of products and process, reducing the lead time, predicting, and minifying production disruption (Pal *et al*., 2014), and lowering the production cost at the level of satisfying customer demand.
Prioritising green manufacturing are driving decision making to consider energy consumption and find ways to achieve energy-efficient production management (Gungor and Gupta, 1999;

Shrouf and Miragliotta, 2015). That makes energy reduction another challenge in manufacturing processes. More challenges have been addressed in literature as following: increasing flexibility by coordination decision in different SC stages (Ekşioğlu *et al*., 2006), integration of production with other operational function (Chen, 2010).

From analysing the data, talking about complexity generating from product variety, two points were identified in this context: Firstly, the need of virtual sample of products instead of manufacturing the sample, which helps in reducing required resources and trying to implement more shorting to put control within the business. Secondly, finding digital solution to large range of historical designs that people come to manufacturers again to ask for them, as moving from one design to another costa manufacturer large amount of time. In the same vine, the manager in automotive industry stressed on the need of digitalisation in order to find a way to detect any defect as early as they can. He stated:

"*How to process all the manufacturing data to be digitalised in order to be able to read it in a smarter way/data analytics way. I discussed the same issue with a guy from another car manufacturer how to understand all data coming is really difficult. One of the guys told me he has an issue with a car gets exactly same defect. It was not easy to identify the problem as it was sold across Europe. It was clearly coming from a facility, it took them 18 months to track*

back what happen, they found that all these cars were delivered by different facilities but one of the facilities had a renovation, so they had to shut down one of their sections then it was transferred to another facility, where they missed one step in this production"

Interviewees' responds on manufacturing challenges question clearly indicated that reducing the lead time, cost, and minimising disruption are the most important challenges in this operation.

Several manufacturing challenges were identified by managers as follow:

- Enhancing capacity by addressing the efficiency of the operation.

"That is one of the things what we're doing to give us more capacity and to do that one we are looking at scheduling software as a potential way to it we reduce change over times between products and make sure we're scheduling more efficiently, that would be certainly one area. increase capacity and reduce lead time. capability to schedule software to reduce change over times between products and make sure we're scheduling more efficiently"

- Speeding the reaction to meet customer demand in having sample quickly, through improving ability to create virtual samples. Moving from one design to another costs company large amount of time and recourses as there are significant differences among designs. Therefore, virtual design will cut down on that number of protentional patterns and reduce change over time between moving from one group to another.
  "*Improving ability to create virtual samples of products, because at the moment if we want to create a sample of that new product you design it there, which is slow requires resources and so we try to improve the ability to create virtual samples it represents those on the screen for people. We are trying to implement more shorting to put control within the business so getting meaningful data quickly to the shop floor so people can act on it quickly"*
- Cutting down design patterns:
  "We have a very large range of historical designs that people can come back to us again ask for it, moving from one design to another design it costs us large amount of time as there is significant differences between designs, we are trying to cut down on that number of potential patterns so that we have patterns that setting to certain kind of groups minimising the changeover time between moving from one group to another"
- Reducing the lead time:

"*Reducing the lead time and the cost are the most important*"

- Controlling (Detecting defect early)
  "*The example I gave if one of the manufacturing guys forgets one operation you can discover it a day before or ten years later. The most important thing you need to discover it somehow before any trouble. It's a key element, detect defect early*".

Therefore, as per to the interviews, manufacturing tasks look after the following tasks:

- Enhancing capacity by addressing the efficiency of the operation.
- Meeting customer demand.
- Reducing resources (cut down design patterns).
- Reducing lead time
- Controlling processes, detect defect early

5.4.6 Logistics Planning

Logistics involves supply of raw material, material management in a factory, and distribution to customers (Islam *et al.*, 2013). Globalisation pressure pushes companies to become more effective and efficient in terms of improving customer service. Online business, and a wide range of companies have played a pivotal role in raising the level of customer satisfaction, which has, in turn, raised the necessity to offer product with best quality, lower cost, shortest time, and best overall experience. Specifically focusing on logistics, some scholars tended to design knowledge-based logistics system to propose optimisation model for logistics problem in facing uncertainty about the future. Manufacturers' survival in today's competitive market count on profoundly on the coordination of the manufacturing and distribution operations (Azadian, *et al*.,2015).

In literature we found three main challenges in logistics processes, *Logistics problem in facing uncertainty about the future* (Jharkharia and Shankar, 2007; Lai, 2004), outsourcing logistics activities to logistics service providers (Yu and Li, 2000), limited capacity of vehicles and time consumption of the shop floor logistics processes (Gyulai *et al.*, 2013). Concurrently, the goal of sustainability has emerged as key corporates destination (Grazia Speranza, 2018). In this study, the author found the challenges in SC logistics, and they are addressed as follow: cutting logistics cost, improving customer service through timely delivery and customised service, environmental issues, and finally minimise the risk of unforeseen incidents.

- In response to the question: what the main tasks /challenges in logistics processes are, four broad themes were emerged from data analysis: timely delivery, vehicles maintenance, unforeseen circumstances, compliance with Regulations. Transportation rules, and security norms that vary from city to city, and quite obviously, from country to country. One of the responses was:

"*Logistics are to expect the unexpected……..For us one of the main challenges is shipping and customer clearance, country law and so on. Theses could be problematic and includes delays, so it is about setting that expectations with the customer with some uncertainty about it. Imagine operation for example, if I want something from John Lewis, I can have it by the next day as the warehouse is local, but when you start talking globally then it becomes more challenging"*

A manager in logistics company stated that a key challenge in logistics operations is trackability, he exclaimed:

"*It is one of the key things, especially if you see a company has one facility around the world. I know that there are existing methods, they are more ahead as they need a system to track everything in term of logistics just to arrange the correct time frame of producing parts*"

Another challenge has been found from data analysis, reported by manager in aeroplane and automotive industry, is uncertainty. The interviewee reported:

"It is what we call in the contract, act of God, something we can't deal with but nevertheless we have to prepare for plan B. We have to be backed up and understand your logistics perspective".

From the above statements, we can conclude that having real-time update on the statues of logistics and adopting tools to increase logistics agility will improve logistics processes efficiency. The main logistics tasks here include:

- Ensuring timely delivery
- Vehicles Maintenance
- Gaining superior visibility
- Providing resilient logistics, customer focused logistics that can overcome disruptions.
- Enhancing traceability

According to the discussion above, **Table 5.2** presents a summary of SCO Portfolio Tasks

SCO	Literature Findings	Source	Practical Experience	
Demand Planning	*Demand estimation *Visibility of stock level, sale data, customer's needs, and market segmentation.	Jain et al., 2014 Albey *et al*., 2015. Jain *et al*., 2015.	*Predicting customer demand more accurately *Controlling of demand variability and process variation *Collaborating with manufacturing *Collecting timely data to segment customer preferences	Interview
Procurement	*Optimising the total procurement cost *Choosing reliable suppliers *Order allocation decision	Bhutta and Huq, 2002 Nazari-Shirkouhi *et al.*, 2013 Li *et al*., 2016 Lamba and Singh, 017 Trivedi *et al*., 2017	*Selecting the best suppliers.	Interview
Inventory Management	*Ensuring visibility for responsiveness and traceability of items * Optimising the total inventory cost * Trade-off between the cost of inventory to increase product availability and the loss from not having the right product in the right time	Derakhshan *et al*., 2007. Wu and Yang, 2012. Chopra and Mendl, 2013. Demey and Wolff, 2016.	*Improving completeness, accuracy, and consistency *Inventory reduction to fee up space	Interview
Manufacturing	*Cutting of production waste *sustainability of products and process *Reducing the lead time, *Predicting and minifying production disruption *lowering the production cost at the level of satisfying customer demand *Prioritising green manufacturing *Increasing flexibility by coordination decision in different SC stages *Integration of production with other operational function *The complexity generated in manufacturing activities due to the exploding product variety	(Pal, *et al*., 2014), Shrouf and Miragliotta, (2015) (Mourtzis, 2016) Gungor and Gupta, 1999 Ekşioğlu *et al*., 2006 Chen, (2010)	*Enhancing capacity by addressing the efficiency of the operation. *Meeting customer demand. *Reducing resources (cut down design patterns). *Reducing lead time *Controlling processes, detect defect early	

Logistic Planning	*facing uncertainty about the future. * Outsourcing logistics activities to logistics service providers *improving capacity of vehicles and time consumption of the shop floor logistics processes *cutting logistics cost, improving customer service through timely delivery and customised service.	Yu and Li, 2000 Lai, 2004 Jharkharia and Shankar, 2007 Gyulai *et al*., 2013 Grazia Speranza, 2018	*Ensuring timely delivery *Vehicles Maintenance *Gaining superior visibility *Providing resilient logistics, customer focused logistics that can overcome disruptions. *Enhancing traceability	Interview

Table 5.2: A Summary of SCO Portfolio Tasks

5.5 Technology Characteristics

BD has the characteristics of the 7" Vs", i.e., volume, variety, value, velocity, veracity, visibility, and variability. These characteristics are helpful in differentiating BD from the conventional data used in the extant analysis techniques. *Volume* refers to the magnitude amount of data stored within the IT infrastructure. *Velocity* refers to the rate at which data is created and become available to all. *Variety* refers to the diversity of BD sources and its formats, what is make data big is greater variety of sources than ever before (Russom, 2011). Veracity refers to the high correctness and quality of captured data (Shu, 2016). *Value* is what practitioners and researcher are working for long time to discover in BD phenomena addressing what the potential benefits and the possible costs of using BD are. *Variability* means the same data in different times gives different meaning (Jukić *et al.*, 2015). *Visualization* or *visibility* can be defined as a tool which interpret the patterns and trend that are present in data in form of chart, graph or picture (Seddon and Currie, 2017).

Following the rapid expansion of data volume, velocity, and variety, significant developments have been documented in terms of techniques and technologies for data storage, analysis, and visualization. Empirical research on BDA potentials is still at a primary state with a general lack of understanding concerning the mechanisms through which such investments result in competitive performance (Mikalef *et al.,* 2020). When the interviewees were asked about BD attributes 7 "Vs", the majority commented that they have no idea regarding the terminologies of 7" Vs" but in their responses, they explained the core meaning of BD characteristics without labelling each characteristic with 7 "Vs". A thematic analysis has been carried out to identify patterns of BD attributes in the interview data, explanation for each V was found as follow:

5.6 BD Attributes

1. Value

   - Getting meaningful data quickly to the shop floor
   - Profitability performance
   - Providing the transport manager in-time information
   - Use of the data was forced to identify defect

2. Variability

   - Cloud data (Castrol)
   - Manufacturing, design data, supplier data, technical data, location
   - Online data

3. Variety

   - Analyse data coming from different sources
   - Analyse data from UK border agency too
   - Cloud data (Castrol)
   - Customer feedback
   - External data
   - Huge amount of data in term of shipment
   - Manufacturing, design data, supplier data, technical data, location
   - Oracle data
   - Vehicles' data such as mileage, carbon emission
   - Weather information
   - Website and database, data bank, archive

4. Velocity

   - Act on it quickly
   - Getting meaningful data quickly

5. Veracity

   - Getting the right information

6. Visibility

   - ERP data

7. Volume

   - Deal with large amount of data
   - Huge amount of data in term of shipment
   - Terabytes of data
   - Unbelievable amount of data

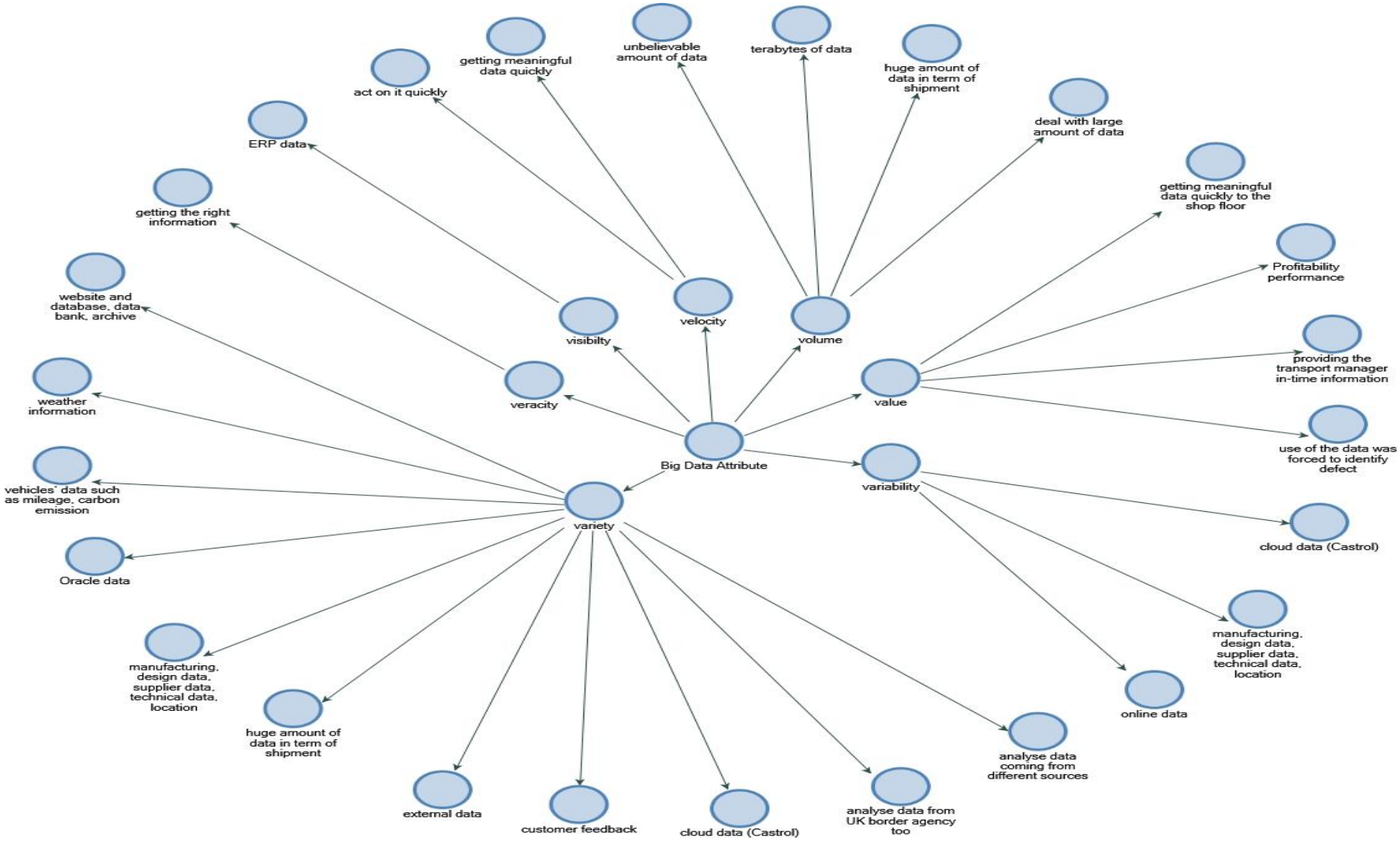

Figure 5.3: BD Attributes Linked with the Tasks

5.7 External Pressure Factors

Internal changes in organisations are responses to external institutional pressures (DiMaggio and Powell, 1991). As per to the literature, the main motive behind processes of developing and using IT are subject to social pressures, which include pressures from competitors and pressures exerted by trading partners (Oliveira and Martins, 2011; Currie, 2011). The main concern here is about the customers, uncertainty, and sustainability.

5.8 Customer Satisfaction, *Coercive Pressure*

Online business, globalization, and wide range choices of companies have played a fatal role to raise the level of customer satisfaction and change customer expectations, which has raised the necessity to offer product with best quality, lower cost, shorter time, and best delivery service. All these factors increased the pressure on organisations to implement a new technology that helps in achieving customer satisfaction.

The group IT manager and value engineer lead were asked if there were pressures from outside motived them to implement BDA, interviewees confirmed that seeking customer satisfaction should be a priority and always new strategy to attract customer attention should be devised.

"*The customer expectations raise the awareness of certain need which must be fulfilled by a supplier and SC strategy and all these integrated strategies (market strategy and so on)".*

"I give example, we have one client we dealt with within the last three years and we made a very good amount of revenue. and the third time we just failed to achieve what he expected so this put a lot of pressure on us from the head-office to do what he expects otherwise we will loss the customer".

The answers from telecom industry and automotive industry stressed on the important role of BDA implementation in adding value to customers in terms of saving time, cost, and detect problems.

"As I said, I am always trying to give actual examples. Example of applying part 20 years ago and the customer figures out there is a problem and in order to be able to identify what is the root causes this sort of problem we need a robust data to do that".

"*Our customers always want you to do things cheaper, so that why the cost saving, you know it was a time of contract negotiations. There was an expectation that we could provide more*

savings, that kind of encouraged us to use BD, it was a very good selling point as well, like oh yeah, we are using BD.

The interviewee from telecom industry confirmed that they employ BDA as an advertising tool that allows manager to reach positive selling point.

"we could use the buzz word and encourage the customers "wow" ok great; they are using BD then they must be good", it is a positive selling point.

5.9 Uncertainty, *Mimetic Pressure*

In the case of SCO, pressures come from an increase uncertainty which causes problems such as bullwhip effect, that in its turn influences the operational efficiency. Uncertainty in SCO means demand and supply uncertainty, uncertainty related to timely delivery of items as row materials or finished products, in addition to multiple new product developments uncertainty due to multiple times variation in the specifications during the trial stage (Bag, 2017).

The increased level of SC uncertainty has stirred an urgent need to adopt mimetic predictable analytics tool and use predictive analytics to uncover future event pattern and make prediction (Kokina *et al*., 2017), alongside providing real insight that enable manager to decide on the basis of evidence rather than uncertainty. To clarify more, having clickstream data improves operational forecasting by reducing demand uncertainty. Without clickstream data, the company can only use its prior demand distribution (Huang and Mieghem, 2014).

Consistent with recent studies and the literature analysis, the majority of those who responded to this question have strongly agreed that supply and demand uncertainty is one of the external pressures to apply BDA. Some responses were as follow:

"You know so there is uncertainty to whether we would be winning that contract. Whether they will use us for that purpose. So, certainly, that influence the use of BD. There was pressure to use it because we had an obligation to do this refresh"

"another factor you need to look at is maybe the forecast for the coming years in term of demand, this comes from many different source's expectations such as market analysis,

internal data analysis, customer feedback, in addition to the future risk take overview. So, we need to understand what sort of data needed to support this"

From the analysis, it has been found that it is prudent to improve flexibility to cope with high uncertainty in SC, which has fomented managers to elicit implicit information and knowledge from different sources of data.

5.10 Sustainability, *Normative Pressure*

Sustainability is relatively new to the business community, and it has already demonstrated staying power. organisations seek to enhance all aspects of sustainability when possible. The ability of a firm to increase measures of sustainability is based in its operational and strategic capabilities (Hazen *et al*., 2016).

In SCO there are several normative pressures related to environmental concerns, individual safety, and SC sustainability. Therefore, making informed operational decisions is an important step needs to be adopted by organizations to execute their operations productively in this new changing environment. This can be achieved through reshaping proactive strategy formulation and decision-making based on BDA in SCO.

From analysing interviewees' responds, no one alluded to the sustainability as a motive to implement BDA, most of them confirmed that customer satisfaction contributed significantly to the move towards BDA implementation, followed by finding a new technique to mitigate the risk of increasing uncertainty in the SC context.

External Pressures Factors
Customer expectations
Forecast
Demand and supply uncertainty
Sustainability is not very much comparing to other

Table 5.3: External Pressures Factors

5.11 BDA Evaluation in SCO Context

In this section, we will try to figure out the real impact of BDA implementation, through presenting BD sources, BDA approach and techniques, BDA capabilities, and investigating its roles in solving different issues in SCO. BD refers to data with the following qualities: volume,

velocity, variety, variability, veracity, visualisation and value (Sivarajah et al., 2017) and has emerged to describe the rapid generating of data from different sources represented in different forms, that is, structured, unstructured and semi structured (Wang *et al*., 2016). BDA, on the other hand, involves the ability to gain insights from data by applying statistics, mathematics, econometrics, simulations, optimisations, or other techniques to help SC businesses to gain better understanding of the hidden value of BD and make better decisions (Sivarajah *et al*., 2017; Wang *et al*., 2018).

5.11.1 BD sources in SCO

We asked all the managers who were interviewed the following question: "What are the main sources that have generated BD in SCO?". In response, it was highlighted that in logistics BD generated from IoT devices like sensor technology, weather data, government data, and other cloud-based legislation data. One of the answers exclaimed: *"The type of cloud data (Castrol) ……We use a satellite system called Castrol which not only provide the location of the vehicle but also gives you the statue of it, whether it is on the move, switched on or off. It is also providing the transport manager in-time information in regard of all vehicles' data such as mileage, carbon emission and pollution created*".

From data analysis, inventory BD generated as well from IoT technology such us unique ID for every component*, another response was: "I think I have described it already from the inventory. When we go to procure, we have the single GPS Global Positioning System, so everything has a unique ID every part so you can imagine a router will be made of different components within it for different function so each will have a unique ID which will be part of the inventory and then that would be the physical side of it and obviously will be like that the IOT, the actual data that one zero, you know the data software, what version of software you running, when did you last reboot, things like that which kind of gathered from the chip inside it".* Regarding manufacturing BD, we found just one source of BD which is produced by machines, another manager responded: *"we collect data as well from some of the machine that we use within the operations of the business".*

BD sources in procurement have been addressed as follow: supplier catalogues data, ERP system data, manufacturer web pages, and price list data. One interviewee stated that: "*We have data for example in our ERP system….In my work, data source will be using supplier*

catalogues so all the equipment the manufacturer would provide they call it end of support date against all their equipment which show when this equipment supported until, so that would be in catalogue provided in file and then we would apply that catalogue into our own data. Also manufacturer data you could obtain from the internet as well, we would have a person whose role was to go and look at the manufacturer web pages and try to identify from their equipment list on the internet what that data point is, so that would be another source of data"

It is also interesting to note that in terms of demand planning, no one of participant managers has mentioned about BD sources. **Figure 5.4** provides with the analysis of the BD sources in SCO based on the views from the interviewees.

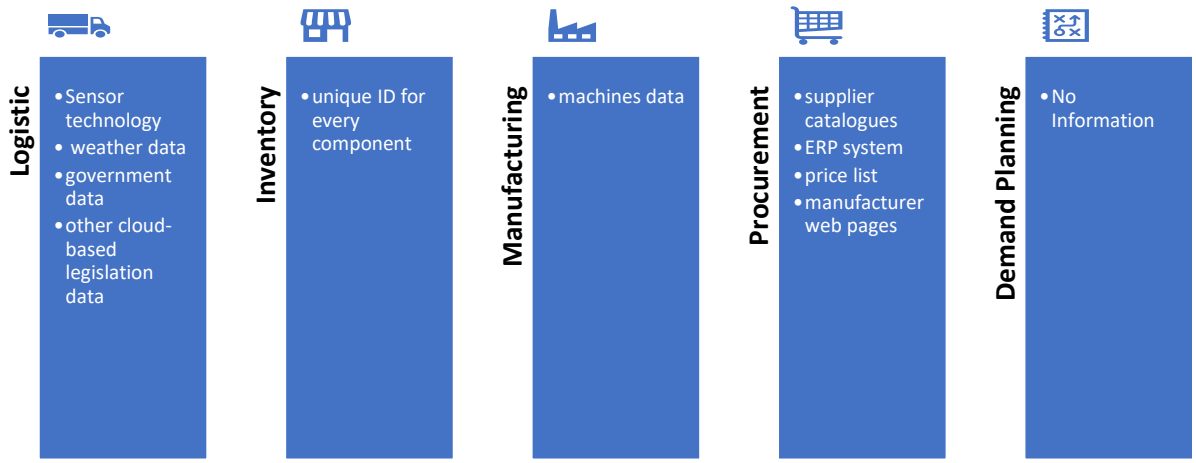

Figure 5.4: BD Sources in SCO (Source: Author Data)

As the above **Figure 5.4** illustrated limited sources of BD have been exploited and analysed compared to the rapid generating of data from different sources represented in different forms. The interview discussion with senior manager at aeroplane and automotive industry stated that:

"we are still understanding what data we got. It was surprising that we have data could help in solving some problems, but we are not aware that we produce it for over 20 years, and nobody ever wanted to look at. In the current stage we are trying to understand what sort of data we got".

5.11.2 BDA approach and techniques used in SCO

A broad range of techniques has been developed to explore the patterns from large volumes of data by number of disciplines such as computer science, economics, mathematics, and statistics. For instance, Manyika *et al*., (2011) identified a number of widely used BDA techniques that includes: Cluster analysis, genetic algorithms, natural language processing, machine learning, neural networks, predictive modelling, regression models, social network analysis, sentiment analysis, signal processing, and data visualisation.

From analysing interviews data, it was found that there is little knowledge of BDA techniques and approaches among interviewees. in addition to limited use of BDA techniques mostly restricted to statistical techniques. Manager in telecommunication industry reported.

"*We still use basic softwires, we use some statistical software for social sciences, I personally use for my own personal capacity, I have not been asked but because I have some background in statistics. I use them for comparisons, to find the flow of data (structured/unstructured), sometimes we conduct small survey within the organisation as well for health and safety requirement, or to take employee feedback on some decision*".

With the importunity of extracting value information of BD there is an urgent need for advanced analytic technique to be adopted by organisations. The advent and pervasive use of such innovative digital technologies has resulted in producing substantial amounts of data, thereby creating challenges for the SC businesses that aim at realising the benefits from analysing this immense incursion of unstructured BD (Wang *et al.,* 2016). These challenges include issues arising from managing large amount of data and dealing with the demand and supply uncertainty. This data has useful hidden information, which makes it an asset for any organisation (Sivarajah *et al.,* 2017).

5.11.3 BDA implementation challenges in SCO

In order to tackle BDA challenges that managers face when mining and analysing data, the participants were asked to identify challenges regarding BDA application in SCO context. All managers mutually agreed that human factor is a considerable stumbling block when applying BDA. Talking about human factor, they addressed two issues. Firstly, changing the mindset of

people toward BDA. Secondly, lack of skilled resources/data scientists such as analytical, data-driven, and technical understanding.

"The major one is the availability of skilled people in this area in addition to the lack of coordination"

"the human factor needs to understand it in order to be able to collect the right information, I am quite sure that there is a bigger overview ongoing".

"Companies should deal with data analytics to shape the future, the cost is not an issue, the biggest fear is the human factor"

"The understanding of people, I have seen a lot of resistance, why do I need this"

It appears from the above statements that the emphasis on changing the mindset is the perfect starting point for applying BDA, and this can be achieved through raising and explaining the businesses value of implementing BDA for employees, in consequence, presenting comprehensive framework about the potential benefits of BDA in SCO. it is logical to argue that the boost of a culture of BDA, knowledge exchange, and predictive analytics can promote data-driven decision-making capabilities (Dubey *et al*.,2019). One of our interviewees explained:

"why do I need this? I have an excel file and my excel file works! They don't understand the bigger overview. For instance, if you are outside your office, your excel file is nothing. When we are talking about 200 Mb file it is difficult to handle, if you are not up to date on it there is no way of getting the right information, there is no other option to link multiple information from different locations. If we talk about 200 to 500 different inputs/part so you have hundreds of thousands of inputs so how we are going to handle all this information. As I said, it is a key for us how to ensure that this information is up to date"

Other challenges highlighted by participants include lack of knowledge on what may be required from this data, in addition to the cost (time and money) generated from gearing up BDA infrastructure.

"Huge cost, for sure. And sometimes the lack of right manpower to implement that. Company wants to do it, but they are not prepared to pay that much"

"Also, the challenges are the investment, that requires a huge amount of the pressure on the management which they are working on but it's a continuous process"

As it has been addressed before, practitioners still lacking knowledge of understanding BD terminology, especially when they were asked to identify BD characteristics (7 ”Vs”), and BDA approaches (predictive, perspective, and descriptive), this might be due to several reasons as BDA is still in its infancy stage; it is a growing area which has recently been given attention by scholars and managers. Senior manager reported

“I don’t have an idea about these approaches, we are still trying to figure out how we are going to use this toy. Often, we do it like the hamster by pressing all buttons to see what the outcome is”

Despite notable efforts in academia to uncover the impact of BDA on SCO efficiency improvement through identifying BD sources, approaches, techniques, and tools, there is disconnect between the hype and knowledge been discussed in literature and the real practice of BDA. It is noteworthy that the current state of BDA use is relatively fragmented and rhetoric in discussion among practitioners and researchers. This result is fully aligned with what our participants mutually reported:

“*At the moment we are not fully into BDA, there is still limited number of parts been missing which means limited number of component and data need to be generated. It is still in transition between data analysis by filtering on Excel to how we can link and filter larger amount of data. Now, we are still in transition, we are doing it in a light way rather than fully integrated*”.

“It was surprising that we have data could help in solving some problems, but we are not aware that we produce it for over 20 years, and nobody ever wanted to look at. In the current stage we are trying to understand what sort of data we got”

“*We like the name BD, we think it will solve some of our problems, but in fact so fact it is creating a problem because it gives you answer very tough to believe. We don’t have yet the tool*”.

Yet, the role of BDA in SCO has not yet thoroughly established, and the light use of BDA applications is consequent of the fragmented picture on potential benefits of BDA in SCO, which could be considered a momentum drive to fully adopt BDA as a revolutionary tool for improving performance.

5.11.4 The performance implications of BDA on SCO

The insights of the massive amount of data for SCO become an essential component of enterprise core competence. BDA offers a lot of benefits to businesses including cost reduction and productivity improvement initiative such as developing cost-effective and strategic plans, optimised product design innovation, precise demand planning, and capacity utilisation, and capital effectiveness (Chien *et al*., 2017). In addition, BDA facilitates evidence-based decision-making. Therefore, SC businesses require efficient approaches to process large volumes of assorted data into meaningful knowledge (Gandomi and Haider, 2015). The potential of using BD is limitless but it is restricted by the availability of technologies, tools and skills related to BDA.

The importance of BDA comes from its ability to support sharing information more easily and efficiently among SC partners, Empowering BDA in SC is not about evaluation but necessarily changing for optimising operational performance and enhancing informed decision-making. Optimising operations related to logistics and transportation area is the most popular application of BDA, for instance logistics companies utilise BDA for real time routing optimisation based on streamline data. IT manager in logistics company reported:

"We use the satellite so we know where our vehicle is and how we can reach it, how long it will take, which day you can arrange the service for. Again, the efficiency of the service availability to address the problem"

The above statement reveals the trackability benefits of BDA implementation when making real time information is available. with the rapid development of technologies, new opportunities were created to build new applications assist in optimising operations in SC, such as enable resources visibility and traceability to be provided to the user on demand to take timely action when need it. Using BDA to enhance the performance of logistics operations is another promising benefit of adopting BDA in SCO context. Our interviewee, IT manager in logistics company, declared that the desired level of performance cannot be achieved in organisations without utilising BDA. Two interviewees in different companies (logistics and telecom) claimed tangible results on their performance due to BDA implementation, they claimed respectively:

"*When we took part in FORS (Fleet Operator Recognition Scheme), we were awarded silver level as per to 8 components of assessment including driver excellence, management skills and*

training provided for the staff, also the equipment excel addressing how our vehicles are secure from every single perspective. As we are on this level, we were not able to achieve and maintain this level without the help of new technology namely making use of all data discussed before. Profitability performance was also improved"

"*From inventory perspective, quality increased from 80 to 90%, our performance was much better, so it was a very important thing that we did using that data source in a structured way was instrumental to be successful*".

Customer satisfaction has always been the prime concern of managers, and one of the most important factors enabling competitive advantage, therefore finding methods to gain insights into customer satisfaction considered as a challenging mission. BD streams overall have provided opportunities of a better understanding of customer needs and one of the best means to reach customer satisfaction, it allows an inclusive assessment of customer satisfaction by integrating multiple extensive data sources *(*Jeske *et al.,* 2013). IT manager in logistics company reported:

"The impact we earn after utilising BDA is portraying the positive image to the clients in this industry, how accurate we are and how timely we have adapted these services,…., The overall benefits are efficiency of the fleet and the client satisfaction".

Analysing production and manufacturing data embedded in IoT drives to improve manufacturing processes that significantly enhance productivity (Kumar *et al*., 2016). Ever growing manufacturing requirements have carried on the necessity of timely fault detection, early warning, and avoid recall minimising the downtime and improve efficiency. The major problem in manufacturing processes is obtaining information in a timely manner. Thus, relying on the potential of analysing manufacturing data and new requirements of production operations, it is evident that BDA has ability to revolutionise the manufacturing process to reach optimal production level. The manger from aeroplane and automotive industry asserted on the importance of BDA in reducing lead time and identifying defect early, he claimed:

"it could have been two second job instead of 18 months. The system will be alarming instantly. We are suffering every day from parts being defected and we try to understand what is going on, we don't know. If I am able to do manufacturing document digitalised coming from a machine, I will be able to check immediately and error, missing steps. We are not only looking at tracking back but controlling"

More impacts have been addressed by a senior manager in telecom industry about BDA utilisation, it is extending life of assets more than what it is said by the manufacturer of those assets in addition to building a consistent inventory structure.

"my management said to us we run this network for this customer, but we believe we can use this asset for longer than really the manufacturer says that it is good to do because ultimately it is good for profitability. So find us a way to extend the life of those assets so what we did is we looked at the data we were collecting from them to figure out how reliable are these assets, how often is a piece or part were failing and needs to be replaced, if they are reliable why we change it. That is when we built this database, we were gathering all these data, and for us, the operational data. That where BD came into it".

"*as I said my previous role was in asset management and so it was around the inventory, we maintain consisted around 30 thousand assets around the globe with different functions, different features, different manufacturers, different models and make. So, I was gathering all that information and building it into consistent format then we could analyse based on what we had. So, from building the tooling that allowed us to use that BD with having a consistent structure and making sure we could easily interpret it".*

Coordination between SC activities can be a source of superior optimised operations. For instance, timely information about demand distribution offers an optimised solution for the online stores to manage their inventory. Thus, it is important to identify the demand distribution as an input to the newsvendor model (See-To and Ngai, 2018). Estimating ordering probability, amount, and timing by analysing clickstream data can achieve advanced demand patterns, which have a significant role of reducing the inventory holding and its cost and accordingly reducing operational cost and reaching optimal inventory (Huang and Van Mieghem, 2014).
Manager in Telecom Company completely acknowledged the role of BDA in fulfilling coordination in SCO when he stated:
"Demand planning works hand in hand with production and manufacturing, it told us when we would need certain piece of equipment. In terms of demand planning, ask the customer in 12 month you will need to replace this, would you need technology, or replacing it like to like, then that will be feeding the manufacturing side that we need x number of these kind of devices. It allows us to be more predictive"

From above discussion, we can classify BDA utilisation in SCO in eight main applications as follow:

- Sharing timely information.
- Enabling trackability.
- Enabling resources visibility.
- Enhancing customer satisfaction.
- Identifying defect early.
- Reducing lead time.
- Extending life of assets.
- Fulfilling coordination.

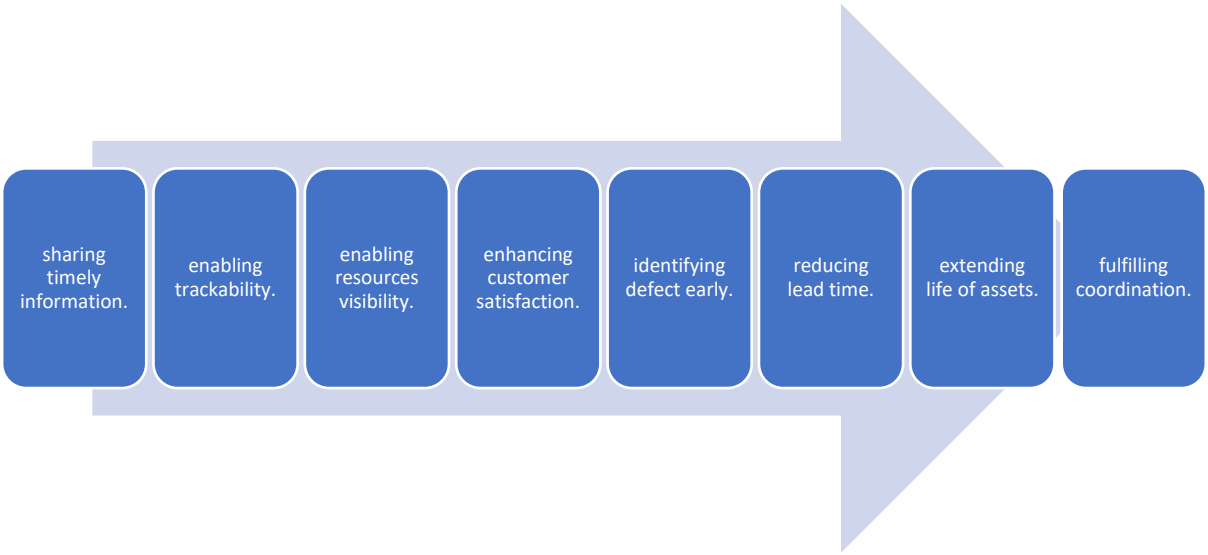

Figure 5.5: Performance implications of BDA in SCO

In sum, **Table 5.4** represents the theoretical constructs for BD implementation studies including BD challenges.

Practitioners' Perception of BD	BD Challenges
Optimisation tool	human factor
Improve profitability	Cost (time, money)
Big size of data	**BD techniques**
internal Motivating Force	Statistical tool
Geographical tracking	**BD sources in SC**
Timely decision making	Sensor technology
Safety standard	weather data
profitability	government data
Improve customers track ability	other cloud-based legislation data
Keep up to date immediately any change	unique ID for every component
Keep knowledge	machines data
Time saving	supplier catalogues
Adding value to client	ERP system
Cost saving	Price list
Save time of contract negotiation	Manufacturer web page
SCO portfolio tasks	**Benefits of BDA implementation**
Procurement (the best possible suppliers)	Quality of performance
Inventory (completeness, accuracy, and consistency	Enable trackability
Demand planning (customer demand forecasting)	Customer satisfaction
Logistics (time delivery, vehicles maintenance, unforeseen circumstances, uncertainty associated with global logistic)	Reducing lead time
Manufacturing (Enhance capacity by addressing the efficiency of the operation, meet customer demand, reduce resources (cut down design patterns), reduce lead time, control processes, detect defect early)	Timely defect identification
External pressures factors	Extending life of assets
Customer expectations	Efficiency of resources
forecast	profitability
Demand and supply uncertainty	Coordination between SC activities
sustainability is not very much comparing to other	Doing a proper analysis of the suppliers
	building a consistent inventory structure

Table 5.4 : Theoretical Constructs for the BD Implementation Study

5.12 Summary

This chapter has analysed and presented the findings of an in-depth cases of the empirical fieldwork answering the research questions. Ahead of introducing the analysis of each case study, an overview of the organisation was discussed. The empirical findings of the case study highlighted that BDA is still in its infancy stage; it is a growing area which has recently been given attention by scholars and managers. There is disconnect between the hype and knowledge been discussed in literature and the real practice of BDA. It is noteworthy that the current state of BDA use is relatively fragmented and rhetoric in discussion among practitioners and researchers. The main conclusions elicited from these findings on exploring the state of BDA technologies in the SCO are presented in **Table 5.5** and summarised below.

- There are drivers behind BDA implementation such as cost saving, increase profitability, having timely information, sharing information between SC partners, and using BDA tool as branding strategy to attract clients.
- The main tasks in SCO determined regarding five activities in SCO, procurement, demand planning, inventory, logistic, and manufacturing.
- From empirical findings, customer satisfaction contributed significantly to the move towards BDA implementation as an external pressure, followed by finding a new technique to mitigate the risk of increasing uncertainty in the SC context. Noone alluded to sustainability as an external motive to implement BDA.
- limited sources of BD have been exploited and analysed compared to the rapid generating of data from different sources represented in different forms.
- it was found that there is little knowledge among interviewees associated with limited use of BDA techniques mostly restricted to statistical techniques.
- Talking about BDA implementation challenges in SCO context, participants marked three issues: firstly, changing the mindset of managers toward BDA. Secondly, lack skilled employees with data analytics. Thirdly, the cost time and money generated from gearing up BDA infrastructure.
- From the empirical fieldwork, positive impacts have been proved from BDA utilisation in SCO context, but it is still incomparable to what has been discussed in the literature.

		The Outcomes of Analysing Case Studies
Participants' perspective of BDA		The hype surrounding BD is beyond what is reasonable, and the perception of the meaning and value of BD is confused
Participants' motivations for implementing BDA		Managers understand BD as a way to create better opportunities of improvement through storing and analysing the huge amount of data generated from different devices. Despite the different terminology used to describe their motivations for implementing BDA, practitioners' motives were twofold: First, improving performance, and increasing profitability.
Internal Pressures Task Technology Fit	**Main tasks in SCO**	***Manufacturing*** • Enhance capacity by addressing the efficiency of the operation. • Meet customer demand. • Reduce resources (cut down design patterns). • Reduce lead time • Control processes, detect defect early ***Demand Planning*** • Predict demand variability and process variation. • Customer demand forecasting was confirmed by interviewee as the most crucial task that led to increasing profitability in the entire SC. ***Inventory*** • Completeness, accuracy, and consistency are the main factors to success inventory operations. • The manager clearly believed that visibility of inventory for traceability is very crucial for inventory. • Increasing capacity regarding space. ***Procurement*** • selecting the best suppliers based on prices and flexibility. ***Logistic*** • the main tasks in logistics processes are, four broad themes were emerged from data analysis: timely delivery, vehicles maintenance, unforeseen circumstances, uncertainty associated with global logistic.
	Technology (BD) characteristics	When the interviewees were asked about BD attributes 7 "Vs", the majority commented that they have no idea regarding the terminologies of 7" Vs" but in their responses, they explained the core meaning of BD characteristics without labelling each characteristic with 7 "Vs". A thematic analysis has been carried out to identify patterns of BD attributes in the interview data. For example: *Getting meaningful data quickly to the shop floor ⟹ Value *Design data, supplier data, technical data, ⟹ location Variability

External Pressures to Implement BDA	**Customer satisfaction**	Interviewees confirmed that seeking customer satisfaction should be a priority and always new strategy to attract customer attention should be devised.
	Uncertainty	From the analysis, it has been found that it is prudent to improve flexibility to cope with high uncertainty in SC, which has fomented managers to elicit implicit information and knowledge from different sources of data
BD sources in SCO		limited sources of BD have been exploited and analysed compared to the rapid generating of data from different sources represented in different forms.
BDA approaches and techniques used in SCO		From analysing interviews data, it was found that there is little knowledge of BDA techniques and approaches among interviewees. in addition to limited use of BDA techniques mostly restricted to statistical techniques.
BDA implementation challenges in SCO		challenges highlighted by participants include: * Lack of knowledge on what may be required from this data, in addition to the cost (time and money) generated from gearing up BDA infrastructure. * Lack of skilled resources/data scientists such as analytical, data-driven, and technical understanding.
Performance implications of BDA		* Logistics companies utilise BDA for real time routing optimisation based on streamline data. *The desired level of performance cannot be achieved in organisations without utilising BDA. * Reducing lead time and identifying defect early. *BDA is extending life of assets more than what it is said by the manufacturer of those assets in addition to building a consistent inventory structure. *Interviewees acknowledged the role of BDA in fulfilling coordination in SCO. *Enhancing sharing information. *Increase visibility.

Table 5.5: A Summary of Cases Analysis

6. CHAPTER SIX: DISCUSSION

6.1 Introduction

While the previous chapter presented and discussed the finding of empirical studies This chapter presents a thorough discussion of the findings and concludes by developing a solid understanding of the performance implications of BDA in SCO context. A critical issue for the development of this chapter was to decide how to develop and propose a theoretically grounded framework that may support the decision makers in enhancing the SC performance and adding value to customers. The aim of this discussion is to delineate and discuss the reality of BDA impact on SCO and to fill the gap of empirical research to assess the business value of BD which in its turn helps to broaden the understanding of BD and its role in capturing business value.

The discussion chapter is divided into four major sections: starting with the TTF model, it was used in this study as a guideline to describe the fit between BDA technology and the SCO portfolio tasks. The second section discusses the BDA adoption related external pressure which speeds up the processes toward utilising BDA. The third section provides detailed empirical evidence about the real-live of BDA implementation to understand the real and current situation of potential value of BDA in SCO. The fourth section of this chapter presents the impact of BDA on the SCO performance related activities. Given this opportunity, the main purpose of this study enhances and supplement current knowledge about BDA technology through develop a theory of TTF in SCO environment.

6.2 Modelling Task Technology Fit (TTF) of BDA for SCO

This study uses the TTF model of Goodhue and Thomson (1995) which argues that technology needs to be willingly accepted and fit well with the tasks to prove its effectiveness (D'Ambra *et al.*,2013). TTF model has four main constituents: task characteristics, technology characteristics, which combine to affect the fit between tasks and technology, which in its turn affects the outcome performance (Lin and Huang, 2008).

6.2.1 The Tasks in SCO

Tasks are broadly defined as the actions carried by individuals in turning inputs to outputs to satisfy their information needs (Goodhue and Thompson, 1995). Zigurs and Buckland (1998) categorized tasks based on task complexity and debated that organizational performance will be improved with a Group Support Systems having technology attributes such as supporting communication, structuring, and information processing. Task characteristics of interest include those motive a user to lean more on certain aspects of the information technology such as, the need to answer many unpredictable questions about company operation would move a user to depend more heavily upon an information system's capability to process queries against a database of operational information (Goodhue and Thompson, 1995)

Following (Zigurs and Buckland ,1998), this study focuses on the kind of tasks that are related to the two level of complexity dimensions. The first dimension is outcome multiplicity which means that there is more than one desired outcome of the tasks. Under this criterion we can list all the tasks related SCO activities. SCO is an integrated set of business functions consisting of many activities from raw material acquisition to final customer delivery(Beamon and Ware M., 1998). For example, accurate modelling of demand and demand distribution has its impact on itself and on successful inventory decision. The second dimension is solution scheme multiplicity which means that there is more than one possible course of action to achieve a goal. For instance, Optimum Assets Work could be done by detection, recognition, and diagnosis of fault and irregularities in timely manner to ensure that all production processes are under control. In addition to optimising machine task list, prioritising maintenance and autonomous (automated decision, control, and diagnostic) (Kumar *et al*., 2016; Ahmadov and Helo 2018; Preethi *et al*., 2016; Wang *et al*., 2016; Bumblauskas *et al*., 2017; Chien *et al*., 2017; Gu 2017; Wan *et al*., 2017).

Because there were no existing items for task and this is exploratory study, the tasks were derived from the responds of interviewees. during the interview, participants were asked to describe the main challenging tasks they face in their operations depending on key activities described in SCO context. Based on interviewees responds, the major tasks of SCO can therefore be categorised as follow:

- Predicting customer demand more accurately
- Controlling of demand variability and process variation

- Collaborating with manufacturing
- Collecting timely data to segment customer preferences
- Selecting the best suppliers.
- Improving completeness, accuracy, and consistency
- Inventory reduction to fee up space
- Enhancing capacity by addressing the efficiency of the operation.
- Meeting customer demand.
- Reducing resources (cut down design patterns).
- Reducing lead time
- Controlling processes, detect defect early
- Ensuring timely delivery
- Vehicles Maintenance
- Gaining superior visibility
- Providing resilient logistics, customer focused logistics that can overcome disruptions.
- Enhancing traceability

6.2.2 Technology characteristics

BDA technology in a SCO context is the tool used by managers to focus on data and information flows and to drive decisions in terms of enhancing performance (Brinch, 2018). to develop new items for BDA technology characteristics, first, we searched the relevant literature on BD and generated the items for BD characteristics constructs. For the sake of better understanding of BD, BD characteristic can be described by 7Vs: Volume, variety, value, velocity, veracity, visibility, and variability: (Leveling *et al*., 2014, Mishra *et al.*, 2016, Demchenko, *et al*., 2013, Seddon and Currie, 2017, McAfee and Brynjolfsson, 2012, Russom, 2011). Then, in empirical study, interviewees were asked to talk about BD in terms of its attributes. They showed no knowledge regarding the terminology of BD attributes represented in 7V. Therefore, thematic analysis has been conducted to identify pattern of BD attributes in the interviews data, interviewees displayed their understanding about BD through explaining perceived capabilities of BDA technology. For example, interviewees expressed their perceptions on the attributes of BDA "analyse of data coming from different sources". Such statement explains the "variety" attribute of BDA.

6.2.3 Task Technology Fit Measurement

TTF theory was developed based on the attributes of required tasks and their relationship to relevant characteristics of technology, it assumes that the fit between task technology and users promotes the user's work performance (Zigurs and Buckland, 1998). From the above, we deduce that the fit between tasks characteristics in SCO and BD attributes is a rational action toward adopting BDA. TTF is the relationship between task requirements and the functionality of the technology (D'Ambra *et al.*,2013).

Two approaches have been identified to empirically operationalise the notion of TTF, the first one is fit -as-match approach which sees fit as being represented by match between task and the capabilities of a technology (Goodhue and Thompson, 1995), this approach measures fit directly rather than constructing fit measures, and it is most used in survey-based study (Furneaux,2012). The second one is fit -as -profile approach which emphasis that fit can be defined as ideal profiles composed of an internally consistent set of task and technology elements that affect the organisation performance (Zigurs and Buckland, 1998).

In the case of measuring the fit between tasks and technology characteristics as a rational action toward adopting BDA, empirical evidence firstly specified the main challenging tasks in SCO processes as presented in **Table 6.1**. Afterward, BDA characteristics were derived from participants responds through carrying out thematic analysis to identify patterns of BD attributes in the interview data. BD attributes are referred to as 7" Vs" i.e., volume, variety, value, velocity, veracity, visibility, and variability. Finally, this study evaluated the fit between task and technology characteristics by applying fit -as -profile approach, which emphasis that fit can be defined as ideal profiles composed of an internally consistent set of task and technology elements that affect the organisation performance.

Our study is guided by Zigurs and Buckland (1998) and D'Ambra *et al.* (2013) in measuring TTF. A qualitive approach was undertaken to clarify the real picture of BDA use in SCO through investigating the perceived impact of BDA implementation in different sectors. Collected answers were analysed and synthesised to constitute fit constructs and identify various dimensions of TTF as shown in the **Table 6.1**.

Construct	items	sources
SCO tasks portfolio	*Predicting customer demand more accurately *Controlling of demand variability and process variation *Collaborating with manufacturing *Collecting timely data to segment customer preferences *Selecting the best suppliers. *Improving completeness, accuracy, and consistency *Inventory reduction to fee up space *Enhancing capacity by addressing the efficiency of the operation. *Meeting customer demand. *Reducing resources (cut down design patterns). *Reducing lead time *Controlling processes, detect defect early *Ensuring timely delivery *Vehicles Maintenance *Gaining superior visibility *Providing resilient logistics, customer focused logistics that can overcome disruptions. *Enhancing traceability	Interviews and (Zigurs and Buckland, 1998)
BDA characteristics	volume, variety, value, velocity, veracity, visibility, and variability	(Leveling *et al*., 2014, Mishra *et al*., 2016, *Demchenko, et al*., 2013, Seddon and Currie, 2017, McAfee and Brynjolfsson,2012, Russom, 2011)
Task Technology Fit	• Quality of performance • Enable trackability • Customer satisfaction • Reducing lead time • Timely defect identification • Extending life of assets • Efficiency of resources • profitability • Coordination between SC activities	Interviews (Zigurs and Buckland, 1998, and D'Ambra *et al.*, 2013)

Table 6.1: Fit Constructs and TTF Dimensions

6.3 BDA Related External Pressures

This study needs a new lens for taking into account the limitations arising within the institutional context that surrounds organisational actors (Mignerat and Rivard, 2009). The institutional theory compensates for the limitation of TTF theory in understanding the social forces behind utilising BDA. In this research, the institutional theory adds to the constructs (IT capabilities and tasks characteristics) of the TTF theory the external pressures, which speeds up the processes toward utilising BDA. These pressures come from the competitors and pressures exerted by trading partners (Oliveira and Martins, 2011). The objective of this framework is to explore the inner factors (fit between technology and task characteristics) and outer factors (social factors) affecting the overall effective utilisation of BDA in the SCO context, resulting in realising the benefits of BDA implementation.

- **BDA Implementation Related Coercive Pressure (Customer Satisfaction)**

This is the outcome of formal and informal external pressures by other organisations, and by culture expectations in the society within which organisations are embedded (Dimaggio and Powell, 2000). The literature supports that in the business field, it has been rationalised that BDA is the process of examining massive data sets and revealing hidden patterns, unknown correlations, market trends and customer preferences, which increase customer satisfaction and enhance strategic competitive advantage (Wong and Wei ,2018). Therefore, businesses are investing heavily in using descriptive and predictive analytics to analyse customer and operations data to attain its goals regarding improving service and increasing customer satisfaction (Power, 2016). In this study, the senior management that contributed to the research noted that seeking customer satisfaction should be priority, and always new strategies to attract customer attention should be devised. Additionally, they emphasised on the important role of BDA in adding value to customers in terms of saving time, cost, and detect problem. Finally, they considered BDA utilisation as an advertising tool that allows managers to reach positive selling point.

- **BDA Implementation Related Mimetic Pressure (Uncertainty)**

This occurs by organisational desire to mimetic other organisation action, especially when the environment creates symbolic uncertainty (Dimaggio and Powell, 1983). Mimesis is more existed in anxiety than in rational action in order to reduce uncertainty and increase predictability (Kauppi, 2013; Pishdad and Haider, 2013). Uncertainty has been considered as

one of the main factors that challenges SCM. There are many sources that cause uncertainties in SC systems but the most important one is delay and inaccuracy of information flows between SC partners (Roe and Song, 2015). More detailed BD governance schemes need to be established to handle SC uncertainties, whereas uncertainty increases, and BDA becomes a core part of operations (Mikalef *et al.*, 2019). Consistent with recent studies and the literature analysis, most interviewees confirmed that it is prudent to improve flexibility to cope with high uncertainty in SC, and this can only be done by collecting and analysing data from various sources such as market analysis, internal data analysis, customer feedback in order to elicit information and knowledge.

- **BDA Implementation Related Normative Pressure (Sustainability)**

Normative pressures consider the moral aspect of legitimacy by assessing whether the organisation performs in desirable way (Pishdad and Haider, 2013). In SCO context, there are several normative pressures related to environmental concerns, individual safety, and SC sustainability. Researchers shed light on the diverse potential use of BDA through classifying the different sources of data concerning manufacturing, and its analytics impact on reducing customer's order time in addition to achieve sustainability. For instance, Kumar *et al*. (2016) developed a Map-Reduce framework for automatic pattern recognition based on fault diagnosis by solving data imbalance problem in cloud-based manufacturing on steel plate manufacturing data-set to help in reducing the occurrence of fault conditions.

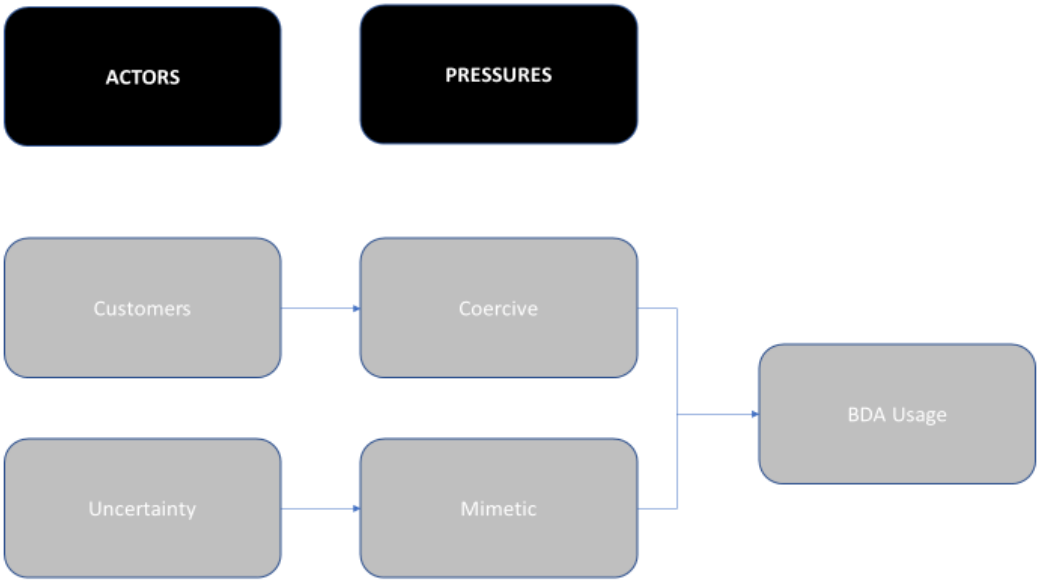

Figure 6.1: Institutional Theory as a Result of the Empirical Study

However, from our empirical data, sustainability was not considered as a drive to adopt BDA and the interviewees confirmed that sustainability as an external pressure is not very much comparing to other pressure such customer satisfaction and uncertainty. Data analysis findings showed that customer satisfaction and unceratianty signifcantly contributed to the move toward BDA implementation.

6.4 The Reality of BDA in Organisation

The aim of this study is to analyse, synthesize and present a state-of-the-art structured analysis of the empirical data on the impact of BDA on SCO to support the signposting of future research directions. Few researchers discussed the impact of BDA on SCO theoretically in relevant to three key areas of operations i.e., logistic, manufacturing, and procurement (Wang *et al*., 2016). Lamba and Singh (2017) considered three phases of a SCO i.e., procurement, manufacturing, and logistics. Addo-Tenkorang and Helo (2016) stated that there is no clear picture that clarifies the valuable use or performance of BD regarding SCO processes. A recent article by Nguyen *et al*. (2018) on BDA and SCM, discusses on how BDA compliments SCM including presenting BDA methods and techniques, although it misses depth in presenting how SCO challenges are handled by BDA.

The findings of the case study and this research support that conducting a BDA is important as a tool to create better decision-making mechanisms, which lead to enhance performance and increase profitability. Senior Managers asserted that desired level of performance cannot be achieved in their companies without leveraging BD. From empirical data, business value of BDA in SCO context has been extracted in terms of enhancing decision making, optimising key activities in SCO, and fulfilling coordination between SC partners. Yet, competitive capabilities of BDA that have been exploited by organisations are still at elementary state, and the light use of BDA applications is consequent of the fragmented picture on potential benefits of BDA in SCO, which could be considered a momentum drive to fully adopt BDA as a revolutionary tool for improving performance.

Case studies illustrated limited sources of BD have been exploited and analysed compared to the rapid generating of data from different sources represented in different forms. Beside the limited utilisation of BD sources, it was found that there is little knowledge among interviewees regarding BDA associated with limited use of BDA techniques mostly restricted to statistical techniques. Therefore, with the importunity of extracting value information of BD, there is an urgent need for advanced analytic technique to be adopted by organisations. Our empirical analysis asserted that the BDA is not fully integrated with businesses and one of the reasons, as addressed by one interviewee, is lack of managerial support. It is indeed a critical factor affecting the success of BD implementation. Other challenges were highlighted by participants include lack of knowledge on what may be required from this data, paucity of skilled resources/data scientists, changing the mindset of people toward BDA, in addition to the cost (time and money) generated from gearing up BDA infrastructure.

6.5 Reflections on the Findings

BDA enabled SCO is not simply about adopting or integrating innovative technologies, it is poised to profoundly transform the way a wide range of manufacturing organisations and SC businesses approach the procurement processing, and distribution of raw materials and finished products. How and why organisations adopt innovative technologies has motivated several academic researchers and practitioners to investigate the drivers and opportunities of technology utilisation (Lee *et al*., 2007, Zhou *et al*., 2010, Lu and Yang, 2014). A common bearing in studies that dealt with BDA is to try to figure out the potential impact of BDA implementation through presenting BDA utilisation drivers, BDA capabilities, and its roles in solving different issues. A theoretical framework is developed by this research to conceptualise the benefits of implementing BDA in SCO and to explain the motives behind adopting BDA in SCO. Two theories were utilised to better understand how and why firms adopt BDA as a novel technology, along with the drivers and opportunities of this technology utilisation.

TTF theory was developed based on the attributes of required tasks and their relationship to relevant characteristics of technology, it assumes that the fit between task technology and users promotes the user's work performance (Zigurs and Buckland, 1998). From the above, we deduce that the fit between tasks characteristics in SCO and BD attributes is a rational action toward adopting BDA. In this case, we need new lens for taking into account the limitations

arising within the institutional context that surrounds organisational actors (Mignerat and Rivard, 2009). The institutional theory compensates for the limitation of TTF theory in understanding the social forces behind utilising BDA.

In this research, the institutional theory adds to the constructs (IT capabilities and tasks characteristics) of the TTF theory the external pressures, which speeds up the processes toward utilising BDA. These pressures include the pressure from the competitors and pressures exerted by trading partners (Oliveira and Martins, 2011). The objective of this framework is to explore the inner factors (fit between technology and task characteristics) and outer factors (social factors) affecting the overall effective utilisation of BDA in the SCO context, resulting in realising the benefits of BDA implementation. **Figure 6.2** presents the reflection of the empirical studies on the proposed framework that may support other researchers in better understanding BDA initiatives in SCO with the objective of making robust investment decisions in BDA.

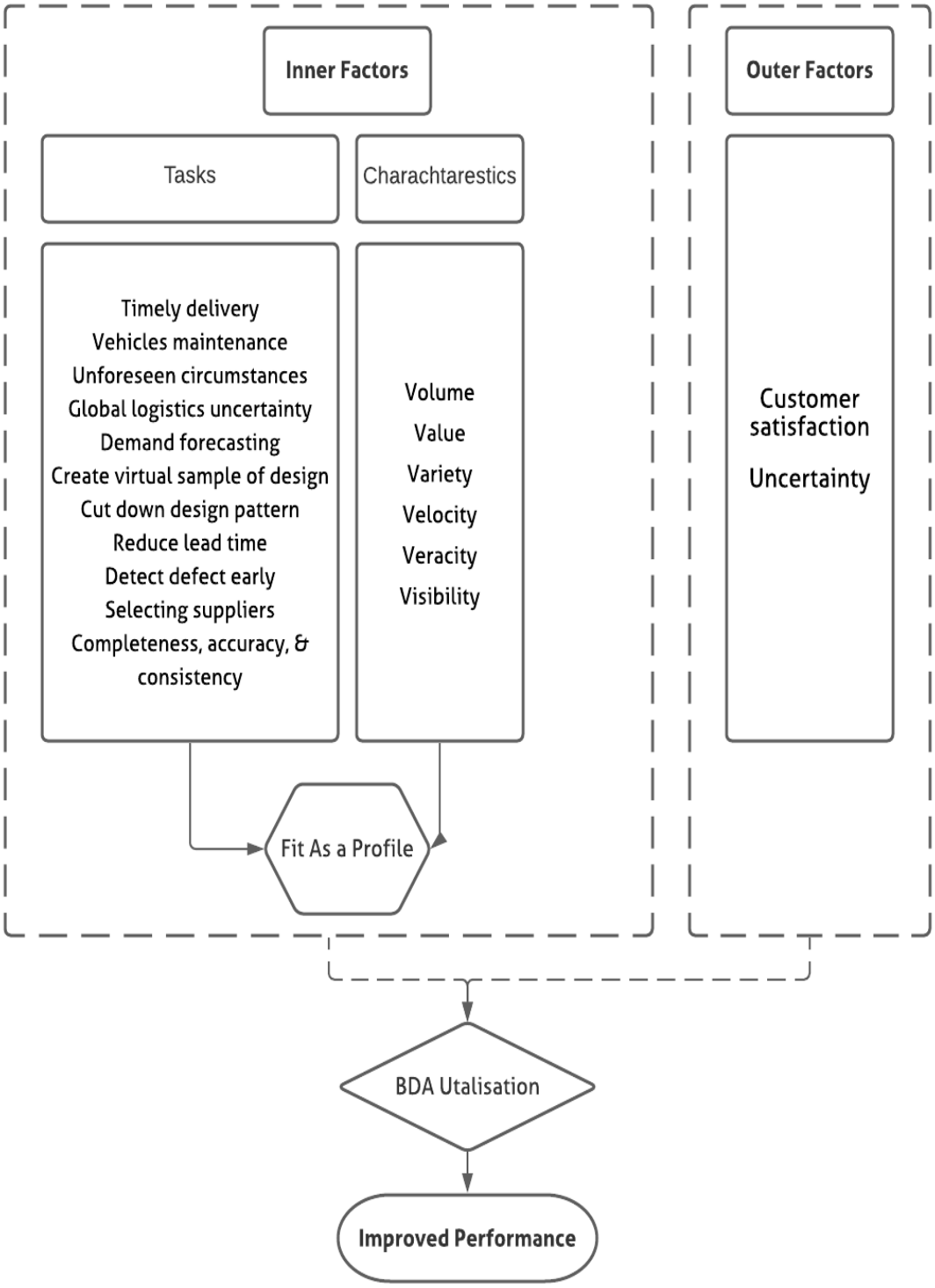

Figure 6.2: Case Analysis Outcomes

6.6 Summary

As the previous chapter presented the analysis findings, this chapter concerns discussing those findings building on the empirical investigation, in addition to revising the conceptional model proposed in chapter (3). Empirical evidence suggest that the conclusions are in keeping with the research assumptions specified in chapter (3), while the minor modification to the main model are presented in this chapter.

Task technology fit and institutional theory are adopted to capture and understand the reality of BDA in SCO. The authors worked on modelling TTF of BDA for SCO by discussing the tasks in SCO, presenting technology characteristics, then a certain measurement was adopted to check the fit of technology for each SCO task and a summary table of fit constructs and TTF dimensions was conducted. We followed this discussion by addressing the literature and the interviews perceptions in term of institutional context figuring out all external pressures. The institutional theory adds the external pressures to the constructs (IT capabilities and tasks characteristics) of the TTF theory, which speeds up the processes toward utilising BDA. The importance of BDA comes from its ability to support sharing information more easily and efficiently among SC channels. A summary of the BDA benefits related to SCO extracted from the articles reviewed and empirical study. At the end of this chapter, the author presented a framework based on the empirical results which utilised two theories to better understand how and why firms adopt BDA along with the drivers and opportunities of this technology utilisation.

In the case of measuring the fit between tasks and technology characteristics as a rational action toward adopting BDA, empirical evidence firstly specified the main challenging tasks in SCO processes as follow: Selecting the best possible suppliers with best price and flexible contract, completeness, accuracy and consistency in inventory, timely delivery, vehicles maintenance, dealing with unforeseen circumstances, uncertainty associated with global logistic, customer demand forecasting, create virtual sample of design, cut down design pattern, reduce lead time, and detect defect early. Afterward, BDA characteristics were derived from participants responds through carrying out thematic analysis to identify patterns of BD attributes in the interview data. BD attributes are referred to as 7" Vs" i.e., volume, variety, value, velocity, veracity, visibility, and variability. Finally, this study evaluated the fit between task and technology characteristics by applying fit -as -profile approach, which emphasis that fit can be

defined as ideal profiles composed of an internally consistent set of task and technology elements that affect the organisation performance.

In the case of investigating the external factors to utilise BDA in SCO, sustainability was not considered as a drive to adopt BDA and the interviewees confirmed that sustainability as an external pressure is not very considered comparing to other pressures such customer satisfaction and uncertainty. Data analysis findings showed that customer satisfaction and unceratianty signifcantly contributed to the move toward BDA implementation.

Empirical data asserted that desired level of performance cannot be achieved in organisations without leveraging BDA. Business value of BDA in SCO context has been extracted in terms of enhancing decision making, optimising key activities processes in SCO, and fulfilling coordination between SC partners. Finally, the importance of BDA comes from its ability to support sharing information more easily and efficiently among SC channels. Despite the proven benefits of BDA, its implementation is still in its early stage and this is due to several reasons including: lack of knowledge on what may be required from this data, the cost (time and money) generated from gearing up BDA infrastructure, lack of skilled resources/data scientists such as analytical, data-driven, and technical understanding, and finally the absence of comprehensive framework showing the potential benefits of BDA in SCO. According to Dubey *et al*., (2019), it is logical to argue that the boost of a culture of BDA, knowledge exchange, and predictive analytics can promote data-driven decision-making capabilities.

It appears from the above statements that the emphasis on changing the mindset is the perfect starting point for applying BDA, and this can be achieved through raising and explaining the businesses value of implementing BDA for employees. Therefore, the resulting model presented in this chapter explores the inner factors (fit between technology and task characteristics) and outer factors (social factors) affecting the overall effective utilisation of BDA in the SCO context. Therefore, it is vital to SCM to realise the benefits of BDA implementation, and this model will be of great important in this regard.

7. CHAPTER SEVEN: CONCLUSIONS

7.1 Research Summary

BDA has been deemed as an instigating tool in remodelling SC to demand chain, which stimulate agility to better deal with market turbulence and adopt ever changing market environment. Whilst in this research it is acknowledged that BDA technology in SCO is no longer a new phenomenon, there are significant issues still to be addressed, such as data sources, analytics techniques, and potential value that the analysed data offers.

This study has offered useful insights on BDA within an SCO context, by investigating the extent to which utilising the former creates operational values in the latter. This research involved examined literature of BDA and SCO and it emerged that the role of BD and BDA in SCO has not yet thoroughly acknowledged. There has been a lack of research studies that comprehensively address the impact of BDA on SCO and that have investigated the opportunities for new theories or emerging practices in this area. This study has addressed this void in the literature by presenting and evaluating a comprehensive framework for BDA application in the context of SCO. The framework is underpinned by the Task-Technology-Fit theory and Institutional Theory. This research contributes to both theory and practice, thereby enhancing understanding of the significance and the implications of using BDA technologies in SCO.

This chapter begins by providing an overview of the research conducted for this thesis, followed by discussion regarding how the research aims and objectives have been met. Subsequently, the key findings of the literature and empirical research reported in the work are presented along with this study's possible limitations. Following this, the contribution of the study is presented and finally, recommendations for further work are proposed.

7.2 Research Overview

This research started with a background to the research problem being presented in chapter 1. The normative literature highlights how organisations are under pressure as a result of increasing demand and supply uncertainty in addition to the urgent need for more precise customer preferences assessment in terms of products and services. This pressure has led them

to look for a new technology which can help in keeping it under control. Among other technologies, embracing BD along with sophisticated analytics tools can help firms to create value business information in various aspects (operational efficiency, improving SCM, improving decision making). It is undisputed that the salient factor to gaining competitive advantage for the long term in today's rapidly changing business environment is the ability to extract useful business information from BD. However, prior to implementing BD analytics techniques, organisations have to determine the desired insight from BD at the preliminary stage: *the relationship between business and BD project is bidirectional business requirement-based analytics and big data –driven business.*

Whilst the focus of the relevant literature has been on proposing novel approaches or presenting comprehensive frameworks relating to BDA in SCM, there is limited published scientific evidence on the real implementation of BDA in SCO that shows the extent to which the proposed benefits of utilising BDA match the real benefits. Moreover, BDA as an IT-related phenomenon needs more textual descriptions and interpretation to understand better the complex reality of it. There is a scarcity of the studies that used qualitative methodology in order to explore the real usage of BDA in SCO. This study was set out to address the following question:

What is the real impact of BDA in SCO? Identify the hype and reality.

In order to meet the aims and objectives of this thesis, chapter (2) was divided into four main sections: the first section began with consideration of SCM and then, discussed SCO. The second section discussed information technology and information management in SCM. The third section defined BD and BDA and their strategies, applications, techniques, tool, and approach, as well as reviewing studies that conducted BDA across various disciplines. The fourth section reviewed in chronological order the publications on BD in relation to SCM applications. Chapter (2) was aimed at clarifying several aspects of BD, BDA, and SCO, in addition to digging deeper into what has been done empirically and theoretically in previous research relating to BDA in SC in order to identify and analyse the existing studies to explore the research gaps.

As from the gaps presented in section 2.7, it was found that most empirical studies have been conducted in respect to one perspective of SCO (either manufacturing, inventory, demand planning, procurement, or logistics), in addition to lack of clear understanding which clarifies

the valuable use of BD in SCO processes, and the scarcity in the studies that used qualitative methodology in order to explore the real usage of BDA in SCO.

Chapter (3) was concentrated on proposing the building blocks of a theoretical framework for understanding the impact of BDA on SCO. The proposed framework underpinned by Task-Technology-Fit theory and Institutional Theory is intended to provide understanding of the value of using BDA and explaining how this adoption of new technology is derived. To this end, first, the main concepts of TTF theory and Institutional Theory were discussed through a review of the relevant literature, which was followed by operationalisation of the particular theoretic perspectives adopted in the research. It was argued that the role of institutional isomorphic pressures (macro institutional logics) on the intention behind BDA implementation, and the effect of fit between technology and tasks requirments on using BDA.

Chapter (4) explained the research approach in terms of the methods used to gather and analyse the required data to address the research problem and research questions. In chapter (5), the data analysis method described in the research methodology was applied. The findings from the analysis of the four cases were presented in order to test whether the proposed conceptual model can provide better understanding of BDA initiatives in SCO with the objective of making robust investment decisions in BDA. The empirical findings of the case studies revealed that BDA is still in its infancy stage; it is a growing area that has recently been given attention by scholars and managers. There is a disconnect between the hype and knowledge discussed in literature and the real practice of BDA. It was found that the current state of BDA use is relatively fragmented and rhetoric in discussion among practitioners and researchers.

Chapter (6) presented a detailed discussion of the findings and was concluded by developing a solid understanding of the impact of BDA applications in SCO context. A critical issue in this chapter was to decide how to develop and propose a theoretically grounded framework that could support decision makers in enhancing SC performance and thus, adding value to customers. The aim of this discussion was to assess the reality of BDA impact on SCO and to fill the gap of empirical research to assess the business value of BD. Such assessment helps to broaden the understanding of BD and its role in capturing business value.

7.3 Meeting the Aims and Objectives of this Thesis

Several objectives were defined in chapter (1) in order to achieve the aims of this thesis. These objectives are summarised in **Table 7.1** and analysed in the following discussion.

Objectives	Chapter
Critically review the literature on BD, evolution of BDA and its application, in addition to current practices, and opportunities	Chapters 1 and 2
Understanding the application of BD and its analytics in enhancing SCO	Chapter 2
Develop and propose a theoretical research framework for BD and BD analytics on SCO	Chapter 3
To assess empirically the framework, and thus, provide a novel contribution to the domain of BDA and SCO	Chapters 4, 5 and 6
Offer conclusions and recommendations for further work	Chapter 7

Table 7.1: The thesis objectives addressed over the chapters

- **Objective 1**

The literature relating to various aspects of the BDA was reviewed. Because BD is a relatively new phenomenon and it is not well established yet, this research explains the philosophies of BD more precisely through:

- ❖ Firstly, reviewing a set of BD definitions and perspectives, (see **Table 2.7**)
- ❖ Secondly, considering how BD attributes have evolved (see **Table 2.8**).
- ❖ Thirdly, discussing kind of applications that can BD bring about.
- ❖ Fourthly, identifying terminologies in BD era.
- ❖ Fifthly, mapping BDA techniques, tools, and approaches.
- ❖ Sixthly, introducing BDA Strategies for Successful Implementation.
- ❖ Finally, revising the significance of BDA in different fields.

- **Objective 2**

Drawing on the extant literature, the empirical and theoretical research related to BDA in the SCO context was reviewed, with the key BDA applications being identified. Accordingly, several research gaps were identified and investigated by the researcher.

- **Objective 3**

The review of the literature confirmed a gap in testing the fit of BD to resolving the issues within each SCO task, Task-Technology Fit was used to address this gap. Furthermore, the Institutional Theory helped in clarifying to what extent the institutional structure can cater for the adoption of BDA. As explained above, neither of these two theories were not previously used in this context.

- **Objective 4**

Using the research methodology set out in chapter 4 to gather and analysis the required data in order to address the research problem and thus, address the research question, chapter 5 presented the findings from the analysis of four cases in order to test the proposed conceptual model for better understanding BDA initiatives in SCO. In chapter 6, the research findings derived from the case studies were considered and used to modify the conceptual model so as to provide a revised BDA application model in the SCO context for decision makers.

7.4 Key Findings of the Thesis

The overall main findings derived from the work presented in this thesis have been drawn from two sources. The first, is the literature review presented in chapter 2 along with the conceptual model presented in chapter 3. The second is regarding the results of the case studies in UK based organisations. The key findings elicited from this research are highlighted below.

7.4.1 Key findings from the literature

- Literature regarding the business aspects of BD is still limited compared to the strong presence of research related to its technical aspects.
- The researchers have predominantly focused on manufacturing and there has been very limited scholarship on other sectors. According to the findings, manufacturing has been the most researched when compared with the logistics, demand planning, inventory, and procurement aspects.
- The most important observation is the lack of a theoretical framework that supports impact assessment of BDA initiatives for enterprises. As discussed in chapter (2), the documents analysed have a very practical orientation and as such, the theoretical

background used, from the management perspective, is limited and contextual to specific cases. To address this, a theoretical framework that could help in addressing the impact assessment of BD and BDA in SCO has been proposed.

- The analysis of the theory showed that there are two main drivers that guide an entity's decision to adopt BDA: institutional and external factors. Clearly, the need to implement BDA, as per the literature, may come either because of the outside environment (institutional change) or as an impetus from the company itself (technological change). According to the literature review, the external pressures that force the implementation of BDA include pressures from competitors and those exerted by partners. Once the origin of the pressure is understood, selecting the right tools and adapting the BDA techniques to the specific SCO context becomes easier.
- Researchers have addressed revolutionary changes caused by BD in healthcare, the public sector, the service sector, business management, crisis management (such as the way of taking decision), emerging new management principle, gaining a considerable lead in the trade world, understanding psychological concepts, and discovering significant insight into the past biological history.
- The scope and scale of BD have the potential to revolutionise SCO performance by collecting real-time data on, e.g. customer hits, browsing time, shopping cart content, reviews and customer-related data.
- Given the importance of information sharing in decision-making processes, BDA has a powerful data processing capability for improving the transparency of information, reducing information asymmetry, reducing cost, saving time and thus, improving business efficiency.
- The convergence of development technologies has resulted in data increasing at an exponential rate. BDA in manufacturing is grounded mainly in the implementation of IoT technologies in products and processes, which generate massive amounts of data on daily basis. This data can provide insights into the whole process of design, production, and service of a product. From the literature, it is evident that BDA has the potential to revolutionise the manufacturing process such that could reach an optimal production level.
- Empowering BDA in the SC is not about evaluation, but rather, optimising operational performance and enhancing informed decision-making.

- The role of BD and BDA in SCO has not yet been thoroughly established. There has been a lack of research studies that comprehensively address the impact of BD and BDA on SCO.

7.4.2 Key findings from the empirical data

- Based on the investigation with the research participants regarding their perception of BD, most participants defined it according to two themes. The first pertains to the significance, applications, and opportunities of BD. The second theme is about BD being perceived in terms of its benefits (profitability) and its attributes (size).
- From analysing data, it would appear managers understand BD as a way to provide better opportunities for improvement through storing and analysing the huge amounts of information generated from different sources. Despite the different terminology used to describe their motivations for implementing BDA, all of these motives pertain to improving performance and increasing profitability.
- According to the empirical findings, customer satisfaction is contributing significantly to the move towards BDA implementation as an external pressure, followed by finding new techniques for mitigating the risk of increasing uncertainty in the SC context. None of the participants alluded to sustainability as an external motive for implementing BDA.
- It was found that there was little knowledge among interviewees regarding the use of BDA techniques, which was mostly restricted to statistical techniques. It also emerged that few sources of BD have been exploited and analysed compared to the rapid generating of data from different sources represented in different forms.
- Given the data sources have not been exploited effectively, many of the benefits remain undiscovered to managers, which reinforces the perspective that the implementation of BDA is still in the primitive stage.
- Regarding BDA implementation challenges in the SCO context, participants identified three issues: Firstly, the need to change the mindset of managers toward BDA. Secondly, the lack of skilled employees with data analytics capabilities. Thirdly, the cost of time and money generated from gearing up BDA infrastructure.
- It appears from the above findings that the emphasis on changing the mindset is the perfect starting point for applying BDA, which can be achieved through explaining the business value of implementing this for employees.

- According to the empirical fieldwork, positive impacts have been elicited from BDA utilisation in the SCO context, although it is still incomparable to what has been discussed in the literature.

Building on BDA technology, BD can provide ubiquitous real time insights into the processes of design, production, and service of products. BDA is expected to be widely adopted in the SC business in order to enhance decision making processes and optimise the efficiency of SCO. However, the reality is that the current utilisation level of BDA is much lower than could be the case.

7.5 Research Contribution

A key part of any thesis is the creation of new knowledge within the context of the particular matter of interest or field of study. The different contributions made by this study flow from different units in this thesis. From the contextual information presented in chapters 1, 2 and 3, to the research methodology justified in chapter 4, through applying data analysis, findings presented out of the four cases enabled the authors to test the proposed conceptual model and provided a better understanding of BDA initiatives in SCO. Such understanding helps practitioners to make robust investment decisions in BDA as explained in chapters 5 and 6. This work made a novel contribution to the area of BDA implementation in SCO.

In this research, the main contribution has been to break down the process of BDA utilisation in order to evaluate its real implementation in the SCO context by drawing on a wide range of existing literature regarding BDA and SCO, in addition to present conceptual framework explaining the potential impact of BDA implementation through presenting BDA utilisation drivers, BDA capabilities, and its roles in solving different issues.

7.5.1 Theoretical contribution

A theoretical framework for conceptualising the benefits of implementing BDA in SCO and to explain the motives behind adopting these analytics has been developed. Two theories have been combined to provide better understanding as to how and why firms adopt BDA as a novel technology, along with the drivers and opportunities of this technology utilisation. TTF theory was developed based on the attributes of required tasks and their relationship to relevant

characteristics of technology. It is assumed that the fit between functionalities of technology and the task requirement promotes the user's work performance.

From the above, it is deduced that the fit between tasks characteristics in SCO and BD attributes is a rational action toward adopting BDA. In this case, a new lens for taking into account the limitations arising within the institutional context that surrounds organisational actors is required. Institutional theory compensates for the limitations of TTF theory in understanding the social forces behind utilising BDA.

In this research, the institutional theory has added to the constructs (IT capabilities and tasks characteristics) of TTF theory the external pressures, which can speed up the processes toward utilising BDA. The objective of this framework is to explore the inner factors (fit between technology and task characteristics) and outer factors (social factors) affecting the overall effective utilisation of BDA in the SCO context, thus resulting in realising the benefits of BDA implementation. **Figure 3.3** in chapter 3 presented the building blocks of the proposed framework, which may support other researchers in better understanding BDA initiatives in SCO, with the objective of making robust investment decisions regarding these analytics. This study offers useful insights on BD and BDA within a SCO context in primarily addressing the strategic fit of the organisation to implement BDA.

7.5.2 Practical Contributions

This study has provided a strong platform for managers to explore the critical role of BDA across SCO as it has considered multiple SC capabilities, specifically, BDA enhanced agility, sustainability, and opportunities for collaboration. The findings indicate that interpreting and analysing data from across SC channels will enable timely solutions and actions through improving the following capabilities: optimum asset work, energy saving, mass customisation, dealing with variation in demand, identifying different behaviour from smart manufacturing objects, improving supplier performance in terms of cost and quality, and resolving delivery inquiries on social media platforms.

The findings of this study have practical implications on how BDA is utilised in SCO. These could be adopted by organisations that currently implement BDA techniques in order to improve their performance and profitability as well as those that are yet to do so. For those organisations that have been applying BDA, the study's findings provide them with a deeper

understanding of state-of-the-art techniques and help them to realise how far they are from the BDA hype discussed in SCM literature context. The findings also help practitioners to understand why they have not been able to capture the full potential of their BDA investments. In addition, the findings will guide them to the right aspects of this technology, which they can pay more attention to in order to reach optimum outcomes. Such aspects are expanding the use of BD sources, applying more sophisticated analytics technique, and mainstreaming a culture of BDA in organisation. For these to be achieved, managers at different levels should be aware of BDA concept and its potential benefits. The abovementioned ideas coincide to what was argued in chapter 2, that the organisational aspects, such as organisational diffusion of such technology and embedding BA decision making into the fabric of the organisation, are the biggest inhibitors in realising the business value from BDA investment (Mikalef *et al*., 2020).

On the other hand, for organisations that have not applied BDA yet, the findings can provide them with a deeper understanding of the factors that encourage the adoption of BDA in SCO and could guide executives in making robust investment decisions. The proposed conceptual framework can be used to support management when taking decisions regarding the adoption of BDA technologies in SCO for enhanced performance and profitability.

7.6 Research Limitations

In this study, a general-purpose framework for the implementation of BDA in SCO has been proposed, which was validated through the interpretation of four cases study. Whilst this thesis has presented theoretical and practical contributions, there were some limitations associated with this research as follows.

- The most important difficulty that the researcher faced was not being able to access UK SCO organisations that implemented BDA technologies for work purposes by their employees. For the practical study, it took a long time to find organisations that applied BDA. However, the choice of four cases was justified in this situation because implementation of BDA in SCO is extremely rare and the researcher was fortunate to have "access to a situation previously inaccessible to scientific observation" (Yin, 2003).
- Another limitation of this research was facing difficulties in interviewing more than one person in each case; the sample of this study includes respondents who were

directly involved in BD initiative, and this was due to lack of mainstreaming BDA culture between employees in different managerial level.

- Additionally, the researched cases are based in the UK context and therefore, for cross country validation purposes, the proposed model in this research needs to be tested in other countries.
- Finally, despite the advantages the qualitative research provides, this methodology has disadvantages as well, such as being time consuming, in that the researcher spent more than one year in the process of finding organisations to collect and analyse data. A large amount of data was collected from the four cases which consumed a lot of time in being transcribed and translated. Moreover, the interpretation was difficult to achieve with a minimal degree of bias. However, the relative difficulty of analysing this data did not invalidate any of the conclusions drawn, since the analysis was applied to data obtained from multiple case studies. Qualitative research is criticised for its inability to establish a scientific link between theory and research.

However, despite these limitations, this study delivers significant empirical evidence and guidance on how and to what extent managers can implement BDA.

7.7 Future Research Recommendations

Given the above research limitations, the following future research in this area is recommended.

- The model of BDA implementation in SCO was based on four case organisations in the United Kingdom. It can be said that local government authorities in other cities within the UK and even other countries may well be distinct in their motivations and their technical preparation for the application of BDA. In addition, the level of understanding may well be different. For example, the study outcomes have shown that sustainability is not a driving factor for implementing BDA, which may not be so in other countries. Therefore, the results of this research cannot be generalised for all organisations. The researcher thus recommends validating this model in the context of different countries located in different geographies.
- This research has presented benefits, motives, and challenges of the BDA adoption through qualitative analysis. Thus, it is recommended to test the BDA benefits, motives,

and challenges through a large-scale survey questionnaire, instead of using interpretive epistemology. However, this was not feasible in the current research due to the shortage of time. A large-scale survey will give the opportunity to determine the identification and validation of the BDA implementation benefits, motives and challenges in the context of SCO, and will contribute to a better decision-making regarding BDA implementation.

- As the research sample included representatives from just one organisational level (managerial level), further research should include representatives from different levels, such as the technical level to gain deeper understanding of the data sources used and the methods applied to analyse this data.
- The available literature is limited and relies on conceptual studies, and a few empirical studies aimed at theory building. In terms of future research directions, the importance of (a) the business value of BDA, (b) their mechanisms and (c) the supporting systems is acknowledged. The main arguments in favour of SCO BDA implementation is that these systems may lead to more informed decisions, thus resulting in improved performance. Despite this assertion, there is a lack of paradigmatic case studies assessing the BDA impact in SCO in the short, medium- and long-term.
- As is apparent, BDA is one of the underlying technologies related to Industry 4.0, and combination between BDA and advanced technologies has restructured SC into the demand chain, which has been deemed as providing sustainable competitive advantage. So, an important recommendation is to expand the research scope to include other cutting-edge technologies, e.g. internet of things and artificial intelligence, to ascertain their implications within the context of SCO.
- Lastly, Covid-19 has changed the world dramatically over the last eight months. Its impact has been evident in the field of business, such as SC break down and disruption to manufacturing operations. Therefore, further research should investigate the role of BDA and artificial intelligence in mitigating disruptions in SC processes during such crises.

References

Addo-Tenkorang, R., Helo, P.T. 2016. Big data applications in operations/supply-chain management: A literature review. Computers and Industrial Engineering, 101, 528-543.

Agar, M. (1980). Getting better quality stuff: Methodological competition in an interdisciplinary niche. *Urban Life*, *9*(1), 34-50.

Ahmadov, Y., & Helo, P. (2018). A cloud based job sequencing with sequence-dependent setup for sheet metal manufacturing. *Annals of Operations Research*, *270*(1-2), 5-24.

Akilu Yunusa-kaltungo, J. K. S. (2017). *Effective vibration-based condition monitoring (eVCM) of rotating machines*.

Akilu Yunusa-kaltungo, J. K. S. (2017). *Effective vibration-based condition monitoring (eVCM) of rotating machines*.

Akter, S., Wamba, S. F., Gunasekaran, A., Dubey, R., & Childe, S. J. (2016). How to improve firm performance using big data analytics capability and business strategy alignment? *International Journal of Production Economics*, *182*, 113-131.

Albey, E., Norouzi, A., Kempf, K. G., & Uzsoy, R. (2015). Demand modeling with forecast evolution: an application to production planning. *IEEE Transactions on Semiconductor Manufacturing*, *28*(3), 374-384.

Alexander, L. W. and 2Cheryl A. (2015). Big Data Driven Supply Chain Management : A Game Changer. *American Journal of Economics and Business Administration*, *February 2015*, 1–9. https://doi.org/10.3844/ajebasp.2015.60.67

Aljukhadar, M., Senecal, S., & Nantel, J. (2014). Is more always better? Investigating the task-technology fit theory in an online user context. *Information and Management*, *51*(4), 391–397. https://doi.org/10.1016/j.im.2013.10.003

Amundson, S. D. (1998). Relationships between theory-driven empirical research in operations management and other disciplines. *Journal of Operations Management*, *16*(4), 341–359. https://doi.org/10.1016/S0272-6963(98)00018-7

Anderson, D. L., Britt, F. F., & Favre, D. J. (2007). The 7 principles of supply chain management. *Supply Chain Management Review*, *11*(3), 41-46.

Arksey, H., & Knight, P. T. (1999). *Interviewing for social scientists: An introductory resource*

with examples. Sage.

Arunachalam, D., Kumar, N., & Kawalek, J. P. (2018). Understanding big data analytics capabilities in supply chain management: Unravelling the issues, challenges, and implications for practice. *Transportation Research Part E: Logistics and Transportation Review*, *114*, 416-436.

Arya, V., Sharma, P., Singh, A., & De Silva, P. T. M. (2017). An exploratory study on supply chain analytics applied to spare parts supply chain. *Benchmarking: An International Journal*.

Ayyildiz, E., & Gumus, A. T. (2021). Interval-valued Pythagorean fuzzy AHP method-based supply chain performance evaluation by a new extension of SCOR model: SCOR 4.0. Complex & Intelligent Systems, 7(1), 559-576.

Azadian, F., Murat, A., & Chinnam, R. B. (2015). Integrated production and logistics planning: Contract manufacturing and choice of air/surface transportation. *European Journal of Operational Research*, *247*(1), 113-123.

Bag, S. (2017). Big data and predictive analysis is key to superior supply chain performance: a South African experience. *International Journal of Information Systems and Supply Chain Management (IJISSCM)*, *10*(2), 66-84.

Bag, S., Wood, L. C., Xu, L., Dhamija, P., Kayikci, Y. 2020. Big data analytics as an operational excellence approach to enhance sustainable supply chain performance. Resources, Conservation and Recycling, 153, 104559.

Baur, C., & Wee, D. (2015). Manufacturing's next act. *McKinsey & Company*, *6*.

Beamon, B. M., & Ware M., T. (1998). A process quality model for the analysis, improvement and control of supply chain systems. *International Journal of Physical Distribution & Logistics Management*, *28*(9/10), 704.

Baxter, P., & Jack, S. (2008). Qualitative case study methodology: Study design and implementation for novice researchers. *The qualitative report*, *13*(4), 544-559.

Benbasat, I., Goldstein, D. K., & Mead, M. (1987). The case Research Strategy in Studies of Information System. *MIS Quarterly*, *11*(3), 369–386. https://doi.org/10.2307/248684

Ben-Daya, M., Hassini, E., Bahroun, Z., 2019. Internet of things and supply chain management: a literature review. International Journal of Production Research, 57 (15-16), 4719-4742.

Bhattacharjya, J., Ellison, A., & Tripathi, S. (2016). An exploration of logistics-related customer service provision on Twitter The case of e-retailers. *International Journal of Physical Distribution & Logistics Management*, *46*(6-7), 659-680.

Bhutta, K. S., and Huq, F. (2002). Supplier selection problem: a comparison of the total cost of ownership and analytic hierarchy process approaches. Supply Chain Management: an international journal, 7(3), 126-135.

Bock, S., & Isik, F. (2015). A new two-dimensional performance measure in purchase order sizing. *International Journal of Production Research*, *53*(16), 4951-4962.

Brandau, A., Tolujevs, J. 2013. Modelling and Analysis of Logistical State Data. Transport and Telecommunication, 14 (2), 102-115.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology*, *3*(2), 77-101.

Brinch, M., Stentoft, J., & Jensen, J. K. (2017, January). Big data and its applications in supply chain management: Findings from a Delphi study. In *Proceedings of the 50th Hawaii International Conference on System Sciences*.

Broom, A. (2006). Ethical issues in social research. *Complementary therapies in medicine*, *14*(2), 151-156.

Bumblauskas, D., Gemmill, D., Igou, A., & Anzengruber, J. (2017). Smart Maintenance Decision Support Systems (SMDSS) based on corporate big data analytics. *Expert systems with applications*, *90*, 303-317.

Burns, E. (2010). Developing email interview practices in qualitative research. *Sociological research online*, *15*(4), 24-35.

Burrell, G., & Morgan, G. (1979). *Sociological Paradigms and Organisational Analysis* (ISBN 97805, Vol. 9781136251). Published 2016 by Routledge 2 Park Square, Milton Park, Abingdon, Oxon OX14 4RN 711 Third Avenue, New York, NY 10017, USA.

Caldera, H. T. S., Desha, C., Dawes, L. 2017. Exploring the role of lean thinking in sustainable business practice: A systematic literature review. Journal of Cleaner Production, 167, 1546-1565.

Carley, K. M., Malik, M., Landwehr, P. M., Pfeffer, J., & Kowalchuck, M. (2016). Crowd sourcing disaster management: The complex nature of Twitter usage in Padang Indonesia. *Safety science*, *90*, 48-61.

Tam, C., & Oliveira, T. (2016). Performance impact of mobile banking: using the task-technology fit (TTF) approach. *International Journal of Bank Marketing*. DOI: 10.1108/IJBM-11-2014-0169

Cavaye, A. L. M. (1996). Case study research: a multi-faceted research approach for IS. *Information Systems Journal*, *6*(1 996), 227–242.

Cecere, L., (2012). Big Data: Go Big or Go Home? Technical Report, *Supply Chain Insights LLC*, pp: 1-19

Cecere, L., Barrett, J., & Mooraj, H. (2009). Sales and Operations Planning: Transformation From Tradition. *Industry Value Chain Strategies*, *May*, 9.

Chae, B. (2015). Insights from hashtag #supplychain and Twitter analytics: Considering Twitter and Twitter data for supply chain practice and research. *International Journal of Production Economics*, *165*, 247–259.

CHAE, B. (KEVIN), & OLSON, D. L. (2013). Business Analytics for Supply Chain: a Dynamic-Capabilities Framework. *International Journal of Information Technology & Decision Making*, *12*(01), 9–26.

Chae, B. K. (2015). Insights from hashtag# supply chain and Twitter Analytics: Considering Twitter and Twitter data for supply chain practice and research. International Journal of Production Economics, 165, 247-259.

Chae, B. K., Olson, D., & Sheu, C. (2014). The impact of supply chain analytics on operational performance: A resource-based view. *International Journal of Production Research*, *52*(16), 4695–4710.

Chavez, R., Yu, W., Jacobs, M.A., Feng, M. 2017. Data-driven supply chains, manufacturing capability and customer satisfaction. Production Planning and Control, 28 (11/12), 906-918.

Chehbi-Gamoura, S., Derrouiche, R., Damand, D., Barth, M. (2020). Insights from big Data Analytics in supply chain management: an all-inclusive literature review using the SCOR model. Production Planning & Control, 31 (5), 355-382.

Chen, C. P., & Zhang, C. Y. (2014). Data-intensive applications, challenges, techniques and technologies: A survey on Big Data. *Information sciences*, *275*, 314-347.

Chen, D. Q., Preston, D. S., & Swink, M. (2015). How the Use of Big Data Analytics Affects Value Creation in Supply Chain Management. *Journal of Management Information Systems*, *32*(4), 4–39.

Chen, H., Chiang, R. H. L., & Storey, V. C. (2012). Business Intelligence and Analytics: From Big Data To Big Impact. *Mis Quarterly*, *36*(4), 1165–1188. https://doi.org/10.1145/2463676.2463712

Chen, P. C., & Kezunovic, M. (2016). Fuzzy logic approach to predictive risk analysis in distribution outage management. *IEEE Transactions on Smart Grid*, *7*(6), 2827-2836.

Chen, W., & Hirschheim, R. (2004). A paradigmatic and methodological examination of information systems research from 1991 to 2001. *Information Systems Journal*, *14*(3), 197–235.

Chen, X., & Lu, W. (2017). Identifying factors influencing demolition waste generation in Hong Kong. *Journal of Cleaner Production*, *141*, 799–811.

Chen, Z.-L. (2010). Integrated Production and Outbound Distribution Scheduling: Review and Extensions. *Operations Research*, *58*(1), 130–148.

Cheng, C.-H., & Kuo, Y.-H. (2016). RFID analytics for hospital ward management. *Flexible Services and Manufacturing Journal*, *28*(4), 593–616.

Chien, C. F., Hong, T. Y., and Guo, H. Z. (2017). An empirical study for smart production for TFT-LCD to empower Industry 3.5. Journal of the Chinese Institute of Engineers, 40(7), 552-561.

Chien, C. F., Liu, C. W., & Chuang, S. C. (2017). Analysing semiconductor manufacturing big data for root cause detection of excursion for yield enhancement. *International Journal of Production Research*, *55*(17), 5095–5107.

Tan, K. C. (2001). A framework of supply chain management literature. *European Journal of*

Purchasing & Supply Management, *7*(1), 39-48.

Chopra, S., Meindl, P., & Kalra, D. V. (2013). *Supply chain management: strategy, planning, and operation* (Vol. 232). Boston, MA: Pearson.

Chopra, S., Meindl, P. (2010). Supply chain management: strategy, planning, and operation, 4th ed. Upper Saddle River, New Jersey: Pearson Education Inc.

Chow, H. K., Choy, K. L., Lee, W. B., & Chan, F. T. (2005). Design of a knowledge-based logistics strategy system. *Expert Systems with Applications*, *29*(2), 272-290.

Christopher, M., and Towill, D. R. (2002). Developing market specific supply chain strategies. The international journal of logistics management, 13(1), 1-14.

Chua, W. F. (1986). Radical Developments in Accounting Thought. *The Accounting Review*, *61*(4), 601–632.

Cinnamon, J., Jones, S. K., & Adger, W. N. (2016). Evidence and future potential of mobile phone data for disease disaster management. *Geoforum*, *75*, 253–264.

Coleman, S, Göb, R., Manco, G., Pievatolo, A., Tort-Martorell, X., & Reis, M. S. (2016). How Can SMEs Benefit from Big Data? Challenges and a Path Forward. *Quality and Reliability Engineering International*, *32*(6), 2151–2164.

Collis, J., & Hussey, R. (2014). *Business research: A practical guide for undergraduate and postgraduate students*. Macmillan International Higher Education.

Connelly, R., Playford, C. J., Gayle, V., & Dibben, C. (2016). The role of administrative data in the big data revolution in social science research. *Social Science Research*, *59*, 1–12.

Creswell, J. W. (2016). *Qualitative inquiry and research design: Choosing among five approaches*. Sage publications.

Creswell, J. W., & Poth, C. N. (2016). Qualitative inquiry and research design: Choosing among five approaches. Sage publications.

Creswell, J. (2009) 'Qualitative inquiry and research design. Choosing among five Approaches', Sage Publications.

Crossan, F. (2003). Research philosophy: towards an understanding. *Nurse Researcher (through 2013)*, *11*(1), 46.

Currie, W. L. (2011). Institutional Theory of Information Technology. In *The Oxford Handbook of Management Information Systems: Critical Perspectives and New Directions* (Issue May 2018).

D'Ambra, J., Wilson, C. S., & Akter, S. (2013). Application of the task-technology fit model to structure and evaluate the adoption of E-books by A cademics. *Journal of the American society for information science and technology*, *64*(1), 48-64.

Daniel, B. (2015). Big Data and analytics in higher education: Opportunities and challenges. *British Journal of Educational Technology*, *46*(5), 904–920.

De Mauro, A., Greco, M., & Grimaldi, M. (2016). A formal definition of Big Data based on its essential features. *Library Review*. Vol. 65 No. 3, pp. 122-135.

Delbufalo, E. 2012. Outcomes of inter-organizational trust in supply chain relationships: a systematic literature review and a meta-analysis of the empirical evidence. Supply Chain Management: An International Journal, 17 (4), 377-402.

Demchenko, Y., Grosso, P., & Membrey, P. (2013). Addressing Big Data Issues in Scientific Data Infrastructure. *Collaboration Technologies and Systems (CTS), 2013 International Conference on (Pp. 48-55). IEEE.*, 48–55.

Demey, Y. T. and Wolff, M. (2016) 'SIMISS: A Model based Searching Strategy for Inventory Management Systems', IEEE Internet of Things Journal, 4(1), pp. 1–1.

Denyer, D., Tranfield, D. 2009. Producing a systematic review. The Sage handbook of organizational research methods, 671-689.

Derakhshan, R., Orlowska, M. E., & Li, X. L. X. (2007). RFID Data Management: Challenges and Opportunities. *2007 IEEE International Conference on RFID*, 175–182.

DiBiano, R., & Mukhopadhyay, S. (2017). Automated diagnostics for manufacturing machinery based on well-regularized deep neural networks. *Integration, the VLSI Journal*, *58*(April 2016), 303–310.

Diebold, F. X. (2012). A Personal Perspective on the Origin(s) and Development of "Big Data": The Phenomenon, the Term, and the Discipline, Second Version. *SSRN Electronic Journal*.

Dimaggio and Powell. (1983). The Iron Cage Revisited : Institutional Isomorphism and

Collective Rationality in Organizational Fields Author (s): Paul J . DiMaggio and Walter W . Powell Source : American Sociological Review , Vol . 48 , No . 2 (Apr ., 1983), pp . 147-160 Published. *American Sociological Review*, *48*(2), 147–160.

Dimaggio, P.J., Powell, W.W. 2000. The iron cage revisited institutional isomorphism and collective rationality in organizational fields, in Joel A.C. Baum, Frank Dobbin (ed.) Economics Meets Sociology in Strategic Management (Advances in Strategic Management, 17, 143-166.

Ding, X., Tian, Y., and Yu, Y. (2016). A real-time big data gathering algorithm based on indoor wireless sensor networks for risk analysis of industrial operations. IEEE transactions on industrial informatics, 12(3), 1232-1242.

Duan, L., & Xiong, Y. (2015). Big data analytics and business analytics. *Journal of Management Analytics*, *2*(1), 1–21.

Canever, M. D., Van Trijp, H. C., & Beers, G. (2008). The emergent demand chain management: key features and illustration from the beef business. *Supply Chain Management: An International Journal*, 13(2), pp. 104–115.

Dubey, R., Gunasekaran, A., Childe, S. J. 2019. Big data analytics capability in supply chain agility. Management Decision, 57 (8), 2092-2112.

Dubey, R., Gunasekaran, A., Childe, S. J., Blome, C., & Papadopoulos, T. (2019). Big data and predictive analytics and manufacturing performance: integrating institutional theory, resource-based view, and big data culture. *British Journal of Management*, *30*(2), 341-361.

Dubey, R., Gunasekaran, A., Childe, S. J., Bryde, D. J., Giannakis, M., Foropon, C., ... & Hazen, B. T. (2020). Big data analytics and artificial intelligence pathway to operational performance under the effects of entrepreneurial orientation and environmental dynamism: A study of manufacturing organisations. *International Journal of Production Economics*, *226*, 107599.

Dubey, R., Gunasekaran, A., Childe, S. J., Wamba, S. F., & Papadopoulos, T. (2016). The impact of big data on world-class sustainable manufacturing. *International Journal of Advanced Manufacturing Technology*, *84*(1–4), 631–645.

Dubey, R., Gunasekaran, A., Papadopoulos, T., Childe, S. J., Shibin, K. T., & Wamba, S. F.

(2017a). Sustainable supply chain management: framework and further research directions. In *Journal of Cleaner Production* (Vol. 142, pp. 1119–1130).

Eisenhardt, K. M. (1989). Building theories from case study research. *Academy of management review*, *14*(4), 532-550.

Ekşioğlu, S. D., Edwin Romeijn, H. and Pardalos, P. M. (2006) 'Cross-facility management of production and transportation planning problem', Computers & Operations Research, 33(11), pp. 3231–3251.

Eltantawy, R., Paulraj, A., Giunipero, L., Naslund, D., & Thute, A. A. (2015). Towards supply chain coordination and productivity in a three echelon supply chain. *International Journal of Operations & Production Management*.

Feki, M., Boughzala, I., & Wamba, S. F. (2016, January). Big data analytics-enabled supply chain transformation: A literature review. In *2016 49th Hawaii International Conference on System Sciences (HICSS)* (pp. 1123-1132). IEEE.

Flick, U. (2008) 'Managing Quality in Qualitative Research', Sage Publications Ltd.

Frankfort-Nachmias, C., & Nachmias, D. (1992). Research methods in the social sciences (4th ed.). New York: St. Martin's Press.

Frehe, V., Kleinschmidt, T., & Teuteberg, F. (2014). Big Data in Logistics-Identifying Potentials through Literature, Case Study and Expert Interview Analyses. In *GI-Jahrestagung* (pp. 173-186).

Frizzo-Barker, J., Chow-White, P. A., Mozafari, M., & Ha, D. (2016). An empirical study of the rise of big data in business scholarship. *International Journal of Information Management*, *36*(3), 403-413.

Furneaux, B. 2012. Task-Technology Fit Theory: A Survey and Synopsis of the Literature. In Information Systems Theory, Vol. 28, edited by Y. K. Dwivedi, M. R. Wade, and S. L. Schneberger, pp. 87-106. New York: Springer.

Gamage, P. (2016). New development: Leveraging 'big data' analytics in the public sector. *Public Money and Management*, *36*(5), 385–390.

Gandomi, A., and Haider, M. (2015). Beyond the hype: Big data concepts, methods, and analytics. International Journal of Information Management, 35(2), 137-144.

Gantz, J., & Reinsel, D. (2012). THE DIGITAL UNIVERSE IN 2020: Big Data, Bigger Digi tal Shadows, and Biggest Growth in the Far East. *Idc*, *2007*(December 2012), 1–16.

Gerring, J. (2007) Case Study Research: Principles and Practices, Cambridge University Press, New York.

Ghauri, P., Grønhaug, K., & Strange, R. (2020). *Research methods in business studies*. Cambridge University Press.

Ginting, Y. M. (2020). Intellectual Capital Investigation in Achieving Sustainable Competitive Advantages in the Creative Industry: Does the Mediation of Knowledge Management System Affect?. *Journal of Management Information and Decision Sciences*, *23*(2), 111-126.

Golafshani, N. (2003). Understanding reliability and validity in qualitative research. *The qualitative report*, *8*(4), 597-607.

Goodhue, D. L., & Thompson, R. L. (1995). Task-Technology Fit and Individual Performance. *MIS Quarterly/June 1995*, *19*(2), 213–236.

Gu, F., Ma, B., Guo, J., Summers, P. A., & Hall, P. (2017). Internet of things and Big Data as potential solutions to the problems in waste electrical and electronic equipment management: An exploratory study. *Waste Management*, *68*, 434–448.

Gu, X. (2017). The impact of maintainability on the manufacturing system architecture. *International Journal of Production Research*, *55*(15), 4392–4410.

Gunasekaran, A., & Ngai, E. W. T. (2004). Information systems in supply chain integration and management. *European Journal of Operational Research*, *159*(2 SPEC. ISS.), 269–295.

Gunasekaran, A., Subramanian, N., & Papadopoulos, T. (2017). Information technology for competitive advantage within logistics and supply chains: A review. *Transportation Research Part E: Logistics and Transportation Review*, *99*(C), 14-33.

Guo, Q., & Karimi, H. A. (2017). A novel methodology for prediction of spatial-temporal activities using latent features. *Computers, Environment and Urban Systems*, *62*, 74-85.

Gunasekaran, A., Yusuf, Y. Y., Adeleye, E. O., and Papadopoulos, T. (2018). Agile manufacturing practices: the role of big data and business analytics with multiple case studies. International Journal of Production Research, 56(1-2), 385-397.

Gunasekaran, Angappa, Papadopoulos, T., Dubey, R., Wamba, S. F., Childe, S. J., Hazen, B., & Akter, S. (2017). Big data and predictive analytics for supply chain and organizational performance. *Journal of Business Research*, *70*, 308–317.

Gungor, A. and Gupta, S. M. (1999) 'Issues in environmentally conscious manufacturing and product recovery: A survey', Computers and Industrial Engineering, 36(4), pp. 811–853.

Guo, Y., Barnes, S. J., & Jia, Q. (2017). Mining meaning from online ratings and reviews: Tourist satisfaction analysis using latent dirichlet allocation. *Tourism Management*, *59*, 467–483.

Gupta, M., & George, J. F. (2016). Toward the development of a big data analytics capability. *Information & Management*, *53*(8), 1049-1064.

Gyulai, D., Pfeiffer, A., Sobottka, T., & Váncza, J. (2013). Milkrun vehicle routing approach for shop-floor logistics. Procedia CIRP, 7, 127-132.

Haider, A. P. and A. (2013). ERP institutionalization: exploring the influential factors. *Journal of Enterprise Information Management*.

Hashem, I. A. T., Yaqoob, I., Anuar, N. B., Mokhtar, S., Gani, A., & Ullah Khan, S. (2015). The rise of "big data" on cloud computing: Review and open research issues. *Information Systems*, *47*, 98–115.

Hazen, B. T., Skipper, J. B., Ezell, J. D., & Boone, C. A. (2016). Big data and predictive analytics for supply chain sustainability: A theory-driven research agenda. *Computers & Industrial Engineering*, *101*, 592-598.

He, J., Liu, H., & Xiong, H. (2016). SocoTraveler: Travel-package recommendations leveraging social influence of different relationship types. *Information and Management*, *53*(8), 934–950.

Hilbert, M. (2016). Big data for development: A review of promises and challenges. *Development Policy Review*, *34*(1), 135-174.

Hofmann, E. (2017). Big data and supply chain decisions: the impact of volume, variety and velocity properties on the bullwhip effect. *International Journal of Production Research*, *55*(17), 5108-5126.

Hosoda, T., & Disney, S. M. (2012). A delayed demand supply chain: incentives for upstream players. *Omega*, *40*(4), 478-487.

Hosoda, T., & Disney, S. M. (2012). On the replenishment policy when the market demand information is lagged. *International Journal of Production Economics*, *135*(1), 458-467.

Huang, S. H., Sheoran, S. K., & Keskar, H. (2005). Computer-assisted supply chain configuration based on supply chain operations reference (SCOR) model. Computers & Industrial Engineering, 48(2), 377-394.

Huan, S. H., Sheoran, S. K., & Wang, G. (2004). A review and analysis of supply chain operations reference (SCOR) model. Supply chain management: An international Journal.

Huang, T. and Van Mieghem, J. A. (2014) 'Clickstream data and inventory management: Model and empirical analysis', Production and Operations Management, 23(3), pp. 333–347.

Huang, Y.-Y. and Handfield, R. B. (2015) 'Measuring the benefits of ERP on supply management maturity model: a "big data" method', International Journal of Operations & Production Management.

Ivanov, D., & Dolgui, A. (2020). A digital supply chain twin for managing the disruption risks and resilience in the era of Industry 4.0. *Production Planning & Control*, 1-14.

Jain, A., Rudi, N., and Wang, T. (2014). Demand estimation and ordering under censoring: Stock-out timing is (almost) all you need. Operations Research, 63(1), 134-150.

Jang, S.-W., & Kim, G.-Y. (2017). A monitoring method of semiconductor manufacturing processes using Internet of Things–based big data analysis. *International Journal of Distributed Sensor Networks*, *13*(7), 155014771772181.

Janssen, M., van der Voort, H., & Wahyudi, A. (2017). Factors influencing big data decision-making quality. *Journal of Business Research*, *70*, 338–345.

Janvier-James, A. M. (2011). A New Introduction to Supply Chains and Supply Chain Management: Definitions and Theories Perspective. *International Business Research*,

5(1), 194–207.

Jeske, M., Grüner, M., & WeiB, F. (2013). Big Data in Logistics. *DHL Customer Solutions & Innovation*, *December*, 1–30.

Jharkharia, S., & Shankar, R. (2007). Selection of logistics service provider: An analytic network process (ANP) approach. *Omega*, *35*(3), 274-289.

Jhang-Li, J. H., & Chang, C. W. (2017). Analyzing the operation of cloud supply chain: adoption barriers and business model. *Electronic Commerce Research*, *17*(4), 627-660.

Ji, G., Hu, L., & Tan, K. H. (2017). A study on decision-making of food supply chain based on big data. *Journal of Systems Science and Systems Engineering*, *26*(2), 183–198.

Ji, W., & Wang, L. (2017). Big data analytics based fault prediction for shop floor scheduling. *Journal of Manufacturing Systems*, *43*, 187–194.

Jin, X., Wah, B. W., Cheng, X., & Wang, Y. (2015). Significance and challenges of big data research. *Big Data Research*, *2*(2), 59-64.

Jin, Y., & Ji, S. (2013). Partner choice of supply chain based on 3d printing and big data. *Information Technology Journal*, *12*(22), 6822–6826.

Storey, J., Emberson, C., Godsell, J., & Harrison, A. (2006). Supply chain management: theory, practice and future challenges. *International Journal of Operations & Production Management*, *26*(7), 754–774.

Jukić, N., Sharma, A., Nestorov, S., & Jukić, B. (2015). Augmenting Data Warehouses with Big Data. *Information Systems Management*, *0530*(July), 150527102705002.

Kache, F., & Seuring, S. (2017). Challenges and opportunities of digital information at the intersection of Big Data Analytics and supply chain management. *International Journal of Operations & Production Management*. Vol. 37 No. 1, pp. 10-36.

Kamal, M. M., Irani, Z. (2014). Analysing Supply Chain Integration through Systematic Literature Review: A Normative Perspective. Supply Chain Management: An International Journal, 19 (5/6), 523-557.

Kauppi, K. (2013). *Extending the use of institutional theory in operations and supply chain management research: Review and research suggestions*.

Kitchin, R. (2014). Big Data, new epistemologies and paradigm shifts. *Big Data & Society*,

1(1), 205395171452848.

Kokina, J., Pachamanova, D., & Corbett, A. (2017). The role of data visualization and analytics in performance management: Guiding entrepreneurial growth decisions. *Journal of Accounting Education*, *38*, 50–62.

Krumeich, J., Werth, D., Loos, P. 2016. Prescriptive Control of Business Processes. Business & Information Systems Engineering, 58 (4), 261-280.

Kshetri, N. (2014). Big datas impact on privacy, security and consumer welfare. *Telecommunications Policy*, *38*(11), 1134–1145.

Ku, J.-H. (2017). A Study on Prediction Model of Equipment Failure Through Analysis of Big Data Based on RHadoop. *Wireless Personal Communications*.

Kuiler, E. W. (2014). From big data to knowledge: An ontological approach to big data analytics. *Review of Policy Research*, *31*(4), 311–318.

Kumar, A., Shankar, R., Choudhary, A., & Thakur, L. S. (2016). A big data MapReduce framework for fault diagnosis in cloud-based manufacturing. *International Journal of Production Research*, *54*(23), 7060–7073.

Lai, K. H. (2004). Service capability and performance of logistics service providers. Transportation Research Part E: Logistics and Transportation Review, 40(5), 385-399.

Lai, P. (2017). the Literature Review of Technology Adoption Models and Theories for the Novelty Technology. *Journal of Information Systems and Technology Management*, *14*(1), 21–38.

Lamba, K., and Singh, S. P. (2017). Big data in operations and supply chain management: current trends and future perspectives. Production Planning & Control, 28(11-12), 877-890.

Lambert, D. M., & Cooper, M. C. (2000). Issues in Supply Chain Management. *Industrial Marketing Management*, *29*(1), 65–83.

Lancaster, G. (2005). Research Methods in Management A concise introduction to research in management and business consultancy. In *Elsevier Butterworth-Heinemann* (Vol. 54).

Landwehr, P. M., Wei, W., Kowalchuck, M., & Carley, K. M. (2015). Using tweets to support disaster planning, warning and response. *Safety Science*, *90*, 33–47.

Lau, R. Y. K., Zhang, W. and Xu, W. (2017) 'Parallel Aspect-Oriented Sentiment Analysis for Sales Forecasting with Big Data', Production and Operations Management, 0(0), pp. 1–20

Lavalle, S., Lesser, E., Shockley, R., Hopkins, M. S., & Kruschwitz, N. (2011). Big Data, Analytics and the Path From Insights to Value. *MIT Sloan Management Review*, *52*(2), 21–32.

Lee, C. C., Cheng, H. K., & Cheng, H. H. (2007). An empirical study of mobile commerce in insurance industry: Task-technology fit and individual differences. *Decision Support Systems*, *43*(1), 95–110.

Lee, C. K. H. (2017). A GA-based optimisation model for big data analytics supporting anticipatory shipping in Retail 4.0. *International Journal of Production Research*, *55*(2), 593–605. https://doi.org/10.1080/00207543.2016.1221162

Lee, H. L., Padmanabhan, V., & Whang, S. (2004). Information Distortion in a Supply Chain: The Bullwhip Effect/Comments on "Information Distortion in a Supply Chain: The Bullwhip Effect." *Management Science*, *50*(January 2015), 1875–1893.

Lee, J., Jin, C., & Bagheri, B. (2017). Cyber physical systems for predictive production systems. *Production Engineering*, *11*(2), 155–165.

Lee, J., Kao, H. A., & Yang, S. (2014). Service innovation and smart analytics for industry 4.0 and big data environment. *Procedia Cirp*, *16*(1), 3-8.

Lee, J.Y., Yoon, J.S., Kim, B.H. 2017. A big data analytics platform for smart factories in small and medium-sized manufacturing enterprises: An empirical case study of a die casting factory. International Journal of Precision Engineering and Manufacturing, 18 (10), 1353-1361.

Lele, Q. and Lihua, K. (2016) 'Technical framework design of safety production information management platform for chemical industrial parks based on cloud computing and the internet of things', International Journal of Grid and Distributed Computing, 9(6), pp. 299–314.

Leveling, J., Edelbrock, M., and Otto, B. (2014, December). Big data analytics for supply chain management. In Industrial Engineering and Engineering Management (IEEM), 2014 IEEE International Conference on (pp. 918-922). IEEE.

Li, G., Zhang, L., Guan, X., and Zheng, J. (2016). Impact of decision sequence on reliability enhancement with supply disruption risks. Transportation Research Part E: Logistics and Transportation Review, 90, 25-38.

Li, H., Ji, Y., Luo, G., & Mi, S. (2016). A modular structure data modeling method for generalized products. *International Journal of Advanced Manufacturing Technology*, *84*(1–4), 197–212.

Li, J., Tao, F., Cheng, Y., & Zhao, L. (2015). Big Data in product lifecycle management. *The International Journal of Advanced Manufacturing Technology*, *81*(1–4), 667–684.

Li, L., Chi, T., Hao, T., & Yu, T. (2018). Customer demand analysis of the electronic commerce supply chain using Big Data. *Annals of Operations Research*, *268*(1-2), 113-128.

Li, L., Su, Q., & Chen, X. (2011). Ensuring supply chain quality performance through applying the SCOR model. International Journal of Production Research, 49(1), 33-57.

Li, Y., Jia, G., Cheng, Y., Hu, Y. 2017. Additive manufacturing technology in spare parts supply chain: a comparative study. International Journal of Production Research, 55 (5), 1498-1515.

Liao, Y., Deschamps, F., Loures, E. D. F. R., & Ramos, L. F. P. (2017). Past, present and future of Industry 4.0-a systematic literature review and research agenda proposal. *International journal of production research*, *55*(12), 3609-3629..

Lin, C.-C., & Lai, P.-L. (2017). Evaluating logistics capabilities on firm performance of the photonics industry in Taiwan. *International Journal of Supply Chain Management*, *6*(1), 186–202.

Lin, T. C., & Huang, C. C. (2008). Understanding knowledge management system usage antecedents: An integration of social cognitive theory and task technology fit. *Information and Management*, *45*(6), 410–417.

Liu, Y., & Wang, H. (2016). Order Allocation for Service Supply Chain Base on the Customer Best Delivery Time Under the Background of Big Data. *IJCSA*, *13*(1), 84-92..

Liu, Z., Wang, Y., Cai, L., Cheng, Q., & Zhang, H. (2016). Design and manufacturing model of customized hydrostatic bearing system based on cloud and big data technology. *The International Journal of Advanced Manufacturing Technology*, *84*(1-4), 261-273..

Lu, H. P., & Yang, Y. W. (2014). Toward an understanding of the behavioral intention to use a social networking site: An extension of task-technology fit to social-technology fit. *Computers in Human Behavior*, *34*, 323–332.

Lummus, R. R., & Vokurka, R. J. (1999). Defining supply chain management: A historical perspective and practical guidelines. *Industrial Management & Data Systems*, *99*(1), 11–17.

Lun, Y. H. V., Lai, K. H., Wong, C. W. Y., & Cheng, T. C. E. (2013). Demand chain management in the container shipping service industry. *International Journal of Production Economics*, *141*(2), 485–492.

M. Giannakis, & Louis, M. (2016). A multi-agent based system with big data processing for enhanced supply chain agility. *Journal of Enterprise Information Management*.

Ma, L., Nie, F., & Lu, Q. (2015). An analysis of supply chain restructuring based on Big Data and mobile Internet ;A case study of warehouse-type supermarkets. *2015 IEEE International Conference on Grey Systems and Intelligent Services (GSIS)*, 446–451.

Manyika, J., Chui, M., Brown, B., Bughin, J., Dobbs, R., Roxburgh, C., & Hung Byers, A. (2011). *Big data: The next frontier for innovation, competition, and productivity*. McKinsey Global Institute.

Marr, B (2020). How Walmart Is Using Machine Learning AI, IoT And Big Data To Boost Retail Performance. Webpage: https://bernardmarr.com/default.asp?contentID=1181

Martin, K. (2016). Data aggregators, consumer data, and responsibility online: Who is tracking consumers online and should they stop?. *The Information Society*, *32*(1), 51-63.

Martinez, V., Bastl, M., Kingston, J., & Evans, S. (2010). Challenges in transforming manufacturing organisations into product-service providers. *Journal of Manufacturing Technology Management*, *21*(4), 449-469.

Maxwell, J. A. (2012). *Qualitative research design: An interactive approach* (Vol. 41). Sage publications.

McAfee, A., & Brynjolfsson, E. (2012). Big Data. The management revolution. *Harvard Buiness Review*, *90*(10), 61–68.

McGill, T. J., & Klobas, J. E. (2009). A task–technology fit view of learning management

system impact. *Computers & Education*, *52*(2), 496-508.

Melnyk, S. A., Flynn, B. B., & Awaysheh, A. (2018). The best of times and the worst of times: empirical operations and supply chain management research. *International Journal of Production Research*, *56*(1-2), 164-192.

Mendes, P., Leal, J. E., & Thomé, A. M. T. (2016). A maturity model for demand-driven supply chains in the consumer product goods industry. *International Journal of Production Economics*, *179*, 153–165.

Mentzer, J. T., Min, S., and Michelle Bobbitt, L. (2004). Toward a unified theory of logistics. International Journal of Physical Distribution & Logistics Management, 34(8), 606-627.

Mentzer, J. T., & Kahn, K. B. (1995). A framework of logistics research. *Journal of Business Logistics*, *16*(1), 231.

Michael D. Williams, Yogesh Kumar Dwivedi, N. R. (2012). A Bibliometric Analysis of Articles Citing the Unified Theory of Acceptance and Use of Technology. In *Integrated Series in Information Systems Volume 28, Springer*, (Vol. 28, Issue August).

Mignerat, M., & Rivard, S. (2009). Positioning the institutional perspective in information systems research. *Journal of Information Technology*, *24*(4), 369–391.

Mikalef, P., Boura, M., Lekakos, G., & Krogstie, J. (2019). Big data analytics capabilities and innovation: the mediating role of dynamic capabilities and moderating effect of the environment. *British Journal of Management*, *30*(2), 272-298.

Mikalef, P., Krogstie, J., Pappas, I. O., & Pavlou, P. (2020). Exploring the relationship between big data analytics capability and competitive performance: The mediating roles of dynamic and operational capabilities. *Information & Management*, *57*(2), 103169.

Mikalef, P., Pappas, I. O., Krogstie, J., & Giannakos, M. (2017). Big data analytics capabilities: a systematic literature review and research agenda. *Information Systems and E-Business Management*, *1*, 1–32.

Miles, M.B., and Huberman, A.M. (1994) 'Qualitative Data Analysis: An Expanded Sourcebook', Sage Publications: London.

Miller, J. W. C. & D. L., & To. (2000). Determining Validity in Qualitative Inquiry John. *Theory Into Practice ISSN:*, *25*(3), 2–10.

Min, H., & Zhou, G. (2002). Supply chain modeling: past, present and future. *Computers & Industrial Engineering*, *43*(1–2), 231–249.

Mishra, D., Gunasekaran, A., Papadopoulos, T., Childe, S. J., & Oper Res, A. (2016). Big Data and supply chain management: a review and bibliometric analysis. *Annals of Operations Research*.

Mishra, N., & Singh, A. (2018). Use of twitter data for waste minimisation in beef supply chain. *Annals of Operations Research*, *270*(1-2), 337-359.

Mishra, N., Singh, A., Rana, N. P., & Dwivedi, Y. K. (2017). Interpretive structural modelling and fuzzy MICMAC approaches for customer centric beef supply chain: application of a big data technique. *Production Planning and Control*, *28*(11–12), 945–963.

Moretto, A., Ronchi, S., & Patrucco, A. S. (2017). Increasing the effectiveness of procurement decisions: The value of big data in the procurement process. *International Journal of RF Technologies: Research and Applications*, *8*(3), 79–103.

Mosterman, P. J., and Zander, J. (2016). Industry 4.0 as a cyber-physical system study. Software & Systems Modeling, 15(1), 17-29.

Mourtzis, D. (2016). Challenges and future perspectives for the life cycle of manufacturing networks in the mass customisation era. Logistics Research, 9(1), 2.

Rathore, M. M. U., Paul, A., Ahmad, A., Chen, B. W., Huang, B., & Ji, W. (2015). Real-time big data analytical architecture for remote sensing application. *IEEE journal of selected topics in applied earth observations and remote sensing*, *8*(10), 4610-4621.

Mustafa Kamal, M., & Irani, Z. (2014). Analysing supply chain integration through a systematic literature review: a normative perspective. In *Supply Chain Management: An International Journal* (Vol. 19, Issue 5/6).

Myers, M. D. (1997). Qualitative research in information systems. *Management Information Systems Quarterly*, *21*(June), 1–18.

Myers, M. D. (2019). *Qualitative research in business and management*. Sage Publications Limited.

Nazari-Shirkouhi, S., Shakouri, H., Javadi, B., and Keramati, A. (2013). Supplier selection and order allocation problem using a two-phase fuzzy multi-objective linear programming.

Applied Mathematical Modelling, 37(22), 9308-9323.

Nguyen, D. T., & Jung, J. E. (2017). Real-time event detection for online behavioral analysis of big social data. *Future Generation Computer Systems*, *66*, 137–145.

Nguyen, T., Li, Z. H. O. U., Spiegler, V., Ieromonachou, P., & Lin, Y. (2018). Big data analytics in supply chain management: A state-of-the-art literature review. *Computers & Operations Research*, *98*, 254-264.

O'Connor, G. C. (2008). Major innovation as a dynamic capability: A systems approach. *Journal of product innovation management*, *25*(4), 313-330.

Matthias, O., Fouweather, I., Gregory, I., & Vernon, A. (2017). Making sense of Big Data–can it transform operations management?. *International Journal of Operations & Production Management*.

Oliveira, T., & Martins, M. F. (2011). Literature review of information technology adoption models at firm level. *Electronic Journal of Information Systems Evaluation*, *14*(1), 110.

Orlikowski, W. J., & Baroudi, J. J. (1991). Studying information technology in organizations: Research approaches and assumptions. *Information Systems Research*, *2*(1), 1–28.

Osuszek, L., Stanek, S., & Twardowski, Z. (2016). Leverage big data analytics for dynamic informed decisions with advanced case management. *Journal of Decision Systems*, *25*, 436–449.

Ouyang, Y., Tang, C., & Rong, W. (2017). Task-technology Fit Aware Expectation-confirmation Model towards Understanding of MOOCs Continued Usage Intention. *Of the 50Th …*, 174–183.

Pal, B., Sana, S. S., & Chaudhuri, K. (2014). A multi-echelon production–inventory system with supply disruption. *Journal of Manufacturing Systems*, *33*(2), 262-276.

Pereira, J. V. (2009). The new supply chain's frontier: Information management. *International Journal of Information Management*, *29*(5), 372–379.

Pfeiffer, S. (2016). Robots, Industry 4.0 and Humans, or Why Assembly Work Is More than Routine Work. *Societies*, *6*(2), 1-26.

Philliber, S. G., Schwab, M. R., & Sloss, G. S. (1980). *Social research*. Adelaide: FE Peacock Publishers.

Phillips-Wren, G., & Hoskisson, A. (2015). An analytical journey towards big data. *Journal of Decision Systems*, *24*(1), 87–102.

Pishdad, A., & Haider, A. (2013). *Responding to external and internal changes: Organizational responsiveness pressures in institutionalising ERP systems* (pp. 2305-2312). IEEE.

Pishdad, A., Koronios, A., Reich, B. H., & Geursen, G. (2014). Identifying Gaps in Institutional Theory. ACIS Australasian Conference on Information Systems, pp. 1-11..

Preethi Varsha, V., Sankar, S. R., & Mathew, R. J. (2016). Predictive analysis using big data analytics for sensors used in fleet truck monitoring system. *International Journal of Engineering and Technology*, *8*(2), 714–719.

Pournarakis, D. E., Sotiropoulos, D. N., & Giaglis, G. M. (2017). A computational model for mining consumer perceptions in social media. *Decision Support Systems*, *93*, 98-110.

Power, D. J. (2016). "Big Brother" can watch us. *Journal of Decision systems*, *25*(sup1), 578-588.

Ranjan, S., Jha, V. K., & Pal, P. (2016). Antecedents and imperatives of integrating SCM and ERP in manufacturing organizations: A coneptual perspective with big data analytics. *International Journal of Control Theory and Applications*, *9*(10), 4423-4431.

Rao, P., Muller, M. R., & Gunn, G. (2017). Conducting a metering assessment to identify submetering needs at a manufacturing facility. *CIRP Journal of Manufacturing Science and Technology*, *18*, 107-114.

Rehman, M. H. U., Chang, V., Batool, A., & Wah, T. Y. (2016). Big data reduction framework for value creation in sustainable enterprises. *International Journal of Information Management*, *36*(6), 917–928.

Reinsel, D., Gantz, J., & Rydning, J. (2017). *Data Age 2025 : Don ' t Focus on Big Data ; Focus on the Data That ' s Big Data Age 2025 : March*, 1–25.

Reyes, A. (2014). Linguistic Anthropology in 2013: Super-New-Big. *American Anthropologist*, *116*(2), 366–378.

Richey, R. G., Morgan, T. R., Lindsey-Hall, K., & Adams, F. G. (2016). A global exploration of big data in the supply chain. *International Journal of Physical Distribution & Logistics*

Management.

Rüßmann, M., Lorenz, M., Gerbert, P., Waldner, M., Justus, J., Engel, P., and Harnisch, M. (2015). Industry 4.0: The future of productivity and growth in manufacturing industries. Boston Consulting Group, 9.

Russom, P. (2011). Big data analytics . *TWDI Best Practices Report, Fourth Quarter*, 1–34. https://doi.org/10.1109/ICCICT.2012.6398180

Ryder, R., & Fearne, A. (2003). Procurement best practice in the food industry: Supplier clustering as a source of strategic competitive advantage. *Supply Chain Management, 8*(1), 12–16. https://doi.org/10.1108/13598540310463314

Sancha, C., Gimenez, C., and Sierra, V. (2016). Achieving a socially responsible supply chain through assessment and collaboration. Journal of Cleaner Production, 112, 1934-1947.

Sanders, N. R. (2014). *Big data driven supply chain management: A framework for implementing analytics and turning information into intelligence*. Pearson Education.

Saunders, M., Lewis, P., & Thornhill, A. (2016). *Research methods for business students*. Pearson education.

Scott, W. (2005). Institutional Theory: Contributing to a Theoretical Research Program: Great minds in management: The process of theory development. *Great Minds in Management: The Process of Theory Development, January 2005*, 460–485.

Seddon, J. J. J. M., & Currie, W. L. (2017). A model for unpacking big data analytics in high-frequency trading. *Journal of Business Research, 70*, 300–307.

See-To, E. W., & Ngai, E. W. (2018). Customer reviews for demand distribution and sales nowcasting: a big data approach. *Annals of Operations Research, 270*(1-2), 415-431.

Selltiz, C., Wrightsman, L. S., & Cook, S. W. (1976). *Research methods in social relations*. Holt, Rinehart and Winston.

Shaw, K., Shankar, R., Yadav, S. S., and Thakur, L. S. (2013). Modeling a low-carbon garment supply chain. *Production Planning & Control,* 24(8-9), 851-865.

Sheng, J., Amankwah-Amoah, J., & Wang, X. (2017). A multidisciplinary perspective of big data in management research. *International Journal of Production Economics*, *191*, 97-112.

Shu, H. (2016). Big data analytics: six techniques. *Geo-spatial Information Science*, *19*(2), 119-128.

Silverman, D. (2005). *Doing qualitative research: A practical handbook*. SAGE publications limited.

Sivarajah, U., Kamal, M. M., Irani, Z., & Weerakkody, V. (2017). Critical analysis of Big Data challenges and analytical methods. *Journal of Business Research*, *70*, 263-286.

Son, J.-Y., Benbasat, I. 2007. Organizational Buyers' Adoption and Use of B2B Electronic Marketplaces: Efficiency- and Legitimacy-Oriented Perspectives. Journal of Management Information Systems, 24 (1), 55-99.

Straub, E.T. 2009. Understanding Technology Adoption: Theory and Future Directions for Informal Learning. Review of Educational Research. 79 (2), 625-649.

Suchman, M. C. (1995). Managing legitimacy: Strategic and institutional approaches. *Academy of management review*, *20*(3), 571-610.

Tan, K. H., Zhan, Y., Ji, G., Ye, F., & Chang, C. (2015). Harvesting big data to enhance supply chain innovation capabilities: An analytic infrastructure based on deduction graph. *International Journal of Production Economics*, *165*, 223-233.

Tao, F., & Qi, Q. (2017). New IT Driven Service-Oriented Smart Manufacturing: Framework and Characteristics. *IEEE Transactions on Systems, Man, and Cybernetics: Systems*, 1–11.

Tao, F., Cheng, J., Qi, Q., Zhang, M., Zhang, H., & Sui, F. (2017). Digital twin-driven product design, manufacturing and service with big data. *The International Journal of Advanced Manufacturing Technology*.

Tao, F., Zhang, L., Liu, Y., Cheng, Y., Wang, L., and Xu, X. (2015). Manufacturing service management in cloud manufacturing: overview and future research directions. Journal of Manufacturing Science and Engineering, 137(4), 040912.

Thoben, K. D., Wiesner, S., and Wuest, T. (2017). Industrie 4.0" and smart manufacturing–a review of research issues and application examples. Int. J. Autom. Technol, 11(1).

Thomas B. Lawrence, M. S. (2008). Institutional theory. *Donsbach, Wolfgang, (Ed.) The International Encyclopedia of Communication. Blackwell Publishers, Oxford, Pp. 2288-*

2293. ISBN 978-1-4051-3199-5, 1–2.

Tiwari, S., Wee, H. M., & Daryanto, Y. (2018). Big data analytics in supply chain management between 2010 and 2016: Insights to industries. *Computers & Industrial Engineering*, *115*, 319-330.

Touboulic, A., & Walker, H. L. (2015). Theories in sustainable supply chain management: a structured literature review. *International Journal of Physical Distribution & Logistics Management*, *45*(1/2), 16-42.

Tranfield, D., Denyer, D., Smart, P. 2003. Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. British Journal of Management, 14 (3), 207-222.

Trivedi, A., Chauhan, A., Singh, S. P., and Kaur, H. (2017). A multi-objective integer linear program to integrate supplier selection and order allocation with market demand in a supply chain. International Journal of Procurement Management, 10(3), 335-359.

van der Spoel, S., Amrit, C., & van Hillegersberg, J. (2017). Predictive analytics for truck arrival time estimation: a field study at a European distribution centre. *International journal of production research*, *55*(17), 5062-5078.

Van Horenbeek, A., Buré, J., Cattrysse, D., Pintelon, L., & Vansteenwegen, P. (2013). Joint maintenance and inventory optimization systems: A review. *International Journal of Production Economics*, *143*(2), 499-508.

Van Teijlingen, E. R., Rennie, A. M., Hundley, V., & Graham, W. (2001). The importance of conducting and reporting pilot studies: the example of the Scottish Births Survey. *Journal of advanced nursing*, *34*(3), 289-295.

van Weele, A. J. (2010, October). Value creation and purchasing strategy. In *International trade forum* (No. 4, p. 34). International Trade Centre.

Vojtovič, S., Navickas, V., & Gruzauskas, V. (2016). Strategy of sustainable competitiveness: Methodology of real-time customers' segmentation for retail shops. *Journal of Security and Sustainability Issues*, *5*(4), 489–499.

Vongjaturapat, S. (2018). Application of the task-technology fit model to structure and evaluation of the adoption of smartphones for online library systems. *Science & Technology Asia*, 39-56.

Waller, M. A., & Fawcett, S. E. (2013). *Data Science , Predictive Analytics , and Big Data : A Revolution That Will Transform Supply Chain Design and Management*. *34*(2), 77–84.

Walsham, G. (1995). The Emergence of Interpretivism in IS Research Geoff. *Information Systems Research 6.4 (1995): 376-394.*, *25*(6.4), 376-394.

Wamba, S. F., & Akter, S. (2019). Understanding supply chain analytics capabilities and agility for data-rich environments. *International Journal of Operations & Production Management*.

Wamba, S. F., & Akter, S. (2015, June). Big data analytics for supply chain management: A literature review and research agenda. *In Workshop on Enterprise and Organizational Modeling and Simulation* (pp. 61-72). Springer, Cham.

Wamba, S. F., Akter, S., Edwards, A., Chopin, G., & Gnanzou, D. (2015). How 'big data'can make big impact: Findings from a systematic review and a longitudinal case study. *International Journal of Production Economics*, *165*, 234-246.

Wamba, S. F., Dubey, R., Gunasekaran, A., & Akter, S. (2020). The performance effects of big data analytics and supply chain ambidexterity: The moderating effect of environmental dynamism. *International Journal of Production Economics*, *222*, 107498.

Wamba, S. F., Gunasekaran, A., Papadopoulos, T., & Ngai, E. (2018). Big data analytics in logistics and supply chain management. *The International Journal of Logistics Management*. doi.org/10.1007/s10479-018-3024-7

Wan, J., Tang, S., Li, D., Wang, S., Liu, C., Abbas, H., and Vasilakos, A. V. (2017). A manufacturing big data solution for active preventive maintenance. IEEE Transactions on Industrial Informatics, 13(4), 2039-2047.

Wang, G., Gunasekaran, A., & Ngai, E. W. T. (2016). Distribution network design with big data: model and analysis. *Annals of Operations Research*, 1–13.

Wang, G., Gunasekaran, A., Ngai, E. W. T., & Papadopoulos, T. (2016). Big data analytics in logistics and supply chain management: Certain investigations for research and applications. *International Journal of Production Economics*, *176*, 98–110.

Wang, G., Gunasekaran, A., Ngai, E. W., and Papadopoulos, T. (2016). Big data analytics in logistics and supply chain management: Certain investigations for research and applications. International Journal of Production Economics, 176, 98-110.

Wang, L., & Alexander, C. A. (2015). Big data driven supply chain management and business administration. *American Journal of Economics and Business Administration*, *7*(2), 60-67.

Wang, S., Wan, J., Li, D., & Zhang, C. (2016). Implementing smart factory of industrie 4.0: an outlook. *International journal of distributed sensor networks*, *12*(1), 3159805.

Wang, S., Wan, J., Zhang, D., Li, D., & Zhang, C. (2016). Towards smart factory for Industry 4.0: A self-organized multi-agent system with big data based feedback and coordination. *Computer Networks*, *101*, 158–168.

Wang, W. Y., Chan, H. K., & Pauleen, D. J. (2010). Aligning business process reengineering in implementing global supply chain systems by the SCOR model. *International Journal of Production Research*, *48*(19), 5647-5669.

Wang, Y, & Hajli, N. (2017). Exploring the path to big data analytics success in healthcare. *Journal of Business Research, 70*, 287–299.

Wang, Y., Kung, L., Byrd, T.A. 2018. Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. Technological Forecasting and Social Change, 126, 3-13.

Wang, Yichuan, Kung, L. A., & Byrd, T. A. (2016). Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. *Technological Forecasting and Social Change*.

Watson, H. J. (2014). Tutorial: Big data analytics: Concepts, technologies, and applications. *Communications of the Association for Information Systems*, *34*(1), 65.

Watson, H. J., & Marjanovic, O. (2012). Big data: The fourth data management generation. *Business Intelligence Journal*, *18*(3), 4–9.

Wei, W., Guimarães, L., Amorim, P., and Almada-Lobo, B. (2017). Tactical production and distribution planning with dependency issues on the production process. Omega, 67, 99-114. doi: 10.1016/j.omega.2016.04.004.

Wu, C., Buyya, R., & Ramamohanarao, K. (2016). Big data analytics= machine learning+ cloud computing. *arXiv preprint arXiv:1601.03115*.

Wu, M. and Yang, K. (2012) 'Research on the algorithms and key factors in optimizing supply

chain inventory', 2012 IEEE 5th International Conference on Advanced Computational Intelligence, ICACI 2012, pp. 433–436.

Wu, M., Yang, K. 2012. Research on the algorithms and key factors in optimizing supply chain inventory. IEEE 5th International Conference on Advanced Computational Intelligence, pp. 433-436.

Xu, K., Zhen, H., Li, Y., and Yue, L. (2016). Big Data Acquisition and Analysis Platform for Intermodal Transport. International Journal of Database Theory and Application, 9(12), 67-78.

Xu, L. D. (2011). Information architecture for supply chain quality management. International Journal of Production Research, 49(1), 183-198.

Xu, L. D., Xu, E. L., & Li, L. (2018). Industry 4.0: state of the art and future trends. International Journal of Production Research, 56(8), 2941-2962.

Xu, M., Cai, H., & Liang, S. (2015). Big data and industrial ecology. *Journal of Industrial Ecology*, *19*(2), 205-210.

Xu, Y., Chen, G., Zheng, J. 2016. An integrated solution – KAGFM for mass customization in customer-oriented product design under cloud manufacturing environment. International Journal of Advanced Manufacturing Technology, 84 (1/4), 85-101.

Yan, J., Xin, S., Liu, Q., Xu, W., Yang, L., Fan, L., ... & Wang, Q. (2014). Intelligent supply chain integration and management based on cloud of things. *International Journal of Distributed Sensor Networks*, *10*(3), 624839.

Yang, C., Lan, S., Shen, W., Huang, G. Q., Wang, X., and Lin, T. (2017). Towards product customization and personalization in IoT-enabled cloud manufacturing. Cluster Computing, 20(2), 1717-1730.

Yin, R. K. (2014). *The Case Study as Serious Research Strategy*. *3*, 97–114.

Yin, R.K. (2009) Case Study Research: Design and Methods, Fourth edn, Sage Publications,

Yin, R. K. (1981). The case study as a serious research strategy. *Knowledge*, *3*(1), 97-114.

Yin, R. K. (1979). *The Case Study as Serious Research Strategy*. *3*, 97–114.

Yu, C.-S. and Li, H.-L. (2000) 'A robust optimization model for stochastic logistic problems', International Journal of Production Economics, 64(1–3), pp. 385–397.

Yu, W., Chavez, R., Jacobs, M. A., & Feng, M. (2016). Data-driven supply chain capabilities and performance: A resource-based view. *Transportation Research Part E: Logistics and Transportation Review*.

Yuan, H., Xu, W., Li, Q., & Lau, R. (2018). Topic sentiment mining for sales performance prediction in e-commerce. *Annals of Operations Research*, *270*(1-2), 553-576.

Yue, X., Cai, H., Yan, H., Zou, C., Zhou, K. 2015. Cloud-assisted industrial cyber-physical systems: An insight. Microprocessors and Microsystems, 39 (8), 1262-1270.

Zhang, D. X., & Cheng, B. (2016). The impact of big data applications on supply chain management. In *Proceedings of the 6th International Asia Conference on Industrial Engineering and Management Innovation* (pp. 127-135). Atlantis Press, Paris.

Zhang, Y., Ren, S., Liu, Y., & Si, S. (2017). A big data analytics architecture for cleaner manufacturing and maintenance processes of complex products. *Journal of Cleaner Production*, *142*, 626–641.

Zheng, M., & Wu, K. (2017). Smart spare parts management systems in semiconductor manufacturing. *Industrial Management & Data Systems*.

Zheng, P., Sang, Z., Zhong, R. Y., Liu, Y., Liu, C., Mubarok, K., ... & Xu, X. (2018). Smart manufacturing systems for Industry 4.0: Conceptual framework, scenarios, and future perspectives. *Frontiers of Mechanical Engineering*, *13*(2), 137-150.

Zhong, R. Y., Newman, S. T., Huang, G. Q., & Lan, S. (2016). Big Data for supply chain management in the service and manufacturing sectors: Challenges, opportunities, and future perspectives. *Computers & Industrial Engineering*, *101*, 572-591.

Zhong, R. Y., Huang, G. Q., Lan, S., Dai, Q. Y., Chen, X., & Zhang, T. (2015). A big data approach for logistics trajectory discovery from RFID-enabled production data. *International Journal of Production Economics*, *165*, 260-272.

Zhong, R. Y., Lan, S., Xu, C., Dai, Q., & Huang, G. Q. (2016). Visualization of RFID-enabled shopfloor logistics Big Data in Cloud Manufacturing. *The International Journal of Advanced Manufacturing Technology*, *84*(1-4), 5-16.

Zhong, R. Y., Xu, C., Chen, C., & Huang, G. Q. (2017). Big data analytics for physical internet-based intelligent manufacturing shop floors. *International journal of production research*, *55*(9), 2610-2621.

Zhou, H., Benton Jr, W. C., Schilling, D. A., & Milligan, G. W. (2011). Supply chain integration and the SCOR model. Journal of Business Logistics, 32(4), 332-344.

Zhou, H., Shou, Y., Zhai, X., Li, L., Wood, C., & Wu, X. (2014). Supply chain practice and information quality: A supply chain strategy study. *International Journal of Production Economics*, *147*, 624-633.

Zigurs, I., Buckland, B.K. 1998. A Theory of Task / Technology Fit and Group Support Systems. MIS Quarterly, 22 (3), 313-334.

APPENDICES

Appendix 1: Interview Protocol and Documents

Section A- General Information of the Organisation (Organisational Background)

Interviewee's position/Role

- How was your data analytics system before the adoption of Big Data Analytics (BDA)?
- Which data is analysed?
- How many BDA techniques are implemented in your organisation? What are they?

Section B - BDA Adoption in Supply Chain Operations (SCO) Information

B.1 how do you identify the BDA innovation? When did you start implementing it?

B.2 what were the main motivations/values for BDA adoption in your organisation?

B.3 did you face any kind of problem while adopting BDA? What are they?

B.4 **Pressure Factors**: In your perspective, has any of the following influenced your decision for BDA utilisation? Please explain

a. customer expectation, b. demand and supply uncertainty, c. seeking supply chain sustainability

Other factors? Please explain

Section C: SCO Phases and Challenges

C.1 what you think about the main challenge in SCO in general?

C.2 more specifically, what are the main challenges in the following area: inventory operations, demand planning operations, logistics operations, procurement operations, manufacturing operations?

Section D: The Role of Big Data in SCO

D.1 what are the main sources that have generated big data in SCO?

. Could you please specify which source in which SCO phases (sources in manufacturing, demand planning, procurement, inventory, logistic)

D.2 Literature indicates that the crucial contribution of big data is represented in the application of three data analytics models, descriptive analytics, predictive analytics, and prescriptive analytics.

. How do you identify these three analytics approach?

D.3 In your perspective, which model is most used in each of the following areas: inventory operations analytics, demand planning operations analytics, logistics operations analytics, procurement operations analytics, manufacturing operations analytics?

D.4 what benefits do you think were provided after BDA implementation in related to each of the following: inventory operations, demand planning operations, logistics operations, procurement operations, manufacturing operations?

D.5 Do you consider the BDA technique as a mean of changing decision-making processes? Please explain

D.6 Literatures identify big data attributes in 7(v) value, volume, variety, veracity, visualisation, velocity, variability. Do you think the nature of big data representing in 7(V) played a main role of enabling BDA to revolutionise SCO? Please explain.

D.7 what other applications offered by BDA to improve SCO. (Please link the application(s) to which SCO's function(s)?

Invitation letter

Dear Sir/Madam

I am a doctoral researcher (PhD) at Brunel University London conducting a study on "the Impact of Big Data Analytics (BDA) on Supply Chain Operations" driven by the considerable debate on this subject.

In modern supply chain environment, huge amount of data is generated as a result of evolving electronic devices that monitor and trace objects and individuals, this opens new path for researchers and practitioners to exploit hidden knowledge pattern inside data through implementing BDA.

This research is attracted by the lack of case studies focused on organisations that have implemented big data analytics or have undergone the period of shifting and adopting BDA. Therefore, the study concerns with exploring the real and current situation of the role of big data analytics in supply chain operations and test the purported bandwagon for big data capabilities regarding business value in supply chain operation.

In this regard, your assistance is sought in gathering the relevant information that we require through semi-structured interviews. In addition to the academic domain, your organisation will significantly benefit from this empirical investigation via identifying the strengths and weaknesses of employing BDA.

I highly appreciate your support and kindly ask you to give me time to conduct the interviews and/or link me with persons whom you know could assist us. As a token of gratitude for your time, we would like to share the finding of our research with you even you are unable to participate.

Please note that no individual response is identified. Thus, by agreeing to participate in the study, you are indicating that your response is confidential. The interview will take about 45-60 minutes of your time.

If you have any additional comments, do not hesitate to contact the researcher on the contact details provided below.

Sincerely

Ruaa Hasan Ruaa.Hasan@brunel.ac.uk

Brunel University London,

Kingstone Lane, Uxbridge, UB8 2PL

PARTICIPANT INFORMATION SHEET

College of Business, Arts and Social Sciences

Brunel Business School

Study title: **Big Data and Big Data Analytics in Supply Chain Operations**

Invitation Paragraph

You are being invited to take a part in a research study. Before you decide, it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with others if you wish. Ask me if there is anything that is not clear or if you would like more information. Take time to decide whether you wish to take a part.

What is the purpose of the study?

The research aim is to investigate the impact of big data and big data analytics on supply chain operations. And describe the reality of big data analytics application in supply chain operations this will be achieved through providing detailed empirical evidence about the real-live of BDA implementation to understand the real and current situation of potential value of BDA in SCO and test the purported bandwagon for big data capabilities regarding business value in SCO To do so, the data will be collected via semi-structured interview. In order to achieve this, I will need to interview the senior managers as well as front line managers of supply chain operations organisations who applied big data analytics. In this respect, the purpose of conducting interview is to examine phenomena in their natural context. Undoubtedly, all the data collected through the interview will be strictly confidential. The researcher only will be having access to the material. Besides, the data will be anonymised on request and then securely stored; as well it will be destroyed when no longer required.

Why have I been invited to participate?

Interviews represent a powerful way to elicit narrative data that enables researchers to investigate people's views in depth. As we said before this study aims to investigate the reality of big data analytic implementation in supply chain operations. Therefore, this study requires information from a People with experiences from developing and implementing big data analytics tool in enhancing supply chain operations performance. To do so, the researcher needs to interview you in order to discuss the role of big data analytics in supply chain operations in order to allow as many aspects of the phenomenon as possible to emerge.

Do I have to take part?

As participation is entirely voluntary, it is up to you to decide whether or not to take part. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

If you agree to do the interview, then you will be requested to sign a consent form. Then you will be asked questions about your experience about your job. However, the interview will be electrically recorded in an audio format and then will be transformed into textual data. The main purpose of recording the interview to allow the researcher to capture all the point that you will mention during the interview so the researcher will be able to analyse the conversation later. The length of the interview might take maximum one hour.

What do I have to do?

You are kindly requested to answer the questions during the interview according to your personal experience within the organisation.

What are the possible disadvantages and risks of taking part?

As far to the researcher knowledge there are no risks expected by conducting this research.

What if something goes wrong?

If you as a participant have any complain in regard to your participations please do not hesitate to inform the Chair of the College of Business School, Art and Social science Research Ethics Committee

Will my taking part in this study be kept confidential?

Yes indeed, even if the researcher will record the interview and it will be coded and anonymised, and your personal information will not be traced to anyone else except the researcher only for analysis, reliability, and validity of data. Data will be stored on the secured password-protected Brunel network server. In addition, once the transcript is completed and checked by the interviewee then all the recorded conversations will be deleted.

What will happen to the results of the research study?

The textual data and analysis based on data will be only part of academic works for example the PhD thesis and publication as outputs of this research.

Who is organising and funding the research?

Brunel Business School/ Brunel University is organising this research and the researcher is the sponsor of this research.

What are the indemnity arrangements?

Brunel University, College of Business School, Art and Social science Research Ethics Committee

Who has reviewed the study?

This study has been reviewed by the College of Business, Art and Social Science Research Ethics Committee

Include a passage on the University's commitment to the UK Concordat on Research Integrity

Brunel University is committed to compliance with the Universities UK Research Integrity Concordat. You are entitled to expect the highest level of integrity from our researchers during the course of their research.

Contact for further information and complaints.

Researcher

Ruaa Hasan

PhD Candidate

Brunel University London

College Business, Arts & Social Sciences Business School, UK

Eastern Gateway Building, Brunel University London, Uxbridge, UB8 3PH, United Kingdom

Ruaa.Hasan@brunel.ac.uk

Principal Supervisor

Dr Muhammad Mustafa Kamal (BBA, MCS, OCP 'DBA', MSc DCS, PhD, FHEA)
Director of Undergraduate Studies
Director of Alumni
UG Business and Management – General Pathway Leader
Senior Lecturer in Operations and Supply Chain Management
T: +44 (0) 1895 267728 | F: +44 (0) 1895 269775 | Twitter: @muhammadmkamal
Office: Room 217, 2nd Floor, Eastern Gateway Building
.

Passage on the University's commitment to the UK Concordat on Research Integrity

Brunel University is committed to compliance with the Universities UK Research Integrity Concordat. You are entitled to expect the highest level of integrity from our researchers during the course of their research.

For complaints and questions about the conduct of the Research

Professor Christina Victor, Chair College of Health and Life Sciences Research Ethics Committee Christina.victor@brunel.ac.uk

College of Health and Life Sciences

College Business, Arts & Social Sciences Business School, UK

CONSENT FORM

The participant should complete the whole of this sheet Please.

tick the appropriate box

The participant should complete the whole of this sheet		
	Please tick the appropriate box	
	YES	NO
Have you read the Research Participant Information Sheet?		
Have you had an opportunity to ask questions and discuss this study?		
Have you received satisfactory answers to all your questions?		
Who have you spoken to?		
Do you understand that you will not be referred to by name in any report concerning the study?		
Do you understand that you are free to withdraw from the study:		
• at any time?		
• without having to give a reason for withdrawing?		
I agree to my interview being recorded.		
I agree to the use of non-attributable direct quotes when the study is written up or published.		
Do you agree to take part in this study?		
Signature of Research Participant:		
Date:		
Name in capitals:		
<u>Witness statement</u>		
I am satisfied that the above-named has given informed consent.		
Witnessed by:		
Date:		
Name in capitals:		

Researcher name:	Signature:
Supervisor name:	Signature:

Appendix 2: Ethical Approval

College of Business, Arts and Social Sciences Research Ethics Committee
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

www.brunel.ac.uk

5 November 2019

CONDITIONAL LETTER OF APPROVAL

APPROVAL HAS BEEN GRANTED FOR THIS STUDY TO BE CARRIED OUT BETWEEN 11/11/2019AND 31/12/2019

Applicant (s): Mrs Ruaa Hasan

Project Title: Big Data and Big Data Analytics in Supply Chain Operations

Reference: 13838-LR-Oct/2019- 20748-1

Dear Mrs Ruaa Hasan

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority has agreed that there is no objection on ethical grounds to the proposed study. Approval is given on the understanding that the conditions of approval set out below are followed:

- You complete the Risk Assessment properly - i.e. you think about the risks of interviewing people off-campus and the rest of your own project and insert this information into the Risk Assessment and delete the examples given which are not relevant to your project.
- On your Participant Information Sheet, you indicate a date by which participants can withdraw their data (bearing in mind your writing up and submission schedule for your thesis).
- Under 'What are the indemnity arrangements?' you state that Brunel provides appropriate insurance cover for research which has received ethical approval.
- Under 'Contact for further information and complaints', delete Christina Victor and add David Gallear.
- The agreed protocol must be followed. Any changes to the protocol will require prior approval from the Committee by way of an application for an amendment.

Please note that:

- Research Participant Information Sheets and (where relevant) flyers, posters, and consent forms should include a clear statement that research ethics approval has been obtained from the relevant Research Ethics Committee.
- The Research Participant Information Sheets should include a clear statement that queries should be directed, in the first instance, to the Supervisor (where relevant), or the researcher. Complaints, on the other hand, should be directed, in the first instance, to the Chair of the relevant Research Ethics Committee.
- Approval to proceed with the study is granted subject to receipt by the Committee of satisfactory responses to any conditions that may appear above, in addition to any subsequent changes to the protocol.
- The Research Ethics Committee reserves the right to sample and review documentation, including raw data, relevant to the study.
- You may not undertake any research activity if you are not a registered student of Brunel University or if you cease to become registered, including abeyance or temporary withdrawal. As a deregistered student you would not be insured to undertake research activity. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.

Professor David Gallear

Chair of the College of Business, Arts and Social Sciences Research Ethics Committee

Brunel University London